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Photosynthetic efficiency in species with C3 and C4 metabolisms

Eficiência fotossintética em espécies dos metabolismos C3 e C4

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Abstract— Beans and corn are very important crops in terms of human nutrition worldwide, however each of them has its particularities, especially in the characteristics of photosynthetic metabolism (energy production), which are C3 and C4, respectively. According to studies in the field of physiology of higher plants, the C4 metabolism is an evolution of the C3 metabolism, being, according to the literature, more efficient from the photosynthetic point of view. The present work was based on the following question: In fact, is C4 metabolism more efficient than C3 from the point of view of energy production?. Thus, this work aimed to quantify and compare the photosynthetic potential of species with C3 and C4 metabolisms. The results of this study, therefore, pointed to C3 metabolism as the major energy producer in the photosynthetic process. On the other hand, it considered that the relationship between the energy produced and the energy stored in grains was higher in the C4 metabolism culture, that can change from species to species.

Resumo— O feijão e o milho são culturas muito importantes no tocante à alimentação humana em todo o mundo, no entanto cada uma delas possui suas particularidades, sobretudo, nas características de metabolismo fotossintético (produção de energia), que são C3 e C4, respectivamente. De acordo com estudos no campo da fisiologia de vegetais superiores, o metabolismo C4 se constitui como uma evolução do metabolismo C3, sendo, de acordo com a literatura, mais eficiente do ponto de vista fotossintético. O presente trabalho se deu a partir do seguinte questionamento: De fato o metabolismo C4 é mais eficiente que o C3 de ponto de vista de produção de energia?. Assim, esse trabalho objetivou quantificar e comparar o potencial fotossintético de espécies dos metabolismos C3 e C4. Os resultados desse estudo, apontaram, portanto, para o metabolismo C3 como maior produtor de energia no processo fotossintético. Por outro lado, considerou que a relação entre a energia produzida e a energia armazenada em grãos foi maior na cultura de metabolismo C4, que pode mudar de espécie para espécie.

I. INTRODUÇÃO

O feijão (Phaseolus vulgaris L.) e o milho (Zea mays L.) são caracterizadas por sua importância a nível global, sendo o Brasil o maior produtor e consumidor da primeira cultura com produção média em 2012/2013 de 2.806.300 toneladas (Pereira et al., 2014), e a segunda se apresenta como o grão mais cultivado no mundo com cerca de 968 milhões de toneladas em 2016 (Souza et al., 2018).

No que diz respeito ao metabolismo fotossintético, ambas as culturas possuem características distintas, onde o feijão possui metabolismo C3 (Tavares et al., 2013) e o milho C4 (Bergamaschi & Matzenauer, 2014; Maciel et al., 2004). De acordo com a literatura, o metabolismo C3 é mais antigo que o C4, onde o segundo surge como uma evolução do primeiro para compensar as limitações relacionadas a baixos níveis de CO2 na atmosfera, cabendo ressaltar que boa parte dos vegetais mais produtivos fazem uso desse mecanismo para potencializar a atividade da rubisco (Taiz et al., 2017), em outras palavras, a fotossíntese C4 é mais eficiente na captação de CO2 que a C3, que por sua vez aumenta a capacidade fotossintética das espécies que possuem esse mecanismo adaptativo, porém, a luz de resultados em torno de balanço de carbono.

Assim, o presente estudo objetivou comparar as capacidades de produção de energia, através da fotossíntese - por meio das entalpias das ligações químicas - dos metabolismos C3 e C4, para que seja possível ter clareza de qual mecanismo é de fato mais eficiente fotossinteticamente.

II. METODOLOGIA

Para a realização do trabalho, foram tomadas como modelo de metabolismo C3 (met.C3) e C4 (met.C4) as culturas de feijão (Phaseolus vulgaris L.) e milho (Zea mays L.), respectivamente. O estudo foi orientado pela pergunta: Realmente o met.C4 é mais eficiente do ponto de vista de produção de energia que o met.C3?. Os dados científicos que deram suportem à realização dos cálculos para a compreensão geral do estudo, foram obtidos através de pesquisas realizadas e publicadas por outros autores no campo da fisiologia da produção e metabolismo vegetal.

III. DESENVOLVIMENTO

Considerando um espaçamento de 15 cm entre plantas e 50 cm entre linhas, um hectare (ha) de feijão possui um total de 13.333 plantas. Um ha de feijão em 2010 chegou a produção de 884 kg/ha (Silveira et al., 2015), logo uma planta de feijão produz ~66g de grãos.

100g Feijão verde possui cerca de 31 calorias (3% gordura, 77% carboidrato, 20% proteína) (internet). Assim, (0,31 x 66), são armazenadas em seus grãos um total de 20,46 calorias, aproximadamente 0,1 KJ.

Para que se produza satisfatoriamente, uma planta de feijão necessita de em média 400 litros de água durante seu ciclo (Arf et al., 2004).

Aproximadamente 1% do que as plantas absorvem pelas raízes é utilizado na fotossíntese e em outras reações metabólicas (Taiz e Zeiger, 2013).

Logo, 1% de 400 litros = 4 litros de água utilizados nos processos metabólicos do feijão. Se considerar que a fotossíntese utiliza algo em torno de 25% desse total, chega-se a um total de 1 litro de água utilizado no metabolismo fotossintético do feijão.

Quantidade de moléculas de H2O em 1 litro de água:

$3,34.10^{25} = 33.400.000.000.000.000.000.000.000$ moléculas

Dados:

Densidade da agua = 1 g/mL

Volume de agua = 1 L = 1000 mL

Massa Molar da agua = 18 g/ mol

Número de Avogadro = 6,02 x 10^{23} moléculas / mol

Cálculos:

Massa de água = densidade x volume = 1 g/ mL x 1000 mL

Massa de água = 1000 g

Mols de H2O em 1 litro - Regra de 3

1 mol ------ 18 gramas

X mol ------ 1000 gramas

X = 1000 / 18 = 55,56 mols

Número de moléculas de H2O em 1 litro - Regra de 3

1 mol ----- 6,02 x 10^{23} moléculas

55,56 mol ----- Y moléculas

Y = 55,56 x 6,02 x 10^{23} = 334 x 10^{23} = 3,34 x 10^{25}

Duas moléculas de H2O gera em média 2 $NADPH_2$ e 3 ATP´s. A energia presente em uma molécula de $NAPH_2$ corresponde a 3 ATP´s, portanto duas moléculas de H2O produz um total de 9 ATP´s (Taiz & Zeiger, 2013; Taiz et al., 2017).

Portanto, as moléculas de ATP formadas a partir de 1 litro de água são:

$3,34.10^{25}/2 = 1,67.10^{25}$ x 9 = $15,03.10^{25}$ ou $150.300.000.000.000.000.000.000.000$ moléculas

No met.C3 são necessárias 18 ATP´s e 12 NADPH$_2$ para formar uma molécula de glicose, assim sendo, será exigida uma energia igual a 54 ATP´s para cada molécula de glicose formada (Taiz & Zeiger, 2013; Taiz et al., 2017).

Logo, de toda a energia produzida a partir de 1 litro de água serão formadas:

$150,3.10^{24}$ / 54 = $2,78.10^{24}$ ou 2.780.000.000.000.000.000.000.000 moléculas de glicose durante todo o ciclo do feijão.

Considerando as entalpias das ligações químicas, uma molécula de glicose possui cerca de 9.481 KJ/mol

Logo, uma planta de feijão chega a produzir em seu ciclo:

$2,78.10^{24}$ x 9.481 kj = $26.357,18.10^{24}$ KJ

De acordo com Neto (2022) - utilizando o mesmo volume de água - o milho (met.C4) produz em um ciclo cerca de $21.521,87.10^{24}$ KJ de energia e armazena em seus grãos um valor próximo de 119,16 calorias, aproximadamente 0,5 KJ.

IV.   CONSIDERAÇÕES FINAIS

Segundo os resultados de produção total de energia fotossintética, em geral, pôde-se notar que o feijão (met.C3) produz mais que o milho (met.C4) durante o ciclo. Por outro lado, quando se observa o percentual de energia armazenada nos grãos (principal órgão de reserva) em relação a energia produzida, percebe-se que o milho armazena um maior percentual, tornando – se, portanto, mais eficiente que o feijão do ponto de vista de balanço energético, no entanto, isso pode mudar de espécie em espécie. Logo, se for considerar a energia total produzida, é necessário rever a ideia de que o metabolismo C4 é mais eficaz que o C3 a luz de suas capacidades fotossintéticas, que por sua vez é determinado na literatura por meio de balanço de carbono e não por produção de energia que é o principal produto da fotossíntese.

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Medicinal use of the main Boldo Species in Brazil and in Lusophone Africa Countries

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Abstract— The use of medicinal plants as an alternative source of treatment, prevention and cure of various diseases is a practice that comes with ancestry. Currently, the search for well-being and new forms of natural treatment without many chemicals, makes the demand for herbal medicines increase every day. Among these, we have the boldo, which has contributed to cure and alleviate some evil diseases such as: liver, poor digestion, stomach, and hemorrhoids. However, in Brazil, as well as in Portuguese-speaking African Countries - (PALOP) there is still a deficit or shortage in research involving this species. The objective of this work is to present a profile of the main boldo species and different forms of use in Brazil and in the PALOP countries (Angola, Cape Verde, Guinea Bissau, Mozambique

and São Tomé and Príncipe) from the perspective of health and sustainability. To carry out the work, a narrative review of the literature was carried out with a descriptive character, through the selection, reading, analysis and interpretation of articles published in full in scientific journals, in Portuguese and in English, available on the internet. In the search for articles, the Boolean AND operator was used. To better obtain the results, it was necessary to use the following keywords: medicinal use, boldo, Brazil, sustainability and medicinal use, Lusophone African countries, PALOP and sustainability. The chosen platforms were SciELO, LILACS and Google and Academic. The use of the highest incidence of 01 species of boldo in Portuguese-speaking African countries, known as Boldo-Africano (Plectranthus barbatus), was identified. In Brazil, 08 species are cultivated, being used commercially the species Vernonia amygdalina, (Gymnanthemum amygdalinum), African Bilberry/Garden Bilberry (Plectranthus barbatus), Boldo possum (Plectranthus backpacks) and Chilean Boldo (Peumus boldus, Monimiaceae), the latter being imported. In Brazil, the health strategies of the Family Health Program - PSF contemplate another look at the needs of the communities assisted by the program, while in Lusophone Africa, the health systems have a small and poorly distributed chain of medicines that, for the most part, do not even arrive for a third of the population. The study points to the need to carry out more research on the subject, as the results of these research can be extremely important in the dissemination of the correct way of use and indication, which can contribute to the preservation of species and maintenance of the cultural legacy of biodiversity, knowledge base on the use of medicinal plants and herbal medicines, such as boldo.

I. INTRODUCTION

Medicinal plants are part of the traditional culture of many peoples, based on the need for healing, well-being, and preventive health. This strategy was the basis for the dissemination of the use of plants for medicinal purposes throughout human history. The contribution of traditional medicine and the use of medicinal plants preceded the pharmacological knowledge that is currently used on a commercial scale. It is noteworthy that the use of plants for medicinal and herbal purposes continues to be a routine practice in many traditional communities around the world.

According to Gadelha (2013, p. 2), medicinal plants are part of plant species with the purpose of treating and curing diseases and their use constitutes a practice that dates to the beginning of civilization. Thus, from the moment that man became aware that it was possible to modify the environment for his own benefit, he began to use some plants for medicinal purposes" (GADELHA, 2013, p. 2).

The processes resulting from globalization point to two well-observed aspects: the first related to the knowledge of local communities, how traditional communities cultivate the culture of using these medicinal plants in each country, and secondly, how medicinal plants are used in other countries from of commercial relationships and social interaction between people from different nations and geographic regions, "the use of medicinal plants from traditional Indian and Chinese medicine, completely unknown to Western peoples , is increasingly frequent " (VEIGA JUNIOR; PINTO; MACIEL, 2005 , p. 519).

However, the cited authors point out that the use of medicinal plants is increasingly associated with commercial actions and not because of the need for quality of life and well-being of the population, and it is healthy to understand the dynamics that exist between different countries, with different cultures. and the existing relationships after the first contact relationships. In this context, the present work presents two perspectives; initially addresses the relationship of the use of medicinal plants in Brazil and the PALOP, also known as Lusophone Africa, with observance in boldo and then an analysis of the use by traditional communities and their purposes from the perspective of health, sustainability, and biodiversity.

The history of relations between Brazil and Africa is permeated by a history of pain and suffering, but positive aspects related to cultural development, such as traditional

medicine, exchanges of experiences and knowledge, as well as the maintenance and appropriation of culture over the centuries, deserve to be highlighted., from the first social interactions even if forced, conflicting and violent. Both in Brazil and in Africa, history shows that, essentially, the basis of tribal and native cultures contributed to the models of social organization, based on knowledge of the environment, here indigenous peoples and there the ethnolinguistic groups that characterize African countries, united language, customs, institutions, and traditions.

Africa is one of the continents known for its biodiversity and its typical tropical forests that provide environments for a vast cultivation of plant species used by the population for different purposes such as food, medicine, and crafts. The use of these medicinal plants is notorious mainly in communities and families that have few financial resources to purchase conventional medicines, thus having as an alternative the use of medicinal plants that mostly grow in their cultivated backyards or spontaneously. In addition to being easily accessible to communities, it is a more accessible and healthier way to treat some diseases, it is traditional knowledge transmitted from generation to generation, carrying with it the high cultural value of communities or regions. As we can see, this biodiversity adds very rich values about the use of plants for medicinal purposes.

Although the use of plants by traditional communities (indigenous, quilombola and rural) is part of our culture, in Brazil, medicinal plants from native flora are consumed with little or no proof of their pharmacological properties, propagated by users or traders. Many times, these plants are even used for medicinal purposes other than those used by forestry (VEIGA JUNIOR; PINTO; MACIEL, 2005, p. 519).

The use of medicinal plants or traditional medicine is still a well-preserved heritage, although these plants do not contribute much to the regional trade in natural products, this can be attributed to the lack of support funds or promotion of research on regional native plants, thus contributing to the very cultural devaluation of native species.

The lack of material and processing of these plants may contribute to their regional extinction. Abdullahi (2011) cites the use of aloe vera (*Aloe vera*), one of the native plants of Africa and known almost everywhere in the world, but which in the African continent itself is not very widespread, processed and much less researched about it, a similar situation that the boldo that, even though it is not native to Africa, adapted very easily and is well known. Its use is nothing more than the empirical knowledge left or passed on by its ancestors and is increasingly in disuse,

being forgotten and becoming extinct.

The revitalization and conservation of these medicinal species of the boldo type is extremely important, mainly because they are species that are mostly used in the treatment and prevention of various diseases since ancient times. Boldo is known to be a crop that is easy to grow, resistant to water stress, does not require much machinery or chemical fertilization and, when necessary, fertilization with well-cured cattle manure, chicken manure or compost is recommended. organic. When the cultivation is controlled it can be done by seedlings or in seeds, in the ground or even in vases, however in Africa the cultivation is still quite traditional, most of the cultivation is done in the soil in beds with a depth of 15 to 20 cm, with a standard spacing of 0.50 x 1 m between plants and when planted in vases, boxes or recyclable basins, the standard depth is 20 cm, which is measured by the same eye (ABDULLAHI, 2011).

Boldo planting should preferably be carried out in regions with a tropical climate, it does not tolerate soggy soils, preferring regions with acidic soils. Borba et al. (2012) state that the information available from an agronomic point of view is scarce, which is why management techniques are mostly unknown. There is a need to intensify research on agronomic management for these species and create standardized material with information on management. In Africa or in some African countries it is treated as Unconventional Food Plants - PANC, as it is a plant that grows spontaneously in backyards, which is why good general agronomic practices of boldo or medicinal plants in general are not widespread, which would help the farmer to be more efficient and make sustainable use of biodiversity in the field.

Boldo is known for its different uses, such as teas for stomach pain, to cure hemorrhoids, intestines, and liver and when processed, the essential oil is extracted with different uses. Loya et al. (2009) state that the consumption of medicinal plants has bases and traits in the family-based tradition passed from generation to generation and in religion, making it the main alternative for promoting health in communities.

With this, it can be understood that many societies still use medicinal plants, either empirically or scientifically, African countries are no exception, as they are part of the 80% of the world's population that use medicinal plants to meet their needs.

In this sense, the work aims to present a profile of the main species of boldo and different forms of use in Brazil and in African countries with the official Portuguese language (PALOP) from the perspective of health and sustainability, through a narrative review of the literature.

II. METHODOLOGY

To carry out the work, a narrative review of the literature was carried out, with a descriptive character, through the selection, reading, analysis and interpretation of articles published in full in scientific journals, in Portuguese and in English, available on the internet. The research was carried out using the following keywords: medicinal use, boldo, Brazil, Lusophone African countries, PALOP and sustainability. During the search for works on the subject on scientific article search platforms, using the Boolean AND operator, the words "medicinal plants and phytotherapy" were directly combined with each of the other keywords. The platforms and databases used were SciELO, LILACS and Google and Academic.

For the selection of the articles, search criteria were established, through the keywords and elaboration of the development of the work, through a significant literature, which could generate knowledge about the use of medicinal plants of the boldo type, the most used species in the countries of Lusophone Africa and Brazil.

III. RESULTS AND DISCUSSION

The methodology used during the bibliographic survey and the results obtained are registered in the indicated repositories, having been characterized by the similarity of objectives identified in each text, as shown in Table 1.

Table 1 - Table of authors, year and publication of the titles used in the research.

AUTHOR	YEAR	TITLE
ABDULLAHI, A.A.	2011	Trends and challenges of traditional medicine in Africa.
AUGUSTINE, AB	2016	Ethnobotany: traditional and scientific knowledge
CESAR, MGA	2021	Chemical study and evaluation of the cytotoxic and antioxidant activities of leaves and flowers of *Plectranthus neochilus Schltr.*
CONDE, P. *et al.*	2014	The Botanical Mission of Mozambique (1942-1948): contributions to the knowledge of the medicinal flora of Mozambique
FERNANDES, JM; LOPES, CRAS; ALMEIDA, AASD	2017	Morphology of medicinal boldo species cultivated in Brazil.
GREGORIO, AS	2021	Ethnobotanical survey of traditional female knowledge of medicinal plant species with emphasis on boldo in urban backyards in the GM3 neighborhood in the municipality of Tabatinga-AM.
MAIA, ICM *et al.*	2017	Development and characterization of boldo oral solution in the pharmaceutical industry of Pernambuco.
MUCHAIA. AJ; NANVONAMUQUITX, SJA	2021	Ethnobotanical survey of medicinal plants used by the Nacuale community, in Quirimbas National Park, Mozambique.
SILVA, LC N	2014	Dissertation for Obtaining a master's degree in Biomedical Sciences
SOUZA, MBR; MORAES, SJV; ALVIM, HGO	2021	Bilberry and its benefits in gastrointestinal diseases.

Source: own authorship (2022)

The cataloged authors in general point out the relevance of the use of medicinal plants for the treatment of diseases, care for the person, associated with the traditional knowledge of the places, pointing to similar paths between Brazil and the Portuguese-speaking African countries. The use with the highest incidence of a species of boldo in the PALOP, known as Boldo-Africano (*Plectranthus barbatus*).

MEDICINAL USE OF BOLDO IN AFRICAN COUNTRIES

The textual analysis of the researched sources points out that over the years the cultivation of boldo has advanced in some countries, but in Africa the most frequent cultivation or that best adapted was the African boldo or simply *Mbozane*, as it is popularly called in Mozambique, or capungo-pungo as it is known in Angola.

The *Plectranthus* barbatus or simply boldo false

originates in India, but became popular in several continental countries, being confused by the name because it originates from Africa; its adaptation and expansion in Africa is since most African countries have tropical/dry climates and the African boldo is characterized by its resistance to dry climates.

Viana (2011) states that African boldo contains a high biological value (AVB), which makes it widely used in traditional medicine. Agostinho (2016) recommends that urgent studies be carried out, especially in regions where medicine is still used. traditional. For Silva (2014), the fact that African countries are poor and of slow development influences the use of traditional medicine, mainly because it is vast and rooted and the healer plays the role of specialist in medicinal plants.

Boldo- African has a bitter taste, characteristic odor and is popularly known as an antidote in colic for newborns, but it is contraindicated for pregnant women. Lukhoba et al. (2006), also mention its uses in the treatment of gastritis, intestinal spasms, liver, and dental diseases; in asthma, bronchitis, pneumonia, and other respiratory diseases. It is widely used in Africa, especially in Mozambique, where it is often used to cure hemorrhoids.

Currently, the use of boldo as a flavoring and essential oils has been conquering important niches in the market and, not only that, but it has also increasingly enriched the scientific shelves. These oils are extracted from plants and the lack of adequate processing and techniques in African countries makes it impossible to carry out research on the processing of oils, thus limiting their use to only the leaves and roots that do not need any processing and it is a knowledge of your domain.

Authors such as Tchamba (2019), in Angola, Silva (2014), in Guinea Bissau and Abdullahi (2011), in his article on the trends and challenges of traditional medicine in Africa, are unanimous in stating that it is extremely urgent that more research and practical studies that demonstrate the importance of preserving and using these plants, such as the African boldo and other medicinal plants with therapeutic actions, to prevent and cure various diseases, mainly because Africa is one of the continents where it is most used traditional medicine . These oils can be defined as complex mixtures of volatile, lipophilic substances, with low molecular weight, generally odoriferous and liquid, consisting, in most cases, of molecules of a terpenic nature and many of these oils have a strong, pleasant, and striking odor or aroma (MORAIS, 2009).

MEDICINAL USE OF BOLDO IN BRAZIL

Brazil's potential for the use of medicinal plants is closely linked to its biological diversity, namely:

It is understood that Brazil, with its broad genetic heritage and cultural diversity, can establish its own and sovereign development model in health and use of medicinal plants and herbal medicines, which excels in the sustainable use of the components of biodiversity and respect the ethical principles and international commitments assumed, notably the CBD, and thus promote the generation of wealth with social inclusion (BRASIL, 2016, p. 19)

The studies by Fernandes, Lopes and Almeida (2021) indicate that in Brazil 08 species of boldo are cultivated, namely *Gymnanthemum amygdalinum; Plectranthus amboinicus; Plectranthus barbatus; Plectranthus grandi; Plectranthus neochilus; Plectranthus ornamen*t and *vernonia condense*. The species most used for medicinal purposes are *Gymnanthemum amygdalinum* (Asteraceae), *Plectranthus barbatus and Plectranthus neochilus* (Lamiaceae), the three medicinal species of boldo, cultivated in Brazil, are used to treat stomach and liver disorders (FERNANDES; LOPES; ALMEIDA, 2021, p. 12).

Associated with the species cultivated in Brazil, Boldo do Chile (*Peumus boldus*), with endemism in the central regions of Chile. In Brazil, although Boldo-do-Chile is imported, it is one of the best known and most popular plants in the culture from north to south of the country, except for different species that are also commonly called boldo (NASCIMENTO, 2019, p. 16).

For the cited authors, the origin of the species cultivated in Brazil refers to the African and Asian continents. The *Gymnanthemum* species *amygdalinum* is native to Tropical Africa, the species *Plectranthus barbatus* is native to the rocky forests of Ethiopia, Sudan, Tanzania, and India. The species *Plectranthus neochilusé*, known colloquially as lobster bush, fly bush or mosquito bush, is native to South Africa, Botswana, Zambia, and Zimbabwe.

Studies indicate that the most used plants in Brazil are the result of the interaction between people of different origins and cultural relations, since in Brazil the use of medicinal plants for the treatment of diseases is rooted in the indigenous, African, and European immigrant cultures (STEFANELLO, 2018, p. 2).

Boldo-do-chile is widely used for the treatment of gastrointestinal and liver diseases, its leaves are rich in oxidants, beneficial in the treatment of gallstones, liver congestion, liver failure and oxidative stress associated with diseases (NASCIMENTO, 2019, p 12).

Converging with this thought, studies reveal that Brazil is the country with the greatest biodiversity on the planet, which, associated with a rich ethnic and cultural diversity, holds valuable traditional knowledge associated with the use of medicinal plants, having the necessary potential for the development of research with results in appropriate technologies and therapies (BRASIL, 2016, p. 14).

As shown, there is a need to carry out research to better understand the possibilities of exploiting the different species of boldo, whether cultivated in Brazil and used commercially or less used. We believe that the results of this research will contribute to the dissemination of correct information regarding the use, function, and medicinal properties of boldo.

IMPACT OF THE POPULAR USE OF BOLDO IN LUSOPHONE AFRICAN COUNTRIES AND IN BRAZIL IN TERMS OF SUSTAINABILITY AND PUBLIC HEALTH

Man's evolution shows that since his ancestry, he has always survived on the basis of products from nature, whether for food, construction or to cure his illnesses; this knowledge has been perpetuated until the present day, because in the whole world there are still several regions that spread the use of plants as medicines, in some of these regions it is the only option to relieve their pain and the use of medicinal plants continues.

Currently, there is concern about the effects that are being generated by allopathic medication such as African boldo, which has led pregnant women to resort to the use of medicinal plants as an alternative in the treatment of some pregnancy symptoms, but many of them are not aware that most of them they can be abortive, as is the case with the African boldo (MORAES et al., 2018).

The use of African boldo as a medicinal plant brings with it some effects that can be very serious for health, especially when ingested in high doses, causing abortions in pregnant women; in the same intensity that conventional medicines cause overdose, medicinal plants of the boldo-African type, when poorly dosed, can cause the same effect. Silva (2014) states that the fact that they are natural medicines does not negate the possibility of being partially harmful. Conde et al. (2014) report that the fact that medicinal plants are used empirically, without many restrictions and that most dosages are measured holistically, can be harmful to public health if they are used irrationally.

Africa is considered one of the poorest continents, with conventional health systems that are still precarious and most of them do not reach everyone, and when they do, they only supply a part of the population, which is why this region still depends heavily on medicinal plants to prevent and cure your pains. Silva (2014) points out that in Africa the use of medicinal plants is rooted and has always been used empirically, based on beliefs and religion, undergoing only field tests, that is, tests were carried out on people, where patients ingested a certain dose and if it worked, the other members of society would start using that dose, which meant that many people, at that time, would even die, because the doses are not linear, this form of use lasts until the present day .

Abdullahi (2011) states that with the evolution and new way of living, young people have been neglecting traditional knowledge and practices, an example of these practitioners is healerism, which has broader knowledge about the use and management of medicinal plants, but the new generations have been eliminating these practices and it is known that this is extremely important knowledge of the intangible cultural heritage. Due to the extreme cultural importance of traditional knowledge, which transcends generations and preserves identities, it is necessary to encourage these practices and cultures among young people. The loss, forgetfulness, and devaluation of the "living tradition" and sustainable practices can cause cultural damage to Africa and humanity (BÂ, 2010).

In Brazil, the health strategies of the Family Health Program - PSF contemplate another look at the needs of the communities assisted by the program. For Pilla, Amorozo and Furlan (2006), in Brazil, although the official health system is free and extends to the interior, it cannot adequately meet the needs of communities and people, mainly due to the lack of purchasing power, such as the lack of of professionals who serve the community satisfactorily. In addition, industrialized medicines are expensive, leading people to use medicinal plants that are usually grown in their own backyards.

It is known that there is a need to guide the population regarding the use of medicinal plants that may be responsible for the treatment of many primary diseases, with good economic results and improvement in the health of the low-income population (BRASILEIRO, 2008, p. 1).

To encourage the use of medicinal plants associated with clinical treatments, the National Policy for Medicinal Plants and Herbal Medicines was launched, approved by Decree No. rational use, promotion of production chains, sustainable use and with a focus on the sustainable development of biodiversity for collective health.

IV.   FINAL CONSIDERATIONS

In Africa, as well as in Brazil, medicinal plants occupy essential levels, hence the need for preservation and conservation of these species is extremely important, especially for new and future generations. The use of African boldo is little explored, with the main species being the *Plectranthus barbatus* or simply African boldo which is recurrent, as well as the species cultivated in Brazil like *Gymnanthemum amygdalinum, Plectranthus barbatus* and *Plectranthus neochilus*, with relevance in popular use and commercialization. In this way, one perceives the need for incentives and investments in cutting-edge technologies, such as the improvement and multiplication of species, as in this way better use is made of the diversity of fertile soils that the region has, both in Portuguese-speaking countries and in the producing regions. in Brazil.

Research based on ethnobotany, such as the investigation of traditional medicine, associated with the study of the phytochemical profile of medicinal plants and/or organic chemistry, associated with pharmacological studies, as well as studies of the active principles and use of herbal medicines, is a path that enables the integration between different areas of knowledge for the study, production, and safe use of products of plant origin. Boldo, as it is a plant used on a large scale, becomes the basis for this proposed action.

It is opportune to mention the recurrent need for further studies of both boldo and other medicinal plants, associated with traditional knowledge, ensuring easy access for communities that hold traditional knowledge about the purposes and uses of medicinal plants.

The results of this study enable us to conclude that research and/or studies on medicinal plants and traditional medicine are relevant and deserve special attention, because in addition to the use of the plant, the traditional knowledge passed on between generations about the local knowledge, the use and usefulness of medicinal plants can contribute to people's health care, in a holistic way, and in terms of sustainability.

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Characterization and Chemical Modification by Octenyl Succinic Acid (OSA) of Pitomba Starch (Talisia esculenta)

Caracterização e Modificação Química por Ácido Octenil Succínico (OSA) do Amido da Pitomba (*Talisia* esculenta)

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Abstract— Native starch has many restrictions in the food sector, requiring modifications to improve its properties. The objective of this work was to modify pitomba starch in order to obtain distinct properties of this biopolymer. Starch was modified with octenyl succinic acid, with subsequent physicochemical analysis. The modified starch had a degree of substitution of 0.3 and could be used as binders and thickeners. Modified starch paste showed a greater tendency to retrogradation with greater variation from the 7th day onwards, not being recommended for foods that require longer storage time. The modified starch paste proved to be opaque, applicable in puddings and ready-to-eat desserts. Modified starch showed higher water absorption capacity and lower oil absorption capacity than native starch. The modified starch was more viscous than the native one. The swelling of the granules occurred above 80°C, with emphasis on the native starch, while the modified starch was more soluble above the temperature of 80°C. A high lipid content was found in both starches. Chemical modification did not cause shift of spectral bands. It is concluded that the modified pitomba starch has great potential to be used in the food segment.

Resumo— O amido nativo possui muitas restrições no setor alimentício, sendo necessário modificações para melhorar suas propriedades. O objetivo deste trabalho foi modificar o amido de pitomba, a fim de se obter propriedades distintas deste biopolímero. O amido foi modificado com ácido octenil succínico, com posteriores análises físico-químicas. O amido modificado apresentou grau de substituição de 0,3 e podendo ser utilizado como ligantes e espessante. A pasta de amido modificado apresentou maior tendência à retrogradação com maior variação a partir do 7º dia, não sendo recomendada para alimentos que demandem maior tempo de armazenamento. A pasta de amido modificada mostrou-se opaca, aplicável em pudins e sobremesas prontas. O amido modificado apresentou maior capacidade de absorção de água e menor capacidade de absorção de óleo do que o amido nativo. O amido modificado

apresentou-se mais viscoso que o nativo. O inchamento dos grânulos ocorreu acima de 80°C, com destaque para o amido nativo, enquanto o amido modificado foi mais solúvel acima da temperatura de 80°C. Um alto teor de lipídeo foi verificado em ambos amidos. A modificação química não ocasionou deslocamento das bandas espectrais. Conclui-se que o amido modificado de pitomba apresentou grande potencial para ser utilizado no segmento alimentício.

I. INTRODUÇÃO

A pitomba (Talisia esculenta) é uma fruta comestível nativa da Amazônia, possui formato ovaloide, com casca marrom de fácil remoção para o consumo de sua polpa. Seu consumo é realizado principalmente in natura e encontrado para venda em mercados regionais (FRAGA & CARVALHO, 2019; SILVA, 2016).

O amido é a principal fonte de carbono e reserva de energia das plantas. Após a celulose, é o segundo biopolímero mais abundante existente na natureza, constitui a maior parte dos carboidratos digestíveis da dieta humana. (BORSATO, 2019).

Apesar de ser amplamente encontrado na natureza, os amidos nativos muita das vezes não são adequados para processamento específico, pois hidratam facilmente, intumescem rapidamente, rompem-se, perdem viscosidade e produzem uma pasta pouco espessa, bastante elástica e coesiva. Então, torna-se necessário modificar o amido nativo para se obter características desejáveis aos alimentos. (MENDES, 2011).

Em meio a diferentes tipos de modificações, destaca-se a modificação química por succinilação. O amido modificado por succinilação tem suas propriedades físico-químicas alterada, fator desejável para inúmeras aplicações industriais, como por exemplo, em produtos alimentares e não alimentares como excipientes de fármacos, em indústrias têxteis e de papel (SANTOS, 2013).

Diante do exposto, esse estudo tem como objetivo a modificação do amido nativo do caroço de pitomba (Talisia esculenta) utilizando o ácido octenil succínico (OSA) visando novas aplicabilidades no setor alimentício.

II. MATERIAIS E MÉTODOS

2.1. Extração do Amido do Caroço de Pitomba (Talisia esculenta)

O processo de extração do amido foi realizado conforme o procedimento descrito por Guraya et al. (2004). Os caroços foram sanitizados com uma solução de 10% de hipoclorito de sódio e posteriormente secos em uma estufa a 50° C por 48h. Após a sanitização, 500g de caroços foram levados em suspensão com 1,05ml de bissulfito de sódio por 48h (Sigma-Aldrich CO., MO, USA). Os caroços foram moídos em um processador e posteriormente passado em uma peneira de 212 mm/µm e levado para a centrifugação por 10 minutos, sendo descartado o sobrenadante. O amido obtido, foi seco em uma estufa a 35° por 48°h.

2.2 Modificação Química do Amido de Pitomba (Talisia esculenta) por Ácido Octenil Succínico.

A modificação totalizou 4h a 35°C em banho-maria com agitação, conforme os procedimentos de Song et al. (2006), utilizando 0,21g de ácido octenil succínico (OSA) na proporção 1:3 com álcool etílico absoluto. Com sete gramas do amido extraído, suspendeu-se em 20ml de água deionizada. No início da succinilação o pH foi ajustado para 8,5 com hidróxido de sódio (NaOH) (0,1 M).

Uma quantidade de 90 µL da solução de OSA foi adicionada a cada 15 minutos durante as duas primeiras horas, já nas duas horas seguintes, houve somente o ajuste do pH de 20 em 20 minutos. No término da reação, o pH foi ajustado para 6,5 com uma solução de ácido clorídrico 3% (HCl) (p/p). A mistura foi centrifugada a 1232,6 g por 10 minutos e lavada com álcool etílico 70%. O sobrenadante foi descartado e posteriormente o resíduo sólido foi seco em uma estufa a 35°C por 48h.

2.3 Determinação do Grau de Substituição (GS) do Amido do Caroço de Pitomba Modificado.

Para determinar o GS, foi realizado uma titulação alcalina, conforme o procedimento descrito por Kweon et al. (2001). Inicialmente, 1g do amido modificado foi colocado em suspensão com 25 ml de uma solução 2,5 mol. L-1 de ácido clorídrico diluído em álcool isopropílico, sob agitação por 30min. A dispersão foi filtrada (papel de filtro) em um funil de separação a vácuo e o resíduo lavado com 100 ml de álcool isopropílico. Posteriormente, o retido foi disperso em 300 ml de água deionizada e levado para o aquecimento em banho-maria por 20min, para a gelatinização do grânulo. A dispersão foi titulada com uma solução de 0,1 mol. L-1 de hidróxido de sódio (NaOH) e o grau de substituição foi determinado de acordo com a equação 1.

$$GS = 0{,}162 \times (A \times N/p) / \qquad (1)$$
$$1 - [0{,}101 \times (A \times N/p)]$$

Onde: A = volume de NaOH utilizado na titulação;

N = normalidade da solução de NaOH;

P = peso do amido seco.

2.4 Claridade de Pasta e Tendência a Retrogradação 4

A claridade de pasta foi determinada por transmitância (T%), conforme descrito na metodologia de Pereira (2012). Foram pesados 0,1g do amido nativo e modificado, e em seguida suspensos em 10mL de água destilada em tubos de ensaios. Os tubos foram levados em banho-maria fervente(100°C) com ocasional agitação, durante 30 minutos.

A porcentagem de transmitância foi determinada em espectofotômetro digital Bel Modelo®: 2000 UV. Para monitorar a tendência de retrogradação, as amostras foram estocadas por 24 horas a 5°C para nucleação, logo após esse tempo permaneceram a 30°C por 6 dias para determinação da transmitância nos dias 1,2,5,7,8 e 9.

2.5 Capacidade de Absorção de Água e Óleo

A capacidade de absorção de água e óleo foi utilizada a metodologia descrita por Pereira (2012). Em tubos de ensaios com 10 ml de óleo de soja comercial, foram adicionados 1g da amostra de amido nativo e modificado. A suspensão foi homogeneizada durante 30 segundos e depois deixada em repouso por 30 minutos. Em seguida foram centrifugados por 1 minuto e 30 segundos. As paredes externas dos tubos foram secas e os tubos pesados. A massa do óleo absorvido foi expressa em g/100g de amido em base seca de acordo com a equação 2:

CA= (peso do tubo após centrifugação) – (peso do tubo + amostra seca)   (2)

2.6 Viscosidade

Para determinar a viscosidade, utilizou-se a metodologia de Yamauchi & Almeida (2014). Foram preparadas duas suspensões, uma com 5g de amido nativo e outra com 5g amido modificado. Em seguida, foram adicionados 100mL de água destilada e as amostras homogeneizadas. A medida de viscosidade foi realizada no viscosímetro Copo Ford n°4, onde a suspensão foi despejada no copo até o seu nível máximo, com o orifício de escoamento fechado. Em seguida o escoamento foi liberado com consequente acionamento do cronômetro para avaliação do tempo de escoamento. Observou-se o filete da amostra que escoou até a primeira interrupção com consequente suspensão do cronômetro.

O tempo decorrido desde a liberação do escoamento até a interrupção do filete foi o valor da viscosidade medida em segundos. A viscosidade foi determinada de acordo com a Equação 3:

Viscosidade= [(3,846x T) - 17,3] x d   (3)

Onde: T= Tempo de escoamento em segundos

d= densidade

2.7 Poder de Intumescimento (PI) e Índice de Solubilização (IS) dos Grânulos

Para determinar o PI e o IS adotou-se a metodologia descrita por Leach et al. (1959), com modificações. Colocou-se em suspensão 1,25g de amido nativo e modificado em 15 ml de água destilada. As suspensões foram colocadas em banho termostático, nas seguintes temperaturas: 40, 50, 60, 70 e 80°C, por 30 minutos. Realizou-se a homogeneização das suspensões a cada 5 minutos. Na etapa seguinte, as suspensões foram centrifugadas a 91g por 10 minuto e o sobrenadante colocado em cadinhos, sendo posteriormente secos em banho maria fervente (100°C) por 1 hora. O amido sedimentado no tubo da centrífuga e o cadinho com o sobrenadante foram pesados, e para a determinação do PI e IS, utilizou-se as equações 4 e 5, respectivamente:

P.I (g.g-1) = PRC/ PA- PRE   (4)

I.S (%) = PRE/ PA x 100   (5)

Onde: PRC = Peso do resíduo da centrifugação em gramas;

PA = Peso da amostra em gramas;

PRE= Peso do resíduo da evaporação em gramas.

2.8 Caracterização Físico-Química do Caroço da Pitomba

2.8.1 Lipídeo

A determinação do percentual de lipídeos nas amostras foi realizada pesando-se 3,5 g das amostras de amido modificado e nativo, sendo posteriormente colocadas em filtro de papel. Extraiu-se em aparelho de Soxhlet, utilizando o solvente Éter de petróleo por três horas. Ao término, colocou-se o balão com resíduo na estufa a 105 °C para evaporar o solvente restante. Esfriou-se em dessecador até a temperatura ambiente e pesou-se. O teor de lipídeos foi determinado conforme a equação 6:

LIPÍDEOS (%) = PL x 100/ P   (6)

PL = Peso do balão com gordura – Peso do balão antes da extração

P = peso da amostra.

2.9 Espectroscopia dos Amidos em Infravermelho (FT-IR)

Para a análise de FTIR, o espectro foi coletado empregando o módulo de ATR, em um espectrômetro de infravermelho com transformada de Fourier, em um intervalo de comprimento de onda de 4000-500 cm^2. (Shimadzu IR Affinity-$^{-1}$). Realizado em Spectrum 100, da Nicolet ®, Modelo Nexus 470 FT-IR. O microdisco foi contruído utilizando a técnica do disco prensado com a

maceração de KBr, juntamente com uma pequena quantidade de amostra.

III. RESULTADOS E DISCUSSÃO

3.1 Grau de Substituição

O grau de substituição para o amido de pitomba modificado foi de 0,3. Ferraz et al. (2014) utilizando o amido modificado extraído do resíduo do processamento agroindustrial da manga, com a metodologia similar a este trabalho, encontrou o valor de GS de 0,04. Já Mendes (2011), utilizando o amido da amêndoa da manga, encontrou um valor de 0,006.

Um GS elevado depende do conteúdo de amilose, tempo e condições da reação. (FERRAZ et al. 2014). Almeida (2012), reporta que a adição de alto GS aos succinatos, torna o amido solúvel em água fria, possuindo baixa temperatura de gelificação, o que favorece o uso desse amido como ligantes e espessantes em alimentos. Feira (2010), afirma que quanto mais alto o grau de substituição maior a estabilidade térmica e propriedades do amido modificado.

3.2 Claridade de Pasta e Tendência a Retrogradação

A Fig. 1 expõe os resultados para claridade de pasta e tendência a retrogradação, do amido nativo e succinilado do caroço da pitomba.
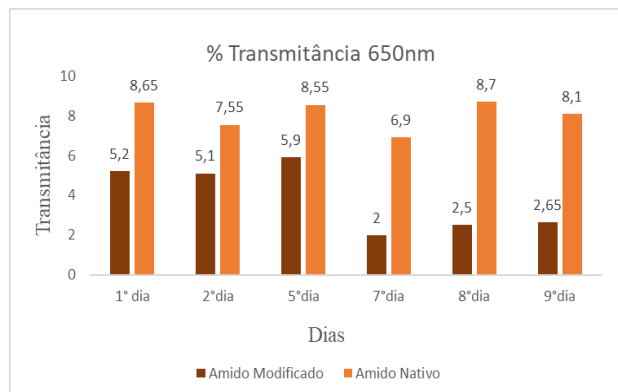
Fonte: Autora (2022)

Fig. 1- Transmitância do amido nativo e succinilado do caroço de pitomba

Os valores de transmitância observado na Fig. 1, revela que a pasta de amido modificado apresenta maior tendência a retrogradação quando comparado à pasta de amido nativo, com uma maior variação a partir do 7° dia.

De acordo com Pereira (2012), o amido da batata-doce nativo e modificado por succinilação, apresentou diminuição da transmitância, no decorrer dos dias em ambos os amidos estudados. Desta maneira evidenciou a tendência à retrogradação, corroborando com o presente estudo. Conforme Campos et al. (2014), o amido do Feijão Andú nativo e modificado por succinilação, apresentou

transmitância constante no amido nativo, no decorrer dos dias, com diminuição nos dias 7 e 8, o que demonstrou baixa tendência à retrogradação. Já para o amido modificado, observou-se declínio da transmitância no 9º dia de análise, resultados semelhantes a este estudo.

Mendes (2011), reporta que fatores como presença de fibras, lipídeos e pigmentos, podem diminuir a transparência das pastas de amidoato esse que pode explicar a redução da transparência no amido do caroço da pitomba.

3.3 Capacidade de Absorção de Água (CAA) e Óleo (CAO)

A Fig. 2 apresenta os resultados sobre a capacidade de absorção de água e óleo do amido modificado e nativo do caroço da pitomba
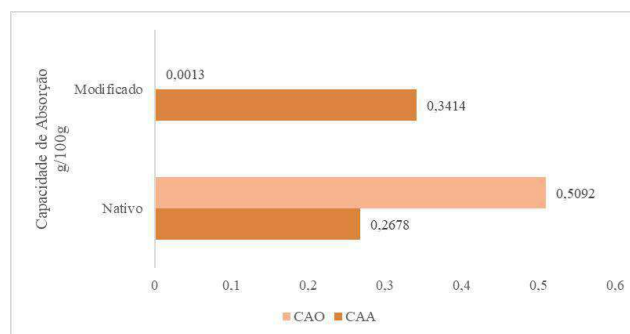
Fonte: Autor (2022).

Fig. 2- Capacidade de absorção de água (CAA) e óleo (CAO) do amido nativo e modificado do caroço da pitomba.

Observa-se que o amido modificado apresentou maior capacidade de absorção de água (CAA) quando comparado ao nativo, em contrapartida os valores de absorção de óleo (CAO) diminuiu com a modificação. Os autores Pereira (2012), Brasileiro (2006) e Lawal (2004), analisando o amido da batata-doce, amido de inhame e amido de milho híbrido respectivamente, todos modificados por succinilação, obtiveram resultados semelhantes com o presente estudo. Afirmam que o amido modificado apresentou maior CAA, quando comparado ao nativo, enquanto que o amido nativo apresentou maiores valores de CAO, quando comparado ao modificado. Lawal (2004) afirma que as cadeias longas do grupo substituinte, por exemplo, o succinil, podem ter prejudicado a absorção do óleo.

A causa do aumento da capacidade de absorção de água nos amidos modificados por succinilação se relaciona com introdução de grupos funcionais volumosos de succinil. No entanto a longa cadeia de substituintes succinil hidrofílicos assim como a presença de substâncias contaminantes, provavelmente prejudicam a absorção de óleo no amido

succinilado. (ARAÚJO, 2008; MENDES, 2011; ALMEIDA, 2012).

3.4 Viscosidade

Em relação a viscosidade dos amidos estudados, encontrou-se um valor de 16,03cp para o amido nativo e 16,33cp para o amido modificado. O tempo de viscosidade das duas amostras de amido, foram de nove segundos (9s). Os dois amidos não possuem diferença significativa entre os valores encontrados, porém, é possível observar que o amido modificado possui maior viscosidade em relação ao amido nativo.

São escassos os trabalhos envolvendo análise de viscosidade em solução de amidos, utilizando o equipamento Copo Ford. Esse fato, dificulta resultados comparativos previsto na literatura.

3.5 Poder de Intumescimento (PI) e Indíce de Solubilização dos Grânulos (IS)

Os valores do poder de intumescimento e solubilidade do amido nativo e modificado do caroço da pitombaestão expressos na Figura 3 e 4
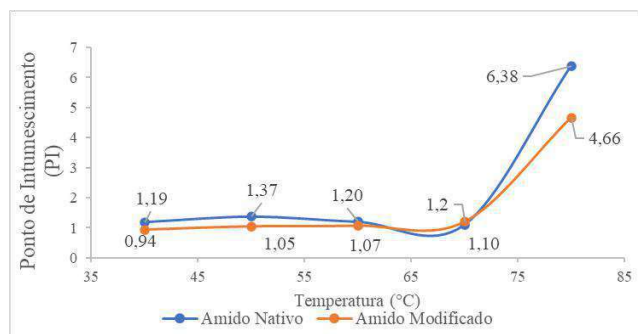
Fonte: Autor (2022).

Fig. 3- Poder de intumescimento (g.g-1) do amido de pitomba nativo e modificado por succinilação.

Por meio da Fig. 3, pode-se observar que até a temperatura de 70°C os valores de PI se mantém constantes sem muitas alterações, porém, acima de 80°C houve um expressivo aumento do PI. Pereira (2012) estudando o amido modificado de batata-doce, encontrou aumento do PI a uma temperatura de 95°C, com resultados semelhantes ao presente estudo, tem-se o de Adebowale (2005), que utilizou o amido da fruta-pão, em que observou um de PI a partir de 80°C. O valor baixo de PI observado nesse trabalho, pode estar atribuído à presença de lipídeos, que formam um complexo estável com a amilose, avalia-se também o grupo carboxílico dos ácidos graxos que dificulta ou impede o instumescimento. (MENDES, 2011).
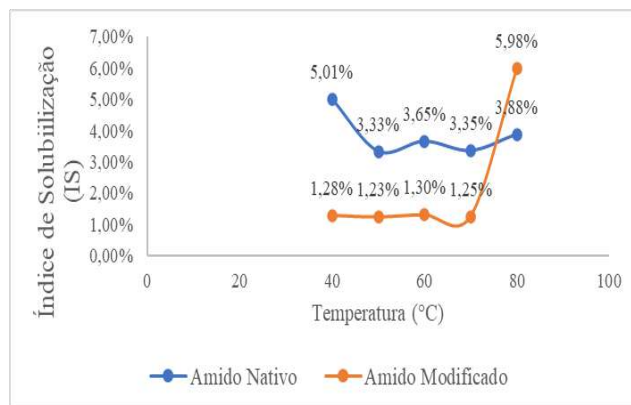
Fonte: Autor (2022).

Fig.4- Índice de solubilização dos grânulos (%) do amido de pitomba nativo e modificado por succinilação.

Conforme a Figura 4, observa-se que o amido modificado obteve um índice de solubilização menor quando comparado ao amido nativo, porém, na temperatura de 80°C é possível observar um pico, constatando-se que nessa temperatura o amido modificado tornouse mais solúvel que o nativo. Cereda e Leonel (2002), estudando o amido de mandioca, observou uma elevada solubilidade a partir de 70°C. Essa reação acontece porque amidos ricos em amilose mostram solubilidade restrita, mesmo após um período prolongado de aquecimento.

Mendes (2011) analisando o amido da amêndoa da semente da manga, observou que o amido modificado por succinilação expressou solubilidade menor do que o amido nativo, corroborando com este estudo.

3.6.1 Lipídio

O amido modificado do caroço da pitomba, apresentou um teor de amido de 1,48g.100g^{-1}, e o amido nativo 9,7 g.100g^{-1}. É possível encontrar na literatura valores próximos ao encontrado no presente estudo com o amido modificado, como o de 1,25g.100g^{-1} em amido de taro encontrado por Almeida (2012) e de 1,52 g.100g^{-1} em amido de milho relatado por Alexandrino (2006).

Almeida (2012), afirma que o lipídeo se trata de um componente interferente no amido, tendo em vista que uma das suas principais caraceterísticas é a formação de complexo com a amilose, como pode ter ocorrido nos valores de claridade de pasta e o poder de intumecimento, observado neste estudo.

3.7 Espectroscopia dos Amidos em Infravermelho (FT-IR)

Os dados obtidos na Fig. 4, apresenta os resultados da análise de espectroscopia em infravermelho.
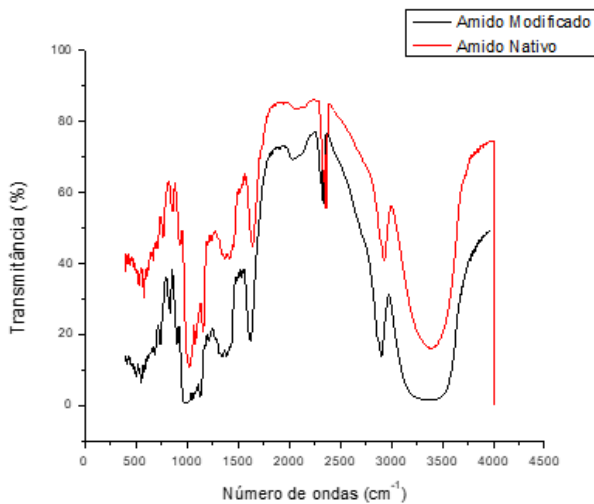
Fonte: Autor (2022).

Fig.4- Espectros de absorção na região do infravermelho do amido do caroço da pitomba.

O amido foi caracterizado por meio de espectroscopia na região do infravermelho, no qual é possível observar as principais bandas características deste polissacarídeo. O pico observado nas bandas fortes de 3000 a 3500 cm^{-1} corresponde ao estiramento e deformação angular de ligações –OH da H2O. Na literatura é comum encontrar picos semelhantes para biopolímeros, como no caso de Halal (2014), com pico na banda de 3000-3600 cm-1 estudando o amido modificado obtido da cevada e Costa Neto (2017), com o amido de junça com bandas fortes de 3000 a 3500 cm^{-1}, resultado semelhante ao presente estudo.

É possível analisar pico nas bandas 1.015,77 cm^{-1}, próximo às bandas na região 1000 a 1200 cm^{-1}. As bandas na região 1000 a 1200 cm-1 são consideradas bandas características do amido e são atribuídas a vibrações de deformação axial de C-O em álcoois e as vibrações de deformação axial do sistema O-C-O. Constata-se que não houve diferença entre os resultados de amido nativo e modificado, uma vez que ambos apresentaram picos na mesma região, corroborando com a preservação da característica do amido.

IV. CONCLUSÃO

O amido modificado da pitomba se mostrou como um grande potencial a ser utilizado no seguimento alimentício, podendo ser aplicado em alimentos como: Espessantes e ligantes; pudins e sobremesas prontas, produtos fritos proporcionando crocância. Porém, por conta da tendência a retrogradação, é recomendável sua aplicação em alimentos que não demandem maior tempo de estocagem.

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Dynamic Characteristics of a Squeeze Film Damper used as Rear Bearing in a Single Spool Aeronautic Gas Turbine

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Abstract— Squeeze film dampers are widely used in aeronautic gas turbines because they effectively absorb vibrations and lessen the stresses on the structural components. In this study, we calculated the stiffness and damping dynamic coefficients of a squeeze film damper with open ends and a circumferential oil-feeding groove. This squeeze film damper was used as a rear bearing in an aeronautic gas turbine designed to generate 5-kN of thrust under ISA conditions. Three different radial clearances were investigated to determine the optimal bearing design configuration for the application because the radial clearance of a squeeze film damper is a crucial element in determining its dynamic stiffness and damping coefficients. To provide superior performance and avoid issues, a rotordynamic analysis using the calculated stiffness and damping dynamic coefficients can be conducted to predict the vibratory behavior of the entire rotating assembly.

I. INTRODUCTION

Aeronautic gas turbines are internal combustion engines that have an operating power rating ranging from small (100 kW) to large (180 MW). Therefore, they are suitable for electrical power generation or aircraft propulsion. Their primary advantage is their small weight and volume compared with other types of heat engines. Low thermal inertia that allows a full load in a short time is another benefit [1].

The aeronautic gas turbine investigated in this study was a high-performance turbojet designed to generate 5-kN of thrust under ISA conditions [2]. For instance, they can be used in military unmanned aerial vehicle applications. The entire project was developed in partnership with the Department of Aerospace Science and Technology (DCTA), which is a military organization of the Brazilian Air Force Command, and TGM Turbinas Ltda (TGM), with the financial support of the Financier of Studies and Projects (FINEP) and the National Fund for Scientific and

Technological Development (FNDCT). The nominal rotation speed of the rotor was 28,150 rpm, although the normal operating range was between 80% and 100% of the nominal speed. It features a single spool system, air intake duct, five-stage axial compressor, direct-flow annular-type combustion chamber, single-stage turbine disk, and exhaust nozzle. Figure 1 shows the aeronautic gas turbine mounted on the test rig. The user-defined specifications were: weight should be approximately 650 N; the length and diameter of the circular section must not exceed 1.5 m and 0.35 m, respectively.

The bearings of an aeronautic gas turbine must be carefully designed to provide the required stiffness and dynamic damping characteristics to the rotating assembly to prevent vibration issues. The front bearing of this aeronautic gas turbine is composed of a deep groove ball bearing and a vibration-absorbing element. The dynamic stiffness and damping coefficients of the front bearing were calculated previously [3]. The rear bearing is composed of an specific

designed squeeze-film damper with open ends and a circumferential oil feeding groove.

Fig. 1: Illustration of the aeronautic gas turbine investigated in this study on test rig.
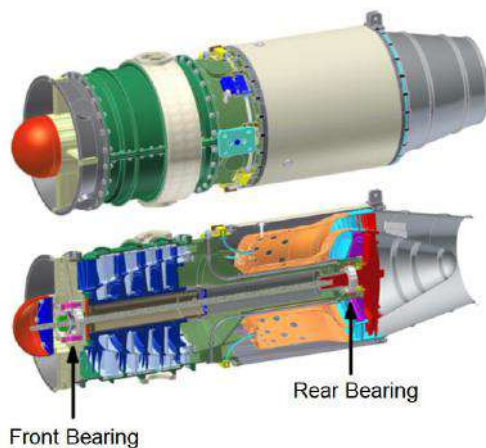
Fig. 2: Cross-section view of the studied aeronautic gas turbine with its main components.

Squeeze film dampers are continuously lubricated elements that support shafts and provide viscous damping in mechanical systems. In its simplest form, a squeeze film damper creates a lubricating oil film using a nonrotating bearing mounted in the housing with specified radial clearance. Owing to their capacity to suppress and isolate vibrations, lessen the stresses imparted to structural components, and eliminate non-synchronous instability, they are widely used in high-speed turbomachinery [4]. Figure 2 displays the cross-section of the aeronautic gas turbine, highlighting its front and rear bearings.

In this study, the dynamic stiffness and damping coefficients of the rear bearing of an aeronautic gas turbine were calculated. The rear bearing is composed of a squeeze film damper with open ends and a circumferential oil-feeding groove. The dynamic stiffness and damping coefficients have been evaluated using published

mathematical models available in literature [5-7]. The circumferential feeding groove was considered a special damper in the analysis of fluid forces. The two adjacent oil film lands and their interactions with the circumferential feeding groove are responsible for the dynamic performance of the bearing. The calculations considered the effects of variations in pressure and fluid velocity within the groove. The radial clearances were analysed to determine the optimal bearing design configuration because the radial clearance of the squeeze film damper is the crucial factor that determines the dynamic stiffness and damping coefficients. The dynamic values of the stiffness and damping coefficients are subsequently used in a rotordynamic analysis to predict the vibratory behaviour of the aeronautic gas turbine rotating assembly to avoid issues and ensure superior performance [8].

II.   LITERATURE REVIEW

Squeeze film dampers have been successfully developed to stabilize a wide variety of unstable rotating assembly units operating with tilt pad bearings. They are essential components in high-speed turbomachinery owing to their unique vibration energy dissipation advantages associated with the effective structural isolation of the mechanical components. Furthermore, squeeze film dampers can significantly increase the dynamic stability of rotating assemblies that exhibit instability due to their own configuration.

San Andres and Santiago have extensively studied the design and characterization of squeeze film dampers. They reported the experimental results of the damping and inertia coefficients considering various loading conditions [4]. An oil film's effective length was used to provide consistency between experimental and analytical results. Oil pressure field measurements reveal the appearance of the air intake, the effects of which increase the amplitude and frequency of dynamic bearing movements.

Siew et al. [5] compared several theoretical models for characterizing the properties of squeeze film dampers with circumferential feeding grooves. Four types of grooves and two types of lubricants were evaluated. The results were compared with experimental data to determine the suitable model for a particular circumferential groove configuration and lubricant type. Highly nonlinear fluid stiffness and damping coefficients were observed, and damping proved to be highly sensitive to oil viscosity and mass imbalance. A special model that considered the groove and the two oil lands proved to be efficient in predicting the vibratory behavior of a squeeze film damper with a shallow depth. However, the conventional two-land theory has proven suitable for squeezing film dampers with deep grooves.

Also, Siew et al. provided several useful instructions for the design and characterization of shallow- or deep-grooved squeeze film dampers.

Tan et al. [6,7] investigated a squeeze film damper model that was similar and applicable to the squeeze film damper used as the rear bearing of the aeronautic gas turbine examined here in this work. This squeeze film damper was composed of a circumferential feeding groove with open ends. They investigated the circumferential feeding groove as a special damper when analyzing the fluid forces. Therefore, the dynamic performance of the squeeze film damper is attributed to this special damper, the two adjacent oil lands and the interaction between the oil lands and groove. From this perspective, the dynamic effects in the groove were examined based on linearized Navier-Stokes equations. Variations in the velocity and pressure of the fluid in the feeding groove were considered in the calculation of the damping forces.

III.   REAR BEARING MODELLING

Figure 3 shows schematic views of an arbitrary squeeze film damper with open ends and a circumferential feeding groove similar to the rear bearing of the aeronautic gas turbine investigated in this study. The theoretical model for determining the dynamic stiffness and damping coefficients of the squeeze film damper is based on the radial and tangential fluid forces acting on the bearing, according to the research carried out by Tan et al. [6] and [7]. The radial and tangential fluid forces are as follows:

$$F_r = \int_{-\frac{L}{2}}^{+\frac{L}{2}} \int_{\theta_1}^{\theta_2} p\cos\theta \, dz R d\theta \tag{1}$$

$$F_t = \int_{-\frac{L}{2}}^{+\frac{L}{2}} \int_{\theta_1}^{\theta_2} p\,\text{sen}\theta \, dz R d\theta \tag{2}$$
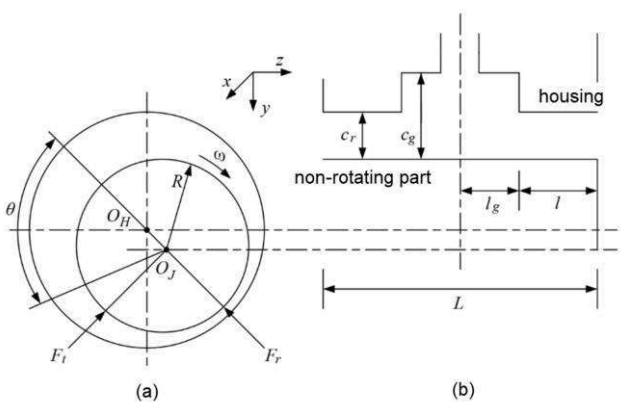
Fig. 3: Schematic of an arbitrary open-end squeeze film damper: (a) front view; and, (b) side view.

Assuming circular-centered orbits rotating at a constant speed, the radial and tangential fluid forces can be expressed using dimensionless force terms f_r and f_t, respectively.

$$F_r = B f_r \in \tag{3}$$

$$F_t = B f_t \in \tag{4}$$

where the dimensionless forces are given by

$$f_r = \frac{2 + 3\varphi + 3C_1\varphi(1 + 2\varphi)}{2(1+\varphi)^3} I_3^{11} - \\ Re\,\frac{2+3\varphi}{2(1+\varphi)^3}\left(\frac{I_1^{02}}{12} + \frac{I_2^{21}}{5}\in\right) \tag{5}$$

$$f_t = \frac{2 + 3\varphi + 3C_1\varphi(1 + 2\varphi)}{2(1+\varphi)^3} I_3^{20} - \\ Re\,\frac{2+3\varphi}{2(1+\varphi)^3}\left(\frac{I_1^{11}}{12} + \frac{I_2^{30}}{5}\in\right) \tag{6}$$

being that,

$$B = \frac{RL^3\eta\omega}{c_r^2}, \quad C_1 = \frac{\gamma^2(3-2\gamma)}{1+\left(\frac{Re}{10\gamma}\right)^2}, \\ \gamma = \frac{c_r}{c_g}, \quad \varphi = \frac{l_g}{l}, \quad Re = \frac{\rho\omega c_r^2}{\eta} \tag{7}$$

where R is the radius of the nonrotating bearing, L is the total length of the oil film, η is the absolute dynamic viscosity of the oil, ω is the precession rate, c_r is the radial clearance, c_g is the depth of the circumferential feeding groove, l_g is the length of half of the circumferential feeding groove, l is the length of an adjacent oil film, and ρ is the density of the lubricating fluid. In the expressions above, the terms I_n^{lm} are defined by Booker integrals:

$$I_n^{lm} = \int_{\vartheta_2}^{\vartheta_1} \frac{\text{sen}^l\vartheta\cos^m\vartheta}{(1+\in\cos\vartheta)^n} d\vartheta \tag{8}$$

For the π-film model, that is, $\theta_1 = 0$ and $\theta_2 = \pi$, we have

$$I_3^{11} = \frac{2\in}{r^4}, \quad I_r = \left(\frac{I_1^{02}}{12} + \frac{I_2^{21}}{5}\in\right) = \\ \frac{\pi(1-r)}{\in^2 r}\left[\frac{1}{12} - \frac{1}{5}(1-r)\right] \tag{9}$$

$$I_3^{20} = \frac{\pi}{2r^3}, \quad I_t = \left(\frac{I_1^{11}}{12} + \frac{I_2^{30}}{5}\in\right) = \\ \frac{19}{60\in^2}\left(2\in - ln\left|\frac{1+\in}{1-\in}\right|\right) \tag{10}$$

where r = $(1-\epsilon^2)^{\frac{1}{2}}$. Therefore, assuming circular-centred orbits and the π-film model, the dynamic stiffness and damping coefficients of the squeeze film damper can be calculated as:

$$K_{SFD}=\frac{F_r}{e} \text{ (stiffness of the squeeze film damper)} \tag{11}$$

$$C_{SFD}=\frac{F_t}{e\omega} \text{ (damping of the squeeze film damper)} \tag{12}$$

Considering circular-centered orbits, e is the eccentricity given by the length $O_H - O_J$ and the eccentricity ratio ϵ is given by $\epsilon = \frac{e}{c_r}$.

IV.   RESULTS

As shown in Figure 4, the squeeze film damper analyzed in this study consists of a Barden 206(HJH) angular contact ball bearing and a centering spring. Lubrication was carried out using Aeroshell® 500 oil. The oil temperature reaches 100°C because this oil circulates close to the combustion chamber, where intense heat exchange occurs. The centering spring applied a preload of 150 N to the outer ring of the bearing, and the oil supply pressure, p_s, in the squeeze film damper was adjusted to approximately 20 psi, based on practical industrial experience.

The bearing inner ring was mounted with interference fit on the rotating assembly shaft. The axial centering spring ensured optimal contact between the balls and raceways. The outer ring acts as a nonrotating bearing, forming a squeeze film damper oil film. There is a radial clearance between the outer ring surfaces and housing that is filled with Aeroshell® 500 oil. The circumferential feeding groove acts as a circumferential oil supply that divides the total film into two adjacent film lands. Three feeding holes were used to supply oil to the squeeze film damper. The three oil-feeding holes were 120° apart. O-rings or sealing seals were not added to the lateral ends of the squeeze film damper because the rear bearing presented small axial slips owing to the thermal expansion behavior of the entire set. The geometric properties that characterize the studied squeeze film damper are listed in Table 1. The radial clearance was not specified in this table because three case studies were carried out, using three different values of the radial clearance to determine the optimal squeeze film damper design according to the verified characteristics.
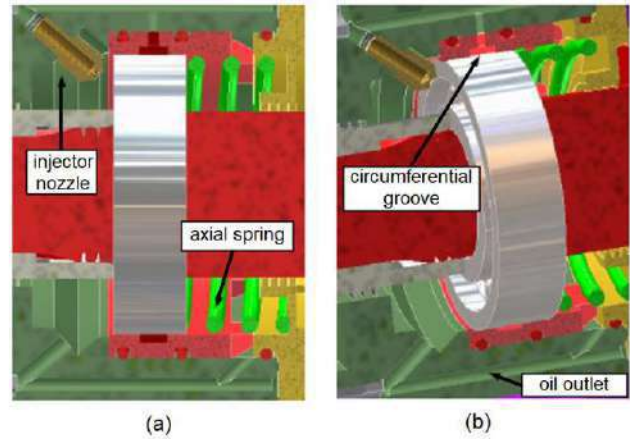
Fig. 4: Squeeze film damper used as rear bearing (a) side view; and, (b) perspective view.

Tab. 1: Geometric properties of the squeeze film damper.

Property	Value
Groove depth, c_g	0.003697 m
Adjacent oil film width, l	0.005 m
Half groove oil film width, l_g	0.003 m
Total oil film width, L	0.016 m
Non-rotating bearing radius, R	0.031 m

Radial clearance is one crucial factor that determines the stiffness and damping dynamic coefficients of the squeeze film damper, which provides optimal values depending on the type of application. The geometric properties listed in Table 1 were held constant for three clearance values of c_r: 0.08, 0.12, and 0.1905 mm, respectively. Using the ISO 1940/1 standard's balance quality grade, G1.0, for the manufacturing process of the rotating assembly, the eccentricity ratio of $\epsilon=0.2$ was used in the calculations. For zero rotation speed, the same stiffness and damping values as for 5,000 rpm were considered to account for the values used in the rotordynamic analysis of the entire rotating assembly.

Table 2 lists the calculated stiffness and damping dynamic coefficients for the rear bearing, considering a squeeze film damper radial clearance of 0.08 mm. The stiffness and damping dynamic coefficients of the squeeze film damper vary according to the rotation speed and oil temperature. According to Table 2, for the radial clearance of 0.08 mm, the stiffness of the rear bearing ranged from 9.4270E+6 to 2.6193E+7 N/m, and the damping ranged from 8.111 to 32.668 Ns/m. For the radial clearance of 0.12

mm, according to Table 3, the stiffness of the rear bearing ranged from 2.935E+6 to 1.2518E+7 N/m, and the damping coefficients ranged from 2,441 to 9,720 Ns/m. Considering the radial clearance of the squeeze film damper of 0.1905 mm, according to Table 4, the stiffness coefficients of the rear bearing ranged from 8.282E+5 to 6.3821E+6 N/m, and the damping coefficients ranged from 635.9 to 2,449 Ns/m.

Tab. 2: Stiffness and damping dynamic coefficients of the studied squeeze film damper considering a radial clearance of 0.08 mm.

Rotation Speed [rpm]	Oil Temperature [°C]	Kinematics Viscosity [m²/s]	Dynamic Viscosity [Pa.s]	Stiffness Coefficients [N/m]	Damping Coefficients [Ns/m]
0	25	3.2755E-5	0.0329	9.4270E+6	32,668
5,000	60	1.9752E-5	0.0199	9.4270E+6	32,668
10,000	70	1.6037E-5	0.0161	1.6085E+7	26,418
15,000	80	1.2322E-5	0.0124	2.0129E+7	20,352
20,000	90	8.6065E-6	0.0086	2.1340E+7	14,137
25,000	95	6.7489E-6	0.0068	2.4363E+7	11,204
30,000	100	4.8913E-6	0.0049	2.6193E+7	8,111

As shown in Figure 5, the values of the calculated stiffness coefficients increased with the rotation speed of the rotating assembly for the three radial clearances evaluated. In contrast, in Figure 6, it is observed that the values of the damping coefficients decrease with the rotation speed of the rotating assembly for the three clearances. This is because of the viscous losses in the lubricant. As the speed of the rotating assembly increases, the temperature of the lubricant increases, and the dynamic viscosity of the oil decreases. The damping capacity of the bearing was thus reduced, and its stiffness increased. Assuming that the *-z* axis of the main reference system is aligned with the axis of the rotating assembly, the values of the calculated stiffness and damping coefficients are related to the *-x* and *-y* directions. That is, $K_{SFD} = K_{xx} = K_{yy}$ and, in the same manner, $C_{SFD} = C_{xx} = C_{yy}$. The cross-coupled terms K_{xy}, K_{yx}, C_{xy} and C_{yx} were considered to be null.

Tab. 3: Stiffness and damping dynamic coefficients of the studied squeeze film damper considering a radial clearance of 0.12 mm.

Rotation Speed [rpm]	Oil Temperature [°C]	Kinematics Viscosity [m²/s]	Dynamic Viscosity [Pa.s]	Stiffness Coefficients [N/m]	Damping Coefficients [Ns/m]
0	25	3.2755E-5	0.0329	2.935E+6	9,720
5,000	60	1.9752E-5	0.0199	2.935E+6	9,720
10,000	70	1.6037E-5	0.0161	5.303E+7	7,856
15,000	80	1.2322E-5	0.0124	7.159E+7	6,056
20,000	90	8.6065E-6	0.0086	8.440E+7	4,216
25,000	95	6.7489E-6	0.0068	1.0523E+7	3,352
30,000	100	4.8913E-6	0.0049	1.2518E+7	2,441

Tab. 4: Stiffness and damping dynamic coefficients of the studied squeeze film damper considering a radial clearance of 0.1905 mm.

Rotation Speed [rpm]	Oil Temperature [°C]	Kinematics Viscosity [m²/s]	Dynamic Viscosity [Pa.s]	Stiffness Coefficients [N/m]	Damping Coefficients [Ns/m]
0	25	3.2755E-5	0.0329	8.282E+5	2,449
5,000	60	1.9752E-5	0.0199	8.282E+5	2,449
10,000	70	1.6037E-5	0.0161	1.6905E+6	1,978
15,000	80	1.2322E-5	0.0124	2.6048E+6	1,529
20,000	90	8.6065E-6	0.0086	3.5563E+6	1,072
25,000	95	6.7489E-6	0.0068	4.8899E+6	859.6
30,000	100	4.8913E-6	0.0049	6.3821E+6	635.9
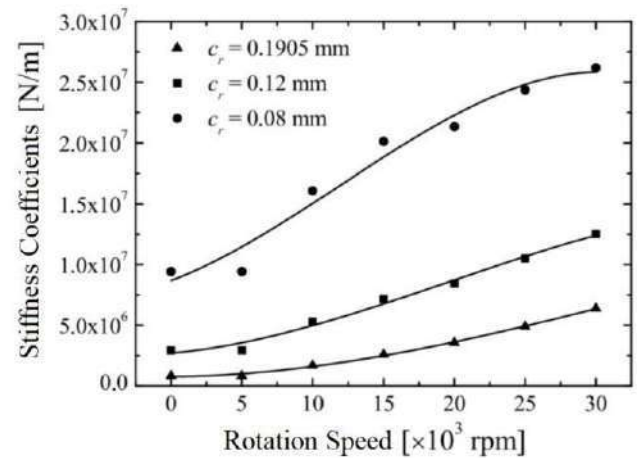
Fig. 5: Dynamic stiffness coefficients considering three values of radial clearance for the squeeze film damper.
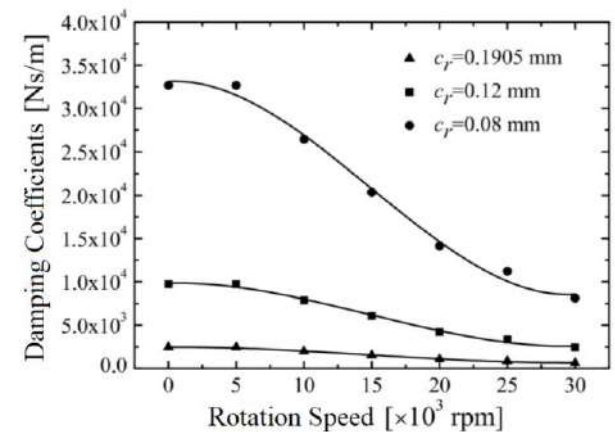
Fig. 6 Dynamic damping coefficients considering three values of radial clearance for the squeeze film damper.

V.   CONCLUSIONS

It is observed that the radial clearance strongly affects the values of the dynamic stiffness and damping coefficients for the aeronautic gas turbine rear bearing. The stiffness

coefficients increase with the increase in the rotation speed of the rotating assembly. In contrast, the damping coefficients decrease with the increase in the rotation speed of the rotating assembly. This is because of the viscous losses in the lubricant as the temperature of the lubricant increases with higher rotation speeds. The dynamic stiffness and damping cross-coupled coefficients were considered null for the application. For a zero-rotation speed, the same stiffness and damping values used for 5,000 rpm were adopted. The calculated stiffness and damping dynamic coefficients for the three different radial clearances can be used in a rotordynamic analysis of the entire rotating assembly to predict its vibratory behavior to ensure superior performance and prevent issues.

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International Legal Cooperation in Criminal Matters: Principles and Aspects Related to the Production of Evidence Abroad

Cooperação Jurídica Internacional em Matéria Penal: Princípios e Aspectos Relacionados à Produção Da Prova No Estrangeiro

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Abstract— The article discusses the international legal cooperation for obtaining evidence in criminal proceedings and shows the modalities admitted in Brazilian Law. It approaches the criteria for achieving the effectiveness of criminal evidence produced abroad, addressing principles, aspects, and communicative channels of international legal cooperation for its production.

Resumo— O artigo discorre sobre cooperação jurídica internacional para obtenção de provas no processo penal e apresenta a modalidades admitidas no Direito Brasileiro. Faz uma abordagem dos critérios para que se alcance a eficácia da prova penal produzida no exterior, abordando princípios, aspectos e canais comunicativos de cooperação Jurídica internacional para a sua produção.

I. INTRODUÇÃO

Fenômenos advindos na contemporaneidade, como a globalização, o surgimento das sociedades complexas, a velocidade da informação e do consumo, o incremento de novas tecnologias e a crescente movimentação de pessoas para um "mundo sem fronteiras", quando se denota 5,3 bilhões de pessoas ligadas à *internet*, potencializaram formas de criminalidade organizada tais como o tráfico

internacional de drogas, de armas e de pessoas, o terrorismo, a lavagem de dinheiro e outros delitos transnacionais.

Assim, como pondera Giacomolli[1], as atividades criminosas se fizeram difusas, voláteis, para abarcar diversos locais, com alto grau de mobilidade. A criminalidade inteligente passou a utilizar a velocidade dos mecanismos de comunicação, as facilidades de circulação, organizando-se em redes, com vínculos territoriais, internos e transfronteiriços, sem marcos territoriais (embora se utilizando das fronteiras), mas com técnicas sofisticadas. O cérebro trabalha em redes, com vários centros de processamento de decisões.

A nova realidade, pela expansão das condutas geradoras de riscos, motivou uma resposta igualmente expansiva do Direito Penal. Além disso, impactou a atividade jurisdicional que precisou rever e ampliar o âmbito do processo penal "clássico", utilizando-se de novos instrumentos com objetivo da produção da prova penal.

Nesse sentido, por meio de acordos bilaterais, tratados regionais e multilaterais, ou com base em promessas de reciprocidade, os países foram criando mecanismos de mútua cooperação, judiciais ou não[2], para a troca de informações e desenvolvimento de suas atividades de controle com maior eficiência.

Por outro lado, a necessária criação de novas possibilidades para um processo penal mais efetivo e aplicável num mundo sem fronteiras[3], fez criar o seu grande desafio na contemporaneidade, no sentido de fazer cumprir os primados da efetividade somada ao garantismo, ainda que se trate de casos penais que envolvem os bens jurídicos supraindividuais ou coletivos, sem jamais perder de vista os diretos humanos dos acusados.

Nessa ordem de ideias, a matéria da prova penal, em casos de cooperação jurídica internacional, deverá respeitar padrões internacionais, havidos como universais, de

Direitos Humanos também pautados em normativas internacionais.

Deve criar-se, portanto, um mecanismo de respeito ao devido processo legal ou "cadeia de custódia" na produção da prova penal no exterior, com respeito às garantias individuais dos acusados de crimes, mantendo-se o padrão de "processo justo".

II. CONCEITO E PRINCÍPIOS DA COOPERAÇÃO JURÍDICA INTERNACIONAL EM MATÉRIA PENAL. O PROCESSO DE CONSTITUCIONALIZAÇÃO DOS DIREITOS HUMANOS

A cooperação jurídica internacional "é um instrumento por meio do qual um Estado pede a outro que execute decisão sua ou profira decisão própria sobre litígio que tem lugar em seu território"[4]. Engloba, contudo, termos como "assistência, ajuda ou auxílio mútuo" internacional. O intercâmbio pode se dar não somente entre órgãos judiciais, como também entre órgãos judiciais e administrativos de Estados distintos.

No Brasil, o Código de Processo Penal, em matéria disciplinada a partir de seu artigo 780, reporta-se a homologação de sentenças estrangeiras e às cartas rogatórias, que não serão cumpridas quando contrárias a "ordem pública e aos bons costumes". Não há também melhor previsão no Projeto 156/2009, e nem mesmo uma legislação específica e geral de cooperação jurídica internacional.

Nesses moldes, os dispositivos legais que versam sobre a cooperação jurídica internacional no Brasil encontram-se fragmentados, sobretudo em textos de tratados internacionais firmados pelo país.

A manutenção de relações com Estados estrangeiros é de competência privativa do Presidente da República, a teor

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[1] GIACOMOLLI, Nereu José. "Valoração da prova no âmbito da cooperação jurídica internacional", in Prado, Geraldo *et al*. Prova Penal. Empório do Direito, Florianópolis, 2015, p. 52.

[2] Segundo Marcio Adriano Anselmo: "o incremento da cooperação internacional em matéria penal fez surgir uma série de mecanismos e formas de cooperação internacional". Dentre eles: 1) cooperação direta policial; 2) cooperação entre Unidades de Inteligência Financeira; 3) cooperação entre autoridades fiscais; 3) cooperação entre Promotorias; 5) rede Ibero-Americana para Troca de Informações; 6) consularização de documentos. ("Lavagem de dinheiro e cooperação jurídica internacional", Editora Saraiva, 2013, p. 137).

[3] "Essa nova ordem mundial (SHAUTHER) carece de uma regulamentação complexa, para além do doméstico e ordinário, de um questionamento das noções estanques e clássicas de soberania, território e de jurisdição. Inafastável a necessidade de solidariedade entre os Estados na *persecutio* da criminalidade transnacional, de cooperação. Esta ultrapassa o plano de mera

cortesia entre os Estados e atinge a conservação do próprio Estado de Direito. Por isso, proclama-se um verdadeiro paradigma de "solidariedade judicial interetática" (Cervini e Polimeni). Nas novas necessidades se inclui a celebração de acordos internacionais entre países, regionais e internacionais, com adaptação da legislação doméstica à nova ordem internacional, na perspectiva da proativização (Cervini). Por isso, inafastável a solidariedade internacional, o auxílio internacional, a cooperação jurídica internacional na persecutio criminis, muito além da jurisdição doméstica, com objetivo da tutela criminal efetiva". (GIACOMOLLI, Nereu José. *Op cit*. p. 53)

[4] Cartilha "Cooperação Jurídica Internacional em Matéria Penal", do Departamento de Recuperação de Ativos e Cooperação Jurídica Internacional", https://www.gov.br/mj/pt-br/assuntos/sua-protecao/lavagem-de-dinheiro/institucional-2/publicacoes/manuais/cooperacao-juridica-internacional-em-materia-penal/cartilha-penal-09-10-14-1.pdf (acesso em 23/12/2022)

dos artigos 21, I e 84, VIII da CF; o Judiciário participa da cooperação com sua atribuição constitucional nas hipóteses de extradição e de execução de sentenças e cartas rogatórias estrangeiras.

Há de se considerar que a cooperação jurídica internacional é pautada em aspectos de solidariedade, que influem na formação jurídica das sociedades.

A Constituição Federal brasileira, em seu artigo 4º, inciso IX, aponta que a "cooperação entre os povos para o progresso da humanidade" como um dos princípios que irão reger as relações internacionais do país. Da mesma maneira, o artigo 3º, I, da carta constitucional reconhece a solidariedade como um dos objetivos da República Federativa do Brasil.

Aludidos princípios, que foram introduzidos no Direito brasileiro, pela Constituição Federal de 1988, deram-se por influência do processo de constitucionalização dos direitos humanos, tendência mundial após o advento da 2ª Guerra Mundial.

Acerca do tema, pondera Flávia Piovesan[5]:

> "Ora, ao prescrever que 'os direitos e garantias expressos na Constituição não excluem outros direitos decorrentes dos tratados internacionais', a contrario sensu, a Carta de 1988 está a inserir, no catálogo de direitos constitucionalmente protegidos, os direitos enunciados nos tratados internacionais em que o Brasil seja parte. Esse processo de inclusão implica a incorporação pelo Texto Constitucional de tais direitos. Ao efetuar a incorporação, a Carta atribui aos direitos internacionais uma natureza especial e diferenciada, qual seja, a natureza de norma constitucional. Os direitos enunciados nos tratados de direitos humanos de que o Brasil é parte integram, portanto, o elenco dos direitos constitucionalmente consagrados".

Nesse cenário, a cooperação jurídica internacional em matéria penal deverá estar atenta aos princípios regentes dos direitos humanos, reconhecidos historicamente como fundamentos da ordem pública internacional, e que tem como marcos: - a Carta de São Francisco de 1945 (Tratado internacional que criou a Organização das Nações Unidas); - a Declaração Universal, de 1948; - Pactos Internacionais de Direitos Civis e Políticos, de Direitos Econômicos e Culturais e Sociais de 1966, que constituem a Carta Internacional de Direitos Humanos.

III. PROCEDIMENTOS DA COOPERAÇÃO JURÍDICA INTERNACIONAL EM MATÉRIA PENAL PARA A PRODUÇÃO DE PROVA: CARTA ROGATÓRIA E O PEDIDO DE AUXÍLIO DIRETO

A cooperação jurídica internacional em matéria penal poderá ser ativa ou passiva, a depender da posição do Estado solicitante. Assim, será ativa quando a autoridade brasileira solicitar a intervenção de outro Estado, e passiva, quando o Brasil for demandado a prestar a cooperação em seu território.

Também é interessante destacar, conforme recorda Márcio Adriano Anselmo[6], que a cooperação poderá ser informal, quando não se demanda um procedimento formal de cooperação e é muito aplicável na fase pré-processual, sem intervenção do Poder Judiciário, como se dá comumente nas atividades da Interpol e do Grupo de *Egmont* (que congrega as Unidades de Inteligência Financeira).

Assim, a cooperação formal se dará quando necessária a institucionalização da via eleita ou para a validação da prova produzida ou do ato a ser executado, quando se fizer indispensável intervenção judicial, ou seja, para diligências com necessária reserva de jurisdição.

Importante destacar a figura da chamada "Autoridade Central", órgão responsável pela boa condução da cooperação jurídica que cada Estado realiza com os demais países. Cabe a Autoridade Central receber, analisar, adequar, transmitir e acompanhar o cumprimento dos pedidos de cooperação jurídica. Essa análise tem o objetivo de verificar o atendimento aos requisitos da lei do Estado requerido, bem como do tratado que fundamenta o pedido, conferindo, assim, maior agilidade ao procedimento[7].

No Brasil, o papel de "Autoridade Central" é exercido pelo Ministério da Justiça e Segurança Pública e o faz por meio do "Departamento de Recuperação de Ativos e Cooperação Jurídica Internacional" (DRCI).

Em termos de cooperação passiva, os mecanismos de cumprimento interno dos pedidos de cooperação jurídica são definidos pela lei processual de cada país.

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[5] PIOVESAN, Flávia. Direitos Humanos e o Direito Constitucional Internacional. Editora Saraiva, 17ª edição, 2017, p. 126.

[6] ANSELMO, Márcio Adriano. Lavagem de dinheiro e cooperação jurídica internacional. Editora Saraiva, São Paulo, 2013, p. 116.

[7] Cartilha "Cooperação Jurídica Internacional em Matéria Penal", do Departamento de Recuperação de Ativos e Cooperação Jurídica Internacional, https://www.gov.br/mj/pt-br/assuntos/sua-protecao/lavagem-de-dinheiro/institucional-2/publicacoes/manuais/cooperacao-juridica-internacional-em-materia-penal/cartilha-penal-09-10-14-1.pdf (acesso em 23/12/2022)

Por tal sorte, os instrumentos de cooperação e os respectivos procedimentos adotados pelo direito brasileiro não irão coincidir, necessariamente, com aqueles adotados pelas leis de outro Estado.

Outro aspecto interessante, por conta dessa realidade, é que no pedido de cooperação passivo, as autoridades brasileiras não levarão em conta o título do documento, pois a classificação da cooperação será dada pelo conteúdo do pedido, por critérios adotados na legislação brasileira.

Nesses moldes, tem-se, para a cooperação jurídica e produção da prova em matéria penal a utilização de dois mecanismos, sendo eles a carta rogatória e o pedido de auxílio direto.

Por meio da carta rogatória, autoridade judiciária estrangeira requer que seja executado no Brasil ato por ela proferido, não cabendo às autoridades brasileiras exercerem cognição de mérito sobre o que é solicitado. Pode se reportar a atos pré-processuais, à fase citatória, probatória de um processo criminal, ou mesmo para aqueles de natureza cautelar, como nas hipóteses de sequestros e arrestos de bens de investigados.

A carta rogatória servirá de instrumento para um pedido de cooperação jurídica do juízo rogante ao juízo rogado. No Brasil, a competência para proferir *exequatu*r às cartas rogatórias é do Superior Tribunal de Justiça, nos termos do artigo 105, I, i, da Constituição Federal, que exercerá o chamado "juízo de delibação".

No juízo de delibação, verifica-se a adequação do pedido aos aspectos formais, bem como à ordem pública, conceito no qual se inserem a soberania e os bons costumes. Não há análise de mérito das razões que levaram a autoridade estrangeira a solicitar a realização da diligência.

O Superior Tribunal de Justiça fará a apreciação do juízo de delibação, levando em conta quatro questões: 1) competência internacional da autoridade que lavrou a decisão; 2) possibilidade de contraditório prévio; 3) ausência de coisa julgada; 4) não-ofensa à ordem pública.

Na hipótese de o juízo de delibação ser positivo, expede-se o *exequatur* (execute-se).

Em vista da disseminação da criminalidade global e transnacional, viu-se a necessidade de se criarem mecanismos mais ágeis e diversos dos mecanismos clássicos de cooperação jurídica internacional. Assim, surgiu o pedido de auxílio direto com outra forma de tramitação. O pedido é recebido pela Autoridade Central brasileira que o encaminha ao órgão responsável pelo atendimento, salvo hipótese de autorização judicial, quando

é submetido inicialmente ao crivo do Ministério Público Federal, que fará o pedido ao juízo federal de primeira instância.

A natureza jurídica do auxílio direto, conforme pondera Denise Alves Abade[8], é de "demanda internacional" da parte de outro Estado, de alçada do Poder Executivo brasileiro, na gestão de relações internacionais (art. 84, IV, da Constituição brasileira). Sendo assim, em tal hipótese de auxílio todas as medidas necessárias deverão ser adotadas pelo Ministério Público Federal para auxiliar na persecução penal, podendo promover, perante o Judiciário brasileiro, irrestritamente as ações necessárias.

Desse modo, o auxílio direto diferencia-se dos demais mecanismos porque nele as autoridades brasileiras não proferem *exequatur* e nem homologam ato jurisdicional estrangeiro. Por meio deste instrumento, as autoridades brasileiras conhecem dos fatos narrados pela autoridade requerente para daí proferirem uma decisão genuinamente nacional.

Podem ser objeto de auxílio direto: obtenção de provas como a oitiva de testemunhas, a quebra de sigilo bancário, fiscal e telemático, a localização de bens e indivíduos, o sequestro de bens congelamento de contas bancárias e até a repatriação de bens ou valores remetidos ilicitamente no exterior.

Saliente-se que no pedido de auxílio direto haverá uma cognição plena do juiz brasileiro acerca do caso, estabelecendo-se o contraditório, com a disposição de todas as ferramentas processuais e recursais aos atores processuais envolvidos.

A lei aplicável, por força de princípio geral do Direito Processual Internacional, é aquela do Estado requerido, chamada *lex diligentiae*.

O Brasil, em relação a acordos bilaterais, foi signatário dos seguintes instrumentos de Assistência Jurídica Mútua em Matéria Penal : Brasil e Itália (1993); Brasil e França (1999); Brasil e Estados Unidos da América (2001); Brasil e Colômbia (2001); Brasil e Peru (2001); Brasil e Ucrânia (2006); Brasil e República da Coréia (2006); Brasil e China (2007); Brasil e Espanha (2008); Brasil e Cuba (2008); Brasil e Canadá (2009); Brasil e Suriname (2009); Brasil e Suíça (2009); Brasil e Panamá (2011); Brasil e Nigéria (2011); Brasil e Estados Unidos Mexicanos (2011); Brasil e Reino Unido da Grã-Bretanha e Irlanda do Norte (2013); Brasil e Honduras (2013); Brasil e Bélgica (2017); Brasil e República da Turquia (2017); Brasil e Jordânia (2019).

Já na perspectiva de Acordos Multilaterais para a cooperação jurídica internacional em matéria penal, o país

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[8] ABADE, Denise Neves. Direitos fundamentais na cooperação jurídica internacional: Extradição, Assistência Jurídica, Execução

de Sentença estrangeira e transferência de presos. Editora Saraiva, São Paulo, 2013, pág. 313.

também aderiu aos seguintes protocolos : Convenção Contra o Tráfico Ilícito de Entorpecentes e Substâncias Psicotrópicas (1991); Convenção Interamericana para o Cumprimento de Sentenças penais no Exterior (1996); Convenção Interamericana sobre Tráfico Internacional de Menores (1998); Convenção Interamericana contra a Fabricação e o Tráfico ilícito de Armas de Fogo, Munições, Explosivos e Outros Materiais Correlatos (1999); Convenção Sobre o Combate da Corrupção de Funcionários Públicos Estrangeiros em Transações Comerciais Internacionais (2000); Protocolo de Assistência Jurídica Mútua em Assuntos Penais-MERCOSUL (2000); Convenção Interamericana contra a Corrupção (2002); Convenção das Nações Unidas contra o Crime Organizado Transnacional (2004); Convenção Interamericana contra o Terrorismo (2005); Convenção das Nações Unidas Contra a Corrupção (2006); Convenção Interamericana sobre Assistência Mútua em Matéria Penal (2008); Acordo Complementar ao Acordo de Assistência Jurídica Mútua em Assuntos Penais entre os Estados Partes do Mercosul, Bolívia e Chile (2014); Convenção de Auxílio Judiciário em Matéria Penal entre os Estados Membros da CPLP (2016); Protocolo para Eliminar o Comércio Ilícito de Produtos de Tabaco (2018).

IV. PROCESSO PENAL JUSTO. CONCEITO DE PROVA PENAL, EFICIÊNCIA E GARANTISMO

O processo penal se desenvolve inteiramente pela reconstrução de um fato passado, por meio da linguagem.

Nesse aspecto, a "busca da verdade", ou probabilidade de ocorrência desse evento naturalístico (fato da vida), necessariamente, irá se utilizar de um canal comunicativo previsto pelo direito processual, para a sua demonstração ou verificação, tornando-se um fato jurídico processual. Esse canal comunicativo poderá ser entendido como "procedimento probatório".

No dizer de Fabio Ramazzini Bechara: "O ciclo da prova compreende a descoberta da fonte de prova (pessoa ou coisa), a sua instrumentação através do meio de prova, o procedimento probatório, os elementos de prova"[9].

Nessa ordem de ideais, faz-se necessário diferenciar prova de elemento de informação, para se alcançar o conceito de prova transnacional.

O artigo 155 do Código de Processo Penal brasileiro, a exemplo de outros diplomas processuais estrangeiros[10], exige do juiz a formação de sua convicção em prova produzida ao contraditório judicial, "não podendo sustentar sua decisão exclusivamente em elementos colhidos na investigação, salvo a hipótese da prova cautelar, não repetível e antecipada".

Portanto, prova é aquela produzida judicialmente e durante o processo, sendo o elemento informativo colhido durante a investigação.

Quanto ao critério do método de produção, prova se colhe durante o contraditório judicial, dialeticamente, com a participação dos atores processuais, o que não ocorre em relação aos elementos informativos.

Salienta bem Bechara, que:

tanto a prova como o elemento de informação possuem função persuasiva e cognitiva. A prova exerce uma função persuasiva em relação à formação da convicção do julgador, e uma função cognitiva em relação à demonstração da veracidade de uma afirmação. O elemento informativo possui uma função persuasiva em relação à convicção das partes, da autoridade que preside a investigação e até mesmo do julgador nas hipóteses de mero juízo de admissibilidade. A função cognitiva do elemento informativo está relacionada à demonstração da verossimilhança ou probabilidade de determinada afirmação[11].

Nesse diapasão, a prova transnacional será aquela cujo meio de prova se encontra num Estado distinto ao da autoridade competente, ou ainda quando os meios de prova de um mesmo fato se encontram em Estados diversos.

Noutro modo, as fontes de prova (pessoas ou coisas) se apresentam, na prova transnacional, nos limites da soberania de outro Estado, exigindo-se a realização da cooperação jurídica internacional.

Para a efetividade do processo, exige-se a eficiência da prova, também na perspectiva da cooperação jurídica internacional, quando se verifica pela aptidão para demonstrar algo, a relevância e a pertinência do elemento de prova que pretende extrair da fonte de prova.

Sob o viés do Garantismo, observa-se a estrita legalidade penal e o processo penal atuando como preservação das garantias individuais e direitos fundamentais dos acusados de crimes.

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[9] BECHARA, Fabio Ramazzini. Cooperação jurídica internacional em matéria penal. São Paulo, Saraiva, 2011, p. 35. E complementa: "Fontes de prova são as pessoas ou coisas a partir das quais pode se extrair o dado probatório. O meio de prova é a atividade por meio da qual os dados probatórios são fixados o processo".

[10] Nesses termos, o artigo 192 do Código de Processo Penal italiano: "192. VALUTAZINE DELLA PROVA. 2. L'esistenza di un fatto non púo essere desunta da indizi a meno che questi siano gravi, precisi e concordanti".

[11] *Op. cit.* p. 37.

Nesse passo, oportuno mencionar o objetivo 16 "e" do Programa de Prevenção ao Crime e a Justiça Criminal da Organização das Nações Unidas (ONU) que propõe aos Estados a busca de uma "administração da Justiça mais eficiente e efetiva, com o devido respeito aos direitos humanos de todos aqueles afetados pelo crime e todos aqueles envolvidos no sistema de justiça criminal".

Definindo processo penal eficiente conclui Antônio Scarance Fernandes:

> Se o processo penal tem por fins assegurar o exercício do direito de defesa do investigado ou acusado e, simultaneamente, o interesse estatal em punir os culpados pelos delitos, será eficiente o processo penal que, de maneira global, consiga alcançar o máximo em ambas as finalidades[12].

É na busca de um processo penal marcado pela eficiência, garantidor dos direitos do acusado e os das pessoas impactadas de algum modo pelo crime, que devem nortear a produção da prova no âmbito da cooperação jurídica internacional.

V.   AFIRMAÇÃO DE DIREITOS HUMANOS COM VALORES UNIVERSAIS. SUPERAÇÃO DAS EVENTUAIS INCOMPATIBILIDADES DOS SISTEMAS PROBATÓRIOS

Em vista do processo histórico de universalização dos direitos humanos, criaram-se padrões normativos universais, que ao contrário de excluírem os regionalismos ou o multiculturalismo dos povos, acabaram por contemplando-os sistematicamente.

Desse modo, as diferenças culturais entre os povos, e mesmo relativas aos sistemas processuais dos países, não fazem óbice à cooperação jurídica internacional em matéria penal, especialmente em razão de quê, por força da universalização dos direitos humanos, edificaram-se princípios universais de confluência entre os sistemas processuais diversos.

Em linhas gerais, recorda Bechara, que

> o sistema probatório europeu-continental remonta suas origens ao período da inquisição, em que a verdade fazia-se por métodos irracionais, posteriormente substituídos pelo inquérito, segundo uma nova racionalidade probatória de reconstrução do fato passado. Trata-se do método

inquisitivo, caracterizado pelo segredo e caráter ilimitado da pesquisa da verdade, em que a atividade probatória constituía uma busca pela confissão[13].

Posteriormente, "a reação ao modelo inquisitivo veio com o movimento iluminista do século XVIII, mais especificamente com a Revolução Francesa e a Revolução Industrial, em que a relação entre Estado e o indivíduo passa a ter uma nova concepção, não mais *ex parte principi*, mas *ex parte Populi*"[14].

Assim, o rompimento com o sistema inquisitivo surgiu com a lei francesa de 16 de setembro de 1791, com o procedimento do julgamento pelos jurados, a adoção irrestrita da oralidade, a presunção de inocência como valor fundamental, o abandono por completo da teoria da prova legal.

Já no sistema probatório anglo-americano se firmou a instituição do Júri, que se faz presente até os dias de hoje, em que a função dos jurados era de recolher informações e prestar testemunhos sobre fatos investigados. Passaram a julgar após o Concílio de Latrão, em 1215.

No sistema anglo-americano, há um sistema de exclusão de provas (*law of evidence*), que impõe um conjunto de regras de exclusão de provas. O objetivo é controlar a qualidade do material que será apresentado aos jurados, como, por exemplo, a testemunha de 'ouvir dizer' ou *hearsay*.

O procedimento do *common law* é caracterizado pelo sistema adversarial, que pressupõe uma competitividade na busca da prova. Suas principais características são: indispensabilidade da seleção do material probatório a ser valorado segundo a norma de exclusão; existência do contraditório na investigação do fato, que é de responsabilidade das partes; preponderância da prova oral sobre a prova escrita, de modo que somente é considerada prova válida a testemunha colhida oralmente perante o julgador e submetida ao confronto *(cross-examination)*.

Malgrado existam diferenças entre os principais sistemas processuais vigentes no mundo ocidental, o fato é que há um processo de harmonização dos direitos humanos que inspira a todos os sistemas processuais vigentes em diferentes países.

Assim, dá-se uma perspectiva de que o Direito Processual Penal, como ramo do Direito, serve a instrumentalização dos direitos humanos, ou seja, denota-se a existência de um processo penal convencional, no desiderato de fazer

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[12] FERNANDES, Antônio Scarance. O equilíbrio na repressão ao crime organizado. p. 10-11. In: _____; ALMEIDA, José Raul Gavião de; MORAIS, Mauricio Zanoide de. (Coords.) Crime organizado: aspectos processuais. São Paulo: RT, 2009. p. 9-28.

[13] BECHARA, Fabio Ramazzini. *Op. cit*., p. 86.
[14] Idem .

cumprir os Tratados Internacionais que versam sobre a matéria.

VI.   PROCESSO JUSTO E PROVA PENAL: "MARCO DE GARANTIAS" NA PROVA PRODUZIDA NO EXTERIOR

As garantias concebidas para a promoção e proteção dos direitos humanos no processo penal, relacionam-se a todos os atores processuais: o acusado, a vítima, a coletividade, a atividade jurisdicional e ao próprio Estado.

Mencionadas garantias, segundo Bechara: "são parâmetros a nortear o relacionamento e a convivência entre todos esses interesses e ao mesmo tempo promover o resultado mais justo possível"[15].

Também é de se considerar que as garantias fundamentais trazidas na Constituição Federal brasileira (CF/88 - promulgada em 05/10/1988) vedam a admissão no processo de prova delas violadoras, não importando se essa ofensa tenha sido produzida no exterior. Dessa forma, o Estado requerente deve respeitar a preservação do núcleo essencial dos direitos fundamentais insculpido no ordenamento jurídico brasileiro, conforme artigo 4º de sua Carta Política[16].

Assim, como "marco de garantias" no sistema brasileiro, nos mesmos moldes de diversos diplomas internacionais, tem-se princípios como os da presunção de inocência; direito à prova e participação do juiz na produção da prova no exterior; direito ao contraditório; igualdade de armas; direito de defesa com assistência gratuita de intérprete; duração razoável do processo; - respeito à vida privada, intimidade, inviolabilidade do domicílio.

Assim, a presunção de inocência (art. 5º, LVII, CF88) é a garantia de que ninguém será considerado culpado antes do trânsito em julgado da sentença penal condenatória, sendo também, no campo probatório, uma constatação de que caberá à acusação o ônus da prova da culpa do acusado em processo penal. Dialoga também com a necessidade de observância do devido processo legal (art. 5º, LIV, CF88), com a possibilidade da ampla defesa (técnica e pessoal, art. 5º, LV, CF88).

A prova penal, conforme já mencionado alhures, será aquela produzida na presença do órgão judicial, com a participação efetiva do Ministério Público e a defesa do acusado, em contraditório judicial. O contraditório, aliás, irá proporcionar a efetivação de um processo penal democrático, contemplando às partes litigantes as possibilidades irrestritas de conhecer e refutar tudo o que venha a ser colhido e trazido ao processo, inaugurando um diálogo processual que reduz o próprio risco de erro judiciário.

Em relação à igualdade de armas faz com que o acusado tenha igual possibilidade de propositura de provas que é conferida à acusação, podendo apresentar documentos, arrolar idêntico número de testemunhas ou solicitar perícia.

No que pertine à duração razoável do processo (art. 5º, LXXVIII, CF88), trata-se de garantia já prevista na Declaração Universal de Direitos Humanos (1948), do Pacto de Direitos Civis e Políticos (1966), Convenção Europeia de Direitos Humanos (1950) e Convenção Interamericana de Direitos Civis e Políticos e se reporta à garantia da dignidade do acusado, que quando preso, deverá ser julgado em prazo razoável, não podendo ser eternizadas as prisões e medidas cautelares de natureza pessoal, que quando aplicadas em abuso, violam o direito fundamental à liberdade, que é regra, e não exceção, no Estado Democrático de Direito.

Quanto ao direito gratuito de um intérprete, tanto o Pacto de Direitos Civis e Políticos (1966), Convenção Europeia de Direitos Humanos (1950) asseguram a participação das partes no processo por meio de um intérprete, possibilitando-as que conheçam a língua empregada no processo.

Por fim, quanto à garantia do respeito à vida privada, intimidade e a inviolabilidade do domicílio também possuem respaldo constitucional (art. 5º, inciso X, CF88), somente podendo ser afastada em situações excepcionais, tais como hipóteses de buscas domiciliares e interceptações telefônicas devidamente fundamentadas e respaldadas em ordem judicial.

Dessa forma, para que se alcance a eficácia da prova produzida no exterior, também se faz necessário o respeito ao "marco de garantias" que se dá em obediência ao padrão normativo universal de colheita da prova, em homenagem aos direitos humanos.

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[15] BECHARA, Fabio Ramazzini. *Op. cit*., p. 92.
[16] Art. 4º A República Federativa do Brasil rege-se nas suas relações internacionais pelos seguintes princípios: I - independência nacional; II - prevalência dos direitos humanos; III - autodeterminação dos povos; IV - não-intervenção; V - igualdade entre os Estados; VI - defesa da paz; VII - solução pacífica dos conflitos; VIII - repúdio ao terrorismo e ao racismo; IX -

cooperação entre os povos para o progresso da humanidade; X - concessão de asilo político. Parágrafo único. A República Federativa do Brasil buscará a integração econômica, política, social e cultural dos povos da América Latina, visando à formação de uma comunidade latino-americana de nações.

VII. NOVAS PERSPECTIVAS RELACIONADAS À SOBERANIA E ORDEM PÚBLICA NACIONAL

A perspectiva de que a soberania do Estado, que em sua esfera de dominação, pode decidir-se independentemente de qualquer modo de controle, resta superada pela nova ordem jurídica universal.

Esse paradigma do soberanismo ou da coexistência desigual serviu até ides de 1945, conforme leciona Nereu José Giacomolli, não mais podendo ser aplicado aos dias atuais:

> O modelo Westfaliano (Paz de Westfália) criado a partir dos Tratados de Munster (1648) e Osnabruck (1648), passando pelo Tratado Germânico (França e Suécia) e dos Pirineus (1659), envolvendo a França e a Espanha, bem como pelo Congresso de Viena de 1815 e pelo Tratado de Versalhes de 1919, entrou em declínio após 1945. Era um modelo marcado pelo conflito religioso como uma questão de Estado, pela paz e equilíbrio de poder entre as nações. Trata-se de um paradigma delimitado de soberania de exclusão, da rivalidade, do Estado-Nação, de território, com poucas necessidades de cooperação na área jurídica. Esse modelo foi cedendo à formação de um novo paradigma, forjado no desequilíbrio de poder, o que ensejou a necessidade de Instituições supranacionais e da solidariedade nacional à afirmação dos Estados de Direito.[17]

Aliás, o conceito de soberania, inicialmente político, foi deslocado para o campo do direito, no sentido de que representa "a capacidade exclusiva do Estado de autodeterminação e autovinculação jurídica".[18]

Após a Segunda Guerra Mundial os elementos de direito constitucional devem ser relativizados para coexistir nas relações entre países os princípios de fraternidade universal, de uma nova ordem jurídica mundial, em que os direitos fundamentais implicam a autolimitação da soberania.

Da mesma maneira, o conceito de ordem pública, definido como conjunto de valorações de caráter político, social, econômico ou moral, próprio de uma comunidade determinada, também apresenta aspecto volátil[19] e não deverá, em regra, ser utilizado de modo a impedir a cooperação jurídica internacional em matéria judiciária, especialmente penal.

Como observa Silvio Antônio Marques, o combate aos crimes e ilícitos graves além das fronteiras territoriais de cada país não significa qualquer mitigação da soberania, pois, ao permitir que seja cumprida uma decisão ou sentença estrangeira em seu território, o Estado requerido reafirma seu poder. Afinal, se não houvesse soberania, essa permissão seria dispensável[20].

Dessa maneira, posteriormente a segunda metade do século XX, o fenômeno da transnacionalidade do crime fez emergir um novo paradigma de cooperação, pautado na "cooperação interessada", quando a cooperação jurídica internacional em matéria penal deve acompanhar a "juridificação" das relações internacionais, ou aceitação da *rule of law*, quando os conflitos em uma sociedade devem ser resolvidos de acordo com o Direito.

Assim, foi se formando um marco jurídico regulatório, quando os Estados negociam diversos tratados (multilaterais, regionais e ainda bilaterais) sob as mais diversas espécies. Conforme leciona Denise Alves Abade, pelo paradigma da cooperação interessada, "os Estados negociam tratados, estruturam órgãos internos responsáveis pela operacionalização dos pleitos cooperacionais (nascem as Autoridades Centrais) e ainda buscam regrar de maneira clara os motivos para a eventual denegação da cooperação"[21].

Não bastasse, em situação diametralmente oposta ao paradigma do soberanismo, surgiram os paradigmas da confiança e reconhecimento mútuo, quando os Estados cada vez mais atuam no sentido de incrementar a cooperação, inclusive pela modificação de sistemas jurídicos internos de modo a que se tenha a homogeneização de regras processuais penais, sem qualquer ofensa ao sistema jurídico interno.

VIII. PRINCÍPIO DA ESPECIALIDADE E DA DUPLA INCRIMINAÇÃO

Em cooperação jurídica internacional em matéria penal, o princípio da especialidade dispõe que as provas obtidas por meio da cooperação jurídica internacional somente poderão ser utilizadas no procedimento que ensejou o pedido.

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[17] GIACOMOLLI, Nereu José. *Op. cit*, p. 52.
[18] FERRIS, Remédio Sanches. El Estado Constitucional y su sistema de fuentes. Valencia. Tirant Io Blanch, 2002, pág. 261, apud Bechara, *op. cit*, p. 131.
[19] É o caso, por exemplo, das sentenças de divórcio, que por serem contrárias a "ordem pública" não eram homologadas no Brasil antes do advento da Lei do divórcio.

[20] MARQUES, Silvio Antonio. Improbidade administrativa: ação civil e cooperação jurídica internacional. São Paulo, Editora Saraiva, 2010. p. 235.
[21] ABADE, Denise Neves. *Op.cit,*, p. 62.

A não observância de tal princípio pode acarretar a ruptura do acordo de cooperação e tem por base a preservação de princípios de um padrão normativo universal de produção da prova, evitando-se, por exemplo, a utilização da prova emprestada em procedimentos nos quais não houve a participação da parte na colheita das provas.

Exceção a essa regra da especialidade, poderá ser aplicada por meio de um "pedido de compartilhamento" ao Estado requerido, através da Autoridade Central.

Nesse pedido de compartilhamento, deve ser mencionado o procedimento em que se originou a solicitação de assistência jurídica internacional e que produziu as provas; o procedimento no qual se utilizará as provas; conterá a descrição dos tipos penais investigados no procedimento que receberá as provas, bem como um resumo dos fatos e as razões para a autorização do pedido de compartilhamento.

Em relação à dupla incriminação, reporta-se ao fato de que diversos países somente prestam cooperação jurídica quando verificam que a conduta investigada no Estado requerente também constitui crime no Estado requerido. Todavia, tal realidade vem sendo desprezada em diversos acordos bilaterais ou multilaterais, como é o caso de cooperação jurídica dos Estados do Mercosul[22].

IX.   CONCLUSÃO

A cooperação jurídica internacional, para a produção da prova penal no estrangeiro deverá se pautar em princípios universais de direitos humanos representados em tratados internacionais.

Referidos princípios constituem um "marco de garantias", conferindo um padrão universal para a colheita da prova que respeite a primados como a da presunção de inocência, o direito à prova e a participação de um juiz na colheita da prova, o contraditório e assim o devido processo legal enquanto cadeia de custódia dessa prova a ser produzida.

As perspectivas de um Processo Penal a ser edificado na contemporaneidade, em vista de fenômenos como a globalização e a consequente criminalidade transnacional, apontam para uma releitura constante dos direitos convencionais, direitos humanos das vítimas e dos acusados de crimes, levando sempre as bandeiras da Eficiência e do Garantismo, no desiderato de se alcançar o processo penal justo.

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[10] **Acordos bilaterais de cooperação jurídica internacional em matéria penal** (site do Ministério da Justiça do Governo do Brasil: https://www.gov.br/mj/pt-br/assuntos/sua-protecao/cooperacao-internacional/cooperacao-juridica-internacional-em-materia-penal/acordos-internacionais/acordos-bilaterais-1 (acesso em 06/12/2022)

[11] **Acordos multilaterais de cooperação jurídica internacional em matéria penal** (site do Ministério da Justiça do Governo do Brasil: https://www.gov.br/mj/pt-br/assuntos/sua-protecao/cooperacao-internacional/cooperacao-juridica-internacional-em-materia-penal/acordos-internacionais/acordos-multilaterais-1 (acesso em 06/12/2022).

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[22] Protocolo de Assistência Jurídica Mútua em Assuntos Penais para o Mercosul, promulgado pelo Decreto nº 3468, de 17 de maio de 2000, diz o Art. 1º - 4. "A assistência será prestada mesmo quando as condutas não constituam delitos no Estado requerido, sem prejuízo do previsto nos artigos 22 e 23".

Mechanism and strengthening effects of carbon fiber on mechanical properties of cement mortar

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Abstract— Carbon fibers have many advantages, such as low density, low heat transfer and expansion coefficients, high tensile strength, and good chemical stability and thermal conductivity. Aiming to improve the properties, this study investigates the effects of adding different amounts of carbon fiber to cement mortar. First, a fluidity test was performed to determine the effects of different carbon-fiber contents on the fluidity of cement mortar. Thereafter, the effects of the amount of carbon fiber on the flexural and compressive strengths of cement mortar were investigated under consistent fluidity conditions by adding a polycarboxylate superplasticizer. The interfacial transition zone of the carbon-fiber-modified cement mortar and the microstructure and morphology of the hydration products were observed via-scanning electron microscopy. Furthermore, the influence of carbon fibers on the mechanical properties of cement mortar and the associated mechanism were studied.

I. INTRODUCTION

The inherent brittleness of cement based materials owing to low tensile strength and poor fracture toughness limits their structural design and long-term durability. The incorporation of fiber into cement mortar has received extensive research attention as it can significantly improve the tensile strength and fracture toughness as well as reduce various defects. Carbon fibers have low density, low heat-transfer and expansion coefficients, high tensile strength and corrosion resistance, and good toughness, durability, chemical stability, and thermal conductivity [1]. Therefore, carbon fibers incorporated into cement-based materials can significantly improve the mechanical properties, enhance the deformation ability, and control the propagation of cracks. Extensive studies have been conducted on the properties of cement-based materials doped with carbon-fibers. Khaleel et al [2]. Found that the addition of 1% CFC to cement mortar resulted in a higher compressive strength under fire and high-temperature conditions. Studies have shown that the strategic application of carbon nanofibers considerably densifies the interfacial transition zone (ITZ) and significantly reduces

voids and defects. It has better mechanical properties against deformation and cracking, thereby enhancing the fiber/matrix bonding and improving the load transfer efficiency between the fiber and the matrix. Chen B[3] studied the effects of carbon-fiber volume, size, cement-based matrix, relative humidity, and curing age on the electrical conductivity of carbon-fiber cement-based materials .Nan et al .[4] studied the electrical conductivity and mechanism of cement paste and carbon-fiber cement-based composites with different carbon fiber and aggregate contents and found that the resistivity of carbon-fiber cement-based composites decreased under compression owing to the difference between the matrix and fiber; compared to the individual components, the composite exhibited improved interfacial contact and an increased probability of fiber bridging. Fiber pullout and breakage under tension results in an increase in the resistivity of composites. Furthermore, aggregates hinder fiber dispersion and contact and result in an increase in the resistivity of composites. Zamir M [5] found that a hybrid coating of carbon-fiber fabrics significantly improved the mechanical properties of composites through the pozzolanic reaction at the fabric–substrate interface.Al-

SaadiN.T.et al.[6] used the finite element method to simulate the bonding behavior between NSM CFRP tape and a cement-based adhesive concrete substrate. Toutanji et al.[7] found that adding carbon fibers with volume fractions of 1%, 2%, and 3% to a cement matrix increased the uniaxial tensile strength by 32%, 48%, and 56%, respectively, and the flexural strength by 72%, 95%, and 138%, respectively. Hossain et al. [8] found that a combination of 3 mm (0.12in) and 6 mm (0.36in) fibers enhanced the crack resistance, ultimate stress, and Young's modulus of fiber-reinforced cement composites. XuY. [9] Used silane-treated carbon fibers and silane-treated silica fume to increase the tensile strength by 56% and the Young's modulus and ductility by 39%.

Herein, the effects of carbon fiber on the mechanical properties of cement mortar were investigated by adding different amounts of carbon fiber to cement mortar. Subsequently, the ITZ of the carbon-fiber-modified cement mortar and the microstructure and morphology of the hydration products were observed via-scanning electron microscopy (SEM).

II. MATERIALS

Raw Materials:

Portland PO 42.5 cement produced by Taiyuan Co.Ltd.based on the relevant Chinese standard was used. The details of the carbon fiber are presented in Table1. A photograph of the carbon fibers is shown in Fig.1, and the SEM micrographs of the carbon fibers are shown in Fig.2.The polycarboxylate superplasticizer (solid content of 20%) was customized by the manufacturer. Standard sand, which conformed to the Chinese ISO sand standard GB/T17671, was obtained from Xiamen Aisio Standard Sand Co .Ltd. Tap water was used for the experiments.

Length (mm)	Single wire diameter (μm)	Strength (MPa)	Modulus (GPa)	Elongation (%)	Linear density (g/m)
6	7.76	>3000	>2100	1.9	1.7

III. EXPERIMENT

Cement mortar fluidity test and mix ratio selection

A fluidity test was performed in accordance with GB/T2419-2005 using a jumping table to measure the consistency and work ability of newly formulated mortar. The poly-carboxylate superplasticizer content in the cement mortar was determined by performing a fluidity test.

Fig1. Photograph of carbon fibers
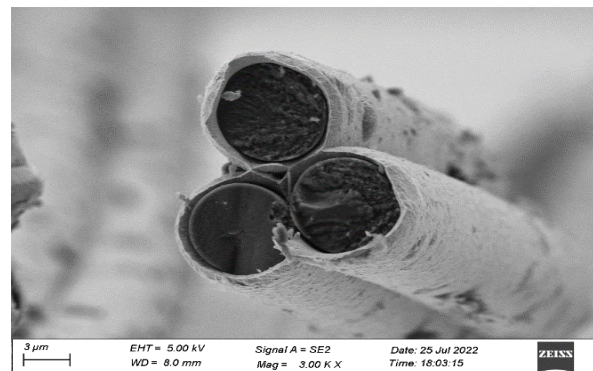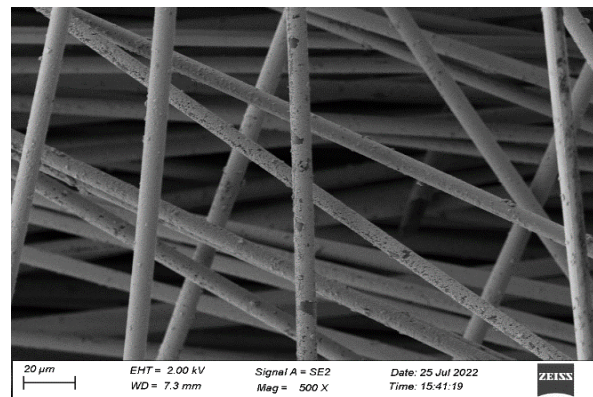
Fig 2.Microstructure of the carbon fibers

Preparation of cement mortar samples

Cement mortar samples with different contents of carbon fibers were prepared. The mixing proportions of the samples are listed in Table 2; the water: cement ratio is 0.4, and the cement: sand ratio is 1:2.The dosage of the water reducer was increased with an increase in the dosage of carbon fibers to a consistent fluidity for each cement mortar sample. Sample M is plain cement mortar. MCFn is cement mortar mixed with a certain amount of carbon fiber, where n denotes that the carbon fibers accounts for one-thousandth the weight of the cement. For example, MCF4 represents a mixed cement mortar with 0.4% carbon fiber with respect to the cement weight.

The cement mortar was prepared as follows:

–The carbon-fiber mixed solution and cement were added to a mixing pot, and the pot was placed on a fixed frame. The mixture was mixed at a low speed for 30s. Standard sand was evenly added via a mixing funnel after 30s, and the mixture was then mixed at a high speed for 30s.

–After the mixer stopped, any material that collected on the side of the bowl was immediately scraped down into the batch. Thereafter, the mixer enclosure was closed, or the bowl was covered with a lid, and the paste was left to stand for 90s.

–The mixture was mixed for 60 s at a high speed.

–The fresh cement mortar was poured into a steel mold and compacted using a standard vibrating table. The molds were then sealed with polyethylene nanosheets to prevent the loss of moisture. After 24h, the samples were demolded and cured in a saturated lime-water bath at 20°C for specific aging durations (3, 7, and 28 d).

Table 2 Mixing proportions of carbon-fiber-modified cement mortar samples

Sample No	Cement(g)	Sand(g)	Water(g)	Carbon Fiber(g)	SP(g)
M	675	1350	270	0	3.6
MCF1	675	1350	270	0.675	3.8
MCF2	675	1350	270	1.35	4.5
MCF3	675	1350	270	2.7	4.7
MCF4	675	1350	270	4.05	5.4

IV.   MECHANICAL TEST

The flexural and compressive strengths of the specimens were determined according to GB/T17671-1999 after 3, 7, and 28 d. For each series, three specimens were tested to determine their strength. The flexural strength test was performed in a three-point bending test apparatus with a loading rate of 0.06N/s. The loading rate for the compression strength test was 2.4KN/s.

SEM characterization of hydration products

SEM (ZEISS Gemini SEM 300) was used to observe the micromorphology of the cement mortar samples at 28d. Samples with flat surfaces and small thicknesses were selected, soaked in absolute ethanol for a week, and then placed in a vacuum desiccators at 40°C. The box was then dried for 72 h .Before performing SEM, the sample surfaces were coated with a thin layer of gold.

V.   RESULT & DISCUSSION

Effects of the carbon fiber on the workability of cement paste.

Fig.3 shows the fluidity of the carbon fibers. Compared with cement mortar M, when the carbon-fiber content is 0.2%, the fluidity of cement mortar decreases by 10.9%.When the carbon-fiber content is 0.6%, the fluidity of the cement mortar decreases by 18.48%. The fluidity of cement mortar decreases with an increase in the carbon fiber content [10], possibly owing to the distribution and orientation of the fibers. Therefore, the addition of a water-reducing agent to the samples ensures consistency in their fluidity values and enables the comparison of their strengths.
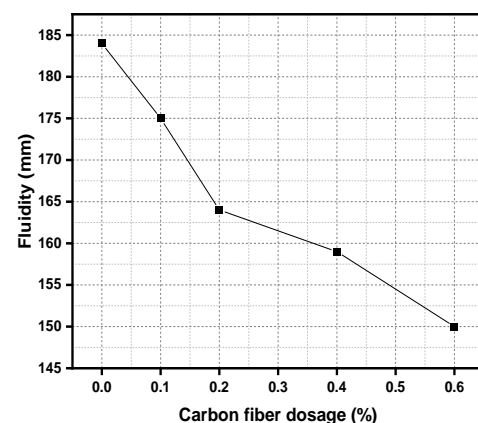
Fig.3 Fluidity of the cement mortar samples Mechanical strength of carbon-fiber-modified cement mortar

Fig.4 (a) shows the flexural strength of the cement mortar mixed with different amounts of carbon fiber at 3, 7, and 28d. The flexural strength of cement mortar gradually increases with an increase in the carbon-fiber content. However, after an optimal carbon-fiber content, the flexural strength starts decreasing. When the carbon-fiber content is 0.4%, the flexural strength of the cement mortar mixed with carbon fiber is at the highest. At curing ages of 3, 7, and 28 d, the flexural strength of Sample MCF4 increases by 16.82%,13.49%, and 7.78%, respectively, compared with that of plain cement mortar Sample M because the high strength of carbon fiber improves the mechanical properties of the cement mortar. When carbon-fiber composites are subjected to an external pressure, cracks are developed. Owing to their high tensile strength, the carbon fibers at both ends of a crack do not break immediately, and the reinforcement mechanism is mainly the crack-resistance mechanism of the fiber. The carbon fiber resists crack formation and improves the mechanical

properties of the carbon-fiber cement-based composite. Under tensile stress, the fibers transfer stress to their ends, thereby reducing the stress concentration in the crack zone and allowing the sample to with stand the applied load [8]. When the amount of carbon fiber is very high, the dispersion of the carbon fiber is very uneven, resulting in a decrease in the strength of the material. The flexural strength of the cement mortar mixed with the carbon fiber continues to increase with an increase in the curing age because of the gradual increase in the degree of hydration of the cement mortar over time.
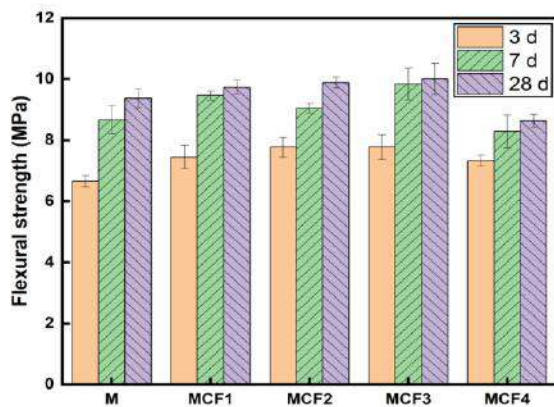
A
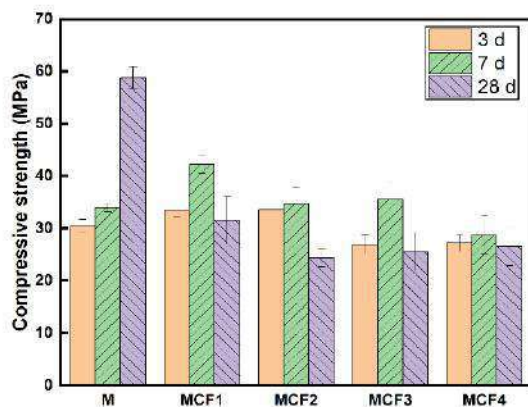
B

Fig.4.Strength of 6 mm carbon-fiber-modified cement mortar at 3, 7, and 28 d: (a) flexural strength and (b) compressive strength

Fig. 4(b) shows the compressive strength of the cement mortar mixed with different amounts of carbon fiber at 3, 7, and 28 d. When the curing ages are 3 and 7 d and the carbon-fiber content is 0.1% (SampleMCF1), the compressive strengths of the cement mortar are 10.02% and 24.42% higher than that of the plain cement mortar,

respectively. However, when the carbon-fiber content continues to increase, the compressive strength of the cement mortar does not increase and is lower than that of the plain cement mortar. The reason for this phenomenon is the uneven distribution of the carbon fibers and the increased porosity. At a curing age of 28 d, the compressive strength of all the mixed cement mortar samples doped with carbon fiber is lower than that of the plain cement mortar. This maybe owing to the uneven dispersion of carbon fibers that trap the flow of free water in the cement slurry, thereby reducing the degree of hydration.

SEM results

SEM analysis was performed to investigate the fiber distribution, adhesion, and failure mechanisms.

Fig. 5(A–C) show the SEM images of the plain cement mortar, revealing microstructures of the ITZ. Cracks and pores are observed in the ITZ, and a direct combination of aggregates and hydration products is not visible [11].Fig. 6(D-E) show the SEM images of cement mortar samples with 0.4% 6 mm carbon fibers. The carbon fibers are distributed in the cement matrix in the confusion. More carbon fibers are present in the 0.6% fiber sample. Therefore, an increase in the carbon-fiber content enhances the conduction of the cement mortar. However, when the carbon-fiber content reaches a certain level, the mechanical properties of the cement mortar deteriorates. The carbon-fiber content has significant effects on the mechanical properties of cement mortar [12] because the mechanical properties are sensitive to the aggregation of carbon fibers. Fig.6 (F) shows that the carbon fiber acts as a bridge and connects the cracks, indicating that the carbon fibers bond well with the cement mortar.

VI. CONCLUSION

This study showed the effects of carbon fibers on the fluidity and mechanical properties of cement mortar. Carbon fibers with lengths of 6 mm were added to cement mortar at different concentrations to prepare high-performance multifunctional cement-based composite materials. The mechanical properties of the carbon-fiber-modified cement mortar were investigated and compared with those of ordinary cement mortar. The following conclusions were drawn based on the results of this study.

The fluidity of cement mortar gradually decreases with an increase in the carbon-fiber content, which may be related to the dispersion and orientation of the carbon fibers in the cement matrix.
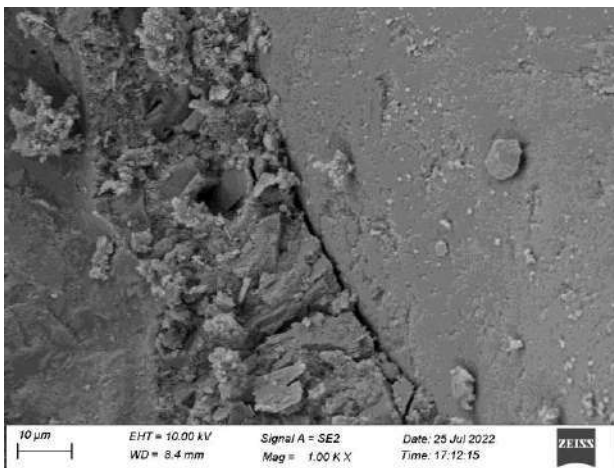
A
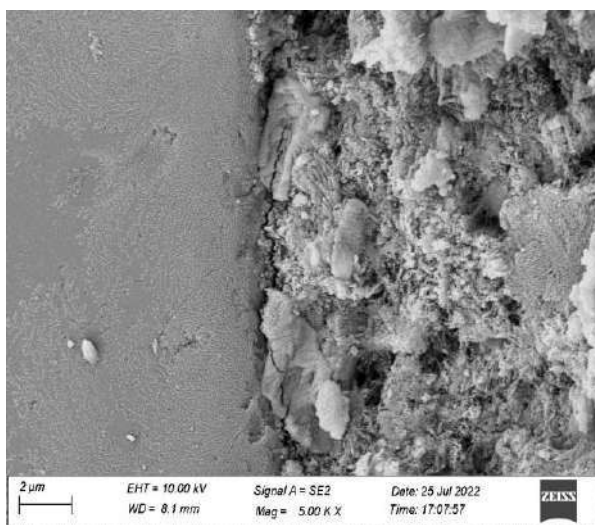
B
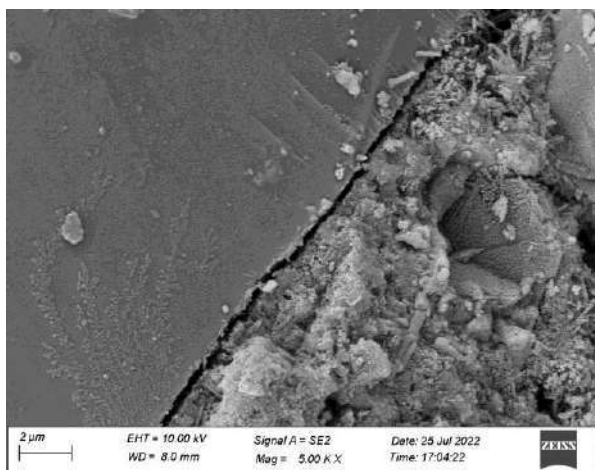
C

Fig 5. (A, B &C) SME images of the plain cement mortar sample
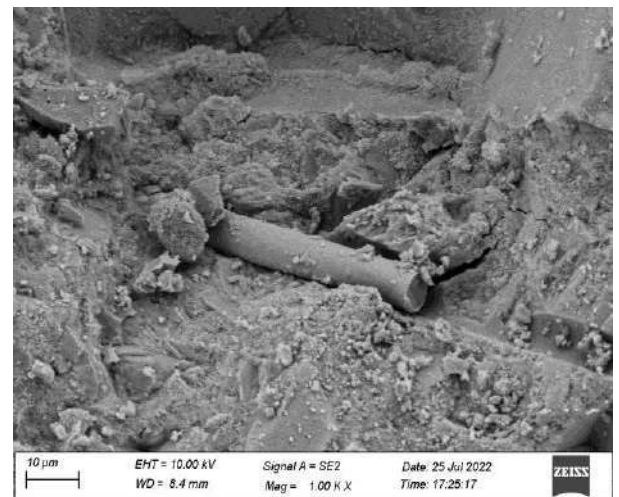
D
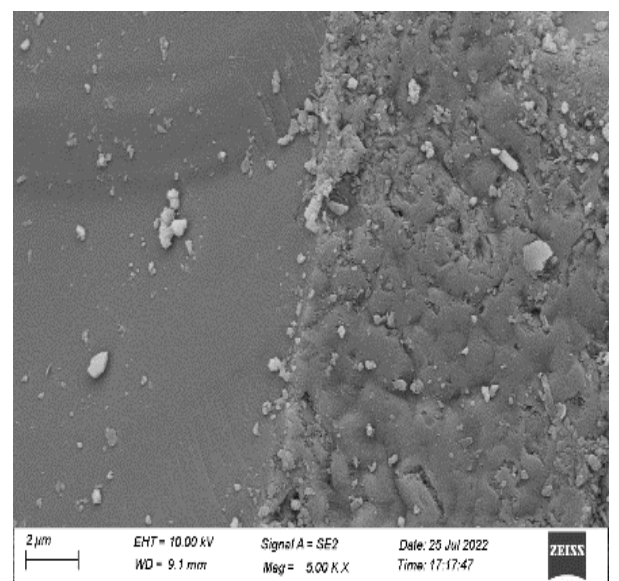
E
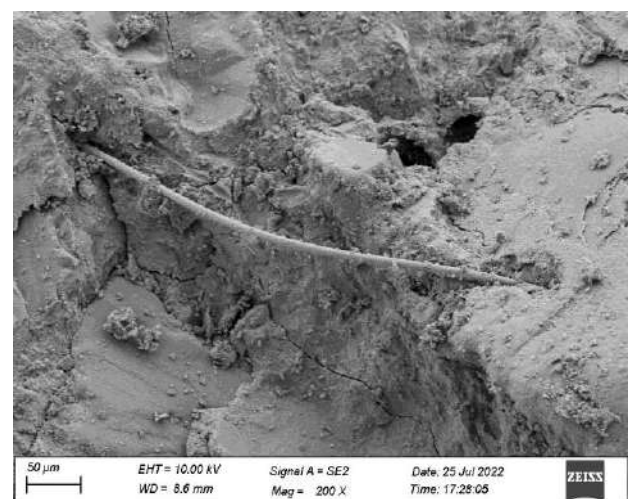
F

Fig 6. (D, E&F) SME images of the cement mortar sample containing 0.4% carbon fiber

The addition of 0.4% carbon fiber improves the strength of cement mortar. The dispersion of carbon fibers in cement mortar is sufficient to produce a high-performance carbon-fiber-modified cement mortar.

Carbon fibers are not uniformly distributed in cement mortar, and they aggregate and generate pores. Simultaneously, they may trap the free water in the cement paste, resulting in a decrease in the degree of hydration. Consequently, the reinforcing effect of carbon fibers on the cement mortar is reduced.

Carbon fibers absorb energy and overcome fiber pullout as well as inhibit the growth of micro- cracks, thereby improving the mechanical properties, particularly the flexural strength of cement mortar.

ACKNOWLEDGEMENTS

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Utility of Laplace Transform in Mathematics

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Abstract—The paper seeks to analyze the use of Laplace transform in mathematics. However it contributes in mathematics as well as in arena of physics and engineering also. Laplace transform is an important skill to solve linear ordinary and partial differential equations with constant coefficients under suitable initial and boundary conditions. It is a good technique to simplify complex differential equations to a simpler form having polynomials in the area of stability and control. The current far-reaching use of the transform (mainly in engineering) happened during and soon after 2nd World War ,With the ease of application of Laplace transforms in myriad of scientific applications, many research softwares have made it possible to activate the Laplace transformable equations directly supporting the researchers. The transformation is usually used in stochastic performance modelling and analysis of computer and communication systems. It gets significant applications in various areas of physics, electrical engineering, control engineering, optics, mathematics and signal processing.

I. INTRODUCTION

In the subject of Mathematics ,a transformation is a way that changes one function into another function. For example, an operation of differentiation on differentiable function is a transformation as it changes a function into another function known as f'(x).The topic of linear transformation reduces a given initial value problem to an algebraic operation and the solution of initial value problem is obtained directly without finding the general solution. Laplace Transformation is a way to solve differential equations. So the knowledge of the subject area is also necessary for science and engineering background scholars for their work. The important field of Mathematical Analysis is Laplace transformation is referred as integral transforms inserting applications in varigated fields like **engineering technology, basic sciences, mathematics and in economics**. It is also used to find the solution of differential equations at boundary value. A great French Mathematician named as **Pierre Simon Marquis De Laplace(1749-1827)** made valuable contributions to potential theory ,astronomy, special functions and probability theory .It would be interesting to

know that a British engineer **Oliver Heaviside (1850-1925)** developed the significant Laplace Transforms techniques after many years of death of Laplace and due to that these transforms are called as Heaviside calculus. Many scholars have highlighted the role of Laplace transform in Mathematics as well as other branches of Physics and engineering such as D. Poularikas explained the transforms and applications [2000] in his work, Kapur, J.N.[2005] mentioned Mathematical Modelling in his work, Karan Asher[2013] described an Introduction to Laplace Transform, Lokanath Sahoo [2020] discussed application of laplace transform for solving problems on newton's law of cooling and so on. I also tried to study the role of this transformation in mathematics after study of literature related to this transform. Laplace Transformations are most commonly used in stochastic performance modelling and analysis of computer and communication systems. Laplace transform is applicable in probability theory like first passage times of stochastic processes, Markov chains and renewal theory. In Physics and engineering, it is used for analysis of linear time-invariant systems such as electric circuits, harmonic oscillations, optical devices etc.

Definition :- Laplace Transformation of a function :
Let f(t) be a function defined for all $t \geq 0$,Then the Laplace Transformation of a function f(t) ,represented by L(f(t)) is defined as

$$L(f(t)) = \int_{0}^{\infty} f(t)\, e^{-st}\, dt \text{ provided the integral exists}$$

The parameter s is a real or complex number, frequently it is assumed as a positive real number.

It is seen that L(f(t)) is a function of s and represented by F(s) i.e. L(f(t)) = F(s)

We can say as f(t) = L^{-1} (F(s)) and f(t) is named as **inverse Laplace Transform of F(s)**.

Note: The symbol 'L' is called the Laplace Transform operator and when applied on f(t), it converts into F(s).The Laplace transform of f(t) exists if the above integral converges for some value of t, otherwise it does not exists.

Theorem: Sufficient condition for existence theorem on Laplace transform: If f(t) is a piecewise continuous function in every finite interval in its domain t ≥ 0 and is of exponential order 'a' , then the Laplace transform of f(t) exists for all s > a .

Let us have a problem of integral equation (by using laplace transform) $f(t) = t + 2\int_{0}^{t} \cos(t-u) f(u) du$

Solution: The given integral equation is

$$f(t) = t + 2\int_{0}^{t} \cos(t-u) f(u) du$$

Write it as $f(t) = t + 2\cos t * f(t)$

Taking laplace transform on both sides, we get

$$F(s) = \frac{1}{s^2} + 2.\frac{s}{1+s^2}.F(s)$$

Or $F(s)(1 - \frac{2s}{1+s^2}) = \frac{1}{s^2}$

Or $F(s) = \frac{1+s^2}{s^2(s-1)^2}$

Taking inverse laplace transform on both sides,we get

$$L^{-1}(F(s)) = L^{-1}(\frac{1+s^2}{s^2(s-1)^2}) \quad or \quad f(t) = L^{-1}(\frac{1+s^2}{s^2(s-1)^2})$$

Or $f(t) = L^{-1}(\frac{1}{s^2(s-1)^2}) + L^{-1}(\frac{1}{(s-1)^2})$

Remark: Above condition is only sufficient for existence theorem on Laplace transform. Converse is not true. There may be a function having Laplace transform but may not satisfy the existence condition.

Integral Equation: An equation of the form

$$f(t) = h(t) + \int_{a}^{b} f(u).g(u,t)du \text{ is called an integral}$$

equation   ----------------------(1)

In this equation h(t) and g(u, t) are known, limits a and b are either constants or functions of t. We have to determine the function f(t) under the integral sign.

The equation $f(t) = h(t) + \int_{a}^{b} f(u).g(t-u)du$ is also of type (1), therefore it is an integral equation. This equation is called integral equation of convolution type.

The equation $\int_{0}^{t} \frac{f(u)}{(t-a)^n} du = g(t)$ where g(t) is also an integral equation called Abel's integral equation.

$$= \int_{0}^{t}\int_{0}^{t} t\, e^t\, dtdt + t\, e^t$$

Or

$$f(t) = t\, e^t - 2e^t + t + 2 + t\, e^t = 2t\, e^t - 2e^t + t + 2$$

We proceed further by taking more examples of different types

A. Solution of Linear differential Equations with constant co-efficients by Laplace Transform of derivatives.

Step1. Take Laplace transform of both sides using the method of derivatives,using initial conditions.

Step2. Step1 gives an algebraic equation called subsidiary equation.

Step3. Divide by co-efficient of $\bar{y}$ that is used in place of F(s).

Step4. Have the inverse laplace transform of both sides.

If f(t) is a function and and its derivatives are represented by f'(t) , f''(t) , -------- etc

We are familiar that   **L(f'(t)) = s F(s) – f(0)**

L(f''(t) = s² F(s) –s f(0) –f'(0)

- -- ----- ----

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L(fⁿ(t)) = sⁿ F(s) –sⁿ⁻¹ f(0) –sⁿ⁻² f'(0)---------- +fⁿ⁻¹(0)

Where L(f(t)) = F(s)

We have another exampleby laplace transform methodin Solution of the following differential equation

$$\frac{d^2 y}{dt^2} + y = 6\cos 2t \quad , \quad y'(0) = 1, \ y(0) = 3$$

Solution : The given equation is $\frac{d^2 y}{dt^2} + y = 6\cos 2t$

Having laplace transform on both sides, we obtain

$$(s^2 \bar{y} - s\, y(0) - y'(0)) + \bar{y} = 6\frac{s}{(s^2 + 4)}$$

Or

$$(s^2 \bar{y} - 3s - 1) + \bar{y} = 6\frac{s}{s^2 + 4} \qquad as\ y(0) = 3,\ y'(0) = 1$$

Or $(s^2 + 1)\bar{y} = 1 + 3s + 6\frac{s}{s^2 + 4}$

Or $\bar{y} = \frac{1}{s^2 + 1} + 3\frac{s}{s^2 + 1} + 6\frac{s}{(s^2 + 4)(s^2 + 1)}$

Having **inverse**laplace transform on both sides, we obtain

$$y = L^{-1}\frac{1}{s^2 + 1} + 3L^{-1}(\frac{s}{s^2 + 1}) + 6L^{-1}(\frac{s}{(s^2 + 4)(s^2 + 1)})$$

$$= \sin t + 3\cos t + 6\int_0^t \frac{1}{2}\sin 2u \cos(t - u)du$$

(convolution theorem)

$$= \sin t + 3\cos t + \frac{3}{2}\int_0^t [\sin(2u + t - u) + \sin(2u - t + u)]du$$

$$= \sin t + 3\cos t + \frac{3}{2}\int_0^t [\sin(u + t) + \sin(3u - t)]du$$

$$= \sin t + 3\cos t + \frac{3}{2}[-\frac{\cos(u + t)}{1} - \frac{\cos(3u - t)}{3}]_0^t$$

$$= \sin t + 3\cos t + \frac{3}{2}[-\frac{\cos(2t)}{1} - \frac{\cos(2t)}{3} + \cos t + \frac{\cos t}{3}]$$

$$= \sin t + 3\cos t - 2\cos 2t + 2\cos t$$

$$= \sin t + 5\cos t - 2\cos 2t$$

Similarily we can produce examples of

B. Solution of ordinary differential equation with variable co-efficient by transform method .

Here we use $L(y(t)) = \bar{y}(s)$,then

$$L(t^n\, y(t)) = (-1)^n \frac{d^n}{ds^n}[\bar{y}(s)]$$

i.e. $L(t^n\, y(t)) = (-1)^n \frac{d^n}{ds^n}[L(y(t)]$

Application of L.T can be seen in solution of the

differential equation $t\frac{d^2 y}{dt^2} + (t-1)\frac{dy}{dt} - y = 0$,

$$y(0) = 5,\ y(\infty) = 0$$

Solution: The given differential equation is

$$t\frac{d^2 y}{dt^2} + (t-1)\frac{dy}{dt} - y = 0 \ ---------(1)$$

Having Laplace transform both sides of equation (1)

$$L(t\frac{d^2 y}{dt^2}) + L(t\frac{dy}{dt}) - L(\frac{dy}{dt}) - L(y) = 0$$

Or $(-1)^n \frac{d}{ds}(L(\frac{d^2 y}{dt^2})) - \frac{d}{ds}(L(\frac{dy}{dt})) - L(\frac{dy}{dt}) - \bar{y}$
$= 0$

Or $-\frac{d}{ds}[s^2\bar{y} - sy(0) - y'(0)] - \frac{d}{ds}(s\bar{y} - y(0))$
$-(s\bar{y} - y(0)) - \bar{y} = 0$

Or

$$-\frac{d}{ds}[s^2\bar{y} - 5s - 0] - \frac{d}{ds}(s\bar{y} - 5) - (s\bar{y} - 5) - \bar{y} = 0$$

Or

$$-[s^2 \frac{d\bar{y}}{ds} + 2s\bar{y} - 5] - s\frac{d\bar{y}}{ds} - \bar{y} + 0 - (s\bar{y} - 5) - \bar{y} = 0$$

Or

$$s^2 \frac{d\bar{y}}{ds} + 2s\bar{y} - 5 + s\frac{d\bar{y}}{ds} + \bar{y} + 0 + s\bar{y} - 5 + \bar{y} = 0$$

Or $(s^2 + s)\frac{d\bar{y}}{ds} + (3s + 2)\bar{y} - 10 = 0$

Or $\dfrac{d\bar{y}}{ds} + \dfrac{3s+2}{s(s+1)}\bar{y} = \dfrac{10}{s(s+1)}$ which is a linear

differential equation.

We know that $\dfrac{dy}{dx} + Py = Q$ **where P , Q are functions**

of x only,

The solution is

$y.\ I.F = \int Q(I.F.)\ dx\ where\ \ I.F. = e^{\int Pdx}$

Here I.F.=

$e^{\int \frac{3s+2}{s(s+2)}ds} = e^{\int(\frac{2}{s}+\frac{1}{s+1})ds} = e^{2\log s + \log(s+1)} = s^2(s+1)$

Then the solution is

$\bar{y}(s^2(s+1)) = \int \dfrac{10}{s(s+1)}.s^2(s+1)\ ds + c$

Or

$\bar{y}(s^2(s+1)) = \int 10s\ ds + c = 5s^2 + c\ \ -----(2)$

Taking limits as s →0 on both sides,   we obtain c = 0

From(2) , $\bar{y} = \dfrac{5s^2}{s^2(s+1)} = \dfrac{5}{s+1}$

Taking inverse laplace transform both sides, we obtain

$y = 5\,e^{-t}$

Obviously where t→ ∞ ,y→ 0

Hence the required solution is $y = 5\,e^{-t}$

C. Solution of Simultaneous Linear Equations with constant co-efficient by transform method

We can solve the following simultaneous equations using Laplace transform method

$\dfrac{dx}{dt} - y = e^t ,\ \dfrac{dy}{dt} + x = \sin t,\ \ x(0) = 1, y(0) = 0$

Solution: The equations are given as

$\dfrac{dx}{dt} - y = e^t ,\ \dfrac{dy}{dt} + x = \sin t$

Having laplace transform on both sides,we obtain

$L(\dfrac{dx}{dt}) - L(y) = \dfrac{1}{s-1}$

i.e. $s\bar{x} - x(0) - \bar{y} = \dfrac{1}{s-1}$

and $L(\dfrac{dy}{dt}) - L(x) = \dfrac{1}{s^2+1}$

i.e. $s\bar{y} - y(0) + \bar{x} = \dfrac{1}{s^2+1}$

But is given that   x(0)=1 , y(0)= 0

i.e. $s\bar{x} - 1 - \bar{y} = \dfrac{1}{s-1}$

$\Rightarrow\ s\bar{x} - \bar{y} = \dfrac{1}{s-1} + 1 = \dfrac{s}{s-1}\ ------(1)$

and $s\bar{y} - 0 + \bar{x} = \dfrac{1}{s^2+1}$

$\Rightarrow\ s\bar{y} + \bar{x} = \dfrac{1}{s^2+1}\ -------(2)$

Multiplying (1) by s ,

$\Rightarrow\ s^2\bar{x} - s\bar{y} = \dfrac{s1}{s-1} + s\ \ ---------(3)$

Adding (2) and (3),we have

$\Rightarrow\ s^2\bar{x} + \bar{x} = \dfrac{1}{s^2+1} + \dfrac{s}{s-1} + s$

$\Rightarrow\ \bar{x} = \dfrac{1}{(s^2+1)^2} + \dfrac{s}{(s-1)(s^2+1)} + \dfrac{s}{(s^2+1)}$

Taking inverse Laplace transform, we obtain

$x = \dfrac{1}{2}(\sin t - t\cos t) + L^{-1}(\dfrac{s}{(s-1)(s^2+1)}) + \cos t$

$\Rightarrow x = \dfrac{1}{2}(\sin t - t\cos t) + \dfrac{1}{2}L^{-1}[\dfrac{1}{(s-1)} - \dfrac{s-1}{(s^2+1)}] + \cos t$

$\Rightarrow x = \dfrac{1}{2}(\sin t - t\cos t) + \dfrac{1}{2}[L^{-1}(\dfrac{1}{s-1}) - L^{-1}(\dfrac{s}{s^2+1})$

$+ L^{-1}(\dfrac{1}{s^2+1})] + \cos t$

$\Rightarrow x = \dfrac{1}{2}(\sin t - t\cos t) + \dfrac{1}{2}[e^t - \cos t + \sin t] + \cos t$

$$\Rightarrow x = \frac{1}{2}[(\sin t - t\cos t) + e^t - \cos t + \sin t + 2\cos t]$$

$$\Rightarrow x = \frac{1}{2}[(\sin t - t\cos t) + e^t + \cos t + \sin t]$$

$$\Rightarrow x = \frac{1}{2}[2\sin t - t\cos t + \cos t + e^t] \quad -----(4)$$

$$\Rightarrow \frac{dx}{dt} = \frac{1}{2}[(2\cos t - \cos t + t\sin t - \sin t + e^t]$$

$$As \quad \frac{dx}{dt} - y = e^t$$

$$\Rightarrow y = \frac{1}{2}[\cos t + t\sin t - \sin t + e^t] - e^t$$

$$\Rightarrow y = \frac{1}{2}[\cos t + t\sin t - \sin t - e^t] --- (5)$$

Hence we get the Solution from equations (4) and (5)

Laplace transform method is used to solve the following simultaneous equations

$$\frac{dx}{dt} = 5x + y \ , \ \frac{dy}{dt} = x + 5y \ \text{ when x(0)= -3 },$$

y(0) = 7

Solution: The given parametric equations are

$$\frac{dx}{dt} = 5x + y \ , \ \frac{dy}{dt} = x + 5y$$

Taking laplace transform of both equations, we obtain

$$s\overline{x} - x(0) = 5\overline{x} + \overline{y}$$

$$s\overline{y} - y(0) = \overline{x} + 5\overline{y}$$

But given that x(0) = -3and y(0) =7

Hence $s\overline{x} + 3 = 5\overline{x} + \overline{y}$

Laplace Transform in Probability Theory

The Laplace transform is defined as an expected value in pure and applied probability theory. Let X is the random variable with probability density function f (say), then the Laplace transform of f is given as the expectation of:

L{f}(s) = E[e^-sX], which is referred to as the Laplace transform of random variable X itself.

Significance of Laplace Transforms:

Usually we listen that Mathematics is the foundation of all sciences. The concept of Laplace Transform is equally

And $s\overline{y} - 7 = \overline{x} + 5\overline{y}$

i.e. $(s-5)\overline{x} - \overline{y} + 3 = 0$

and $\overline{x} + (5-s)\overline{y} + 7 = 0$

On solving,we obtain

$$\frac{\overline{x}}{-7 - 3(5-s)} = \frac{\overline{y}}{3 - 7(s-5)} = \frac{1}{-(s-5)^2 + 1}$$

Therefore

$$\overline{x} = \frac{3s - 22}{-(s-5)^2 + 1} = \frac{3s - 22}{-s^2 + 10s - 24} = -\frac{3s - 22}{s^2 - 10s + 24}$$

$$= -\frac{(3s - 22)}{(s-4)(s-6)}$$

$$\overline{x} = -[\frac{5}{s-4} - \frac{2}{s-6}] = -\frac{5}{s-4} + \frac{2}{s-6}$$

Taking inverse laplace transform ,we get

$$x = -5e^{4t} + 2e^{6t}$$

Similarly

$$\overline{y} = \frac{-7s + 38}{-(s-5)^2 + 1} = -\frac{-7s + 38)}{s^2 - 10s - 24} = -\frac{(-7s + 38)}{(s-6)(s-4)}$$

or $\quad \overline{y} = -[-\frac{5}{s-4} - \frac{2}{s-6}]$

or $\quad \overline{y} = \frac{5}{s-4} + \frac{2}{s-6}$

after having inverse laplace transform both sides , we get

$$y = 5e^{4t} + 2e^{5t}$$

Hence the solution is $\quad x = -5e^{4t} + 2e^{6t}$,

$$y = 5e^{4t} + 2e^{5t}$$

important in other fields of study besides mathematics. It's application is much appropriate in arena of science and engineering.

- Engineers make use of above mentioned Transform to solve swiftly differential equations occurring in the analysis of electronic circuits.
- It is applied to simplify calculations in system modeling, where large number of differential equations are used.

- By making use of Laplace Transform, one finds help in solving digital signal processing problems.
- Laplace Transform is used to get the true form of radioactive decay. It makes comfortable to study analytic part of Nuclear physics possible.
- This Transform is much used for process controls. It is supportive to analyze the variables which when changed, produce desired manipulations in the result.

II.   METHODOLOGY

I studied many papers and books thoroughly and then reviewed application of laplace transform in the subject of mathematics as well as in other branches of science and engineering.

III.   CONCLUSION

In the present paper we have seen how Laplace transform is supportive to solve different problems in the subject of mathematics. The aforementioned topic is favorable in multifarious arena of Probability theory, Physics, Electrical engineering, Control engineering, Economics, Mathematics, Signal processing and Electronics engineering. The scholars can get benefitted by knowledge of above mentioned topic and can do their work in a better way.

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A Review of Laminated Object Manufacturing (LOM) Aspects and Various Processes used in It

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Abstract— The purpose of this review is to present a break-through technology named Laminated Object Manufacturing (LOM), which can produce a real three-dimensional object directly from a CAD model in a matter of hours. The present paper discusses the rationale for this technology describes the LOM process and presents an overview of LOM machines currently available on the market. Software interfaces and the use of various materials are discussed as well. The laminated object manufacturing LOM process is an effective rapid prototyping technology with a variety of application possibilities. Applying LOM in rapid tooling and patternmaking is especially advantageous because of the LOM objects, robustness, their wood-like properties, and their comparably low material costs. This review paper presents an extension of the sheet lamination object manufacturing process by using a robotic cell to perform the sheet manipulation and handling as well as proposes a frozen slurry-based laminated object manufacturing (FS-LOM) for processing porous ceramics.

I. INTRODUCTION

It is a 3D-printing technology developed by Helisys Inc. (now Cubic Technologies). In it, layers of adhesive-coated paper, plastic, or metal laminates are successively joined together and cut to an appropriate shape with a laser cutter. Objects printed with this technique may be additionally modified by machining after the printing process. [1,2,] The typical layer resolution for this process is defined by material feedstock and usually ranges in thickness from many sheets of paper to a copy. Laminated object manufacturing (LOM) is one of the most popular rapid prototyping (RP) techniques in terms of speed and cost-effectiveness.

II. RATIONALE

In a concurrent engineering environment, a multi-disciplinary team whose members cover all aspects of product development including design, manufacturing, quality control, finance, marketing, etc. is formed at an early phase to bring a product to market better, faster, and cheaper than the competition.

Efficient communication and computer integrated tools are two key factors required to fulfill this task, and, although a computer-generated 3-D image may well serve the purpose, a real physical replica of the part is often more persuasive and useful. [3]

LOM technology has been developed to manufacture a real part from its CAD model rapidly and inexpensively. [4,14,26] Through LOM's software, the CAD model is sliced horizontally into a stack of thin layers, each layer representing an average cross-section at a given height [1]. A laser beam then cuts the periphery of each cross-section from a continuous sheet of material, one layer at a time from the bottom up. Every cut is automatically and precisely attached to its predecessor. Eventually, a three-dimensional object is built in this layer-to-layer fashion.

LOM technology belongs to a new field variously called Rapid Prototyping, Desktop Manufacturing, Freeform Fabrication, etc. Other technologies belonging to this

category include a similar layer-to-layer idea, yet utilize different approaches. 3D System's Stereo Lithography has pioneered this industry, using a laser that solidifies liquid photopolymer to form successive layers. The unpredictable shrinkage due to solidification, the extra effort needed to create support structures for overhanging portions, costly and limited material availability, and long production times are some of its drawbacks. Many companies have developed similar systems. Another approach using liquid polymer has been incorporated into Cubita's solider system. Here a flood lamp and photomasks are used to expose a layer of liquid photopolymer in a flash. The non-activated polymer is then replaced by wax, and a milling head cuts the surface down to a precise thickness. This procedure is repeated until a part is completed [5,9]. The complexity of this system is its main drawback. Selective Laser Sintering (SLS) utilizes powder materials as media, which melt and resolidify when sintered by a laser. Here the main problems are shrinkage and warpage due to internal stress. In Stratasys's Fused Deposition Modeling system, a thin thermoplastic wire is fed through an extruding head, and droplets of molten material are then deposited into layers to form a part. Supporting structures are required in this process. [6] Perception Systems Inc's Ballistic Particle Manufacturing employs a similar idea. Another technique discovered by MIT uses an ink-jet printer head to spread the adhesive onto a layer of powdered material; the powder soaks the adhesive thus forming a layer. This technique is still in the research stage.

III. BASIC CONCEPT OF THE LOM PROCESS

In the Laminated Object Manufacturing (LOM) process, three-dimensional objects are manufactured by sequentially laminating and cutting two-dimensional cross-sections. The medium used in LOM processes consists of adhesive-coated sheet materials. Fig. 1 shows a typical type of the LOM process. The LOM process is performed by layered manufacturing as in other AM. The main components of the LOM machine are a feed mechanism that advances a sheet over a build platform, a heated roller to apply pressure to bond the sheet to the layer below, and a laser to cut the outline of the part in each sheet layer. Parts are produced by stacking, bonding, and cutting layers of adhesive-coated sheet material on top of the previous one. A laser cuts the contour of the part into each layer according to prepared CAD data [7,8]. After each cut is completed, the platform is lowered by a depth equal to the sheet thickness, and another sheet is loaded on top of the previously deposited layers.

The platform then rises slightly, and the heated roller applies pressure to bond the new layer. The laser cuts the outline, and the process is repeated until the last layer.

As shown in Figure 2, the sheet material holds the adhesive either on one or on both sides and contains the adhesive within itself like woven composite material impregnated with a bonding agent. The adhesive, which can be pre-coated onto the material or deposited before bonding, enables layers of sheet material to adhere to each other to so constructing a three-dimensional object. Fig. 2 shows a surface profile of the part fabricated by LOM technology. Stairsteps are clearly shown on the surface of the part due to stacking the sheet layers. This phenomenon is known as the "stair-stepping effect" and is found generally in AM. The surface profile is changed by the variation of surface angle on inclined surfaces. That is to say, the profile is even closer to the vertical surface and, is rougher closer to the horizontal plane. The curved shape machined by laser cutting is shown in the outline of each layer. It is estimated that the curve form is influenced by the

Gaussian laser beam deduced an equation by assuming that the absorption of laser radiation within the resin follows the Beer-Lambert law and took the shape of the cured resin into account in the working curve in SL, as given in Eq. (1). Each variable x and y denotes the length from the center of the Gaussian laser beam in the radial direction and a normal distance from the resin surface to the cured depth. The coefficients a, b and c are constants determined by the characteristics of the laser beam and material resin.

$$ax^2 + by + c = 0 \qquad\qquad (1)$$

Using Eq. (1), showed that the edge profile of the layer machined by laser can be a parabolic curve in LOM . The magnified surface profile also supports the approach, as shown in Fig. 2. Thus, the edge profile is subordinated by Eq. (1). After a layer is deposited, the peripheral shape of this layer's cross-section is cut by a laser beam from the information provided by the CAD model. This bonding-before cutting procedure is repeated until the full height of the part is reached (Figure 2).
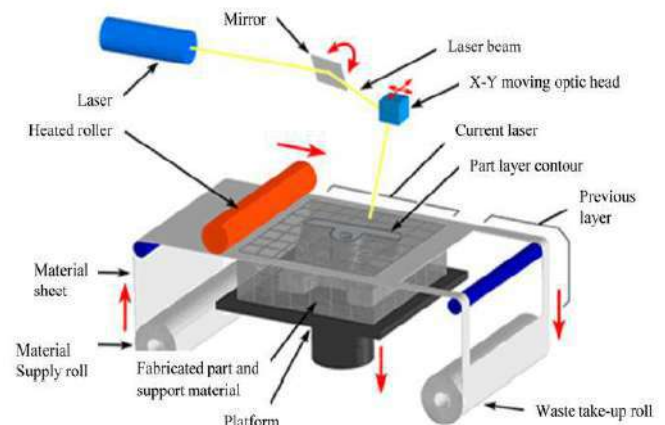
Fig. 1. A typical type of LOM process.
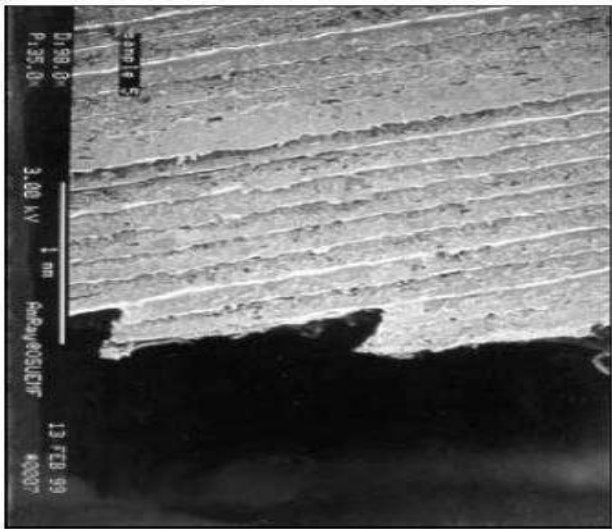
Fig. 2. The magnified surface profile of the LOM manufactured part (Paul and Voorakarnam, 2001).

IV.   PROCESSES

Many different 3D printing processes and technologies have been invented since the late 1970. The printers were originally very large and expensive in what they could produce. [9] A large number of Additive manufacturing processes are now available.

4.1. Robotic cell for performing sheet lamination-based additive manufacturing

Advances in material science and manufacturing technologies are leading to significant improvements in the way we design and manufacture products. Many applications require structures composed of layers of heterogeneous materials and prefabricated components embedded between the layers. The existing additive manufacturing process based on layered object manufacturing is not able to handle multiple layer materials and cannot embed prefabricated components. Moreover, the existing process imposes restrictions on the material options. This significantly limits the type of heterogeneous structures that can be manufactured using traditional additive manufacturing. The latest research presents an extension of the sheet lamination object manufacturing process by using a robotic cell to perform sheet manipulation and handling. It makes the following three advances: (1) enabling the use of multi-material layers and inclusion of prefabricated components between the layers, (2) developing an algorithmic foundation to facilitate the automated generation of robot instructions, and (3) identifying the relevant process constraints related to speed, accuracy, and strength. We demonstrate the system's capabilities by using three case studies. Fabrication of complex geometric structures is made possible due to advances in additive manufacturing. Additive manufacturing has become capable of building complex parts with heterogeneous materials.

Heterogeneous structures are composed of many different materials to obtain the desired functional properties [10,11]. They are beneficial in several applications, for example, to provide thermal insulation as well as supporting mechanical loading in aerospace structures. Such structures can be manufactured using additive manufacturing. In additive manufacturing (AM), parts are created by depositing material layer-by-layer using computer control. VAT photopolymerization, powder bed fusion, binder jetting, material jetting, sheet lamination, material extrusion, and direct energy deposition are the seven types of AM classified by the American Society for Testing and Materials (ASTM). The sheet lamination process can be classified into the following two categories: (1) laminated object manufacturing and (2) ultrasonic consolidation. Laminated object manufacturing (LOM) is one of the oldest additive manufacturing processes. Objects are made from prefabricated layers. [12,31] Therefore this method is fast compared to pixel-based AM methods. However, the traditional LOM method is not able to work on multi-material structures. This limits the kind of structures that can be produced using LOM.

Realizing a sheet lamination based additive manufacturing cell-based on robots offers the following benefits:

• It allows the use of different materials for different layers.

• It enables the addition of prefabricated components between laminated sheets.

The use of robots adds new functional capabilities to the LOM process (required to manufacture heterogeneous structures). At the same time, the process of planning for the system becomes significantly more challenging due to the use of robots. Converting object manipulation requirements to robot trajectories is computationally challenging. Robot trajectories need to meet robot joint limit and joint speed constraints, avoid singularities and produce consistent paths [13]. As a part of our preliminary investigation, it is demonstrated how robots can be used to execute sheet lamination-based AM. Research develops a general system for performing sheet lamination-based additive manufacturing for a heterogeneous component. Ideas and methods from existing areas of LOM are integrated into the design of a robotic cell that performs the following manufacturing process steps: (1) sheet placement, (2) sheet cutting, (3) assembly of externally fabricated components, (4) adhesive dispensing, (5) bonding, and (6) trimming. It also presents an approach for addressing the challenging process planning required for the robotic cell to perform

each step. This consists of (1) generating each layer from a mesh of the structure, (2) generating the tool path and trajectory using contour tracing, (3) generating the trajectory of the robot arm from the tool trajectory, (4) generating assembly instructions, (5) generating the trajectory for point-to-point motion using an optimization-based algorithm, and (6) sequencing the robot motion for the six process steps.

Finally, it characterizes the relevant process constraints related to speed, accuracy, and strength, and presents three case studies: (1) a flexible wing for an unmanned aerial vehicle (UAV), and (2) a multi-layer insulation (MLI) blanket (3) a scaled aircraft wingtip.

4.1.1. Design of additive manufacturing cell

The cell concept is shown in Fig. 3. A block diagram indicating the manufacturing process steps is presented in Fig. 4. We can use multiple materials for different layers and embed prefabricated materials between layers using this cell. The work we have done in the inclusion of prefabricated materials can handle three types of cases (see Fig. 5). (A) If the thickness of the prefabricated component in the direction of the build is less than or equal to some threshold (decided by the material sheet properties), it is sandwiched between sheets. (B) If it is greater than that threshold it needs to be inserted. Such insertion is only possible if the component does not possess an inward slope in the direction of the build (see Fig. 6). (C) A hybrid of cases A and B.

Methodology

The cell executes the following basic steps:
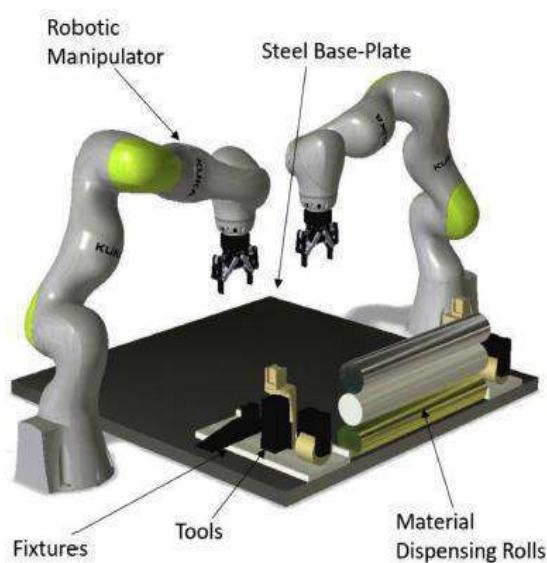
Fig.3 The design of the cell setup illustration

1 Sheet Placement: This process step allows the selection of materials for the laminated layers. A steel base plate is mounted on the same plane as that of the 7-DOF robot. Different sheet material rolls, tools, and fixtures are housed in the base plate. [14,15] Having robotic manipulators provides the flexibility to select the material of the current layer.
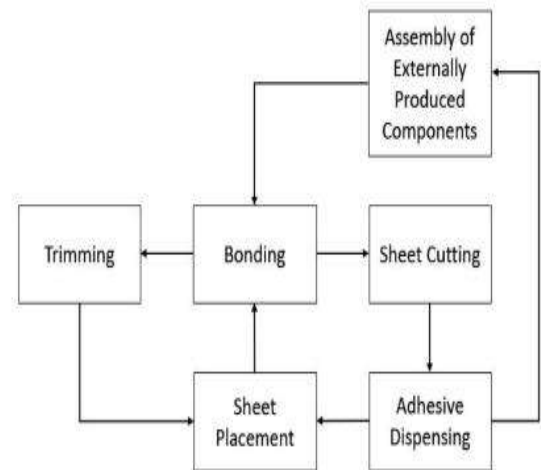
Fig.4 The block diagram illustrating the sequence of the basic manufacturing process steps.

The selected material is pulled from the roll by the robotic manipulator with the assistance of a force-sensitive gripper. The sheet is then placed on the steel base plate and clamped using magnetic clamps. Our designed setup illustration for the basic process is shown in Fig. 7. While performing sheet placement operations the problem of sheet draping or wrinkling might arise in the case of thin-walled sheets. We suggest the use of a flat gripper attachment to increase the gripping area (see Fig. 7) and the material dispensing rolls with torsion springs to get a wrinkle-free sheet. This will allow us to have enough tension in the sheet while placing it on the build platform to avoid any wrinkling or draping . A second manipulator as shown in Fig. 3 or a human operator can clamp the sheet while it is being held in tension by the first manipulator.

2 Sheet Cutting:

The illustration of the sheet cutting step is shown in Fig. 8. It is the second step in the sheet lamination-based additive manufacturing system. A pulsed laser module controlled by the onboard transistor-transistor logic (TTL) circuit is used in our setup. For cutting different materials, the power can be varied by a pulse width modulated (PWM) signal generated using a microcontroller. [16] A laser module is mounted on the robotic arms end effector.

As the violet laser beam is generated and the end effector moves over the sheet at a constant speed, a fine cut is

obtained. The speed and duty cycle of the laser are adjusted based on the material type, thickness, and cut quality.
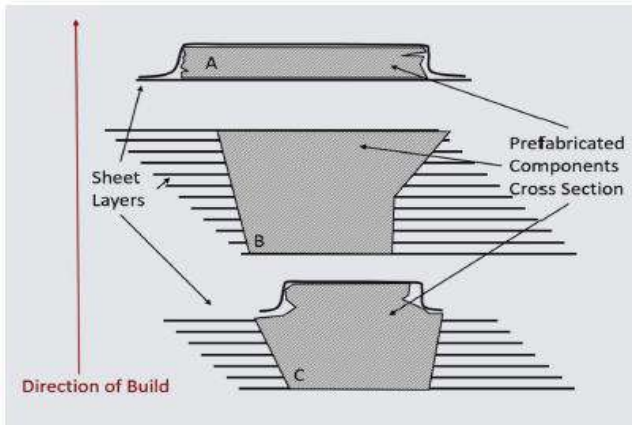
Fig. 5. The illustration of the inclusion of prefabricated components as (A) Sandwich type (B) Insertion type (C) Hybrid type.
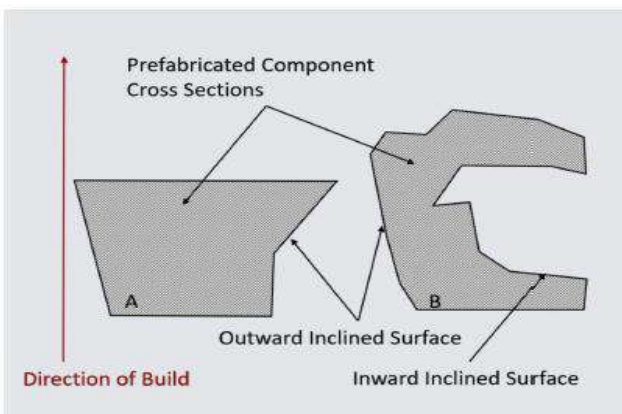
Fig. 6. The illustration of prefabricated components (A)With no inward inclined surfaces and (B) With inwards inclined surfaces in the direction of build.

3 Assembly of Externally Fabricated Components:

This process step allows the addition of prefabricated components between the laminated layers. The assembly process is divided into three parts.

• The first part is the placement of magnetic fixtures on the steel base plate for accurate assembly of the prefabricated components.

• The second part is the placement of the prefabricated components in the fixtures. The fixtures act as the placeholders and guiding pieces in the second step.

• The final part is the removal of the fixture so that the next sheet lamination layer can be placed.

The fixtures initially rest at predefined coordinates on top of the steel base plate from which the robot picks them up and is placed them back at this location before executing the next step. The illustration of the assembly step is shown in Fig. 9.

Moreover, as mentioned before it should be noted that the shape of the prefabricated component and build direction of the part is such that the part can be easily sandwiched between the layers or can be inserted from the top [17,18].
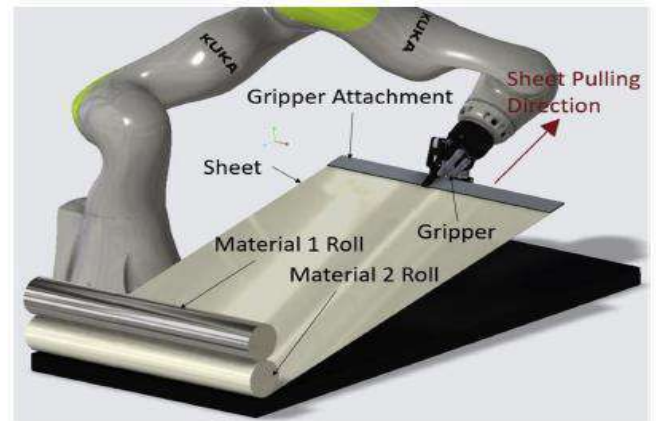
Fig. 7. Illustration showing 7-DOF robotic arm performing sheet placement operation.
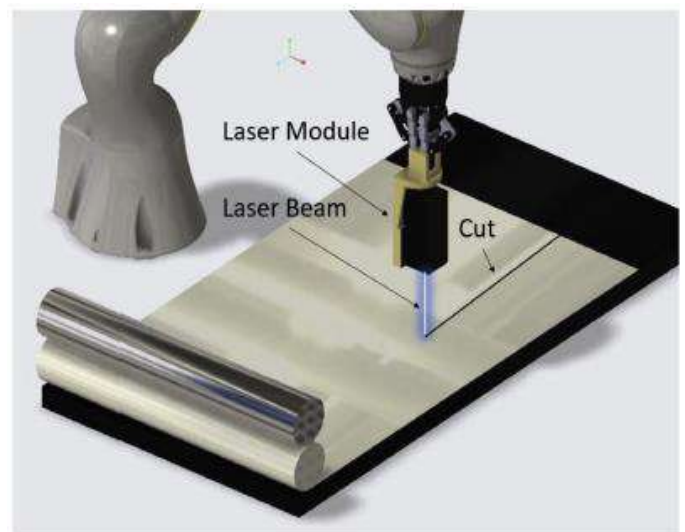
Fig. 8. Illustration of automated laser cutting of a material sheet layer using a visible laser.

4 Adhesive Dispensing: To bond any prefabricated component with the sheet or to bond two consecutive sheets, the dispensing of adhesive is required. This is done using an adhesive dispensing head attached to the robot end-effector with the aid of the gripper. An illustration of this step is shown in Fig. 10.

5 Bonding: The design of this process is very important for the proper bonding between layers in the sheet lamination-based additive manufacturing system. Three different binding methods could be used: (1) tape bonding, (2) adhesive bonding, and (3) tagging. The selection of the

bonding method depends on the layer or the component to be bonded and its application. The tape binding method is used to achieve fast bonding (pressure-sensitive adhesive layer on tape). It works by conforming the tape to the component and bonding it to the sheet by applying pressure with a roller. Adhesive bonding is the most versatile method as it can use pressure-sensitive adhesive or heat-activated resin between sheets and bond them using a roller. [19,20,2] The tagging method is used for dry bonding between thin sheets. It is achieved by using a tagging gun to join thin flexible layers together.

The process step for carrying out adhesive bonding is shown in Fig. 11. The tape binding and tagging steps are not shown for the sake of brevity.
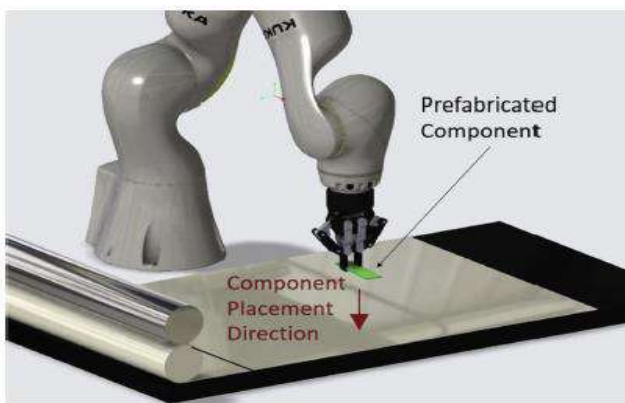
Fig. 9. Illustration showing the sandwich assembly operation of a prefabricated components.
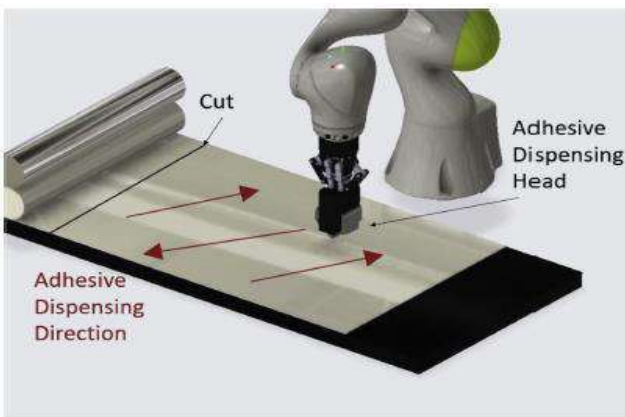
Fig. 10. Illustration showing adhesive dispensing over the sheet surface.

6 Trimming: The trimming step is the final step in the designed system. A variable speed rotary cutting tool or a laser cutting module can be utilized in this step. The illustration for this step is shown in Fig. 12.
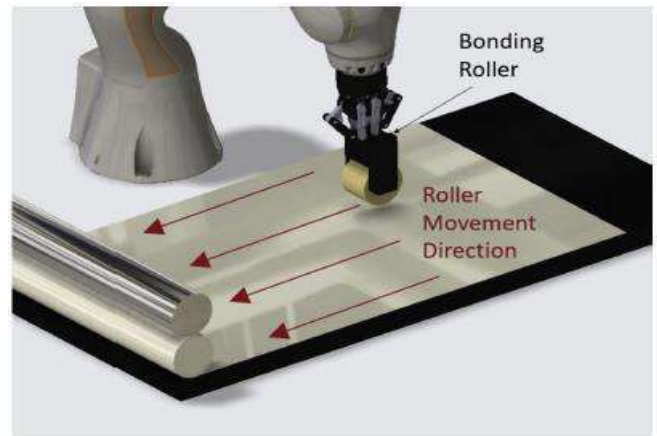
Fig. 11. Illustration showing bonding of layers using a silicone roller tool.
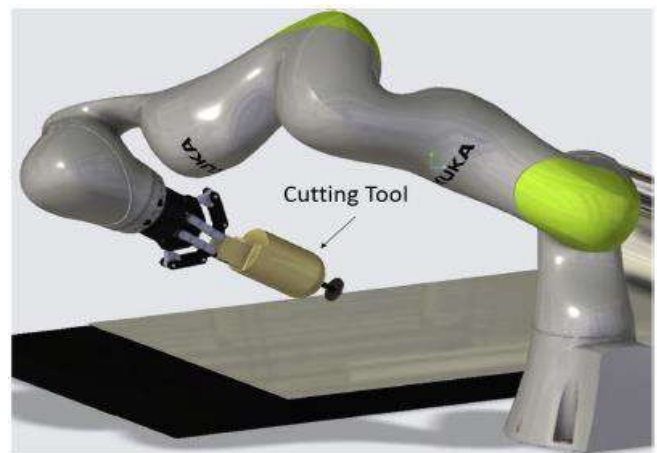
Fig. 12. Illustration showing trimming of the components using a rotary cutting tool.

4.2. Frozen slurry-based laminated object manufacturing

Lack of freezing direction leads to a disorderly porous structure. The freeze-drying-based additive manufacturing can be used to process porous ceramics.

Porous ceramics have important applications in many fields, such as filtration, catalyst carrier, thermal insulation, biological medicine, sound absorption, and so on. [22,23] Some additive manufacturing (AM) methods can be used to process porous ceramics with complicated shapes, such as three-dimensional printing (3DP), selective laser sintering (SLS), fused deposition modeling (FDM), selective laser gelling (SLG), selective laser burn-out (SLB), and selective laser gasifying of frozen Slurry (FSLG for short). These methods can be used to process parts with bimodal porosity. [24,7] A millimeter-scale porosity is processed by controlling the machining path (i.e the pore size depends on the precision of the mechanical control system), and residual

μm-level porosity after sintering due to binder reaction/melting solidification or solvent evaporation. However, the processes of binder reaction/melting-solidification or solvent evaporation are difficult to control, resulting in poor design ability of the micrometer-scale macroporous structure. To improve the design ability of the macroporous structure, the properties of the material must be controlled in the whole process of processing. Through the direct extrusion process (without changing the physical and chemical properties of the material), the ceramic parts with macroporous structure can be obtained by combining the corresponding post-processing technology. Direct ink writing (DIW) takes shear-thinning ceramic ink as the material. [25] It is extruded from the slim-hole nozzle into threadiness, and then the 3D part is constructed through the accumulation of layers. Emulsion/foam templating has the advantages of simplicity and strong applicability to processing porous structures [14]. As a raw material, the emulsion/foam dispersion system with stable rheological performance is used in DIW to process ceramic parts with pore structure. The freeze-drying method uses the sublimation principle of the frozen solvent to obtain a designed porous structure. Porous ceramics with lamellar structure can be obtained by theeze form extrusion fabrication (FEF). Unlike FEF, ceramic/camphene-based slurry is used as raw material in the 3-dimensional ceramic/camphene-based extrusion (3D-Ex) process, the frozen solvent can be sublimated at room temperature. In these freeze drying-based processes, the crystals grow randomly during the freezing process, resulting in a lack of orientation in the lamellar structure. In addition, the extruded slurry filament can easily cause the deformation of the cathe cantilever structure due to gravity. [26,26,27] This study aims to propose a frozen slurry-based laminated object manufacturing (FS-LOM) method, which employed laser cuts in the two-dimensional contour of frozen the furry layer, and freeze-drying to obtain porous structure. [28] The new method enhances the orientation of the lamellar pore structure. Compared with the extrusion process, the deformation of the cantilever structure is avoided.
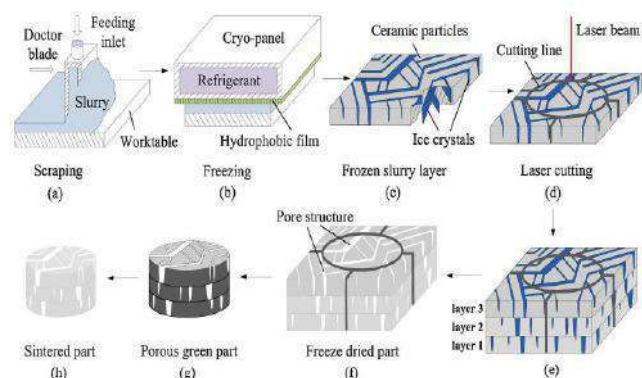
Fig. 13. Diagram of the manufacturing steps of FS-LOM.

4.2.1 Materials

The alumina powder (structural material, D50=0.3 μm), carboxymethylcellulose sodium (binder, 1 wt.%), Ammonium polyacrylate (dispersant, 2 wt.%) are mixed thoroughly in the ball mill to prepare a water-based ceramic slurry (alumina content: 50, 55, 60, and 65 wt.%).

4.2.2. Process of FS-LOM

FS-LOM processing includes paving, freezing, cutting, freeze-drying, and sintering, as shown in Fig. 13. The vertical motion worktable is placed in a −20 °C processing environment. [29,30] After the worktable is lowered one layer, the prepared slurry is supplied to the doctor blade through the feeding inlet and scraped on the worktable (Fig. 13a). Then a cryo-panel with an internal circulation of refrigerant is used for freezing. A layer of hydrophobic film was applied to the lower surface of the cryo-panel to avoid the bonding of frozen slurry (Fig. 13b). After the slurry is frozen to the temperature below the eutectic point, the ice crystals are fully grown and the ceramic particles are squeezed together (Fig. 13c); Then the laser gasification is used to incise the outer contours of the 2D pattern (Fig. 13d); The slurry in the region where the laser did not scan remains frozen. [31,5] When a new layer is just paved, the micro-ice crystals on the surface of the formerly frozen slurry are melted. After the new layer is frozen, the water produced by the micro-melting is crystallized together with the water in the new layer, and a combination of adjacent layers is achieved. After layers are accumulated, the 3D green part wrapped in the frozen slurry is obtained (Fig. 13e). Then the entire sample is placed in a vacuum freeze dryer (Fig. 13f). After drying is completed, the periphery excess material should be removed, and the ceramic green body is obtained (Fig. 13g). Finally, the ceramic parts with pore structure were obtained after sintering (Fig. 13h).

Fig. 14 shows the principle of laser cutting. The CO_2 laser is used because the ice has a high absorption coefficient (158,000/m) for a laser with a wavelength of 10.6 μm. The temperature of the materials rises instantly by laser irradiation. When the temperature exceeds the boiling point, the ice crystals and organic additives are gasified directly to form a gasification area, which makes the ceramic particles free from bondage. [33,34,6] Some free particles are ejected by the rapidly escaping gas, and the others remain on the scanning line. In the gasification area, some organic additives that have no contact with the air are high-temperature carbonized by laser. [35] With the increase of laser incident depth, the attenuation of energy increases. Below the gasification area, the laser energy is not enough to make the ice crystals gasified, but it can make the ice crystals melt to form a transition area. In the transition area, the ceramic particles are separated from the extrusion of the

ice crystals and redistributed in the molten area. Finally, the transition area is refrozen by the surrounding low-temperature frozen slurry.
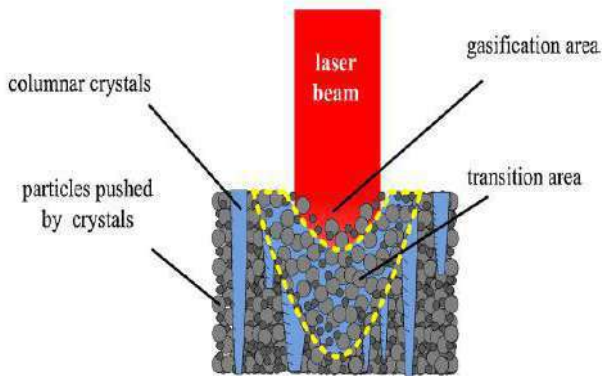
Fig. 14. Schematic diagram of the laser gasification of frozen slurry.

V.   CONCLUSION

The introduction part is about the brief history of 3D printing-LOM technology, the next section depicted the processes used in LOM and the properties of the materials. One can conclude that the 3-D printing LOM technology's importance and social impact increase gradually day by day and influence human life, the economy, and modern society. The recent development in LOM technology could revolutionize the world. Advances in technology can significantly change and improve the way we manufacture products and produce goods worldwide. An object is scanned or designed with Computer-Aided Design software, then sliced up into thin layers, which can then be printed out to form a solid three three-dimensional product. As shown, it can have an application in almost all of the categories of human needs as described by Maslow. While it may not fill an empty unloved heart, it will provide companies and individuals with fast and easy manufacturing in any size or scale limited only by their imagination. 3D printing, on the other hand, can enable fast, reliable, and repeatable means of producing tailor-made products which can still be made inexpensively due to automation of processes and distribution of manufacturing needs.

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Applications and Prospects of 3D Printing in the Packaging Industry

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Abstract— In this paper four 3D printing technologies fused deposition modeling (FDM), selective laser sintering (SLS), stereo lithography appearance (SLA), and laminated object manufacturing (LOM) were examined for their characteristics its applications. Technology for 3D printing Since the 1980s, when the field of applications first began to take off, rapid advancement has been made. Materials for 3D printing have been introduced. In order to build items with a variety of shape, size, rigidity, and color, it entails layering materials such as plastics, composites, or biomaterials. Another innovation was the use of 3D printing in the engineering of packaging. It has been noted that the benefits of 3D printing technology in the packaging business are unmatched by other comparable packaging production technologies, and that 3D printing technology has a very broad range of competitive advantage through innovation in the future packaging industry. The development of 3D printing raw material technology determines the development of 3D printing technology Development boundary. It has high requirements on the purity, sphericity, particle size distribution, bulk density, oxygen content, fluidity and other properties of metal powder materials.

I. INTRODUCTION

In contrast to the conventional subtractive manufacturing process, 3D printing uses layered manufacturing, which involves molding the part one layer at a time. a more conventional manufacturing process, and 3D printing It offers the benefits of cost savings and the ability to mold products with any complex shape. In theory, the warp is flexible. Mechanisms for 3D printing allow for sampling of designed models [1,5]. Technology for 3D printing Since the 1980s, there has been a lot of development, and the area of application has been growing. Containers, materials, and auxiliary materials used to protect products, make storage and transportation easier, and encourage sales while in circulation are collectively referred to as being packaged [2]. Technical measures are also used to accomplish the aforementioned goals. The use of 3D printing technology in the Chinese packaging industry has only recently begun, but

there is still a lot of room for research because it can speed up packaging, cut down on material loss, and reduce the cost and time of molding.[3] The author summarizes the methods of 3D printing technology and the types of materials at home and abroad, so that readers can better understand the research status of 3D printing technology and materials at home and abroad and their application and prospect in packaging industry.

Printing technology

Currently commonly used 3D printing technology: 1 extrusion molding: melt deposition molding (FDM) technology; 2 granular materials forming: selective laser sintering (SLS) technology; 3 photopolymerization molding: light curing stereo molding (SLA) technology; 4 laminated type: layered solid manufacturing (LOM) technology. The main difference between these 3D printing technologies lies

in the type, price, speed and color diversity of printing materials.

Fig 1: 3D Printing Technology

1.1 FDM technology

The fundamental principle FDM technology is to slightly heat the extrusion head above the material's melting point. Melt the polymer under the nozzle's guidance, layer by layer, and then use the computer to control the polymer's heat accumulation to complete the molding. The technology has the benefits of being easy to use and maintain, affordable overall, quick, low-pollution, and made of recyclable materials. O. S. Carneiro et al. used polypropylene as 3D printing raw material, used melt deposition molding technology to print materials, and discussed the factors affecting the molding properties of materials. M. Domingo espin et al. used FDM technology to build models with polycarbonate as raw materials, and designed and manufactured models for physical test performance in different directions. Ning f et al [4]. showed the construction of FDM thermoplastic carbon fiber reinforced plastics and tested the reinforcement of the mechanical properties of the model constructed by FDM method by adding carbon fibers with different lengths.
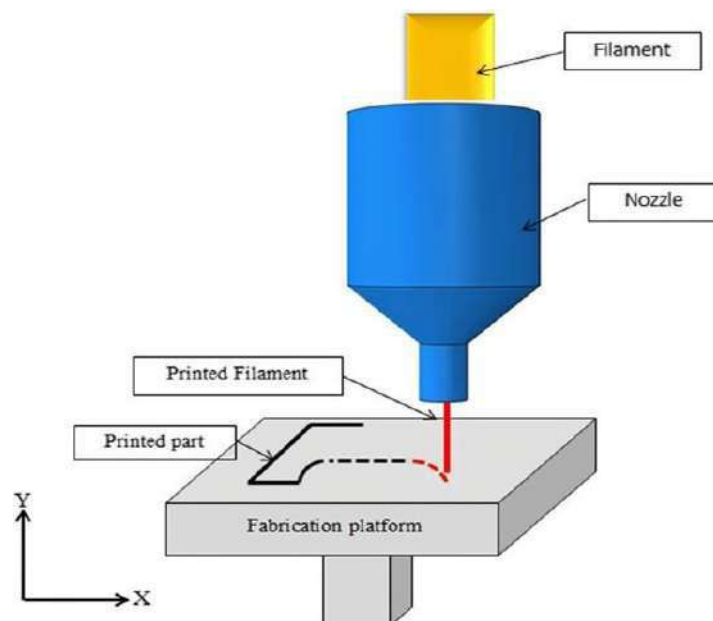
Fig.2: FDM Technology Process

1.2

1.3 SLS technology

SLS technology uses a high-power carbon laser that is controlled by software to sinter solid particle powder material that has already been laid out [3]. The sintered part is then solidified and formed during processing to form a layer of the part. Instead of using additional supporting materials, the non-sintered material is used as the supporting material and then superimposed to the entire model for molding [10]. After removing the unreacted powder, post-treatment is carried out to produce fine parts.
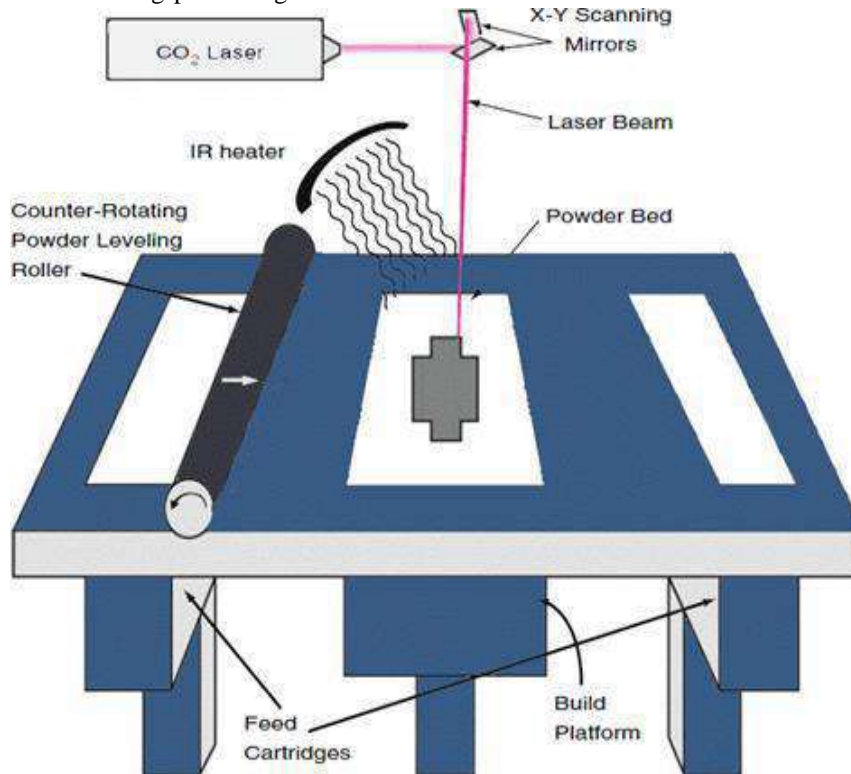
Fig: 3 SLS Technology process

This technology is characterized by good precision and high strength of finished products [5]. The main advantage lies in the production of finished metal products. SLS technology can produce high-strength nylon plastic parts directly used for equipment parts and strong and tough carbon fiber composite plastic resin parts instead of metal tools. Lu Zhongliang et al [6]. found that the densification of AISI316L products formed by SLS can be improved by using isotactic pressing technology and liquid-phase sintering of trace Si. Shi Yusheng et al. the polypropylene powder material prepared by cryogenic crushing method has excellent sintering performance and the SLS formed parts prepared by it have high mechanical properties and dimensional accuracy.

1.4 SLA technology

of all of the other the rapid prototyping technologies, SLA technology has the longest history, the most extensive research, and the greatest adoption. In order to finish the graphics of the single-layer material and stack it layer by layer to the entire sample, the UV laser is focused on the surface of the liquid photosensitive resin layer to cause it to solidify quickly from point to surface [7]. Immerse the formed component in the prepared chemical solution, wash off any extra resin, and then finish the product's additional curing under ultraviolet light in the oven.
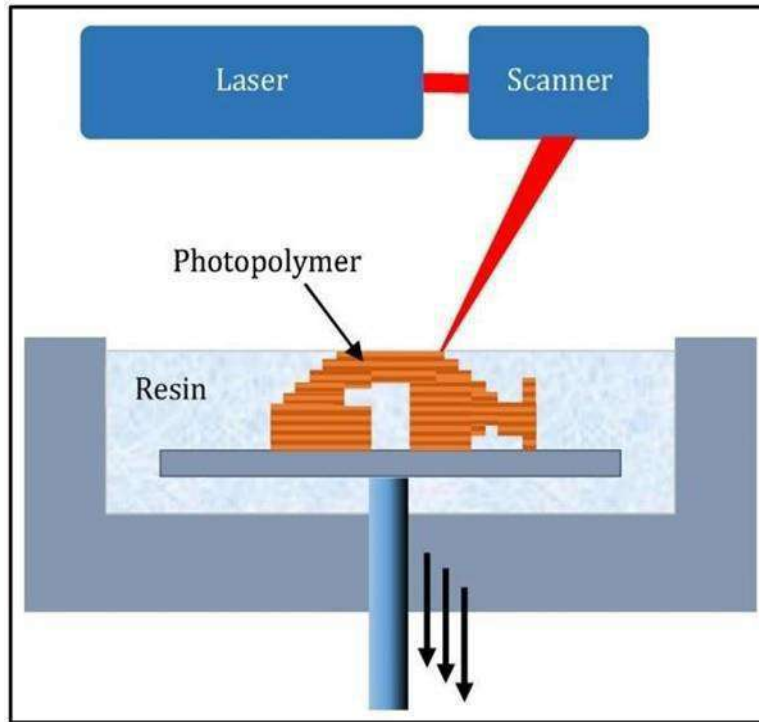
Fig 4: SLA Technology
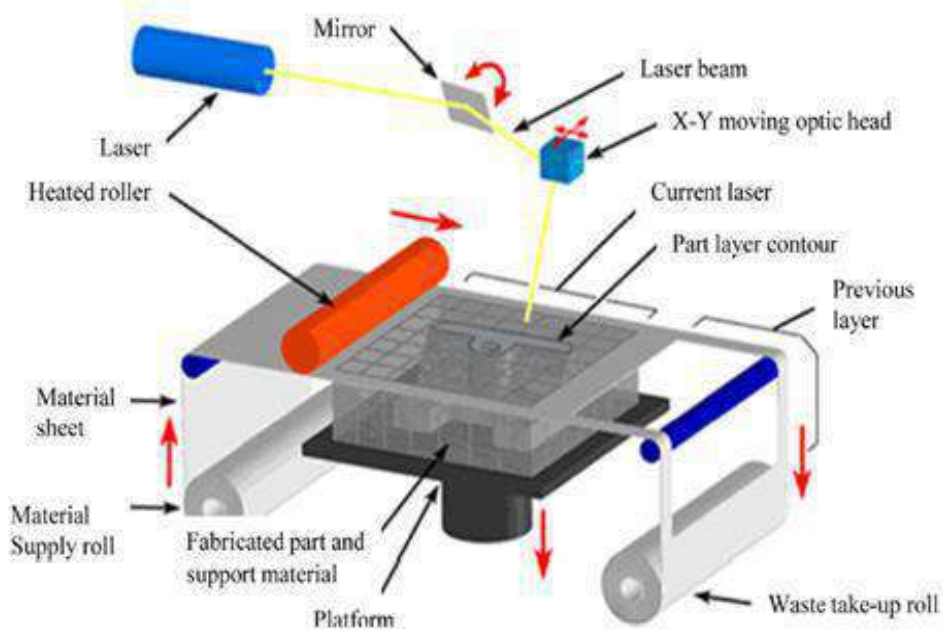
Fig:5 A typical type of LOM process

The benefits of SLA technology include a nearly 100% raw material utilization rate, high dimensional accuracy, excellent surface quality, quick forming speeds, and a high level of automation. It can create models with extremely intricate structures. Despite the fact that it requires post-processing, it is currently the technology with the highest machining accuracy. According to Xi Jun et al [8]. stereo molding technology that uses light curing to project a series of mask images onto a resin surface has a quick molding time and is inexpensive. SLA has a wide range of potential applications because it can use various types of raw materials.

1.5 LOM technology

LOM technology takes solid sheet as raw material and precuts laser cutting hot pressing roller for the thin material heated first and coated with hot melt adhesive on the back in advance, after cutting the internal and external contour of a layer of material, stack a layer of new paper sent by the feeding mechanism, and the cut layers are bonded together by the bonding device. Repeat this to prepare the sample. The combination between each layer of metal plates is usually realized by welding and bolt connection. LOM technology has the advantages of reliable operation, good model support, low cost and high efficiency. Zhong, H et al [9]. found that LOM is suitable for the manufacturing of silicon carbide products, especially the small batch manufacturing of ceramic parts with complex shapes.

II.   PRINTING MATERIALS

The materials used in 3D printing typically come in the forms of powder, filament, flake, and liquid Shape, among others. The main market in China today is still comprised of imported raw materials, and the price is high [10]. Alternatively, the development of 3D printing raw material technology establishes the development boundary for 3D printing technology.

2.1   Polymer composites

Wendel B, et al [11]. invented a 3D printing aromatic polyester material and its preparation method. The method adopts aromatic polyester, thermoplastic elastomer, etc. for blending modification to improve the impact resistance of the material. Shi Yusheng et al [12]. prepared polymer composites for SLS 3D printing, and prepared composites by adding micro / nano fillers or post-treatment infiltration to improve some properties of SLS formed parts. Guo Yanling et al. proposed the preparation method of stone plastic composite powder for laser sintering 3D manufacturing technology, using powdered nylon 12 and limestone as raw materials to solve the existing problems of materials for laser sintering. Arevo laboratory in Silicon Valley, USA, 3D printed high-strength carbon fiber reinforced composites that can strictly set their comprehensive properties, and optimized specific electrical, mechanical and thermal properties by accurately controlling the orientation of carbon fibers during printing.

2.2   Photosensitive resin

The liquid photosensitive resin composed of polymer monomer and prepolymer added with UV initiator can react and complete curing immediately under UV light to make high-temperature resistant, high-strength and waterproof materials. Du Yulei, et al [13]. synthesized a series of prepolymers acrylic acid as main raw materials, and used the synthesized products as photosensitive prepolymers to

make 3D printing light curing resin with low volume shrinkage. Du Yulei, et al. invented a photosensitive resin modified by 3D printed polystyrene microspheres with fast molding speed, high mechanical strength and good dimensional stability. Min Qinqin, et al [2]. reported a preparation method of 3dpsl-1 photosensitive resin applied to 3D printing stereo lithography rapid prototyping. The results show that the resin has moderate viscosity, good photosensitivity, small volume shrinkage of cured product, and good mechanical and thermal properties.

2.3   Green and environmentally friendly materials
a)   Materials containing vegetable fibers

Liu Kewu proposed a preparation method of plant fiber composites, which takes filamentous plants such as bamboo, coconut or sugarcane as raw materials. The finished products prepared by using the composites have the characteristics of high bending strength, light weight, not easy to thermal deformation and small thermal shrinkage. Liu Kewu et al [14]. proposed the preparation method of rice husk hot melt adhesive composite powder for SLS. Taking rice husk powder as the main raw material, there is no need to modify rice husk powder in the preparation process, which simplifies the process and reduces the production cost while ensuring various properties of the composite. Cheng Lingyu, et al [10]. prepared PVC / distiller's grains wood plastic composites by hot pressing technology, and effectively improved the mechanical properties of wood plastic composites by adding calcium zinc composite heat stabilizer and maleic anhydride. Cheng Lingyu, et al. prepared a 3D printed wood plastic composite with natural plant fibers, which has the appearance of wood products and the processing characteristics of wood plastic materials.

b)   Polylactic acid materials

Lactic acid serves as the primary raw material in the polymerization of polylactic acid (PLA), which is an eco-friendly polymer. Texture feature extraction, good clarity, good biocompatibility, good high thermal stability, good solvent resistance, and a variety of processing options are all benefits of PLA. The stability of PLA is higher, it does not easily warp, and it has a low shrinkage ratio. Several different renewable sources, primarily corn and cassava, are used to produce raw materials. By using the melt blending method, Serra T, et al [15]. prepared general injection grade PLA materials. It was discovered that a synergistic toughening agent had a better toughening effect on PLA than a single toughening agent. Tang Yiwen et al [16]. found that inorganic toughening agent can improve the toughness and rigidity of PLA at the same time. Tang Yiwen et al. proposed a preparation method of 3D printing modified PLA material. The modified PLA was prepared by low-temperature crushing and mixing method, which greatly

improved its thermal deformation temperature, toughness and impact strength.

2.4 Metal materials

Metal is typically a very expensive raw material for 3D printing technology. Purity, sphericity, particle size distribution, bulk density, oxygen content, fluidity, and other properties of metal powder materials must meet strict requirements for 3D printing. Due to its affordable price and resistance to chemical corrosion, stain-less steel is widely used. It is a type of expensive metal powder material that is frequently used in 3D printing with metal. Its design is strong and suitable for printing large-sized items.

Cheng Lingyu et al [10]. studied the microstructure and mechanical properties of laser selective melting formed stainless steel and nano hydroxyapatite (NHA) composites. It was found that when the content of NHA was 5%, the density and tensile strength of the materials were similar to those of pure stainless steel. Cheng Lingyu et al. densified the aerosol 316L austenitic stainless-steel powder by hot isostatic pressing. Its density is close to the theoretical full density, with high tensile strength, yield strength, hardness and excellent elongation.

2.5 Ceramic materials

A specific binder powder is combined with ceramic powder to create the ceramic powder used in 3D printing. The performance of ceramic powder is transformed by adhesive bonding, making it comparable to the performance when only metal powder is used. Ceramic products can be 3D printed using aluminum silicate ceramic powder. The products are non-toxic, recyclable, and have good airtightness and high temperature resistance.

In order to create AlN ceramics with a relative density greater than 98% using spark plasma sintering technology in an N2 atmosphere [17]. used AlN powder as the raw material, tin powder as the regulator, and rare earth metal sintering additives. It has reduced electrical properties and a dense sintering. Zirconia ceramic parts were produced using laser selective sintering/cold isostatic pressing composite forming technology by Shi Yusheng et al. They proposed a near net forming process method for zirconia parts, which has a great deal of potential for producing ceramic parts with complex shapes and high performance, despite the fact that the density and hardness of the final sintered parts still needs to be improved.

III. APPLICATION OF 3D PRINTING IN THE PACKAGING INDUSTRY

3.1 Application in packaging container molding

The advancement of human society and the development of packaging containers are closely related. It has now evolved into a product that combines function and aesthetics and is a significant component of commodities [18]. There are many different types of packaging containers, and because different materials are used, their properties also vary. Molds must frequently be made before parts can be molded in the traditional packaging container process, which is laborious, time-consuming, and difficult to modify. Through 3D software, 3D printing technology simulates physical reality and allows for easy modification. At the same time, it increases technology's accuracy while reducing costs and using less raw materials.

Direct molding and indirect molding are both possible with 3D printing molding technology. After treatment, the 3D-printed sample can serve as the master mold, and the polyimide compound can be added to the vacuum pouring machine to replicate a specific batch of parts and containers. Due to this, the technology of 3D printing has numerous potential applications in the process of molding packaging containers. Straw can be used to create 3D printing materials thanks to a new technology created by Zhao Chenfei and colleagues. Products printed with this material have a woodsy feel to them. The printing of packaging boxes and other items using this material increases packaging efficiency, lowers costs, and creates new development opportunities for the packaging sector's future growth. Zhao Chenfei proposed a technique to produce exquisitely printed cartons by printing raw materials like plant fibers using 3D printing technology [19]. The utility model addresses the issues of the existing packaging carton's extended production cycle, significant material waste, and environmental pollution.

3.2 Application in the manufacture of packaging materials

Nowadays, there are many kinds of packaging materials, including paper, plastic, metal, ceramic, biodegradable and so on. We mainly discuss the following.

a) Polymer composites

A method for preparing polypropylene and polyethylene composite consumables for 3D printing was recommended by Xie Jinneng et al. The items printed using the consumables don't absorb moisture or water. The products are also simple to color and have a good surface gloss. With basic hemihydrate calcium sulfate and polyvinyl alcohol, Liu Kew created a composite powder material suitable for industrial 3D printing. A method for preparing soft, elastic 3D printing rubber consumables was suggested by Xie Jinneng et al. The three-dimensional model that was printed has excellent dimensional stability, viscosity, and very little shrinkage [20]. A 3D printing-based preparation method for new acrylonitrile butadiene styrene plastic (ABS) was created by Xie Jinneng et al and colleagues. After

polymerization, the preparation technique uses a continuous bulk method to produce ABS resin.

b) Green and environmentally friendly materials.

A 3D printing material preparation technique based on edible wax was proposed by Wang Hong [21]. After the mixture has been heated, stirred, reacted, thoroughly dispersed, and cooled, it is crushed and ready to be utilized for wire extrusion. Wax wire that has been extruded can be used right away in 3D printing. A method for preparing the materials for wood 3D printing was suggested by Xie Jinneng et al [20]. The consumables are used to create molded parts that have been well-optimized physical and chemical qualities throughout and a texture that is similar to that of real wood. By using a two-step process, Huang Xuhui et al [22]. created a modified PLA material for 3D printers that addresses the offset and poor effect issues brought on by the direct addition of a tiny molecular crosslinking agent.

c) Metallic materials

The Extrude Hone firm in the United States uses an ultraviolet light-curing process to cure metal pieces using metal and resin adhesive powder materials. Its benefit is that a variety of metal powder materials are available for application [23]. The Pro Metal Company of the United States sinters the created sample and produces metal components directly using the technique of spraying adhesive into metal alloy powder and bonding layer by layer.

IV. CONCLUSION

The use of 3D printing technology significantly accelerates and streamlines packaging. certain procedure Enhance the packaging industry's structure to a certain level and encourage multi polarization in the sector. Additionally, it reduces the need for raw materials, makes recycling easier, and supports environmental preservation and sustainable development. This lessens the workload of the environmental protection division and increases the efficiency with which resources and energy are used.

The preparation of packaging materials, the molding of packaging containers, and the entire packaging business all benefit greatly from 3D printing technology. As 3D printing technology advances and becomes more sophisticated, it is paired with cutting-edge packaging materials and containers to create products that are more energy-efficient and environmentally beneficial. Other comparable packaging manufacturing processes cannot compare to the benefits of adopting 3D printing technology. In the future packaging sector, 3D printing technology has a very broad range of potential applications.

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ϖ-Interpolative Ciric-Reich-Rus-Type Contactions in m-metric space

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Abstract— In this paper, using the concept of ϖ-admissibility, we prove some fixed -point results for interpolate Ciric-Reich-Rus-type contraction mappings. We also present some consequences and a useful example.

I.   INTRODUCTION AND PRELIMINARIES:

In [2], the notion of an interpolative Kannan-type contraction was introduced and the following fixed-point theorem was stated: A self-mapping T on a complete metric space (X, d) such that:

$$d(Tx, Ty) \leq \lambda[d(x, Tx)]^{\alpha}[d(y, Ty)]^{\alpha-1}$$

where $\lambda \in [0,1)$ and $\alpha \in (0,1)$, and $x, y \in X$ with $x \neq Tx$, has a unique fixed point in X. Very recently, the authors in [2] (see also [3]) pointed out a gap in [2], that is the guaranteed fixed point in the theorem above need not be unique. In 2012, Bessem Samet [5] introduced a new concept of contraction named α-admissible and proved a fixed-point theorem which generalizes Banach contraction principle. Bessem Samet further established fxed point result for $\alpha - \psi$ −contractive type mappings and establish various fixed-point theorems for such mappings in complete metric spaces. Afterwards Karapinar and Samet [5] generalized these notions to obtain fixed point results. The aim of this paper is to modify further the notions of $\alpha - \psi$ −contractive and α −admissible mappings and establish

fixed point theorems for such mappings in complete metric spaces. The notion of α-admissible mapping is an interesting increase in improving the Banach contraction mapping in order to make the mapping become more general including the case that it is continuous or discontinuous. There is now extensive variety of literature dealing with fixed point problems via α −admissible mappings. In 2014, M. Asadi et al. [6] extended the concept of partial metric space to an m −metric space, and showed that their definition is a real generalization of partial metric by presenting some examples. Partial metric space (in short PMS), is one of the attempts to generalize the notion of the metric space that by replacing the condition $d(x, x) = 0$ with the condition $d(x, x) \leq d(x, y)$ for all $x, y \in X$ in the definition of the metric [7, 8]. Regarding the contributions of these authors, we shall call the following result the Ciri´c-Reich-Rus theorem, by which our main result is inspired. Ciri´c-Reich-Rus theorem: A self-mapping ´ T on a complete metric space (X, d) such that:

$$d(Tx, Ty) \leq \lambda[d(x, y) + d(x, Tx) + d(y, Ty)]$$

for all $x, y \in X$, where $\lambda \in \left(0, \frac{1}{3}\right)$, possesses a unique fixed point. Denote by Ψ the set of all nondecreasing self-mappings ψ on $[0, \infty)$ such that:

$$\sum_{n=1}^{\infty} \psi^n(t) < \infty \quad for\ each \quad t > 0$$

Note that for $\psi \in \Psi$, we have $\psi(0) = 0$ and $\psi(t) < t$ for each $t > 0$; see, e.g., [9,10]. The notion of ϖ −orbital admissible maps was introduced by Popescu as a refinement of the concept of α-admissible maps of Samet et al.[11].

Definition [14] Let $\varpi: X \times X \to [0, \infty)$ be a mapping and $X \neq \emptyset$. A self mapping $T: X \to X$ is said to be an ϖ −orbital admissible if for all $s \in X$, we have: $\varpi(s, Ts) \geq 1 \Rightarrow \varpi(Ts, T^2 s) \geq 1$

Definition [6] For a given non empty set X, we say that a function $m: X \times X \to [0,1)$ is an m-metric if

(m1) $m(x, x) = m(y, y) = m(x, y) \Leftrightarrow x = y$,

(m2) $\qquad\qquad m_{x,y} \leq m(x, y), where\ m_{x,y} := min\{m(x, x), m(y, y)\}$,

(m3) $m(x, y) = m(y, x)$,

(m4) $\left(m(x, y) - m_{x,y}\right) \leq \left(m(x, z) - m_{x,z}\right) + \left(m(z, y) - m_{z,y}\right)$.

In this case, the pair (x, m) is called an m −metric space.

Example [6] Let $X = [0, +\infty)$ and $m(x, y) = x^2 + y^2$ on X. Then (X, m) is an m −metric space.

Solution

(m1) If $x = y$ then $m(x, x) = m(x, y) = m(y, y)$ where

$$m(x, x) = x^2 + x^2 = 2x^2,$$
$$m(x, y) = x^2 + y^2 = 2x^2\ because\ x = y,$$
$$m(y, y) = y^2 + y^2 = 2y^2 = 2x^2.$$

Conversely suppose that $m(x, x) = m(x, y) = m(y, y)$ then $x = y$.

(m2) We have to show that $m_{xy} \leq m(x, y)$ where $m_{xy} = min\{m(x, x), m(y, y)\}$,

If $x < y$ then

$$m_{x,y} = min\{m(x, x), m(y, y)\} = m(x, x)$$

Similarly for $x > y \Rightarrow m_{x,y} \leq m(x, y)$

(m3) If

$$m(x, y) = x^2 + y^2 = y^2 + x^2 = m(y, x) \Rightarrow m(x, y) = m(y, x)$$

(m4) We have to show that

$$m(x, y) - m_{x,y} \leq \left(m(x, z) - m_{x,z}\right) - \left(m(z, y) - m_{z,y}\right)$$

Take $x = 1, y = 3$ and $z = 5$ where

$$m(1,3) = min\{m(1,1), m(3,3)\} = min\{1,9\} = 1,$$
$$m(1,5) = min\{m(1,1), m(5,5)\} = min\{1,25\} = 1,$$
$$m(3,5) = min\{m(3,3), m(5,5)\} = min\{9,25\} = 9.$$

Then

$$m(1,3) - m_{1,3} \leq \left(m(1,5) - m_{1,5}\right) + \left(m(5,3) - m_{5,3}\right),$$
$$10 - 1 \leq (26 - 1) + (36 - 9),$$
$$9 \leq 25 + 27 = 52.$$

Similarly for all $x, y \in X$ which satisfied

$$m(x, y) - m_{x,y} \leq \left(m(x, z) - m_{x,z}\right) - \left(m(z, y) - m_{z,y}\right).$$

So all condition of m −metric space are satisfied so (x, m) is a m −metric space on X.

Example [6] Let m be an m −metric space. Put

(1) $m^z(x, y) = m(x, y) - 2m_{xy} + M_{xy}$,

(2) $m^s(x, y) = m(x, y) - m_{xy}$ if $x \neq y$, and $m^s(x, y) = 0$ if $x = y$.

Then m^z and m^s are ordinary metrics.

As mentioned in [2], each m −metric on X generates a T_o topoplogy τ_m on X. Then set

$$\{B_m(x, \varepsilon): x \in X, \varepsilon > 0\}$$

where

$$B_m(x, \varepsilon) : \left\{y \in X, m(x, y) < m_{x,y} + \varepsilon\right\}$$

for all $x \in X$ and $\varepsilon > 0$, forms a basis of τ_m.

Remark [6] For every $x, y \in X$

1. $0 \leq M_{xy} + m_{xy} = m(x, x) + m(y, y)$,

2. $0 \leq M_{xy} - m_{xy} = |m(x, x) + m(y, y)|$,

3. $M_{xy} - m_{xy} \leq (M_{xz} - m_{xz}) + \left(M_{zy} + m_{zy}\right)$

Definition [6] Let (X, m) be a m-metric space. Then:

1. A sequence $\{x_n\}$ in m-metric space (X, m) converges to a point $x \in X$ if and only if

$$lim_{n \to \infty}(m(x_n, x) - m_{x_n, x}) = 0$$

2. A sequence $\{x_n\}$ in m-metric space (X, m) is called an m −Cauchy sequence if

$$lim_{n \to \infty}\left(m(x_n, x_m) - m_{x_n, x_m}\right), \quad lim_{n \to \infty}\left(M_{x_n, x_m} - m_{x_n, x_m}\right),$$

exist (and are finite).

3. An $m-$metric space (X, m) is said to be complete if every $m-$Cauchy sequence $\{x_n\}$ in X converges, with respect to τ_m, to a point $x \in X$ such that

$$lim_{n\to\infty}\big(m(x_n, x) - m_{x_n,x}\big)$$
$$= 0 \quad and \quad lim_{n\to\infty}(M_{x_n,x} - m_{x_n,x})$$
$$= 0$$

Lemma 1: If $\{x_n\}_{n\in N}$ and $\{y_n\}_{n\in N}$ are two sequence such that $x_n \to \infty$ and $y_n \to y$ as $n \to \infty$ in an m-metric space (X, m), then

$$lim_{n\to\infty}(m(x_n, y_n) - m_{x_n,y_n}) = m(x,y) - m_{x,y}$$

Lemma 2: If $\{x_n\}_{n\in N}$ be an sequence such that $x_n \to \infty$ as $n \to \infty$ in an $m-$metric space (X, m), then

$$lim_{n\to\infty}(m(x_n, y) - m_{x_n,y}) = m(x,y) - m_{x,y}$$

(H) If $\{u_n\}$ is a sequence in X such that $\varpi(u_n, u_{n+1}) \geq 1$ for each n and $u_n \to u \in X$ as $n \to \infty$, then there exists $\{u_{n(k)}\}$ from $\{u_n\}$ such that $\varpi\big(u_{n(k)}, u\big) \geq 1$ for each k.

Main Body:

At the start of this section, we define a $\varpi -$interolative Ciric-Reich-Rus-type contraction in m-metric space, which is cited in a well-known paper on Ciric-Reich-Rus-type contraction metric by Karapinar [1].

First, we initiate the concept of $\varpi -$interolative Ciric-Reich-Rus-type contraction.

Definition-1: Let (X, m) be a m-metric space. The mapping $T: X \to X$ is said to be an $\varpi -$interolative Ciric-Reich-Rus-type contraction if there exist $\psi \in \Psi, \varpi : X \times X \to [0, \infty)$ and positive reals $\gamma, \beta > 0$, verifying $\gamma + \beta < 1$, such that:

$$\varpi(u, v)m(Tu, Tv)$$
$$\leq \psi\big([m(u,v)]^{\beta}.[m(u,Tu)]^{\gamma}.[m(v,Tv)]^{1-\gamma-\beta}\big) \quad (2.1)$$

for all $u, v \in X\backslash Fix(T)$, where $Fix(t)$ denotes the set of fixed point of T (that is, point $a \in X$ such that $Ta = a$).

The essential main result is given as follows.

* We use the m-metric space instead of metric in [1] theorem 1.

Theorem 1: Suppose a continuous self-mapping $T : X \to X$ is $\varpi -$orbital admissible and forms an $\varpi -$interpolative Ciric-Reich-Rus-type contraction on a complete m-metric space (X, m). If there exist $u_0 \in X$ such that $\varpi(u_0, Tu_0) \geq 1$, then T possesses a fixed point in X.

Proof Let $u_0 \in X$ be a point such that $\varpi(u_0, Tu_0) \geq 1$. Let $\{u_n\}$ be a sequence defined by $u_n = T^n(u_0)$, $n > 0$. If for some n_0, we have $u_{n_0} = u_{n_0+1}$, then u_{n_0} is a fixed point of T, which ends the proof. Otherwise, $u_n \neq u_{n+1}$ for each $n \geq 0$. we have $\varpi(u_0, u_1) > 1$. Since T is $\varpi -$orbital admissible,

$$\varpi(u_1, u_2) = \varpi(Tu_0, Tu_1) \geq 1.$$

Continuing as above, we obtain that:

$$\varpi(u_n, u_{n+1}) \geq 1 \; for \; all \; n \geq 0. \quad (2.2)$$

Taking $u = u_n$ and $v = u_{n-1}$ in (2.1), we find that:

$$m(u_{n+1}, u_n) \leq \varpi(u_n, u_{n-1})m(Tu_n, Tu_{n-1})$$
$$\leq \psi\big([m(u_n, u_{n-1})]^{\beta}.[m(u_n, Tu_n)]^{\gamma}.[m(u_{n-1}, Tu_{n-1})]^{1-\gamma-\beta}\big)$$
$$\leq \psi\big([m(u_n, u_{n-1})]^{\beta}.[m(u_n, u_{n+1})]^{\gamma}.[m(u_{n-1}, u_n)]^{1-\gamma-\beta}\big)$$
$$\leq \psi\big([m(u_{n-1}, u_n)]^{1-\gamma}.[m(u_n, u_{n+1})]^{\gamma}\big) \quad (2.3)$$

In particular, as $\psi(t) < t$ for each $t > 0$,

$$m(u_{n+1}, u_n) \leq \psi\big([m(u_{n-1}, u_n)]^{1-\gamma}.[m(u_n, u_{n+1})]^{\gamma}\big)$$
$$< [m(u_{n-1}, u_n)]^{1-\gamma}.[m(u_n, u_{n+1})]^{\gamma} \quad (2.4)$$

We derive:

$$[m(u_n, u_{n+1})]^{1-\gamma} < [m(u_{n-1}, u_n)]^{1-\gamma} \quad (2.5)$$

Therefore:

$$m(u_n, u_{n+1}) < m(u_{n-1}, u_n) \; for \; all \; n \geq 1 \quad (2.6)$$

Hence, the positive sequence $\{m(u_{n-1}, u_n)\}$ is decreasing. Eventually, there is a real $\ell \geq 0$ in order that $lim_{n\to\infty}m(u_{n-1}, u_n) = \ell$. Taking into account (2.6),

$$[m(u_{n-1}, u_n)]^{1-\gamma}[m(u_n, u_{n+1})]^{\gamma}$$
$$\leq [m(u_{n-1}, u_n)]^{1-\gamma}[m(u_{n-1}, u_n)]^{\gamma}$$
$$= m(u_{n-1}, u_n),$$

so (2.3) together with the non-decreasing character of ψ lead to:

$$m(u_{n+1}, u_n) \leq \psi\big([m(u_{n-1}, u_n)]^{1-\gamma}.[m(u_n, u_{n+1})]^{\gamma}\big)$$
$$\leq \psi\big(m(u_{n-1}, u_n)\big)$$

By repeating this argument, we get:

$$m(u_{n+1}, u_n) \leq \psi\big(m(u_{n-1}, u_n)\big) \leq \psi^2\big(m(u_{n-2}, u_{n-1})\big)$$
$$\leq \cdots \leq \psi^n\big(m(u^0, u^1)\big) \quad (2.7)$$

Taking $n \to \infty$ in (2.7) and using the fact $lim_{n\to\infty}\psi^n(t) = 0$ for each $t > 0$, we conclude that $\ell = 0$, that is,

$$lim_{n\to\infty}m(u_{n+1}, u_n) = 0$$

Now, we prove that the sequence $\{u_n\}$ for $n \in N$ is an $m-$cauchy sequence. Take $m, n \in N$ with $m > n > n_0$. First notice that the following fact above triangular inequality of $m-$metric space.

$$m(u,v) - m_{u,v} \leq \big(m(u,w) - m_{u,w}\big)$$
$$+ \big(m(w,v) - m_{w,v}\big)$$
$$\leq m(u,w) + m(w,v), for\ all\ u,v,w \in X$$

Thus it is clear that

$$m(u_n, u_m) - m_{u_n,u_m}$$
$$\leq m(u_n, u_{n+1}) + m(u_{n+1}, u_{n+2}) + \cdots$$
$$+ m(u_m, u_{m+1})$$
$$< \sum_{i=n}^{\infty} m(u_i, u_{i+1})$$
$$\leq \sum_{i=n}^{\infty} \frac{1}{i^{\frac{1}{\hbar}}}$$

Since the series $\sum_{i=n}^{\infty} \frac{1}{i^{\frac{1}{\hbar}}}$ is converges, it implies that $m(u_n, u_m) - m_{u_n,u_m}$ converges as $m, n \to \infty$. Now, if $M_{u_n,u_m} = 0$, then $m_{u_n,u_m} = 0$ which implies that $M_{u_n,u_m} - m_{u_n,u_m} = 0$, so we may assume that $M_{u_n,u_m} > 0$. Then

$$m(u_n, u_n) \leq \psi\big(m(u_{n-1}, u_{n-1})\big) \leq \psi^2\big(m(u_{n-1}, u_{n-1})\big)$$
$$\leq \cdots \leq \psi^n\big(m(u^0, u^0)\big) \quad (2.8)$$

Taking $n \to \infty$ in (2.8) and using that fact $lim_{n\to\infty}\psi^n(t) = 0$ for $t > 0$. We deduce that $lim_{n\to\infty}m(u_n, u_n) = 0$. Thus there exist $n_1 \in N$ such that $m(u_n, u_n) \leq 1$ for $n > n_1$. Consequently, we have $m(u_n, u_n) < \frac{1}{i^{\frac{1}{\hbar}}}$ for all $n > n_1$.

Therefore, we obtain

$$m(u_n, u_n) - m(u_m, u_m)$$
$$\leq m(u_n, u_n) + m(u_{n+1}, u_{n+1}) + \cdots + m(u_m, u_m),$$
$$< \sum_{i=n}^{\infty} m(u_i, u_i)$$
$$\leq \sum_{i=n}^{\infty} \frac{1}{i^{\frac{1}{\hbar}}}$$

Since the series $\sum_{i=n}^{\infty} \frac{1}{i^{\frac{1}{\hbar}}}$ is convergent, we conclude that $m(u_n, u_n) - m(u_m, u_m)$ converges as $m, n \to \infty$, which implies that $M_{u_n,u_m} - m_{u_n,u_m}$ converges as desired. Therefore $\{u_n\}$ is an $m-$cauchy sequence in X. Since (X,m) is an complete m-metric space, $\{u_n\}$ converges to some $z^* \in X$.

$$lim_{n\to\infty}(u_n, Tu_n) \to 0$$

Since $m(u_n, u_{n+1}) < m(z^*, z^*)$. Now using the fact that $m_{u_n,Tu_n} \to 0$ by lemma (1) and (2) we conclude that the

$$m(z^*, Tz^*) = m_{z^*,Tz^*} = m(Tz^*, Tz^*) \quad (2.9)$$

That is $Tz^* = z^*$

In this theorem also use the m-metric space instead of metric space theorem 2 in [2].

In what follows, we replace the continuity criteria by a weakened condition (H).

Theorem 2: Suppose a self mapping $T: X \to X$ is $\varpi -$orbital admissible and forms an $\varpi -$interpolative Ciric-Reich-Rus-type contraction on a complete m-metric space (X, m). Suppose also that the condition (H) is fulfilled. If there exist $u_0 \in X$ such that $\varpi(u_0, Tu_0) \geq 1$, then T possesses a fixed point in X.

Proof By the proof By the proof of Theorem (1) verbatim, we conclude that the constructed sequence $\{u_n\}$ is Cauchy and (1.9) holds. Suppose the condition (H) holds. We argue by contradiction by assuming that $u \neq Tu$. Recall that $u_{n(k)} \neq Tu_{n(k)}$ for each $k \geq 0$. Due to (H), there exist a partial subsequence $\{u_{n(k)}\}$ of $\{u_n\}$ such that $\varpi\big(u_{n(k)}, Tu\big) \geq 1$ for all k. Since $\{m\big(u_{n(k)}, u\big)\} \to 0, \{m\big(u_{n(k)}, Tu_{n(k)}\big)\} \to 0$ and $m(u, Tu) > 0$, there is $N \in \mathbb{N}$ such that, for each $k \geq N$,

$$m\big(u_{n(k)}, u\big) \leq m(u, Tu)\ and\ m\big(u_{n(k)}, Tu_{n(k)}\big)$$
$$\leq m(u, Tu)$$

Taking $u = u_{n(k)}$ and $v = u$ in (2.1), we get that:

$$m(u_{n(k)+1}, Tu) \leq \varpi\big(u_{n(k)}, u\big)m\big(Tu_{n(k)}, Tu\big)$$
$$\leq \psi\left([m\big(u_{n(k)}, u\big)]^{\beta} \cdot [m\big(u_{n(k)}, Tu_{n(k)}\big)]^{\gamma} \cdot [m(u, Tu)]^{1-\gamma-\beta}\right) \quad (2.10)$$

As ψ is non-decreasing, it follows from (2.10) that:

$$m(u_{n(k)+1}, Tu)$$
$$\leq \psi\big([m(u, Tu)]^{\beta} \cdot [m(u, Tu)]^{\gamma} \cdot [m(u, Tu)]^{1-\gamma-\beta}\big)$$
$$= \psi(m(u, Tu)).$$

Letting $k \to \infty$, we find that:

$$0 < m(u, Tu) \leq \psi(m(u, Tu)) < m(u, Tu),$$

which is a contradiction. Thus, $u = Tu$.

In what follows, we introduce tha notion of $\varpi -$interpolative Kannan-type contractions.

Definition The self-mapping T on the $m-$metric space (X, m) is called an $\varpi -$interpolative Kannan-type contractions if there exist $\psi \in \Psi$, $\varpi: X \times X \to [0, \infty)$ and $\beta \in (0,1)$ such that:

$$\varpi(u,v)m(Tu, Tv) \leq \psi\big([m(u,v)]^{\beta} \cdot [m(v, Tv)]^{1-\beta}\big)$$

for all $u, v \in X \backslash Fix(T)$.

The following one is our second main result.

Theorem 3: Let a self-mapping $T: X \to X$ is $\varpi -$orbital admissible and forms an $\varpi -$interpolative Kannan-type contraction on a complete $m -$metric space (X, m). Assume

also that either T is continuous on (X, m) or (H) holds. If there exist $u_0 \in X$ such that $\varpi(u_0, Tu_0) \geq 1$, then T possesses a fixed point in X.

We skipped the proof due to the verbatim proof of Theorem 1.

By considering $\varpi(u, v) = 1$, in Theorem 1, we state the following.

Corollary 1: Let T is self-mapping on a complete m−metric space (X, m) such that:

$$m(Tu, Tv) \leq \psi\big([m(u,v)]^\beta . [m(u, Tu)]^\gamma . [m(v, Tv)]^{1-\gamma-\beta}\big)$$

for all $u, v \in X \backslash Fix(T)$, where $\gamma, \beta > 0$ are positive reals satisfying $\gamma + \beta < 1$. Then, T admit a fixed point.

Corollary 2: Let T is self-mapping on a complete m-metric space (X, m) such that:

$$m(Tu, Tv) \leq \psi\big([m(u,v)]^\beta . [m(v, Tv)]^{1-\beta}\big),$$

for all $u, v \in X \backslash Fix(T)$, where $0 < \beta < 1$. Then, T admit a fixed point.

Taking $\psi(t) = \lambda t$ (where $\lambda \in [0,1]$) in Corollary 1, we state:

Corollary 3: Let T is self-mapping on a complete m-metric space (X, m) such that:

$$m(Tu, Tv) \leq \lambda . [m(u,v)]^\beta . [m(u, Tu)]^\gamma . [m(v, Tv)]^{1-\gamma-\beta},$$

for all $u, v \in X \backslash Fix(T)$, where γ, β are positive reals satisfying $\gamma + \beta < 1$ and $\lambda \in [0,1)$. Then, T admit a fixed point.

Taking $\psi(t) = \lambda t$ (where $\lambda \in [0,1]$) in Corollary 2, we state:

Corollary 4: Let T is self-mapping on a complete m−metric space (X, m) such that:

$$m(Tu, Tv) \leq \lambda . [m(u,v)]^\beta . [m(v, Tv)]^{1-\beta},$$

or all $u, v \in X \backslash Fix(T)$, where $0 < \beta < 1$ and $\lambda \in [0,1)$. Then, T admit a fixed point.

Remark 1: Corollary 3 corresponds to Corollary 2.1 in [2].

Let $(X, m, \preccurlyeq)$ be a complete partially-ordered m−metric space. Let us consider the following condition.

(G) If $\{u_n\}$ is a sequence in X such that $u_n \preccurlyeq u_{n+1}$ for each n and $u_n \to u \in X$ as $n \to \infty$, then there exists $\{u_{n(k)}\}$ from $\{u_n\}$ such that $u_{n(k)} \preccurlyeq u$ for each k.

Following [1], we may state the following consequences of Theorem 1.

Corollary 5: Let $(X, m, \preccurlyeq)$ be a complete partially-ordered m−metric space. Let $T: X \to X$ be the mapping such that:

$$\varpi(u,v) m(Tu, Tv) \leq \psi\big([m(u,v)]^\beta . [m(u, Tu)]^\gamma . [m(v, Tv)]^{1-\gamma-\beta}\big),$$

for all $u, v \in X \backslash Fix(T)$ with $u \preccurlyeq v$, where $\psi \in \Psi$ and $\gamma, \beta > 0$ are positive reals satisfying $\gamma + \beta < 1$. Assume that:

(i) T is non-decreasing with respect to $\preccurlyeq$;

(ii) there exist $u_0 \in X$ such that $u_0 \preccurlyeq Tu_0$;

(iii) either T is continuous on (X, m) or (G) holds.

Then, T has a fixed point in X.

Proof It suffices to take, in Theorem 1,

$$\varpi(u,v) = \begin{cases} 1 & if \quad (u \preccurlyeq v) \; or \; (v \preccurlyeq u) \\ 0 & otherwise \end{cases}$$

Corollary 6: Let $(X, m, \preccurlyeq)$ be a complete partially-ordered m−metric space. Let $T: X \to X$ be tha mapping such that:

$$\varpi(u,v) m(Tu, Tv) \leq \psi\big([m(u,v)]^\beta . [m(v, Tv)]^{1-\beta}\big),$$

for all $u, v \in X \backslash Fix(T)$ with $u \preccurlyeq v$, where $\psi \in \Psi$ and $0 < \beta < 1$. Assume that:

(i) T is non-decreasing with respect to $\preccurlyeq$;

(ii) there exist $u_0 \in X$ such that $u_0 \preccurlyeq Tu_0$;

(iii) either T is continuous on (X, m) or (G) holds.

Then, T has a fixed point in X.

Proof We take in Theorem 3,

$$\varpi(u,v) = \begin{cases} 1 & if \quad (u \preccurlyeq v) \; or \; (v \preccurlyeq u) \\ 0 & otherwise \end{cases}$$

Corollary 7: Suppose that the subsets A_1 and A_2 of a complete m−metric space (X, m) are closed. Suppose also that $T: A_1 \cup A_2 \to A_1 \cup A_2$ satisfies:

$$\varpi(u,v) m(Tu, Tv) \leq \psi\big([m(u,v)]^\beta . [m(u, Tu)]^\gamma . [m(v, Tv)]^{1-\gamma-\beta}\big),$$

for all $u \in A_1$ and $v \in A_2$ such that $u, v \notin Fix(T)$, where $\psi \in \Psi$ and $\gamma, \beta > 0$ are positive reals satisfying $\gamma + \beta < 1$. If $T(A_1) \subseteq A_2$ and $T(A_2) \subseteq A_1$, then there exist a fixed point of T in $A_1 \cap A_2$.

Proof It suffices to take, in Theorem 1,

$$\varpi(u,v) = \begin{cases} 1 & if \quad (A_1 \times A_2) \cup (A_1 \times A_2) \\ 0 & otherwise \end{cases}$$

Corollary 8: Suppose that the subsets A_1 and A_2 of a complete $m-$metric space (X, m) are closed. Suppose also that $T: A_1 \cup A_2 \to A_1 \cup A_2$ satisfies:

$$\varpi(u,v)m(Tu,Tv) \leq \psi\big([m(u,v)]^{\beta}.[m(v,Tv)]^{1-\beta}\big),$$

for all $u \in A_1$ and $v \in A_2$ such that $u, v \notin Fix(T)$, where $\psi \in \Psi$ and $\gamma, \beta > 0$ are positive reals satisfying $\gamma + \beta < 1$. If $T(A_1) \subseteq A_2$ and $T(A_2) \subseteq A_1$, then there exist a fixed point of T in $A_1 \cap A_2$.

Proof It suffices to take, in Theorem 3,

$$\varpi(u,v) = \begin{cases} 1 & if \quad (A_1 \times A_2) \cup (A_1 \times A_2) \\ 0 & otherwise \end{cases}$$

Exapmle 1: Let us consider the set $X = [0,1]$ endowed with $m(u,v) = \left(\frac{u+v}{2}\right)$. Let T be a self-mapping on X defined by:

$$T(u) = \left(\frac{1+u}{2}\right) \ for \ all \ u \in X.$$

Take

$$\varpi(u,v) = 1 \ for \ all \ u, v \in X.$$

Let $u, v \in X$ be such that $u \neq Tu, v \neq Tv$ and $\varpi(u,v) \geq 1$. We first show that T is $\varpi-$orbital admissible, if for all $u \in X$, we have $\varpi(u, Tu) \geq 1$ then this implies that $\varpi(Tu, T^2u) \geq 1$, which satisfes.

Hence, T is $\varpi-$orbital admissible.

Clearly, $m(u,v) = \left(\frac{u+v}{2}\right)$ is $m-$metric space.

Hence by Equation (2.1),

$$\varpi(u,v)m(Tu,Tv)$$
$$\leq \psi\big([m(u,v)]^{\beta}.[m(u,Tu)]^{\gamma}.[m(v,Tv)]^{1-\gamma-\beta}\big).$$

The above inequality hold for all $u, v \in X$ with $\beta = \left(\frac{1}{5}\right)$ and $\gamma = \left(\frac{1}{2}\right)$. We defined $\psi(u) = e^u$ for all $u \in X$.

Hence, all condition of Theorem 1 is Hold so T has a fixed point which is $T(1) = 1$.

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Breaker Indices in Water Wave Formulated from *Kinematic Free Surface Boundary Condition*, *Conservation Equation of Wave Number* and *Equation of Energy Conservation*

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Abstract— In this research, the breaker index equations are formulated using the kinematic free surface boundary condition. By substituting the potential velocity equation for the solution of Laplace's equation in this equation, it is obtained the wave amplitude function equation. From the wave amplitude function equation two breaker indices are extracted, they are the breaker length index which is the ratio between the breaker height and the breaker length; and the breaker depth index which is the ratio between the breaker height and the breaker depth. The next breaker index, which is a ratio between breaker depth and breaker length, is obtained from the wave number conservation law. Consistency testing of the three breaker index equations obtained shows that there is consistency in the three equations. Consistency testing is done by using the connectivity equation, where a breaker index is the product of the multiplication of the other two breaker indexes. The breaker height index, which is the ratio between the breaker height and the deep water wave height, is obtained by substituting the breaker length index in the energy conservation equation. Thus the breaker height equation is obtained which works a function of the breaker length at the breaking point. With the availability of the four breaker indexes, the breaking parameter can be calculated easily.

I. INTRODUCTION

The breaking parameter is the wave characteristics at the time of breaking. There are three breaking parameters, namely the *breaking wave height* or also known as the breaker height, the *water depth at the breaking point* which is called the breaker depth and the *wavelength at the breaking point* which is called the breaker length. Breaker index is a ratio between breaking parameters. The breaker depth index is the ratio between the breaker height and the breaker depth, the breaker length index is the ratio between the breaker height and the breaker length. There is a breaker index which is rarely researched or used, namely the ratio between breaker depth and breaker length; this

breaker index is hereinafter referred to as the breaker depth-length index. Breaker height index is the ratio between breaking wave height and deep water wave height.

Several explicit equations to the breaker depth index were put forward by, among others, McCowan (1894), Weggel (1972), Galvin (1969), Collins and Weir (1969), Madsen (1976) and Smith and Krauss (1989).

There is a critical wave steepness criterion, which is the *wave steepness before breaking* which is the ratio between the wave height and wavelength before breaking. This criterion can also be considered as a *breaker length index*. Two researchers who put forward the criterion of critical

wave steepness are Michell (1894) and Toffoli et al (2010). The breaker length index is in the form of an implicit equation which is a function of another breaker index, namely the *Mieche equation* (1944). This equation connects the breaker length index with the breaker depth-length index. Many researchers have developed the breaker length index by modifying the Mieche equation (1944), including Battjes and Jansen (1978), Ostendorf and Madsen (1979) and Rattanapittikon and Shibayama (2000). The various breaker index equations are formulated separately, where the breaker depth index is formulated only by examining the breaker depth index, the breaker length index is formulated only by examining the breaker length index, as well as the breaker height. There should be a relationship or connectivity between breaker indexes, where the value of one breaker index is related to the value of another breaker index. In the breaker index equations obtained in this study, an examination of the linkages between breaker indexes was carried out using the connectivity equation. As a result, it is found that there is connectivity between breaker indexes.

II. THE VELOCITY POTENTIAL EQUATION

The complete velocity potential solution of the Laplace equation (Dean (1991)) using the variable separation method is:

$$\phi(x,z,t) = G\,(\cos kx + \sin kx)\cosh k(h+z)\sin \sigma t$$

(1)

Where x is the horizontal axis, z is vertical axis and t is time, while h is water depth. G, k dan σ is called the wave constant, G is the energy transmission rate, k is wave number, $k = \frac{2\pi}{L}$ where L is a wavelength and $\sigma = \frac{2\pi}{T}$ is angular frequency while T is for wave period.

The three wave constants need to be determined by their value or equation. As shown in (1), the velocity potential consists of two components, namely the cos and the sin component. In both components there is a point where $\cos kx = \sin kx$, these points are called characteristic points. Analysis of wave constants will be easier if done at characteristic points, where the constants obtained will satisfy both wave components. By using only components $\cos kx$ then the velocity potential equation becomes,

$$\phi(x,z,t) = G\,\cos kx \cosh k(h+z)\sin \sigma t \qquad …(2)$$

Note that the G in (2) has a double value.

III. THE WAVE AMPLITUDE FUNCTION EQUATION

The *wave amplitude function* is the relationship between wave amplitude and other wave constants. This equation is

obtained by substituting the velocity potential for the kinematic free surface boundary condition and the equation obtained is integrated with time t to obtain the elevation water surface equation.

As a kinematic free surface boundary condition, a weighted kinematic free surface boundary condition from Hutahaean (2022) is used in the form,

$$\gamma_2 \frac{\mathrm{d}\eta}{\mathrm{d}t} = w_\eta - u_\eta \frac{\mathrm{d}\eta}{\mathrm{d}x} \qquad …(3)$$

γ_2 is a coefficient that is greater than 1, but the value of this coefficient has no effect on the breaker index. $\eta(x,t)$ is the water surface elevation relative to the still water level, w_η surface vertical water particle velocity u_η surface horizontal water particle velocity.
By using the velocity potential equation,

$$u(x,z,t) = -\frac{\mathrm{d}\phi}{\mathrm{d}x}$$
$$= Gk \sin kx \cosh k(h+z)\sin \sigma t$$
$$u_\eta = Gk \sin kx \cosh k(h+\eta)\sin \sigma t$$
$$w(x,z,t) = -\frac{\mathrm{d}\phi}{\mathrm{d}z}$$
$$= -Gk \cos kx \sinh k(h+z)\sin \sigma t$$
$$w_\eta = -Gk \cos kx \sinh k(h+\eta)\sin \sigma t$$

Substitute these velocity equations into (3) and work on the characteristic points,

$$\frac{\mathrm{d}\eta}{\mathrm{d}t} = -\frac{Gk}{\gamma_2}\cosh k(h+\eta)$$
$$\left(\tanh k(h+\eta) + \frac{\mathrm{d}\eta}{\mathrm{d}x}\right)\cos kx \sin \sigma t \quad …….(4)$$

As a periodic function, then

$$Gk\,\cosh k(h+\eta)\left(\tanh k(h+\eta) + \frac{\mathrm{d}\eta}{\mathrm{d}x}\right)$$
$$= constant$$

Then integration (4) can be completed by integrating the elements of $\sin \sigma t$, and is obtained water surface elevation equation of,

$$\eta(x,t) = \frac{Gk}{\sigma\gamma_2}\cosh k(h+\eta)$$
$$\left(\tanh k(h+\eta) + \frac{\mathrm{d}\eta}{\mathrm{d}x}\right)\cos kx \cos \sigma t$$

Wave amplitude is defined as,

$$A = \frac{Gk}{\sigma\gamma_2}\cosh k(h+\eta)\left(\tanh k(h+\eta) + \frac{\mathrm{d}\eta}{\mathrm{d}x}\right)$$

Considering that G has a double value, then

$$A = \frac{Gk}{2\sigma\gamma_2}\cosh k(h+\eta)\left(\tanh k(h+\eta) + \frac{\mathrm{d}\eta}{\mathrm{d}x}\right)$$

A is the wave amplitude, the water surface elevation equation becomes,

$$\eta(x,t) = A\cos kx \sin \sigma t$$

At a characteristic point of space and time, $\eta = \frac{A}{2}$ dan $\frac{d\eta}{dx} = -\frac{kA}{2}$, wave amplitude function becomes

$$A = \frac{Gk}{2\sigma\gamma_2} \cosh k\left(h + \frac{A}{2}\right) \left(\tanh k\left(h + \frac{A}{2}\right) - \frac{kA}{2}\right)$$
.......(5)

In the wave amplitude function there is an element of $\tanh k\left(h + \frac{A}{2}\right)$ which has a constant value. The constant value of the function of $\tanh k\left(h + \frac{A}{2}\right)$ is reached at a large value of h, at $h = h_0$, h_0 is the deep water depth where the influence of waves still reaches the bottom of the waters even though it is very small or close to zero. The constant value is,

$$\tanh k_0 \left(h_0 + \frac{A_0}{2}\right) = 1$$

Therefore, in deep waters even at depths greater than h_0, the waves seem to move on water depth h_0, where

$$k_0 \left(h_0 + \frac{A_0}{2}\right) = \theta\pi$$

θ is the deep water coefficient whose value needs to be determined. However, based on the wave number conservation law discussed in section (6), this equation applies at all depths, so it can be written in general as:

$$k\left(h + \frac{A}{2}\right) = \theta\pi$$
......(6)

The determination of the value θ is to use $\tanh \theta\pi = 1$. However, this criterion is very dependent on the level of accuracy used, as shown in Table (1).

Table (1) Value $\tanh \theta\pi$

θ	$\tanh \theta\pi$		
	(5)	(6)	(7)
1.95	0.99999	0.999990	0.9999905
2	0.99999	0.999993	0.9999930
2.05	0.99999	0.999995	0.9999949
2.1	1	0.999996	0.9999963
2.4	1	0.999999	0.9999994
2.45	1	1.000000	0.9999996
2.75	1	1.000000	0.9999999
2.8	1	1.000000	1.0000000

In Table (1), (5), (6) and (7) is the number of digits after the decimal point.
- With an accuracy of 5 decimal places, it is found that $\tanh \theta\pi = 1$ at $\theta = 2.1$
- With an accuracy of 6 decimal places, it is found that $\tanh \theta\pi = 1$ at $\theta = 2.45$
- With an accuracy of 7 decimal places, it is found that $\tanh \theta\pi = 1$ at $\theta = 2.80$

Due to this condition, the value of θ cannot be determined only by using the criterion of $\tanh \theta\pi = 1$, thus additional criteria are needed. The more precise determination of value θ will be done in section 9.

IV.   Equation of Breaker Length Index $\frac{H_b}{L_b}$.

In (5) there is a breaking characteristic, when

$$\tanh k\left(h + \frac{A}{2}\right) - \frac{kA}{2} = 0$$
.......(7)

In this condition the wave amplitude function is zero. In (7) substituted (6) in the 1st term as well $k = \frac{2\pi}{L}$ dan $A = \frac{H}{2}$ in the second term it is obtained, breaker length index of

$$\frac{H_b}{L_b} = \frac{2 \tanh \theta\pi}{\pi}$$
.....(8)

V.   Equation of Breaker Depth Index $\frac{H_b}{h_b}$.

It is defined as,

$$\tanh k\left(h + \frac{A}{2}\right) = \beta k\left(h + \frac{A}{2}\right)$$

An equation is obtained as,

$$\beta - (1 - \beta)\frac{H}{4h} = 0$$

By using (6) thus,

$$\beta = \frac{\tanh \theta\pi}{\theta\pi}$$

With this equation, the breaking equation becomes,

$$\frac{H_b}{h_b} = \frac{4 \tanh \theta\pi}{\theta\pi - \tanh \theta\pi}$$
......(9)

VI.   Equation for $\frac{h_b}{L_b}$

The equation for $\frac{h_b}{L_b}$ is formulated by using the conservation equation of the wave number.

In solving the Laplace equation with the *variable separation method*, the velocity potential is considered to be a multiplication of 3 functions (Dean (1991)), that is:
$$\phi(x, z, t) = X(x)Z(z)T(t)$$
where $X(x)$ is only the function of x, $Z(z)$ is only the function of z and $T(t)$ is only for the t time. In (1), which is $Z(z)$:
$$Z(z) = \cosh k(h + z)$$
where h is for *water depth*. As the function is only of z then at sloping bottom where water depth $h = h(x)$, also for $k = k(x)$,
$$\frac{dZ(z)}{dx} = \sinh k(h + z)\frac{dk(h + z)}{dx} = 0$$
In this equation the value is zero:
$$\frac{dk(h + z)}{dx} = 0$$
If this equation is worked on $z = \frac{A}{2}$ thus,
$$\frac{dk\left(h + \frac{A}{2}\right)}{dx} = 0$$

Thus,

$$k\left(h+\frac{A}{2}\right) = constant$$

By using (6), the equation for the conservation of the waave number is obtained,

$$k\left(h+\frac{A}{2}\right) = \theta\pi$$

The equation for the conservation of the wave number applies to all water depths, including the breaker depth, therefore it applies to the breaking point,

$$k_b\left(h_b+\frac{A_b}{2}\right) = \theta\pi$$

Substitute $k_b = \frac{2\pi}{L_b}$ and $A_b = \frac{H_b}{2}$,

$$\frac{h_b}{L_b} = \frac{\theta}{2} - \frac{H_b}{4L_b}$$

Substitute $\frac{H_b}{L_b}$ with (8),

$$\frac{h_b}{L_b} = \frac{\theta}{2} - \frac{\tanh\theta\pi}{2\pi} \qquad \qquad …..(10)$$

VII.   CONSISTENCY CHECKING $\frac{H_b}{h_b}, \frac{H_b}{L_b}$ DAN $\frac{h_b}{L_b}$

The consistency test is proof that a breaker index is the product of the multiplication of the other two breaker indexes. The consistency test is done using the connectivity equation,

$$\frac{H_b}{L_b} = \frac{H_b}{h_b}\frac{h_b}{L_b} \qquad \qquad ……(11)$$

This equation states that the multiplication between the equations $\frac{H_b}{h_b}$ and $\frac{h_b}{L_b}$ must create an equation of $\frac{H_b}{L_b}$ which is the same as (8).

Substitute $\frac{H_b}{h_b}$ with (9) and $\frac{h_b}{L_b}$ with (10),

$$\frac{H_b}{L_b} == \left(\frac{4\tanh\theta\pi}{\theta\pi - \tanh\theta\pi}\right)\left(\frac{\theta}{2} - \frac{\tanh\theta\pi}{2\pi}\right)$$

It is obtained,

$$\frac{H_b}{L_b} = \frac{2\tanh\theta\pi}{\pi}$$

The equation is the same as (8). Therefore, the equations of $\frac{H_b}{h_b}, \frac{H_b}{L_b}$ and $\frac{h_b}{L_b}$ meet the consistency requirements. This consistency character also shows that the value of one breaker index is determined by another breaker index, or in other words there is interdependence between breaker indexes. Therefore, the formulation of the three breaker indexes should be done simultaneously so that consistency can be checked and there is connectivity between the breaker indexes.

VIII.   Breaker Height Index $\frac{H_b}{H_0}$.

The wave energy at one wavelength for a sinusoidal wave is

$$E = c_E\rho g H^2 L \text{ (m)}$$

c_E is a coefficient, which in linear wave theory $c_E = \frac{1}{8}$ (Dean (1991)). ρ is water mass density, g is gravitational force, H is wave height and L is wavelength.

Based on the law of conservation of energy, the wave energy at the breaker point is the same as the wave energy in deep water,

$$c_E\rho g H_b^2 L_b = c_E\rho g H_0^2 L_0$$

The same elements cancel each other out,

$$H_b^2 L_b = H_0^2 L_0$$

Substituting the breaker length index (8), we get the breaker height equation associated with the breaker length index value

$$H_b^3 = \frac{2\tanh\theta\pi}{\pi} H_0^2 L_0 \qquad \qquad …..(12)$$

Hutahaean (2022) obtained the deep water wave number is,

$$k_0 = \frac{\gamma_3}{\left(\gamma_2 + \frac{\gamma_3}{2}\right)\frac{H_0}{2}}$$

γ_2 and γ_3 are coeficients where $\gamma_2 = 1.4$ and $\gamma_3 = 1.8$. By this wave number, the deep water wavelength is:

$$L_0 = \frac{\pi\left(\gamma_2 + \frac{\gamma_3}{2}\right)H_0}{\gamma_3}$$

Substituting L_0 to (12), it is obtained

$$\frac{H_b}{H_0} = \left(\frac{2\tanh(\theta\pi)\left(\gamma_2 + \frac{\gamma_3}{2}\right)}{\gamma_3}\right)^{1/3} \qquad ….(13)$$

IX.   DETERMINATION OF VALUE OF θ

The calculation results for $\frac{H_b}{h_b}, \frac{H_b}{L_b}, \frac{h_b}{L_b}$ and $\frac{H_b}{H_0}$ for some deep water depth coefficient values θ is presented in Table (2) below. To save space, only calculation results are presented where there is a match between $\frac{H_b}{h_b}$ with previous research.

Table (2) the value θ which results $\frac{H_b}{h_b}$ that is in a line with previous research

θ	$\frac{H_b}{L_b}$	$\frac{H_b}{h_b}$	$\frac{h_b}{L_b}$	$\frac{H_b}{H_0}$
1.95	0.637	0.78	0.816	1.367
2.1	0.637	0.715	0.891	1.367
2.6	0.637	0.56	1.141	1.367

There is a match between the values of $\frac{H_b}{h_b}$ from several previous studies, where the match can be found in the value of θ that varies.

- In $\theta = 1.95$, it is obtained $\frac{H_b}{h_b} = 0.78$, which is in a line with:

   a. Mc Cowan (1894) : $\frac{H_b}{h_b} = 0.78$

b. Weggel (1972) :

$$\frac{H_b}{h_b} = \frac{gT^2 1.56/[1+exp(-19.5m)]}{gT^2 + h_b 43.75[1-exp(-19m)]}$$

m is bottom slope, for $m = 0$; $\frac{H_b}{h_b} = 0.78$

- In $\theta = 2.10$, it is obtained $\frac{H_b}{h_b} = 0.715$, which is in a line with:

  a. Galvin (1969) : $\frac{H_b}{h_b} = \frac{1}{1.4 - 6.85\,m}$; for bottom slope $m \leq 0.07$

   In $m = 0$, $\frac{H_b}{h_b} = \frac{1}{1.4} = 0.714$

  b. Collins and Weir (1969) : $\frac{H_b}{h_b} = 0.72 + 5.6\,m$

   In $m = 0$, $\frac{H_b}{h_b} = 0.72$

  c. Madsen (1976) : $\frac{H_b}{h_b} = 0.72(1 + 6.4m)$

   In $m = 0$, $\frac{H_b}{h_b} = 0.72$

- In $\theta = 2.60$, it is obtained $\frac{H_b}{h_b} = 0.56$, that matches with Smith and Krauss (1989)

$$\frac{H_b}{h_b} = \frac{1.12}{1+exp(-60m)} - 5(1 - \exp(-43m))\frac{H_0}{L_0}$$

In $m = 0$, $\frac{H_b}{h_b} = 0.56$

To determine the θ the value of $\frac{h_b}{L_b}$ is examined where $\frac{h_b}{L_b} < 1$ shows that the waterdepth is smaller than wavelength. This condition causes water depth unable to support wave hydrodynamics resulting in breaking. In $\theta = 2.6$, the value of $\frac{h_b}{L_b} > 1$, it can be assumed that breaking will not occur in that condition.

Then, to select between $\theta = 2.1$ and $\theta = 1.95$ where both result in $\frac{h_b}{L_b} < 1$, a review will be carried out based on deep water depth criteria by using the wave number conservation equation in deep waters. Equation (6) is done in deep water,

$$k_0\left(h_0 + \frac{A_0}{2}\right) = \theta\pi$$

Substitute $k = \frac{2\pi}{L}$, and the equation can be expressed as

$$\frac{h_0}{L_0} = \frac{\theta}{2} - \frac{H_0}{4L_0}$$

h_0 in this case is the transitional depth between shallow water and deep water, where the water depth is smaller than h_0 is shallow water while the water depth is greater than h_0 belongs to deep water. At the depth of the transition, $\frac{h_0}{L_0}$ should be greater than one or at least 1. This suggests that θ must be greater than 2. From this, it can be concluded that the breaker index that corresponds to Table (2) is the breaker index formulated by $\theta = 2.1$.

Breaker depth index in $\theta = 2.1$ produces a breaker depth index that is in accordance with the results of research from Galvin (1969), Collins and Weir (1969) and Madsen (1976). In addition, the values in Table (1) show that $\tanh \theta\pi$ untuk $\theta = 2.1$ has reached 1 in the accuracy of 5 decimal places while in $\theta = 1.95$ it has not reached 1. Both of these strengthen the conclusion that the appropriate value of the depth coefficient θ is 2.1, with the breaker index on Table (2).

From the above discussion it can be seen that the breaker index is determined by the deep water coefficient θ which means that the breaker index is set by determining the deep water depth. Thus there is a possibility that the diversity of breaker index obtained from previous research is also caused by differences in determining deep water depth.

It has been shown that there is a match between the breaker depth index obtained with the breaker depth index from previous studies. In the following section, the value of the breaker length index will be studied $\frac{H_b}{L_b}$ where the value of $\frac{H_b}{L_b}$ obtained is a constant for all θ that is $\frac{H_b}{L_b} = 0.637$. This value is much larger than the critical wave steepness:

a. Michell, J.H. (1894) : $\frac{H}{L} = 0.142$

b. Toffoli et al (2010) : $\frac{H}{L} = 0.170$

Then it is studied the critical wave steepness from Michell, J.H. and Toffoli et al for the associated breaker depth index values. By specifying the value of $\frac{H_b}{L_b}$ then θ can be calculate with (8), with the value of θ obtained $\frac{H_b}{h_b}$ using (9). The result for $\frac{H_b}{L_b} = 0.142 - 0.170$ is shown in Table (3).

Table (3) the value θ in some values of $\frac{H_b}{L_b} = 0.142 - 0.170$

$\frac{H_b}{L_b}$	θ	$\frac{H_b}{h_b}$	$\frac{\tanh \theta\pi}{\theta\pi}$
0.142	0.072	233.951	0.98319
0.146	0.074	220.914	0.98222
0.150	0.076	208.905	0.98121
0.154	0.079	197.819	0.98018
0.158	0.081	187.565	0.97912
0.162	0.083	178.060	0.97803
0.166	0.085	169.234	0.97691
0.170	0.087	161.023	0.97576

In $\frac{H_b}{L_b}$ from 0.142 to 0.170, it is obtained the value of θ which is smal, as much as 0.072-0.087, with $\frac{\tanh \theta\pi}{\theta\pi}$ ranges

from 0.98319 to 0.97576 closer to 1. The value of $\frac{H_b}{h_b}$ obtained is very large not found in the results of previous studies. The large value is due to $\tanh \theta\pi \approx \theta\pi$.

According to (6), in small amplitude it applies $\theta\pi = kh$ thus $\frac{\tanh kh}{kh} \approx 1$, this is a shallow water long wave condition. From this condition it can be concluded that both Michell's (1894) and Toffoli et al's (2010) criteria are for long waves in shallow waters.

a.   Miche's Equation Study.

Miche (1944), create a breaker index equation connecting the two breaker indexes, that is

$$\frac{H_b}{L_b} = 0.142 \tanh\left(\frac{2\pi h_b}{L_b}\right) \qquad \text{......(14)}$$

The equation connects two breaker indexes of $\frac{H_b}{L_b}$ and $\frac{h_b}{L_b}$. By determining the value of $\frac{H_b}{L_b}$ thus the value of $\frac{h_b}{L_b}$ can be calculated. After that, by using the connectivity equation, $\frac{H_b}{h_b}$ can be calculated. The calculation results is shown in Table (4).

Table (4) Calculation of the breaker index using the Miche equation.

$\frac{H_b}{L_b}$	$\frac{h_b}{L_b}$	$\frac{H_b}{h_b}$
0.082	0.10483	0.78224
0.099	0.13716	0.72179
0.126	0.22428	0.5618
0,142	1.15351	0.12397

In Table (4) it can be seen that there is a match between $\frac{H_b}{h_b}$ and previous studies and in $\frac{H_b}{L_b}$ maximum which is 0.142. It was obtained that the match is in the values of $\frac{H_b}{L_b}$ and $\frac{h_b}{L_b}$ is very small, in which this is the condition of long wave in shallow water.

Then, the Miche's equation is modified to,

$$\frac{H_b}{L_b} = 0.637 \tanh\left(\frac{2\pi h_b}{L_b}\right) \qquad \text{.....(15)}$$

The calculation results where there are matches between $\frac{H_b}{h_b}$ and previous studies are presented in Table (5).

Table (5) Calculation of breaker index using (15).

$\frac{H_b}{L_b}$	$\frac{h_b}{L_b}$	$\frac{H_b}{h_b}$
0.636955	0.815732	0.780839
0.636980	0.880247	0.723638
0.636995	0.990467	0.643126
0.637000	1.153513	0.552226

Table (5) indicates that there is conformity with Table (2) in the value of $\frac{H_b}{L_b}$. $\frac{h_b}{L_b}$ and also $\frac{H_b}{h_b}$. Then Miche's equation can be modified into an equation for short waves by using $\frac{H_b}{L_b} \approx 0.637$ or in other words, $\frac{H_b}{L_b} \approx 0.637$ is according to Miche's equation.

X. CALCULATION RESULTS OF BREAKING PARAMETERS USING THE BREAKER INDEX

In section 9, it was obtained $\frac{H_b}{L_b} = 0.637$, $\frac{H_b}{h_b} = 0.715$, $\frac{h_b}{L_b} = 0.891$ and $\frac{H_b}{H_0} = 1.367$ in $\theta = 2.1$. An example of calculating the breaking parameter with the breaker indexes for several deep water wave heights H_0 is presented in Table (6).

Table (6) The calculation of parameters breaking

H_0 (m)	T (sec)	H_b (m)	L_b (m)	h_b (m)
1	4.61	1.37	2.15	1.91
1.5	5.65	2.05	3.22	2.87
2	6.53	2.73	4.3	3.83
2.5	7.3	3.42	5.37	4.78
3	7.99	4.1	6.44	5.74

Wave period in Table (6) is obtained from the relation of wave period with wave height (Hutahaean (2022)),

$$T = \sqrt{\frac{8\pi^2\left(\gamma_2+\frac{\gamma_3}{2}\right)^2\frac{H_0}{2}}{g}} \qquad \text{.....(16)}$$

To get an overview of the conditions resulting from the calculation of the breaker parameter with the breaker index equation obtained, we will review the breaker height from the previous breaker height equations.

The empirical breaker height index equation $\frac{H_b}{H_0}$ is quite a lot and can be divided into two groups, namely those that use the bottom slope as a parameter and those that do not use. In this study, the breaker depth index is used without a bottom slope as a parameter and or the bottom slope is given a value of zero. Researchers in this group include Komar and Gaughan (1972), Larson and Krauss (1989), Smith and Krauss (1990) and Gourlay (1992).

Komar and Gaughan (1972) :

$$\frac{H_b}{H_0} = 0.56 \left(\frac{H_0}{L_0}\right)^{-0.2} \qquad \text{......(17)}$$

Larson and Kraus (1989 :

$$\frac{H_b}{H_0} = 0.53 \left(\frac{H_0}{L_0}\right)^{-0.24} \qquad \text{......(18)}$$

Smith and Kraus (1990) :

$$\frac{H_b}{H_0} = (0.34 + 2.47\,m) \left(\frac{H_0}{L_0}\right)^{-0.30+0.88\,m} \qquad \text{.....(19)}$$

m is the bottom slope, this research uses $m = 0$

Gourlay (1992) : $\frac{H_b}{H_0} = 0.478 \left(\frac{H_0}{L_0}\right)^{-0.28}$ ....(20)

From these equations, the deep water wave length is calculated using the dispersion equations of linear wave theory, $L_0 = \frac{gT^2}{2\pi}$.

The breaker height calculation results using the empirical breaker height index equations are presented in Table (6).

Table (7) Breaker height from empirical equation.

H_0 (m)	T (sec)	$H_b(m)$			
		(17)	(18)	(19)	(20)
1	4.61	1.13	1.23	0.97	1.27
1.5	5.65	1.69	1.84	1.46	1.91
2	6.53	2.26	2.46	1.95	2.55
2.5	7.3	2.82	3.07	2.43	3.19
3	7.99	3.39	3.69	2.92	3.82

Note : (17), (18), (19), (20) are the equation code number.

Of the four breaker height index equations, (20) gives the largest and closest result to the breaker height in this study. Furthermore, the difference between the breaker height from this study and the breaker height from (20) was studied. The comparison results are presented in Table (8).

Table (8) Comparison between breaker height and Gourlay's breaker height

H_0 (m)	T (sec)	H_b (m)		δ (%)
		(13)	(20)	
1	4.61	1.37	1.27	7.24
1.5	5.65	2.05	1.91	7.24
2	6.53	2.73	2.55	7.24
2.5	7.3	3.42	3.19	7.24
3	7.99	4.1	3.82	7.24

Note : $\delta = \left|\frac{(13)-(20)}{(20)}\right| x100 \%$

In Table (8), the breaker height of the results of this study is greater than the breaker height of (20) with a constant difference of 7.24%. To bring the results (13) closer to (20), it can be done by reducing the value of θ, when $\theta = 0.35$, it is obtained $\delta = 0.44$ %, but if $\frac{H_b}{h_b} = 10.7$, it shows that the (20) is for long wave.

XI. CONCLUSION

The first conclusion from this study is that the Kinematic Free Surface Boundary Condition has breaking characteristics and the breaker index equation can be formulated. Meanwhile, in the wave number conservation equation there is a breaker index in the form of a ratio between breaker depth and breaker length. The breaker height equation can be obtained by substituting the breaker length index in the energy conservation equation. With this procedure the breaker index equations for short waves are obtained.

From the results of the connectivity test on the resulting breaker index equations, it was found that there is a link between the breaker indexes. This also gives the conclusion that there is interaction between breaking parameters that the value of one breaking parameter depends on the value of another breaking parameter.

Thus it can also be concluded that breaking wave research, both laboratory and analytical research cannot be done separately, it should be done simultaneously for all breaker indexes or all breaking parameters.

Determining the deep water depth affects the breaking parameters, especially the breaker depth. Therefore it is estimated that the difference between the breaker depth index results of previous studies is due to differences in the determination of deep water depth.

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Comparative study between the lean manufacturing versus the cleaner production

Estudo comparativo entre o lean manufacturing *versus* a produção mais limpa

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Abstract— *Cost reduction, making the most of resources, whether raw materials, machines or labor, are a great challenge for organizations and their managers, which occasionally in day-to-day life do not always have their full utilization. In addition to these, there are efforts to search for increasingly ecologically correct processes and products. Coming to common sense and delivering a quality product, on time and that generates the least amount of waste and impact on the environment is the current challenge. The article shows two systems, lean manufacturing and its tools to help reduce waste, and Cleaner Production, which seeks to optimize resources in favor of the lowest impact to be generated. In addition to these, it aims to show the benefits generated by them when applied correctly. The article was developed through qualitative research, with searches carried out for case studies and articles, through exploratory and bibliographical research. Lean Manufacturing aims to highlight and eliminate all waste, whether in the productive area or in the administrative area, Cleaner Production aims to identify the generation of impacts and highlight them in the search for the elimination of generation. As a result, there is a similarity between both methodologies, but with different focuses, one more structured with defined methodologies and analysis and implementation tools, the other with step-by-step implementation, but somewhat superficial.*

Resumo— *Redução de custos, aproveitar o máximo possível dos recursos, sejam eles matéria-prima, maquinas e mão-de-obra, são um grande desafio das organizações e seus gestores, o que ocasionalmente no dia-a-dia nem sempre têm seu aproveitamento por total. Além desses existem os esforços para a busca de processos e produtos cada vez mais ecologicamente corretos. Chegar ao senso comum e entregar um produto com qualidade, no tempo certo e que gere o mínimo de resíduos e impacto ao meio ambiente é o desafio nos momentos atuais. O artigo vem mostrar dois sistemas, lean manufacturing e suas ferramentas para auxiliar na redução de desperdícios, e Produção mais Limpa, que busca*

otimizar recursos em prol do menor impacto a ser gerado. Além desses tem como objetivo mostrar os benefícios por eles gerados quando aplicado de forma correta. O artigo foi desenvolvido através de pesquisas qualitativas, com buscas realizadas estudos de casos e artigos, através de pesquisa exploratória e bibliográfica. O Lean Manufacturing tem como objetivos evidenciar e eliminar todos os desperdícios sejam eles na área produtiva como também na administrativa, a Produção mais limpa têm como objetivo identificar a geração de impactos e evidencia-los na busca da eliminação da geração. Como resultados, se observa similaridade entre ambas as metodologias, porém com focos diferentes, uma mais estruturada com metodologias e ferramentas de análises e implementação definidas, já outra com passo-a-passo de implementação, porém algo superficial.

I. INTRODUÇÃO

Quando se obtêm altos volumes de produção, pedidos em abundância, pouco se preocupa com os desperdícios que estão ocorrendo ao longo do processo produtivo. Nesse cenário, a procura está maior que a oferta e então se pode praticar preços com margens de lucros maiores, e os pequenos problemas são absorvidos e desaparecem perante o grande volume produtivo, porém não deixam de serem custos (DENNIS, 2008; WOMACK; JONES; ROOS, 2004).

Entretanto, esses desperdícios ou pequenos problemas começam a ficar evidentes quando o mercado está em recessão e a concorrência mais acirrada. Notam-se os inúmeros problemas, mesmo que pequenos, sejam eles de informação, movimento, estoque, capacidade ociosa, processamento, espera, defeitos, que existiam anteriormente, porém devido ao grande volume e lucro não eram solucionados e aumentavam o custo final do produto (OHNO, 1997; DENNIS, 2008; LIKER, 2005).

Além dos aspectos mencionados, também é necessário pensar em um desenvolvimento sustentável e, para tal, é imprescindível adotar soluções inovadoras, com foco em desenvolver novos padrões de consumo, produção e exploração dos serviços ecossistêmicos. A busca por uma produção industrial sustentável leva ao uso mais eficiente dos recursos naturais, com menores impactos ao meio ambiente (Luiz & Junior 2014).

Empresas que não aplicam uma forma enxuta de produção e gestão para reduzir esses desperdícios, de modo a aumentar os lucros ou ganhar novos clientes com preços mais accessíveis, agora estão sofrendo com a recessão, pois não estão preparados para produzir sobre demanda real do cliente. Isso leva a uma produção sobre previsões, na qual a compra de matéria-prima, maquinários, entre outros, é feita de forma errada o que ocasiona custos elevados (OHNO, 1997; WOMACK; JONES; ROOS, 2004; LIKER, 2005).

As empresas precisam pensar na implementação de ideias voltadas para a gestão ambiental, buscando melhorias nos processos produtivos. Além disso, é muito importante envolver clientes e fornecedores no desenvolvimento de produtos e componentes menos poluentes (Miller et al., 2015).

Analisando o perfil atual das empresas notam-se desperdícios durante o processo produtivo, sejam eles em estoques, máquinas ou mão de obra parada, entre outros citados anteriormente.Além desses aspectos, observa-se o crescente problema voltado às questões ambientais e, desse modo, dentre as filosofias *Lean Manufacturing* e P+L as quais preconizam a redução dos desperdícios, como seria a integração entre elas a ser aplicada em busca dos melhores resultados tanto no âmbito de custos quanto no âmbito ambiental?

Este estudo tem por propósito realizar uma comparação entre as filosofias *Lean Manufacturing* e Produção mais Limpa, visando a integração das aplicações e dos benefícios de cada uma. De modo a alcançar o objetivo proposto foram identificados os objetivos do *Lean Manufacturing* e da Produção mais Limpa e a forma de abordagem dessas filosofias para essa integração.

II. REFERENCIAL TEÓRICO

2.1 *Lean Manufacturing*

Womack e Jones (2004) e (Staats et al. 2011) definem a manufatura enxuta como um processo de cinco passos: definir o valor do cliente, definir o fluxo de valor, fazê-lo "fluir", "puxar" a partir do cliente e lutar pela excelência. "O pensamento enxuto é uma forma de especificar valor, alinhar na melhor sequência de ações que criam valor, realizar essas atividades sem interrupção toda vez que alguém as solicita e realizá-la de forma cada vez mais eficaz" (WOMACK; JONES, 2004, p. 4).

Liker (2005) e (Browning & Heath 2009) descrevem que o Sistema Toyota de Produção é um sistema baseado em uma estrutura e não somente em um conjunto de técnicas e ferramentas. Essa estrutura foi representada na forma de uma casa, identificada na figura 1.

Fig.1: Estrutura do Sistema Toyota de Produção

Fonte: Adaptado de Liker (2005)

Iniciando pelo telhado, existem as metas de maior qualidade, custo menor e o prazo de entrega reduzido (*lead time*). As colunas representam o *Just in Time,* possivelmente a característica mais marcante do sistema, principal pilar do Sistema Toyota de Produção.O JIT é muito mais do que uma técnica ou ferramenta de administração da produção, é considerado uma completa filosofia que inclui aspectos de administração de materiais, gestão da qualidade, arranjo físico, projeto de produto, organização do trabalho, gestão de recursos humanos, entre outros (CORRÊA; CORRÊA, 2012; FERREIRA, 2004; SANTOS, 2014; SHINGO, 2000; Hicks, McGovern, Prior, & Smith, 2015).

O *Jidoka*, também conhecido por automação (automação com um toque humano), que significa nunca deixar um defeito passar para a próxima estação, garantindo a qualidade na fonte, dando a capacidade às máquinas identificarem anomalias no processo e dessa forma interrompê-lo, evitando a produção de peças defeituosas. Com isso o *Jidoka* possibilita liberar as pessoas das máquinas (YAMACHIKA, 2010).

No centro do sistema tem-se as pessoas, quem executam as atividades, sendo fundamental a estabilidade do clima dos colaboradores e que a filosofia da manufatura enxuta seja bem disseminada, compreendida e aceita por todos para que o resultado seja positivo. A cultura da melhoria contínua (*Kaizen*) ligada às pessoas é a alma do negócio para a evolução da empresa, melhorando gradualmente e constantemente, envolvendo tudo e todos (LIKER, 2005; IMAI, 1994; FERREIRA, 2004; CHIEVENATO; 2004).

Para Machado et al. (2013), o segredo para a implantação da manufatura enxuta é a transparência, pois dependemos das pessoas. O trabalho em equipe e pessoas comprometidas, que compreendam esta nova cultura, é fundamental para a utilização desta filosofia na empresa.

Por último, na base, funcionando como alicerce, existem diversos processos os quais são fundamentais para manter a estabilidade e sustentabilidade do sistema. O *Heijunka* significa o nivelamento da produção, tanto em volume como em variedade, o qual é importante tanto para manter a estabilidade do sistema quanto manter o mínimo de estoques (YAMACHIKA, 2010).

Outras importantes ferramentas formam a base do sistema, como o trabalho padronizado, uma vez que a padronização é aplicada na manufatura a fim de garantir a estabilidade nos processos, fazendo com que as atividades ocorram sempre na melhor sequência e utilizando do

melhor método possível, evitando ao máximo os desperdícios, conseguindo elevada qualidade e alta produtividade. É a base para a melhoria contínua, eliminando ainda mais desperdícios e encurtando cada vez mais o *lead time* (NISHIDA, 2007; LIKER, 2005; BERKMANN; LORENZONI, 2010; OHNO, 1997).

Por último tem-se o 5S, que consiste numa filosofia de trabalho visando a utilização do necessário, mantendo-se a ordem da empresa como um todo, através da limpeza e organização, identificando fatores que possam prejudicar a saúde, zelando pela manutenção do processo com autodisciplina e conduta adequada (LIKER, 2005; CARPINETTI, 2012; RODRIGUES, 2006; MARQUES, 1995; Del, La, Pérez-rave, Cortés-zapata, & Restrepo-rico, 2015).

A Casa Toyota só é forte se o telhado, os pilares e as fundações forem fortes, pois uma conexão fraca fragiliza todo o sistema. Cada elemento da casa é essencial por si só, mas mais importante é o modo como cada um dos elementos se inter-relacionam, fortalecendo uns aos outros, dando estabilidade e força ao STP (BARBOSA, 2012).

O STP não é apenas um conjunto de metodologias.Ele é um sistema sofisticado que contribui para o sucesso do todo, procurando estimular as pessoas a melhorarem os processos nos quais trabalham. (Liker, 2005).

O principal objetivo do STP é a redução do tempo entre o pedido do cliente e o momento da entrega do produto ou serviço para ele. Esta redução é obtida com o controle e eliminação dos desperdícios da produção, buscando melhores produtos com os menores custos (LUSTOSA et al., 2008; Macedo & Possamai, 2013).

A Toyota focou-se na redução dos desperdícios de produção, na redução do tempo de atravessamento (*lead time*) e na flexibilidade do processo produtivo para manter-se viva no mercado, e acabou por desenvolver uma nova filosofia de produção (Martin et al. 2014).

Olhando de maneira mais ampla, o STP é muito mais que somente reduzir o *lead time* e eliminar os desperdícios, é uma filosofia de produção, uma maneira enxuta de pensar e agir que deve ser aplicada a toda a empresa. O foco inicial continua nos processos produtivos, mas os princípios da filosofia são amplos e aplicam-se tanto na engenharia e administração, quantos aos serviços (LUSTOSA et al., 2008; Atkinson & Mukaetova-Ladinska, 2012).

Não é apenas uma técnica, é uma filosofia que representa a otimização dos recursos, melhoria da qualidade, aumento da produtividade e, consequentemente, menores custos de produção (WOMACK; JONES; ROOS, 2004; LaGanga, 2011).

A produção enxuta classifica os desperdícios em oito tipos, e sua total ou parcial eliminação pode gerar grandes ganhos para a organização. São eles: desperdício de processamento, espera, transporte, movimentação, defeitos, estoque, conhecimento sem ligação e superprodução (DENNIS, 2008; HINES; TAYLOR, 2000; MARQUES, 1995; Esmemr, Ceti, & Tuna, 2010).

O desperdício por processamento representa para a empresa a produção além do necessário, talvez para cumprir alguma meta, gerando estoque em excessoe maior utilização de embalagens. (DENNIS, 2008; MARQUES, 1995; BARBOSA, 2012).

Têm-se o desperdício por espera, que ocorre quando há operadores ou máquinas paradas, esperando por algum produto ou serviço. Essa espera implica diretamente no tempo em que o produto será enviado para o cliente, sendo assim aumentará o *lead-time* (DENNIS, 2008; MARQUES; MELLO, 2013; LIKER, 2004).

Os desperdícios por transporte equivalem à perda de tempo para carregar grandes lotes. Trabalhar em vazioe *layout* irregular também propiciam transportes desnecessários (ANTUNES et al., 2008; DENNIS, 2008; SLACK; CHAMBERS; JOHNSTON, 2009).

Têm-se também desperdícios por movimento, o qual é desenvolvido por pessoas e máquinas e sua eliminação pode trazer muitos ganhos para a empresa.Projetos ergonômicos inadequados fazem com que a produtividade seja afetada, além de contribuir para possíveis acidentes, e movimentos desnecessários em máquinas contribuem para altos tempos de ciclos, consequentemente sendo necessária a compra de novos equipamentos (CORRÊA; CORRÊA, 2012; DENNIS, 2008; SUZAKI, 2010).

Já os desperdícios por defeitos são para a empresa produtos produzidos que deverão sofrer retrabalhos (SLACK; CHAMBERS; JOHNSTON, 2009; SUZAKI, 2010).

Outro desperdício muito comum nas empresas é o estoque, que por sua vez representa dinheiro parado, e que ocorre em empresas que não produzem no ritmo do mercado (Demeter & Matyusz 2011).

O sétimo desperdício verifica o conhecimento sem ligação, que trata da falta de comunicação internamente e externamente, fazendo com que o fluxo de informações seja bloqueado e, assim, ideias, criatividade e oportunidades são perdidas (FERREIRA, 2004; MARQUES, 2005).

O oitavo e último, e um dos mais importantes, é o desperdício por superprodução, pois o mesmo influencia a geração de todos os outros sete desperdícios. Explica

Dennis apud Ohno (2008, p. 42): "Taiichi Ohno via a produção em excesso como a origem de todo o mal na área da manufatura. A produção em excesso significa produzir coisas que não serão vendidas".

Na sua produção em excesso, contraem-se vários desperdícios como, construção e manutenção de grandes depósitos, mais trabalhadores e máquinas, mais peças e materiais, mais energia, combustível, mais embalagens, pallets, empilhadeiras, e devido a esses excessos, os problemas acabam ficando escondidos por traz dessas "montanhas" de seguranças (CORRÊA; CORRÊA, 2012; DENNIS, 2008; LIKER, 2005; SUZAKI, 2010; OHNO, 1997).

Esses desperdícios geram estoques excessivos, mão-de-obra e máquina paradas, capacidade produtiva ociosa, entre outros.Dessa maneira, as ferramentas do sistema enxuto de produção ajudam a identificar e resolver esses desperdícios (ANAND e MOODY, 2003; LIKER, 2005; SUZAKI, 2010).

Empresas que implantam esse processo inovador apresentam uma gestão visual muito mais agradável e um sistema que procura aproveitar ao máximo a mãodeobra e recursos, apresentando um *layout* mais organizado, divididos por células e famílias de produtos e os operadores trabalham com uma quantidade padrão de estoque, o que requer menor movimentação (ANAND e MOODY, 2003).

O foco principal do STP é o envolvimento humano, buscando a participação deste como um membro da equipe, totalmente flexível e motivado, constantemente a procura de uma melhor forma de executar as tarefas. Aqui se têm os componentes que fazem a produção enxuta ganhar vida em face ao seu simples modelo de sistema produtivo. (Dennis, 2008).

2.2 Produção mais Limpa (P+L)

Desenvolvida pela *United Nations Industrial Development Organization* (UNIDO) e pela *United Nation Environmental Program* (UNEP) para nações em desenvolvimento, e no Brasil pela Rede Brasileira de P+L, a filosofia P+L visa uma estratégia ambiental preventiva e integrada (Domingos et al., 2012; Sousa, Herrera, Taroco, Belotti, & Miyabara, 2012; Ometto, Oliveira, Guardia, Cobra, & Oliveira, 2015).

Dentro do contexto atual, as empresas necessitam não somente pensar em melhorar seus produtos tornando-os mais baratos e com melhor qualidade, mas também otimizar processos em busca de melhores eficiências para reduzir o impacto ambiental dos mesmos sobre as atividades geradas na produção ou fora dela (Cesar,

Santos, Bruno, & Ufal, 2012; Farias, Medeiros, Freitas, & Engenharia, 2012; Ometto et al., 2015).

Nesse sentido, surge um conceito com foco estratégico na otimização de recursos, máquinas, matéria-prima e processos, em prol da prevenção da poluição, redução da geração de resíduos, reduzindo assim os riscos ambientais e trazendo benefícios econômicos para a empresa (Cesar et al., 2012; Ines, Bohm, & Salle, 2013).

Para tal existem os pilares da sustentabilidade, esses buscam o desenvolvimento sustentável na indústria manufatureira, e oferecem um custo-benefício nos desempenhos econômico, ambiental e social. (Ines et al., 2013). Conforme mostra a figura 02.

Fig.2: Pilares da sustentabilidade.

Fonte: Ines et al., 2013

Os princípios da P+L estão subdivididos em quatro: Eliminação dos resíduos, minimização da produção de resíduos, reciclagem dentro da empresa e reciclagem fora do processo produtivo. Esse conceito descreve um enfoque preventivo de gestão ambiental e uma nova mentalidade de redução dos impactos gerados (Farias et al., 2012; Miller, Ganga, Costa, Devós & Costa, 2015).

Um dos enfoques principais da P+L é a busca pela eliminação da geração dos resíduos. Nesse sentido, o processo seria 100% robusto no que tange a gestão ambiental, porém alcançar esse percentual é muito difícil, por isso se deve além da busca pela eliminação, trabalhar nos outros princípios (Pizzolato et al. 2012).

O segundo passo é a busca pela minimização da produção de resíduos, buscando alternativas para gerar o mínimo de resíduos e, se necessário, alterando o produto. "A mudança de produto é uma importante abordagem, entretanto só é recomendada quando as medidas mais simples tiverem sido esgotadas, mesmo que seja de difícil realização" (Araujo & Pimenta 2012).

Caso não seja possível a eliminação dos resíduos dos processos produtivos, utiliza-se o terceiro princípio, que é a reciclagem dentro da empresa, a qual tem por objetivo revalorizar o resíduo na forma de retorno de material reciclado (Santana & Silva 2014).

Se nos três primeiros passos não for possível sua inserção, o quarto e último deve ser considerado, que seria a reciclagem fora da empresa. Esta deve ser designada para uma empresa que fará o destino correto dos resíduos (Santana & Silva, 2014; Miller et al., 2015).

A P+L sugere desde novos processos a modificações nos produtos, buscando alcançar os seus princípios, os quais são norteados por níveis que vão em direção da máxima eficiência na redução à máxima eficiência na reutilização, conforme mostra a figura 03.
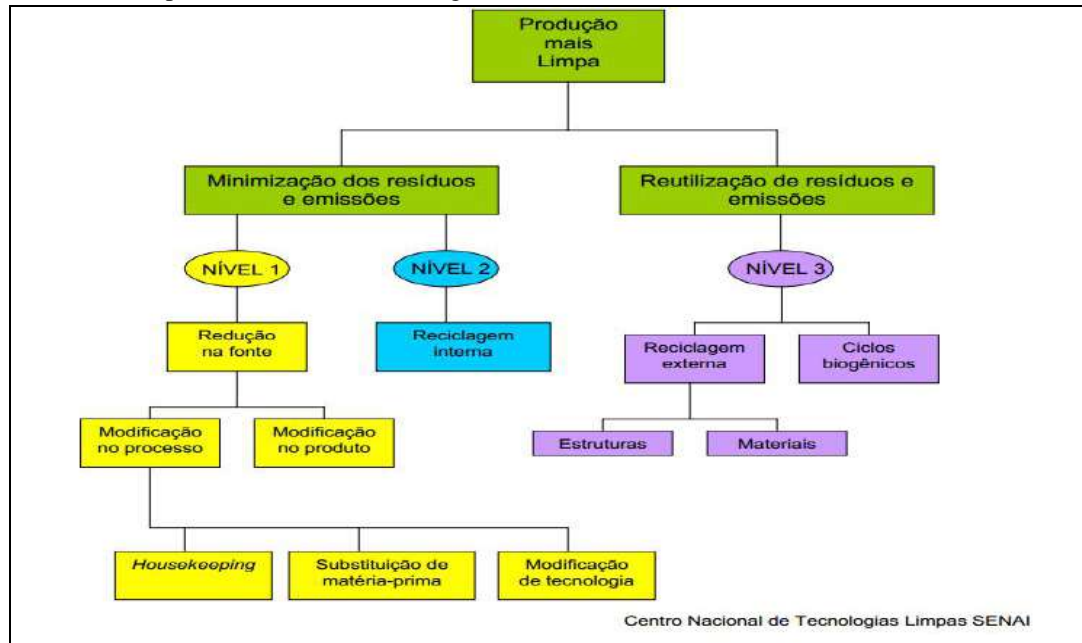
Fig.3: Estratégias da P+L.

Fonte: Pizzolato et al. 2012

Conforme a figura 3, pode-se perceber que o foco da Produção mais Limpa está no topo (à esquerda): evitar a geração de resíduos e emissões (nível 1). O que não pode ser evitado deve ser reintegrado ao processo de produção da empresa (nível 2). Não sendo possível a execução dos níveis 01 e 02, se faz necessário medidas de reciclagem fora das empresas (nível 3) (Pizzolato et al., 2012; Sousa, Herrera, Taroco, Belotti, & Miyabara, 2012; Araujo & Pimenta, 2012).

A produção mais Limpa pode ser implementada em todo e qualquer processo produtivo ou de serviços, atuando na melhoria ambiental das organizações. Essa melhoria pode representar para as empresas desde a redução da poluição, redução ou inexistência de multas e penalidades por emissão de poluição, melhores condições de saúde e segurança do trabalhador, valorização da imagem da empresa junto a consumidores, fornecedores, poder público, órgãos ambientais e comunidade (Sousa et al., 2012; Vicente & Filho, 2012; Dias, Ufrgs, Felipe, & Ufrgs, 2014).

A sua implementação requer o desenvolvimento de 5 fases, na qual cada uma desempenha papel importante no seu sucesso e continuidade (Ometto et al., 2015; Severino, Marques, Severino, & Neiva, 2014; Maia, Alvarenga, Battistelle, & Araujo, 2013; Miller et al., 2015; Huang, Luo, & Xia, 2013).

As cinco fases são:

- Planejamento e organização – Definem-se os passos e o comprometimento da gerência; definição de time; objetivos, metas e identificação das barreiras;

- Pré-avaliação – Elaboração do fluxograma do processo; entradas e saídas e determinação dos focos da avaliação de P+L;

- Avaliação – Levantamento do balanço de material; verificação das causas; identificação das melhorias e oportunidades de P+L;

- Estudo da viabilidade – Avaliação preliminar para avaliação técnica; avaliação econômica; avaliação ambiental; e seleção das potenciais oportunidades;

- Implementação e monitoramento – Execução do plano de P+L; implementação de oportunidades de P+L; monitoramento e avaliação; e sustentação das atividades de P+L.

Esse passo a passo auxilia na implementação e continuidade da aplicação do P+L dentro de processos que requerem a eliminação, minimização ou reciclagem da emissão de resíduos.

III.   METODOLOGIA

Por se tratar de *Lean Manufacturing e Produção mais Limpa*, os objetivos serão envoltos de pesquisa exploratória, pois envolverá levantamento bibliográfico(Gil, 2007, p. 41).

A Abordagem do problema será por meio de pesquisa qualitativa, uma vez que se propõem melhorias e é recomendada para tratar melhorar a efetividade de um programa, propor planos, atribuir metas e obter intervenções, a importância das variáveis qualitativas contribuem ao conhecimento ou na pesquisa com informação mais acurada (FERRARI,1974).

Serão utilizados estudos de casos para levantamento das informações e extração de dados, os estudos de casos possuem informações teóricas e práticas, conseguindo assim o confronto entre a revisão bibliográfica e a realidade. Para o estudo se utilizou diversos estudos de casos, pois a pesquisa têm por objetivo ultrapassar a unicidade, tornando assim o estudo mais completo e adequado a realizada. (Ometto et al. 2015).

Esta pesquisa baseou-se no estudo de 100 artigos sobre os temas, os quais foram extraídos da base de dados de Periódicos   sobre pesquisas de implementação ou estudo do Lean Manufacturing e Produção mais limpa.

A investigação tem por escopo identificar os principais objetivos e fazendo a comparação entre os resultados buscado com a implementação das duas metodologias: Lean Manufacturing e Produção mais Limpa. Abaixo tabela 01 com fluxo do método utilizado:

Tabela 01: Fluxo metodológico.

Nº	O que?	Como?
1	Tema e Objetivos	Delineamento do tema e objetivos
2	Revisão Bibliográfica	Revisão de literatura
3	Seleção dos artigos	Busca de artigos de 2012 a 2016 sobre os temas
4	Matriz de análise	Elaboração da matriz para pesquisa dos principais objetivos
5	Tabulação do dados	Levantamento dos objetivos por tema
6	Analise e discussões	Somatório dos totais e discussões
7	Conclusões finais	Coclusão sobre o tema obrdado

Fonte: Elaborado pelo autor, 2016

Com o levantamento dos dados foi possível encontrar seus principais atributos, palavras chaves, os objetivos de cada metodologia e o foco de suas aplicações. Além de gerar sugestões sobre os modelos do estudo.

IV.   RESULTADOS E DISCUSSÕES

Após levantamento bibliográfico foi possível elaborar síntese do estudo para o alcance dos objetivos. O primeiro ponto foi levantar quais os princípios de cada

filosofia para entender e delimitar o foco de cada atuação, conforme tabela abaixo:

Tabela 02: Princípios Lean e P+L.

Princípios do Lean Manufacturing	• Definir o valor para o cliente; • Definir o fluxo de valor; • Fazê-lo "fluir"; • Puxar a produção a partir do cliente;

	• Lutar pela excelência.
Princípios da Produção mais Limpa	• Eliminação dos resíduos; • Minimizar a produção de resíduos; • Reciclagem dentro da empresa; • Reciclagem fora do processo produtivo.

Fonte: Elaborado pelo autor, 2016

Assim se consegue perceber que o Lean possui um foco mais amplo, olhando de fora para dentro da empresa (Cliente-empresa), focando nos processos e fluxos. Já a P+L trabalha com foco mais específico, de dentro da empresa para fora (Empresa-cliente), ocupando-se dos produtos e resíduos.

Identificados os princípios, foram então levantadas as metas de cada foco de atuação, ou seja, onde pretende-se chegar aplicando o Lean Manufacturing ou a Produção mais Limpa.Por meio dessa análise, chegou-se às seguintes metas, conforme tabela 03.

Tabela 03: Metas Lean e P+L.

Metas do Lean Manufacturing	• Melhor qualidade; • Menor custo; • Menor tempo de entrega.
Metas da Produção mais Limpa	• Melhorar o desempenho econômico; • Melhorar o desempenho ambiental • Melhorar o desempenho social

Fonte: Elaborado pelo autor, 2016

Dentre as metas levantadas se consegue observar que o direcionamento do Lean está totalmente voltado a redução de custos dentro da empresa, trazendo assim vantagens competitivas para a empresa e os clientes. A P+L, por outro lado, além do econômico, também desenvolve as questões ambiental e social, buscando vantagens para empresa, cliente e sociedade onde atua, porém poderá haver custos adicionais para adquirir tal vantagem.

Observando os princípios e as metas, se conseguiu elaborar quais os principais problemas ou desperdícios atacados por ambas as metodologias, esses por sua vez são as formas ou tipos de dificuldades que

consomem recursos e não agregam valor.A tabela 04 traz a descrição dos mesmos.

Tabela 04: Desperdícios do Lean e P+L.

Desperdícios do Lean Manufacturing	• Processamento desnecessário; • Espera; • Transporte; • Movimentação; • Defeitos; • Estoque; • Conhecimento sem ligação; • Superprodução.
Desperdícios da Produção mais Limpa	• Não utilização correta de recursos (máquinas, matéria-prima e processos); • Poluição; • Geração de resíduos; • Riscos ambientais

Fonte: Elaborado pelo autor, 2016

Levantados os desperdícios se nota que o Lean está mais organizado no que tange a definição dos problemas. Outro ponto interessante é que ambas as metodologias têm um alinhamento nesse ponto, no que se refere a recursos (máquinas, matéria-prima e processos), tanto o Lean quanto a P+L buscam a otimização de recursos, uma em prol da redução de custo, outra para da melhora no desempenho econômico, ambiental e social.

Identificados os desperdícios, como esses aspectos são resolvidos em cada metodologia. Dessa forma, cada filosofia traz, alinhada com seus princípios e metas, as ferramentas para eliminar ou reduzir os problemas listados na Tabela 04. A tabela 05 descreve os mesmos.

Tabela 05: Ferramentas do Lean e P+L.

Ferramentas do Lean Manufacturing	• Estabilidade processo: Trabalho padronizado, 5'S, TPM, Troca rápida de ferramenta, Mapeamento do Fluxo de Valor; • JIT: Kanban, Fluxo contínuo, Supermercado. • Jidoka: Poka-yoke, Gestão

	• visual, atividade que agregam ou não valor;
	• Kaizen: Envolvimento humano, aplicação rápida das ações.
Ferramentas da Produção mais Limpa	• Evitar a geração de resíduos e emissões (nível 1).
	• O que não podem ser evitados devem ser reintegrados ao processo de produção da empresa (nível 2).
	• Não sendo possível a execução dos níveis 01 e 02, se faz necessário medidas de reciclagem fora da empresas (nível 3).

Fonte: Elaborado pelo autor, 2016

Nesse ponto encontra-se a disparidade entre as duas metodologias (Lean versus P+L).Pode-se observar que o Lean tem muito bem definidas as ferramentas que ajudam na implementação e na manutenção da implementação em busca de seus princípios e metas, onde aplicá-las, qual a sequência e quando.

Em contrapartida, a Produção mais Limpa elenca apenas um passo-a-passo de verificação, indicando a melhor sequência, mas o como não fica definido, nessa forma ela se define muito mais para um conceito do que uma metodologia de aplicação.

Apresentados os princípios, metas, desperdícios e ferramentas, procedeu-se ao estudo dos 100 artigos publicados nas bases de dados, 50 deles voltados a Produção mais Limpa e 50 deles voltados ao Lean Manufacturing, buscando entender o objeto principal do estudo através de suas palavras chave.Após o levantamento dos artigos foi possível identificar o foco de cada estudo.

Nota-se que os artigos voltados para o Lean apresentam grande tendência para seu próprio foco (41%), suas metodologias (26%) e produção (16%), o que representa 82% dos alvos dos estudos. Apenas 2% das palavras chave focavam em sustentabilidade ou meio ambiente, não houve nenhuma relação do Lean com a Produção mais Limpa, conforme mostra a tabela 06.

Tabela 06: Palavras chave artigos do Lean.

PALAVRAS CHAVE ARTIGO LEAN	
LEAN	41%
METODOLOGIAS	26%
PRODUÇÃO	16%
MELHORIA	6%
GESTÃO	5%
QUALIDADE	5%
SUSTENTABILIDADE	2%
PRODUÇÃO MAIS LIMPA	0%

Fonte: Elaborado pelo autor, 2016

Na sequência, procedeu-se ao estudo dos artigos voltados para a Produção mais Limpa. Da mesma forma nota-se que os artigos apresentam grande tendência para seu próprio foco (48,6%), um grande foco também voltado para o meio Ambiental (33,3%) e a parte de gestão também é citada com (9,5%), e que representam 91,4% dos alvos dos estudos. Apenas 4,8% das palavras chave focavam em lean manufacturing, produção e melhoria, houve apenas 1% de correlação com o lean nas palavras chave, abaixo tabela com resultados:

Tabela 07: Palavras chave artigos de P+L

PALAVRAS CHAVE ARTIGO P+L	
PRODUÇÃO MAIS LIMPA	48,6%
FOCO AMBIENTAL	33,3%
GESTÃO	9,5%
SUSTENTABILIDADE	2,9%
PRODUÇÃO	1,9%
MELHORIA	1,9%
LEAN	1,0%
QUALIDADE	1,0%
METODOLOGIAS	0,0%

Fonte: Elaborado pelo autor, 2016

Correlacionando ambas as tabelas, também se consegue observar a questão quanto ao uso de metodologias/ferramentas para a resolução dos problemas propostos nas pesquisas, nos artigos de Lean Manufacturing, em 26% das palavras chave continham alguma ferramenta que foi utilizada para buscar o resultado, já nos artigos de Produção mais limpa, nenhum buscou alguma ferramenta de auxilio, apenas 1% das palavras chave continha a correlação com o lean manufacturing.

Fica claro que as metas e desperdícios de ambos estão muito correlacionados, porém quando aplicados, existe uma lacuna entre o foco de cada filosofia. Entretanto, com a união de ambos, seria possível alcançar melhores

resultados, tanto no cunho econômico, quanto no ambiental e social, afinal, ambos deixam bem claro a importância na redução de desperdícios.

Nos estudos observou-se a fragilidade da Produção mais Limpa no que tange encontrar desperdícios

e ferramentas para tratar, eliminar ou reduzir os mesmos. Nesse sentido foi elaborado um quadro com as estratégias do P+L e os desperdícios do Lean mais quais ferramentas poderiam auxiliar nos seus objetivos, como mostra o Quadro 01.

Quadro 01: Estratégias da P+L

	Redução na fonte	**Reciclagem interna**	**Reciclagem externa e ciclos biogênicos**
DESPEDÍCIOS P+L	Poluição	Poluição	Poluição
	Geração de resíduos	Geração de resíduos	Geração de resíduos
	Riscos ambientais	Riscos ambientais	Riscos ambientais
DESPEDÍCIOS LEAN	Processamento desnecessário	Processamento desnecessário	Processamento desnecessário
	Transporte	Transporte	Transporte
	Defeitos	Defeitos	Defeitos
	Estoque	Estoque	Estoque
	Conhecimento sem ligação	Conhecimento sem ligação	Conhecimento sem ligação
	Superprodução	Superprodução	Superprodução
FERRAMENTAS			
	5'S	Kanban	MFV
	TP	JIT	KAIZEN
	TPM	poka-yoke	Gestão visual

Fonte: Adaptado pelo autor, 2016

O objetivo é com esse novo modelo de estratégia, buscar encontrar além dos três desperdícios da P+L com os seis desperdícios do Lean. Utilizando as ferramentas do lean como base metodológica para encontrar, resolver e sustentar.

Como também se observou nos estudos, as aplicações do Lean Manufacturing têm havia muito pouco foco em sustentabilidade e meio ambiente. Levando em consideração que cada vez mais os clientes estão buscando empresas ecologicamente corretas, sugere-se adicionar aos princípios ou metas do Lean Manufacturing a minimização dos resíduos e emissões e incluir nos seus oito desperdícios a poluição, geração de resíduos e riscos ambientais.

Dessa forma, ambas as filosofias estariam mais bem estruturadas, sendo que o P+L teria uma visão mais aprimorada e ferramentas de resolução e o Lean Manufacturing aumentaria seu foco de atuação buscando não somente a redução de custos, mais a sustentabilidade ambiental e social.

V. CONSIDERAÇÕES FINAIS

O objetivo deste estudo foi o de realizar uma comparação entre as filosofias *Lean Manufacturing* e Produção mais Limpa, de forma a integrar as aplicações e os benefícios de cada uma.

Por meio da comparação das filosofias, foi possível compreender melhor o enfoque de cada uma e os resultados buscados, o que permitiu observar uma similaridade entre alguns objetivos e desperdícios. Foi possível concluir que, trabalhando-se as filosofias de forma conjunta, acredita-se que os resultados podem e devem ser melhores do que de forma isolada.

Quando elaborou-se a relação entre os objetivos da P+L com os desperdícios do *Lean* e suas ferramentas, foi possível verificar novas oportunidade de aplicação da P+L em empresas de diversos ramos de atuação, concomitantemente à aplicação do *Lean*.

Sugeriu-se, também, adicionar um novo objetivo ou meta no "telhado" do modelo do STP , gerando assim um foco não só econômico mas também sustentável e social. Além disso, poderia-se adicionar mais três tipos de desperdícios, esses com foco voltado para as questões ambientais.

Como sugestão de estudo para os próximos trabalhos, seria relevante realizar a comparação entre uma aplicação de P+L e a aplicação envolvendo os desperdícios e ferramentas do *Lean*, assim como também a aplicação do *Lean* com foco tradicional e com o foco no quarto objetivo, sustentabilidade e social.

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Toner Technology Route: A Case Study

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Abstract— The unbridled increase in the generation of solid waste, especially electronic waste, due to its dangerousness, has been worrying the world. The Judiciary, based on shared responsibility, has already been promoting some sustainable practices to improve the environment and society as a whole. The aim of this study is to contribute, with possible improvements in the Solid Waste Technological Route (Toners) in the Thomaz aquino Forum, an integral unit of the Judiciary of the State of Pernambuco, Brazil, located in the central area of the city of Recife. The methodology was carried out through a bibliographic survey, including qualitative and quantitative research, by data collection, through questionnaires, about the management of the Toner Technological Route of 14 offices, located in the Thomaz Aquino Forum, in order to propose more effective adjustments and adjustments, in addition to expanding information on the importance of knowledge and participation of all in sustainable actions. The study is relevant, given the importance of adequate solid waste management, which make it possible to contribute effectively to the protection of the environment in order to avoid or minimize environmental and institutional degradation, to provide subsidies to propose new actions in updating the next Sustainable Logistics Plan (PLS), in order to achieve its goals and objectives. It was concluded that the Court, although it works positively in the realization of sustainable practices, still demonstrates fragility of some measures from the simplest measures such as information and guidance to the effective improvements, especially in the management of electronic waste and its technological routes.

I. INTRODUCTION

In the context of the Third Industrial Revolution, in the mid-twentieth century, society began to experience the development of new products at a faster pace. The possibility of creating more in less times and with fewer human resources - due to technological advances and the consequent automation of processes, generated a relevant impact on the business strategy of large companies and various sectors of the economy.

To increase the revenues of companies, it is noticeable the tendency to reduce the durability of certain industrialized products and the consequent need to replace them more frequently, due to the launch of virtual products, such as software and applications, because it forces the exchange of physical products (hardware) because the old models can not run this new tool. The waste strategy, based on the programmed obsolescence of products (industrial and virtual) has been further leveraged by globalization and technological progress. (ROSSINE, 2017).

Despite being something beneficial for the movement of the economy, this strategy has been harmful to the environment and human health by generating an accumulation of waste, especially of electronic equipment, which contain dangerous substances.

The risk to human health lies mainly through the handling of printer toners, which are one of the most contaminating WEEs, due to the components of the equipment's own housing, composed of plastic, resin and pigments. In addition, the smoke powder contains heavy metals, among them: cadmium, gold, copper, mercury, lead, beryllium, carbon with polymers metal oxides such as manganese and some salts (DOMINGUES, et al., 2016).

It is necessary to turn to the source of production with the knowledge that capital cannot supplant the reality of the destruction of natural resources (FRÁGUAS, 2019).

In Brazil, more than a decade ago, Law 12,305 of 2010 instituted the National Solid Waste Policy (PNRS). However, the absolute volume of waste continued to grow in the following years. According to data from the Solid Waste Overview in Brazil 2020, generation went from 66.7 million tons in 2010 to 79.1 million in 2019, a difference of 12.4 million tons. The same study also says that each Brazilian produces, on average, 379.2 kg per day (BRASIL, 2021).

The National Solid Waste Policy (PNRS) deals with shared responsibility for the product life cycle, reverse logistics, encouraging the creation and development of cooperatives or other forms of association of waste pickers of reusable and recyclable materials. According to the Brazilian Institute of the Environment (IBAMA), states and municipalities can use PNRS instruments to organize reverse logistics chains with less coverage. In such cases, they may expand, but not slow down, the environmental protection measures signed in the sectoral agreements and terms of commitment with greater geographical scope (BRASIL, 2010).

According to IBAMA, the legal entity is obliged to develop hazardous waste management plans, for the identification of technical responsible duly qualified for the preparation, implementation, and monitoring of all stages of the management plan, including control of the final disposal environmentally appropriate to tailings (BRASIL, 2022).

The research is justified by seeking to understand the current waste management system of the Court of Justice of Pernambuco (TJPE), a state agency that updated its Sustainable Logistics Plan (PLS) for the financial year 2021 (PERNAMBUCO, 2016), in order to monitor the achievement of the goals and objectives established by the National Council of Justice (CNJ), where the theme solid waste management, is among the indicators aimed at

rationalizing public spending and reducing its effects on the environment (PERNAMBUCO, 2020). Article 3 of the Resolution of the CNJ deals in its item I, shared responsibility, sustainability actions, and says that this institutional practice should promote ethical behaviors that contribute to the environmental, social, cultural, economic development, as the purpose of improving, simultaneously, the environment and the quality of life of the staff and auxiliary of the judiciary, as well as the local community and society.

Focusing on the objective of this research, the following question arises: does the staff know about the Sustainability Policy within the judiciary? And the managers of each unit, are performing their role adequately to the PNRS and the goals and objectives established in the PLS of the TJPE?

In this same resolution, also in Art. 3, item IV, item IV, item iv, it embodies shared contracts: joint acquisition of goods and services that generate less environmental impact, greater social inclusion, consider the cultural dimension of sustainability and economic efficiency, as a scale gain, carried out by public organizations from different sectors or between units of the same public organization, sustainable production and consumption in the country.

II. METHODOLOGY

The study was carried out in 14 (fourteen) offices of judges, which operate on the 6 (six) floors, of the Thomaz Aquino Forum, considering that there are a total of 23 offices on site, the study conducted a random sample, directed to gabineetes of better accessibility, convenience, in addition to excluding those who are not with full activities, this fact occurs when the incumbent judges are appointed to be the Board of Directors, that is, when they move away to occupy positions of President, Vice-Presidents, Corregedor and Vice-Corregedor or removed by other administrative circumstances.

The said organ is located on Av. Martins de Barros, 593, santo antônio neighborhood, in the city of Recife, capital of the state of Pernambuco, in the central region of Recife.

The city of Recife is in the northeast region of Brazil, bathed by the Atlantic Ocean. The capital of Pernambuco is inserted in the Atlantic Forest Biome, the most threatened forest in Brazil, with only 12.5% of the original area preserved. Recife is the third capital of Brazil with the highest percentage of natural vegetation, according to a study by the SOS Mata Atlântica Foundation and the National Institute of Space Research (INPE).

According to Cheng et al. (2014), the contamination of the biome occurs due to the significant presence of toxic substances present in electronic waste, as is the case of

Toners, the object of the present study.

The exploratory slap was initiated by bibliographical research, pertinent to the theme, where it was possible to deepen knowledge for a better analysis, from previous studies, International Agreements, Federal Constitution of 1988, infraconstitutional legislation - such as the National Solid Waste Policy, instituted by Law 12.305/2010 - to Institutional Policies, such as resolution 400/2021 of the CNJ and the current Sustainable Logistics Plan PLS/TJPE 2020/2021.

In a second moment, a descriptive, quali-quantitative survey was conducted, whose survey was using the survey method.

A survey is defined as a research technique that uses the "direct interrogation of people whose behavior you want to know" (GIL, 2008, p.55).

In the case study, the researcher usually uses a variety of data collected at different times, through various sources of information. Its fundamental research techniques are observation and interview. It produces reports that present a more informal, narrative style, illustrated with quotations, examples and descriptions provided by the subjects, and can also use photos, drawings, collages or any other type of material that helps you in the transmission of the case (FABÍOLLA, 2007).

In exploratory stage 2, questionnaires were applied, with the same questions to all interviewees, the questions were opened and closed, directed to each person responsible for the Technological Route of the (Toners), for two weeks in a row, where the researcher went to the field and questioned each of the responsible in each office, in addition to the managers of the sectors involved in the route until its destination.

In addition to the interviews, photographic records were made on site, the printers, and Toners, as well as the packaging where the toners are transported and the material request form, a document by which the input and output of the toners is recorded.

In the last stages, already with the data collected, with the help of Microsoft's Excel program, it was possible to build the graphs, flowcharts, and tables, for a better visualization, understanding and discussion about the results on the management of the WEEe of the Technological Route, in the 14 Offices of the Thomaz Aquino Forum, units that are part of the Judiciary of the State of Pernambuco.

III. RESULTS AND DISCUSSION

The study made it possible to evaluate several aspects involving the Technological Route of the Thomaz Aquino Forum, such as the finding that no research had been conducted in this forum in this sense, it was also possible to verify that the institution makes use of the same model of printers. Andeach of the 14 offices visited, were found between 3 to 6 equipment.

Andin relation to the quantity of toners used in the period of 1 year, the result was a total of 41, ranging from 1 to 6 units in each cabinet. The research found that such variation occurs because, in some cabinets, Toners are ordered in a larger amount than necessary, because the surplus is as reserve stock, while other cabinets require toners in the exact amount to replace what was used.

Another factor that contributed to the reduction in the consumption of Toners, has a direct connection with the volume of decisions in the offices, considering that most of them come from the PJE - Electronic Judicial Process, that is, where there is no printingof documents. In this case, decisions, orders, among other expedients, are sent by the system itself, without the need for printing.

An event that also reflected in the reduction of the generation of REE studied, was the Covid-19 Pandemic, when there was a long period of remote work or home office model.

When64% of the interviewees answered that, when they were dangerous, 36% of the interviewees answered that they knew it was dangerous waste, and 36% of the interviewees answered that they did not know about the possible dangers. It was also observed that during the handling of the cartridges, the employees do not make use of PPEs.

As for thetoners' technological route, they are sent tothe supply sector and when they receive the new Toners, they also forward, by request form, to the offices. On the other hand, the head of the supply sector, when asked about the route and destination of the toners, replied that the institution already states, in contract, that the manufacturer is responsible for the proper collection and disposal of toners, that is, there is the recent adoption of the reverse logistics practice.

In a research to the Sustainable Logistics Plan, it was confirmed that the disposal of waste from the printing supply is based on logistics agreements formalized between the TJPE and representatives of the manufacturers of cartridges/Toners used by the agency and proved successful with regard to the correct destination. In 2021, the institution registered a collection of 1,272 unusable units.

Itis possible to show that there is no standardization in the TonerS Technological Route held at the Thomaz Aquino Forum, because there are currently two Exit Routes: nthe first, the Toners leave the offices, go to the Administration of the Forum and this is responsible for continuing the route,

forwarding them to the Supply Sector, intended for suppliers. The second route, practiced in 50% of the offices, makes a shorter path, since the Toners are sent directly to the Supply sector, without going through the Forum Administration.

Although the study noted the lack of standardization in the Technological Route, this fact does not lead to the conclusion of poor waste management, however, it is important to realign the Technological Routes so that there is better future planning.

Similar studies, when compared with the results found in the present study, state that the identification of technological routes in analysis of management models makes the system simpler and the assembly of strategies to be studied in decision-making process. It is therefore a path of solutions that involves several dimensions, explores diverse and relevant techniques. (PIMENTEL, 2017)

On reverse logistics, an action already practiced by the TJPE, an integral part of the technological route studied, the case study of (ASSIS, et al, 2015) says that reverse logistics is a tool that aims to revalue everything that is discarded, thus making an ally for sustainability and found that there is still a lot of resistance, both by companies, as for the generating agents, who are generally uneducated and aware of the problems caused by the incorrect disposal of these materials and highlighted the importance of a model to be followed, such as that developed by the Center for Disposal and Reuse of Computer Waste (CEDIR). The model provides for how it is possible to perform the treatment and ensure the sustainable destination of electronic waste and its components.

Also on Reverse Logistics, considering that the present study found that in the 14 Offices, all printers are of the same brand and that the supply sector reported that the manufacturer itself is responsible for reverse logistics, a similar study conducted by (SILVA, 2018) at the Federal University of Paraíba - UFPB, found that manufacturers of toners of brands such as HP, LEXMARK, XEROX and SAMSUNG, through the reverse logistics process, outsource companies for environmentally correct final collection and destination.

The same study also affirms the importance of better disseminating information about the appropriate place of disposal of this type of waste to the academic community, in addition to an awareness to employees and teachers, through environmental education and alert ing about risks to health and the environment, in case of destination and incorrect disposal.

IV.   CONCLUSION

The research analyzed the structure of the current technological route of toner residues generated in the 14 offices of Judges of the Thomaz Aquino Forum and with the results obtained it was possible to corroborate the importance of adequate waste management, especially of the hazardous waste of toners.

The adoption of Reverse Logistics was a recent measure, implemented in the last update of the PLS, however, it was possible to notice that there is a lack of alignment between the various sectors involved in waste management, especially at the study site, regarding the pattern to be followed. Even in one of the answers, the guardians stated that they did not receive any type of guidance or determination to be followed, a relevant fact to be analyzed in the future strategic planning, which demonstrates the feasibility of effecting one of the objectives proposed in the present study.

It is important to point out that the concern around sustainable practices should go beyond goals and institutional duty, a fact that is also noted in the institutional reports, which demonstrates the need for a more preventive action-oriented approach, to avoid both environmental degradation and possible damage to human health.

From this diagnosis on the current Technological Route of Toners in the Thomaz Aquino Forum, it will be possible to subsidize managers in decision-making, when implementing and updating the Sustainable Logistics Plan of the TJPE - 2022/2023, as well as serving as parameters for other public or private bodies, as well as references for future studies of other researchers, including in the same institution.

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Influence of Oncoproteins E6 and E7 of high-risk Human Papilloma Virus on Breast Cancer

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Abstract— Breast cancer is the most frequent neoplasm in the world, and its causes are multifactorial. Some risk factors are already well established, and others are still being studied, such as infections with certain agents, like the human papillomavirus (HPV). This study aimed to carry out a literature review about the association between breast cancer and HPV, aiming to analyze the role of their E6 and E7 oncoproteins, using PUBMED and LILACS databases for the research. Of the 41 articles included in the study, 30 endorse the association of HPV with breast cancer, of these, only eight with statistically significant values. This study found HPV 16 as the genotype with the highest detection rate and ductal carcinoma as the histological pattern with the highest frequency. Formalin-fixed and paraffin-embedded tissue (FFPE) was the most studied type of sample storage and preservation, and polymerase chain reaction (PCR) was the most used detection method. The virus genetic material was found integrated into the host cell genome in most of the samples. Given the findings, it was concluded that HPV can have a great influence on breast carcinogenesis, however, studies involving the carcinogenic pathways of HPV, and morphological and molecular patterns should be carried out involving a larger sample.

I. INTRODUCTION

Breast cancer has the greatest incidence in the world, among all the types of cancer, with approximately 2.3 million new cases per year, representing 11.7% of new cancer diagnoses worldwide[1]. It is also the most frequent cancer in women, corresponding to 24.2% of neoplasms in this group[2]. It is one of the main causes of cancer deaths in women in both developed and developing countries[3].

Breast cancer has multifactorial causes. Female gender, early menarche, late menopause [4], aging, family history of breast cancer, nulliparity, first pregnancy after the age of 30, high breast tissue density, excessive alcohol consumption, physical inactivity, overweight, exposure to ionizing radiation[5], use of hormonal contraceptives, post-menopausal hormone therapy, smoking[6], breast cancer gene 1 and 2 (BRCA1 and BRCA2) mutations, and ovarian

cancer in the family[2] are among the most well-established risk factors.

Age over 50 years is considered the most important risk factor[2]. The incidence increases with age, doubling the risk every 10 years until menopause[7]. Other factors, however, may be associated with a lower risk of developing this cancer, such as breastfeeding, adequate physical activity, a regular healthy diet, normal body weight[5], and early pregnancy[4].

In addition to the well-established risk factors for breast cancer, infectious agents may represent a new factor that plays a key role as carcinogens or cancer promoters [3]. Several viruses have been documented to have oncogenic potential, including mouse mammary tumor virus (MMTV); bovine leukemia virus (BLV); Epstein-Barr virus (EBV), also known as human herpes virus type 4; and human papillomavirus (HPV)[4].

HPV DNA has already been found in breast tumors in several studies involving several countries [8–11]. In addition to the genome, koilocytes, and oncoproteins E6 and E7 were also found in breast cancer [4].

The evidence on the role of HPV in breast cancer is substantial, but not conclusive [4]. This study aims to gather information about the possible etiological association of HPV and its E6 and E7 oncoproteins in breast carcinogenesis.

1.1 BREAST CANCER

There are more than 20 different histological patterns of this disease, with about 80% being represented by ductal carcinoma[5]. Other frequent carcinoma subtypes are lobular, tubular, mucinous, medullary, micropapillary, papillary, and cribriform[5,12]. They can be further categorized according to the degree of infiltration in the breast tissue, in situ or invasive; and subclassified by the degree of tissue differentiation based on the level of nuclear pleomorphism, the mitotic index, and glandular and tubular formation, in well-differentiated (grade 1), moderately differentiated (grade 2) and poorly differentiated (grade 3)[12].

Molecular classification, on the other hand, better assesses the risk of tumor recurrence and progression, allowing the selection of the best therapy and estimating the final prognosis[12]. The most widely used markers, especially in patients with invasive carcinoma, are estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor type 2 (HER2), and the mutation in the p53 tumor suppressor gene[12].

There are currently four known classical molecular patterns: Luminal A, the most common, corresponding to about 40% of cases, represented by positive ER and/or PR, negative HER2, and low proliferation rate (reduced Ki67); Luminal B, the second most frequent, with 20% of the neoplasms, characterized by positive ER and/or PR, HER2 negative and high Ki67; Overexpression of HER2, corresponding for 10-15% of tumors and characterized by positive and overexpressed HER2, and ER and PR generally negative; Basaloid, representing 15-20% of carcinomas, also known as triple negative (TN), that is, ER, PR and HER2 negative, with a lower survival rate (TABLE 1). Other patterns still mentioned are the Breast-normal simile and Claudin-low, corresponding to 12-14% of cancers [12,13].

Table 1. Classical molecular patterns of breast cancer

MOLECULAR PATTERNS	FREQUENCY	ER	PR	HER2	Ki67
Luminal A	40%	+	+	-	< 20%
Luminal B	20%	+	+	-	> 20%
Overexpression of HER2	10-15%	-	-	+	
Basaloid	15-20%	-	-	-	

ER = estrogen receptor; PR = progesterone receptor; HER2 = human epidermal growth fator type 2

1.2 HUMAN PAPILLOMAVIRUS - HPV

The Papilloma Virus (PV) is a virus formed by a small double strand of circular, encapsulated DNA, composed of eight genes [14]. It has a tropism for cutaneous or mucocutaneous epithelium and uses the host's enzymatic mechanism to replicate its genome[15]. The Human Papillomavirus (HPV) comprehends a total of 40 different viral genotypes that are infections in humans, although several others animals species, such as birds, reptiles, marsupials, and other mammals are also infected by PV [14,15].

The HPV genome measures eight kilobases (kb) in length and is formed by eight open reading frames (ORF)[6]. It is divided into three segments: long control

region (LCR), early region (E), and late region (L)[3]. The LCR region represents 10% of the genome and regulates E6 and E7 transcription; E is formed by six genes, known as E1, E2, E4, E5, E6, and E7, responsible for encoding proteins involved in viral replication, transcription, and transformation; and L encodes the structural proteins, L1 and L2[3,6].

There are approximately 200 HPV subtypes listed [16]. An HPV is classified into a new lineage when its nucleotide sequence in the L1 ORF gene differs by at least 10% from any other type already characterized [14,15].

The alphapapillomavirus genus (alpha HPV) is detected in the mucosal epithelium and is related to the development of benign and malignant diseases, such as cervical, anal, and head and neck cancer[15].

HPV can be subdivided into high-risk (hr HPV) or low-risk (lr HPV), depending on its propensity to develop malignant lesions[6].

In cervical cancer, the most oncogenic subtypes, hr HPV, are alpha groups 5, 6, 7, and 9, responsible for about 90% of all cervical neoplasms in the world. The most common sublines in this cancer are: alpha 9 – HPV 16, 31, 33, 35, 52, 58 and 67; alpha 7 – HPV 18, 39, 45, 59, 68, 70, 85 and 97, and alpha 10 – HPV 6 and 11. Among all the sublines, HPV 16 is the most involved with cervical cancer[15].

The natural course of cervical cancer development involves an initial sexual exposure to an oncogenic HPV, followed by the persistence of the virus and the development of a precursor intraepithelial lesion, subsequently evolving to an invasive lesion[15].

HPV in cervical cancer infects cells of the basal layer of the stratified squamous epithelium, through microcracks, and these cells, when generating mitosis, synthesize new viruses and produce daughter cells that can undergo modifications. The infected basal cell becomes a reservoir of infection, with the viral genome maintained at low copy numbers in the episomal form. After the virus accesses the cell, it integrates into the host genome and makes use of the cellular mechanisms of the host to replicate, causing high levels of copies in the upper layers of the epithelium. In this integration, the virus may lose part of its E2 gene, leading to deregulated expression of E6 and E7 proteins, which inhibit tumor suppressor proteins, such as p53 and retinoblastoma protein (pRB)[6].

E6 and E7 oncoproteins act as stimulators of host cell proliferation. E6 is an antagonist of the p53 and BCL2 gene (B-Cell Leukemia/Lymphoma 2), increasing chromosomal instability and cellular resistance to apoptosis; and E7 interacts with pRB releasing a transcription factor, called E2F, which promotes cell proliferation. E7 also upregulates

S-phase genes and cyclin A and E, however, it also inhibits cyclin-dependent kinase inhibitors, such as WAF1 and kinesin-like protein (KIP 1), known as p21 and p27. The E6 and E7 proteins also interact with the BRCA1 and BRCA2 genes, antagonizing their functions, which prevent the development of tumors, by repairing DNA damage[3].

In addition to the association of HPV infection with cervical cancer, other tumors have also shown this relationship, such as anal canal and head and neck neoplasms, however, the involvement with breast lesions remains controversial[17].

1.3 HPV AND BREAST CANCER

Because Band, in 1991[18], identified that HPV 16 and 18 can immortalize mammary epithelial cells by inhibiting apoptosis, the detection of HPV in adenocarcinomas was observed in several tissue sites, alerting to the possibility that it is involved in the pathogenesis of some types of breast carcinomas[8,17,19].

The first time that HPV was observed in a breast tumor was in 1992, by Di Lonardo[20], when HPV 16 DNA was identified in 29.4% of malignant breast tissues embedded in paraffin using the technique of Polymerase Chain Reaction(PCR) with specific primers for HPV 11, 16 and 18[17].

The prevalence of HPV is significantly higher in breast cancer tissues compared to normal and benign breast tissues. Hr-HPV is four times more prevalent in breast tumors when compared to patients without cancer, and its infection is associated with an increased risk of developing this cancer by about 5.4 times. Hr-HPV was also identified in benign breast tissues, a finding that was associated with the emergence of HPV-positive breast cancer between 1 and 11 years later[4].

The prevalence of HPV positivity in breast cancer, as well as the HPV subtypes, varies greatly between countries and even between regions within the same country. For example, the rates of hr HPV associated with breast cancer in some Chinese Provinces are around 0-2%, while in North America is 86%[4].

II. METHODOLOGY

This study consists of an analytical literature review about the association between breast cancer and the HPV virus, aiming to analyze the role of the viral E6 and E7 oncoproteins.

Data collection was carried out from April 1st to April 30th, 2021, using the National Library of Medicine (PUBMED), Science Direct and Latin American and

Caribbean Literature on Health Sciences (LILACS) databases for the research.

Articles published in the last 10 years (between 2011 and 2021), were included. The descriptors "breast cancer", "HPV", "E6 and/or E7", their combinations and variants in English were used, with publications in Portuguese and English were sought.

As exclusion criteria, articles with an impact factor lower than 0.8 were removed from the study.

As a result, 41 articles were selected that fit the inclusion criteria and descriptors analyzed. After this selection, the following steps were followed: exploratory reading,

selective reading and choice of material that fit the objectives and theme of this study, analytical reading and text analysis, and interpretive reading and writing.

III.   RESULTS AND DISCUSSION

3.1 PERCENTAGES OF FREQUENCY OF HPV IN BREAST CANCER

Eight articles advocate for the association of HPV with breast cancer, with a detection of the virus in carcinoma tissues ranging from 7.5% to 95.5%, with statistical significance (TABLE 2)[3,8–10,21–24].

Table 2: Studies confirming the presence of HPV DNA in breast cancer samples (P value < 0.05).

Author/year	Tissue preservation	Detection means (primers)	Result	P value
Sigaroodi et al.,2012	FFPE	PCR (GP5+/GP6+, CP, and FAP)	15/79 (25.9%)	0,019
Piana et al., 2014	FFPE	PCR (SPF10)	6/80 (7.5%)	0,026
Fu et al., 2015	FFPE	PCR and ISH (HPV58 E7)	PCR: 25/169 (14.8%) ISH: 17/169 (10.06%)	PCR: 0.001 ISH: 0.008
Delgado-Garcia et al., 2017	FFPE	PCR (GP5+/GP6+), CLART, and DIRECT FLOW CHIP	130/251 (51.8%)	<0,001
Islam et al., 2017	Fresh frozen	PCR (MY09/MY11, LCR, and HPV16 E6-E7)	Pre-therapeutic = 174/272 (63.9%) After treatment w/ chemotherapy = 29/41 (71%)	0.001
Afshar et al., 2018	FFPE	RT-PCR (MY09/MY11)	8/98 (8.2%)	0,051
Cavalcante et al., 2018	FFPE	PCR (MY09/MY11, GP5+/GP6+) mPCR (E6 and E7)	51/103 (49.5%)	<0,0001
Khodabandehlou et al., 2019	Liquid nitrogen (-80ºC)	PCR (L1 and E7)	35/72 (48.6%)	0,003

bp= base pairs, FFPE = formalin-fixed and paraffin-embedded tissue, PCR= Polymerase chain reaction, ISH = in situ hybridization, LCR = long control region, RT-PCR = Real-time PCR

GP5+/GP6+: L1 specific primers (150bp)/ SPF10: L1 specific primers (65bp)/ MY09/MY11: L1 specific primers (450bp)

Some articles also show evidence of association and/or do not deny exclusion of association, however, they present a non-significant or unreported p-value. The detection rate ranged from 10% to 79.3% (TABLE 3)[7,13,25–43].

Table 3: Studies that defend the association of HPV with breast cancer and/or do not deny exclusion of association, but with non-statistical or unreported p values.

Author/year	Tissue preservation	Detection means (primers and bp)	Result	P value
Herrera-Goepfert et al., 2011	FFPE	PCR (SPF10 and HPV 18 and 33 E6) e RT-PCR (HPV 16)	6/60 (10%)	NR
Glenn et al., 2012	Fresh frozen	PCR (HPV 16, 18 and 33 E6)	10/27 (37%)	NR

Herrera-Goepfert et al., 2013	FFPE	PCR (LIC1/LIC2, MY09/MY11, GP5+/GP6+ and HPV 16 and 18 E6).	8/20 (40%)	NR
Suarez et al., 2013	Fresh frozen	PCR (MY09/MY11 and GP5+/GP6+)	16/61 (26%)	NR
Ahangar-Oskouee et al., 2014	FFPE	Nested PCR (MY09/MY11 and GP5+/GP6)	22/65 (33,8%)	NR
Corbex et al., 2014	FFPE	TS-MPG: mPCR and Luminex (specific primers)	15/123 (12,19%)	NR
Ting Wang et al., 2014	Liquid nitrogen (-80ºC)	HPV capture with MPS	1/7	NR
Ohba et al., 2014	Fresh frozen	DNA Chip technology – DNA microarray (TOSHIBA)	65/210 (31%)	NR
Banerjee et al., 2015	FFPE	PathoChip and PCR (E2, E4, L1 and L2)	79/100 (79,3%)	NR
Yan Chen et al., 2016	FFPE	Dual-PCR (HPV 16 and 18 E6 and E7)	HPV18E7 18/76(23.68%) HPV18E6 5/76(6.58%) HPV16 E6 and E7 0/76(0%)	NR
Ilahi et al., 2016	FFPE	PCR (GP5+/GP6+) TS (HPV 16 and 18)	HPV16 8/46 (17.3%) HPV18 0/46 (0%)	NR
Wang et al., 2016	FFPE	HIS	52/146 (35.6%)	NR
Naushad et al., 2017	FFPE	Standard PCR (GP5+/GP6+)	45/250 (18.1%)	NR
Salman et al., 2017	Fresh frozen	PCR and Imunnoblotting (*western blot* and *dot blot* for E7)	35/74 (47%)	NR
Wang, Y. X. et al., 2017	FFPE	qPCR (HPV 16 E6)	14/50 (28%)	NR
Wang Y. W. et al., 2017	Fresh	HC2 assay	14/81 (17.3%)	NR
Elamrani et al., 2018	Frozen	PCR TS-MPG	19/76 (25%)	0,28
Habyarimana et al., 2018	FFPE	PCR (GP5+/GP6+, MY09/MY11)	22/47(46.81%)	NR
Carolis et al.,2019	FFPE	HIS and PCR (MY09/MY11 and HPV 16 E6)	83/273 (30.4%)	NR
Sher et al., 2020	Fresh	PCR	5/50 (10%)	NR
El-Sheikh et al., 2021	Frozen	RT-PCR (E1, E2, E6, and E7)	16/72 (22.2%)	NR
Mofrad et al., 2021	FFPE	PCR (MY09/MY11, GP5+/GP6+, HPV 18 E6 and HPV 16 E7)	7/59 (11.8%)	NR

bp= base pairs, FFPE = formalin-fixed and paraffin-embedded tissue, PCR= Polymerase chain reaction, NR = Not reported, TS-MPG = bead-based multiplex genotyping (combine multiplex PCR and bead-base Luminex technology) , MPS =

massive paralleled sequencing, mPCR = multiplex PCR, HIS = in situ hybridization, qPCR = real-time quantitative PCR, HC2 = hybrid capture, RT-PCR = Real-time PCR

GP5+/GP6+: L1 specific primers (150bp)/ SPF10: L1 specific primers (65bp)/ MY09/MY11: L1 specific primers (450bp)

Eleven articles reported finding no association between breast malignancy and HPV[19,44–53]. Of these, five had a 0% rate of finding [45–48,52]. Some, however, observed some degree of detection, although in low percentages, ranging from 1.6% to 16%([19,44,49–51,53](TABLE 4).

Table 4: Studies that do not support the association between HPV and breast cancer.

Author/year	Tissue preservation	Detection means (primers and bp)	Result	P value
Aguayo et al., 2011	FFPE	PCR (SPF10 and HPV 16 E6 and E7)	L1 4/46 (8.7%) E6 and E7 0/3 (0%)	NR
Hedau et al., 2011	Fresh frozen	PCR and RT-PCR	0/228 (0%)	NR
Chang et al., 2012	Fresh	FQ-PCR (HPV 6, 11, 16, and 18 E6 and E7) and HIS	0/48 (0%)	NR
Herrera-Romano et al., 2012	FFPE and Fresh	PCR (GPE5+/GP6+ and HPV 16 E6)	0/118 (0%)	NR
Junping Peng et al., 2014	Liquid nitrogen (-80ºC)	PCR	2/100 (2%)	NR
Gannon et al., 2015	Fresh frozen	PCR (GP5+/GP6+ and MY09/MY11)	13/80 (16%)	0,6072
Li et al., 2015	FFPE	Nested PCR (GP5+/GP6+, MY09/MY11, and E6 and E7)	3/187 (1,6%)	NR
Karimi et al., 2016	FFPE	PCR (GP5+/GP6+ and E7)	2/70 (2,56%)	0,496
Bakhtiyrizadeh et al., 2017	FFPE	PCR (GP5+/GP6+ and MY09/MY11)	0/150 (0%)	NR
Ngamkham et al., 2017	Fresh frozen	PCR (GP5+/GP6+)	15/350 (4.285%)	NR
Kouloura et al., 2018	Preservative liquid (ThinPrep®)	PapilloCheck® genotyping assay (DNA chip)	0/201 (0%)	NR

FFPE = formalin fixed and paraffin-embedded tissue, PCR= Polymerase chain reaction, bp= base pairs, NR = Not reported, RT-PCR = Real-time PCR, FQ-PCR = real time fluorescence quantitative PCR, HIS = in situ hybridization

GP5+/GP6+: L1 specific primers (150bp)/ SPF10: L1 specific primers (65bp)/ MY09/MY11: L1 specific primers (450bp)

3.2 HPV SUBTYPES AND BREAST CANCER

In this study, we also sought to correlate the detection method used with the detection rate of viral histological subtypes. Among articles with statistical significance [3,8–10,21–24], viral detection for high-risk subtypes varied between 0.6%, referring to the detection rate of HPV 31 and 33, in the study by Afshar et al., 2018[24], to 69%, referring to HPV 16, by Islam et al., 2017[9]. HPV 16 also had the highest average detection rate in this review, appearing in 34.23% of the samples analyzed in the articles studied[3,8–10,21,22,24]. The higher detection of HPV subtype 16 found is an expected result, given its oncogenic potential observed in other malignant tumors caused by HPV[54].

It is important to note that both the study that presented the lowest detection rate of HPV 16, corresponding to

0%[10] and the one that presented the highest, referring to the rate of 69%[9], used PCR with primers for L1 gene and specific primers for E6 and/or E7 oncoproteins, suggesting that the difference in results was not influenced by the detection method. It is also worth noting that most samples (78.4%) from Cavalcante et al., 2018[10], did not identify any specific viral genotype.

HPV 16 was also the most prevalent viral subtype among studies that did not obtain a statistically significant value and/or did not include a "p-value" in the article but did not deny the association between the virus and breast carcinogenesis[7,13,25,27,28,30,31,33–35,37–43] with an average rate of 30.34%. Despite finding a rate of 10% of HPV 16 in their samples, the study by Herrera-Goepfert et al., 2011[35], concluded as insufficient to indicate an association. Ahangar-Oskouee et al, 2014[40], found 26.5% of HPV 6 and 1.5% of HPV 16, 35, 52, and 11 in Iran; since most samples that tested positive showed low-risk genotypes for malignancy, it was not possible to conclude a causal relationship between the variables. Furthermore, this study did not use primers to search for E6 and/or E7 proteins, only for L1, which may have contributed to the results obtained and the conclusions drawn about it.

In this review, eleven studies deny or did not find an association between HPV and breast cancer [23,44–53]. Of these, seven[19,44–48,53] attempted to detect HPV 16, eight[19,45–47,49–51,53] HPV 18, and four[19,45,46,53] the low-risk genotypes, 6 and 11. One study[52] did not specify the genotypes investigated. Kouloura et al., 2018[45], in addition to the subtypes mentioned above, also analyzed the presence of another 20 genotypes, including HPV 31 and 33, also high-risk. The detection methods used by these studies were predominantly the same used by studies with evidence of viral presence, in this case, it does not seem that there was a relationship between the method and the absence of detection.

These results support the hypothesis that HPV may have a role in breast carcinogenesis. Among the articles that showed an association or did not deny the possibility of its existence, genotypes 16 and 18 were the most prevalent, in agreement with the literature[15].

3.3 HISTOLOGICAL AND MOLECULAR PATTERNS OF BREAST CANCER AND HPV

Ductal carcinoma was the most frequently found histological subtype in breast cancer samples with HPV DNA detection [3,7,19,21,26,29,30,32–36,39,40,44,50,53,55], especially the invasive pattern (ICD)[7,19,21,26,30,32–35,39,40,50,53,55]. This percentage ranged from 45.7%[3] to 100%[26,32,35,36,44].

The second most frequent histological pattern in some reports was the lobular pattern [3,21,30,33,40], ranging

from 9.52%[40] to 33,3%[33]. Ohba et al. 2014[43] found, however, a higher frequency of this pattern with 10/11 positives (90,9%), while the ductal was positive in 99/191(51,83%) (p=0.047).

HPV was also detected in other histological types of cancer, such as tubular[3,39], medullary[3,43], metaplastic[7], mammary[7], mucinous[35,43,53], papillary[35,39] and Phyllodes[40].

Some authors have not found HPV positivity in some histological patterns of carcinoma such as invasive lobular[26,32,34,44,52], mucinous[3,39,40,44], medullary[21], ductal in situ[21,53], adenocystic, apocrine, comedocarcinoma[39], Phyllodes[32]. All these studies, however, had the same limitation, the small sampling of these histological types, which may explain the absence of detection observed. The low viral load detected in several studies could also explain the low frequency of HPV detection in some samples[22].

This higher prevalence of HPV in the ICD raises the hypothesis that the gateway to HPV infection is due to the exposure of the mammary ducts to the external environment, and therefore, most breast cancers originate from this epithelium [30,34,36]. Also, it is believed that this virus could interact or act to initiate the development of cancer or increase the progression of the lesion in the presence of other cofactors[34].

Despite this predominance in the ICD, no significant association between the histological patterns of breast cancer and HPV infection, however, was found among the articles[3,21,33,35,39,48,53,55].

Other studies found significant HPV detection results when compared to breast cancer samples with normal or benign breast tissue, however, the histological categories were not specified[8–10,24,37].

Naushad et al. 2017[29], Aguayo et al. 2011[44], and Habyarimana et al. 2018[33], in turn, observed a greater detection of HPV infection in patients with more advanced breast cancer, with lymph node metastatic involvement, although not statistically significant, as did Mofrad et al. 2021[36], in which all HPV-positive cases were high-grade tumors. Glenn et al. 2012[37], Ilahi et al. 2016[27], Naushad et al. 2017[29], and Habyarimana et al. 2018[33] found no significance between tumor grade and HPV positivity in samples with cancer; as well as, Suarez et al. 2013[39], Ngamkham et al. 2017[53] and Delgado-Garcia et al, 2017[8], when they evaluated the lymph node status; and Delgado-García et al. 2017[8] and Habyarimana et al. 2018[33], with the clinical stage.

Few studies have compared the detection of HPV with hormone receptors, such as RE, RP, HER, p53, and Ki67,

and most have not found statistical relevance[8,29,33,35,37,39,43,50,53,55], however, some samples were small, which causes this limitation[33,37].

Ohba et al. 2014[43], however, noted that ER-positive breast cancer had a statistically higher HPV prevalence than ER-negative ones (p=0.0378), as Ilahi et al. 2016[27] for HPV 16 in hormone receptor-positive breast cancer (ER/RP and HER-2 positive) (p=0,032). Habyarimana et al. 2018[33] also observed greater detection in luminal A pattern (57.14%, 12/21), when compared with luminal B (33.33%, 3/10), TN (44.4%, 4/9) and HER2 overexpression (50%, 3/6); already Delgado-Gárcia et al. 2017[8] found a greater association with negative luminal B/HER2 immunophenotype, but both with non-significant p. In luminal subtypes, in A, HPV DNA was proportionally related to lymph node invasion (p=0.0007); in B, it was associated with high levels of Ki67 expression, that is, with a higher rate of cell proliferation, which infers greater aggressiveness (p=0,0188)[13].

Hormonal factors are involved in breast carcinogenesis, and HPV is a hormone-responsive virus, which has increased replication in the presence of steroid hormones. Its E6 and E7 oncoproteins, together with the action of estrogens cause cervical cancer, and this may be one of the roles of HPV in hormone receptor-positive breast cancer, but the association between HPV infection and ER expression is still controversial[33].

Piana et al. 2014[22], however, compared 40 samples of the TN phenotype with non-TN, finding HPV DNA only in the first group, with statistical relevance, suggesting a potential etiopathogenic role in this poorly differentiated tumor type (15%, p=0.026). Herrera-Goepfert et al. 2013, identified a viral DNA rate of 40% in samples of TN metaplastic carcinomas, [38]. Carolis et al. 2019[13] identified a statistical predominance in breast cancer with aggressive characteristics, the TN subtype (12/27.44%) and HER2+ (15/31.48.4%), comparing to Luminal A (34/142, 23.9%) and Luminal B (22/73.30.1%) (p=0.0181). Proteins E6 and E7 collaborate with HER2/neu, inducing breast tumorigenesis, in addition to acting in the metastatic process[33], which could explain the findings of these studies.

3.4 SAMPLE TYPES FOR RESEARCH FOR HPV IN BREAST CANCER

The studies in this research used different forms of breast tissue samples for HPV research: formalin-fixed and paraffin-embedded (FFPE), fresh tissue, and frozen tissue.

Six of the eight analyzes that showed a statistically significant association of the virus with carcinogenesis used FFPE samples[10,21–24], with HPV detection rates ranging from 7.5% to 51.8% (mean of 26.28% considering detections by PCR). Islam et al., 2017[9] used fresh frozen tissue, finding 63.9% of viral detection in pre-chemotherapy tumors, and 71%, in post-chemotherapy. Khodabandehlou et al.,2019[3] used liquid nitrogen at -80o, with detection of 48.6% among samples with cancer.

The largest sample of this review is that of studies that advocate for/do not deny the association between the variables but did not obtain or did not report results of statistical significance. Among these, FFPE was the most used sample type [13,25–29,31,33,35,36,38,40,41] with an average detection rate of 29.76%. Seven studies used fresh frozen tissue [7,30,32,34,37,39,43] and obtained a mean detection rate of 28.31%. Only the study by Ting Wang et al., 2014[42] used liquid nitrogen, detecting 14.28% of viral presence.

The study described by Chang et al., 2012 (42), analyzing fresh samples, found the presence of viral genetic material in 10% of benign lesions, but without evidence of infection in malignant lesions. This study also verified that the samples initially positive were later negative in a period of 3 months of freezing at -70ºC. This finding raises the importance of using fresh samples, as they are more sensitive than paraffinized samples.

Of the studies that achieved no degree of detection, three used fresh frozen tissue [46–48]. The study by Hedau et al., 2011[47], together with Bakhtiyrizadeh et al., 2017[52], also used FFPE. Only one [49] used liquid nitrogen and one [45] used liquid medium (Thin Prep®).

It was not possible to define the best way of tissue sample/storage in this review since the detection averages were very close between the different media and most articles used FFPE.

3.5 HPV DETECTION METHODS IN BREAST CANCER

The HPV viral load in breast cancer is extremely low compared to cervical cancer (approximately two thousand times lower) [4]. As a result, techniques used to detect the virus may present divergences in expressing them [56]. Factors involved in the detection of HPV DNA in breast samples such as the type of study performed, sensitivity of the molecular analysis method, histological type of the tumor, quality and integrity of the extracted DNA, conservation of samples, genotypic variation, population group evaluated and non-use of good laboratory practices with compliance with protocols, influence the results found[17,31,33].

Inadequacies in the screening and identification processes of the HPV virus can compromise clinical screening of oncogenic types of the virus [57]. Studies show that the viral DNA used for PCR may be subject to

degradation by contamination [17]. Minimizing dubious responses to viral presence, using PCR solutions controlled for DNA quality through a test with proven accuracy prevents false negatives [7,57].

The presence of HPV DNA in samples of benign and malignant breast lesions using quantitative real-time PCR (qPCR) and primers for regions E6 and E7 identified high-risk human papillomavirus, with a higher prevalence of hr HPV genotypes 16, 18, and 33. Of the 72 tumors selected, 35 were HPV positive, and 30 (86%) had the physical state of the integrated HPV[7]. Some authors consider the viral load together with the persistence of the infection a predictive factor for the genesis of the cervical lesion[23,38]. Based on this information, determining the viral load and the physical status of the virus in studies involving the association of HPV positivity and breast carcinogenesis becomes important.

More studies show the presence of oncogenic HPV DNA, such as 16, 18, 31, 33, 35, 45, 52, and 58. There were variations in the percentages of hr HPV from 1% to 51.8%[8,19,23,33].

Some analyzes did not confirm the presence of the virus in the tumor samples evaluated [45,47,48], therefore, the etiological role of HPV in breast carcinogenesis remains inconclusive [58]. Kouloura et al. 2018[45] performed a Microarray assay with 201 patients who had breast cancer, to detect HPV DNA of 24 types. Despite the high sensitivity of the technique used, no HPV DNA was identified in the samples evaluated, however, some characteristics of breast tumors were different among patients with HPV DNA in their cervical samples.

In cervical cancer, the interactions between HPV and carcinogenesis of the cervix are already consolidated[59], however, the pathways of interactions between HPV and breast cancer continue to need clarification [6]. An important condition is that even in studies with positive results, the subtypes detected tend to be diverse [8,19,23,33,42].

Virus amplification by PCR was the most used technique for HPV detection, presenting results that range from positive [3,8–10,21–24], statistically not relevant [7,13,25–27,29–41] and negative [19,44,46–53]. The use of genomic sequencing [42], in situ hybridization [46], hybrid capture [55], and immunohistochemistry (IHC)[31], are also capable of detecting HPV, however, they present controversial results compared to other studies[45].

Studies that employ the use of PCR using primers GP5+/6+, MY09/11, or SPF10 for amplification of the L1 region, can detect a greater number of genotypes. However, methodologies that only look for the presence of L1 are susceptible to negative results, since, when the viral genome

is integrated, the L1 structural protein is absent because the viral capsid is lost in the integration[34,60,61], resulting in an unreliable outcome. Therefore, it is necessary that researchers also use specific primers for HPV proteins with oncogenic potentials such as E6 and E7, whose presence suggests greater viral activity[62,63], so that their findings can support that the oncogenic activity of HPV has functional aptitude in breast carcinogenesis.

This hypothesis is supported in this review by the fact that, among the studies presented in table 1, three articles [3,9,10] investigated both the L1 gene and the viral oncoproteins, with 54% of detection, considering the pre-chemotherapy rate by Islam et al., 2017[9]. On the other hand, those who sought to detect only L1 [8,10,22,24] or E6 and/or E7 [23], detected only 29.02% and 14.8% of viral genetic material, respectively.

In addition to the technique of using specific primers for E6/E7 showing good sensitivity and specificity [62], changes in the genetic material occur more frequently in the L1 gene than in E6 and E7, which can make it difficult to anneal the primer during PCR, which may lead to non-detection of the virus[60].

In contrast to what is expected, and the results obtained from the articles in table 1, there are studies that support the possibility of association without statistical significance (table 2) and studies that did not find evidence of this association (table 3). In Table 2, the lowest detection rate was among the studies that analyzed both the presence of L1 and E6/E7, with 23.05% of detection[13,35,36,38]. The study by Banerjee et al., 2015[25], which used specific primers for E2, E4, and L1, detected viral genetic material from HPV 6 and 16 in triple-negative breast cancer in 79% of cases.

A curious fact among the studies, which reported not having found evidence of an association between HPV and breast cancer (Table 3), is that in addition to the higher detection rate being among studies that only searched for L1 (average rate of 6,76%) [50,52,53], in the study by Aguayo et al., 2011[44], the viral genome was only detected when using primes for the L1 gene, with no detection with the use of primers for E6/E7.

Studies show that the presence of the viral genome is not a sufficient condition to establish a causal relationship[35]. Analysis of the association between the presence of HPV and the expression of oncoproteins E6 and E7 adjoins the tumor suppressor proteins p53, pRb, and p16ink4a in breast carcinomas, represent relevant findings, as they indicate that in addition to viral DNA, oncoproteins were identified in the tissues[64–66]. The possibility that E6 activity prevents p53 function in breast tissue has been associated

with aggressive clinical pathological behavior and poor prognosis in these patients[55,67,68].

The relationship between the presence of HPV DNA in non-cancerous tissue is still poorly understood [6,17,40], however, reports show the presence of hr-HPV in benign breast lesions of Australian and Turkish patients[23]. It is necessary to assess whether HPV infection in normal tissue becomes a favorable and/or necessary condition for the development of a malignant neoplasm [46].

It is noteworthy that the presence of HPV proteins per cell is sufficient for immortalization, cumulative changes [34,69], and neoplastic transformation, as occurs in SiHa cells, where there are 1-2 copies of HPV16 per cell [65]. Several studies have confirmed the presence of HPV DNA in breast tumors, however, the carcinogenic mechanisms are inconclusive [70]. On the other hand, in vivo, and in vitro functional studies confirmed the involvement of HPV infection in carcinogenesis, activation, progression, invasion, and metastasis in breast cancer[6].

3.6 INTEGRATION OF HPV INTO THE BREAST CANCER GENOME

As previously described, HPV may or may not integrate part of its genetic material into that of the host, presenting itself in an episomal, integrated, or mixed form. There is evidence that when the virus integrates, it loses the L1 gene, as well as E1 and E2[6,34,60,61], at the same time that it increases the expression of the viral proteins E6 and E7[3], responsible for the inactivation of the p53 and Rb genes, respectively.

Because viral integration, in addition to being associated with the inactivation of tumor suppressor genes, also acts on the activation of oncogenes, this type of presentation is associated with a greater relationship with neoplasms with a higher degree of malignancy[29,43,44]. Therefore, apart from just detecting or not the presence of HPV in the analyzed sample, it is important to assess its integration status [6]. Some studies in this review analyzed the association of viral status with the presence or absence of malignancy in the studied lesion, as well as with tumor characteristics [3,9,28,44].

The study by Khodabandehlou et al., 2019[3] showed the absence of E2 in 86% of the analyzed cases of malignant lesions, which supports the hypothesis that the integrated status of the virus would be related to carcinogenesis. Furthermore, an E2/E6 ratio <1 was found in 14% of malignant lesion cases, which suggests a mixed status of the virus (episomal + integrated). Isolated episomal status was not evidenced in any sample. These results are similar to those found by Islam et al in 2017[9], which showed integration of the viral genome in 87.5% of the malignant samples. In this study, 8.3% had mixed virus status and

4.2% had episomal status. In addition, the authors of this last study mentioned that they could not find statistical significance in relation to histopathological differences when related to viral status, probably because most of the samples presented with the integration of the genetic material.

Aguayo et al. 2011[44], in turn, showed viral integration in 100% of the 14 samples analyzed, as none showed amplification of the E2 gene. Wang et al., 2016[28], found, that in the 52 (35,6%) positive cases for HPV, in 146 breast cancer samples analyzed, the mixed status of the virus.

So, the detection of HPV with integrated or mixed status in this review, among the studies that did this analysis, ranged between 35.6%-100% in the samples diagnosed with cancer, while the episomal form ranged between 0-4.2 %, corroborating the hypothesis that the integrated form would be more associated with lesions with characteristics of malignancy.

IV. CONCLUSION

In this study, most of the articles analyzed showed a positive association between HPV and breast carcinoma, although some did not present a statistical "p-value". The most common genotype was HPV 16, followed by HPV 18, high-risk genotypes that are also the most frequent among other types of carcinomas caused by this virus. The main histopathological diagnosis of HPV-related breast cancer was invasive ductal carcinoma, which, despite being the most frequent histological type among breast carcinomas, may also be related to the fact that the ducts are in contact with the external environment, increasing the chance of contamination. In addition, it is important to highlight the percentage difference between the detection of genetic material in the integrated form, found in 35.6%-100% of the cancer samples studied, and the episomal, found only between 0-4.2%, which is directly related to the expression of E6 and E7 proteins, which have their expression increased when the viral DNA integrates with that of the host, decreasing the activity of tumor suppressor genes and increasing the activity of oncogenes. The results of this study, in agreement with others included in our review, support the hypothesis that HPV may have a great influence on breast carcinogenesis.

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Determinants of Customer Satisfaction and Customer Loyalty (Case Study of Café Grind & Pull Makassar)

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Abstract— The lifestyle of drinking coffee is currently becoming a trend among people in the millennial era. This is the reason for the growth of the domestic coffee shop industry.The purpose of this study was to determine the effect of service quality, price on customer satisfaction and customer loyalty. In addition to testing the effect of customer satisfaction on customer loyalty and testing the role of customer satisfaction in mediating the effect of service quality, price (price) on customer loyalty. This study uses a quantitative approach with an explanatory method, namely in the research being conducted is to explain the symptoms that arise in a research subject. The data analysis technique of this study used Amos' SEM, where the findings of this study were that service quality and price had a positive and significant effect on customer satisfaction and customer loyalty at Grind & Pull, Makassar.

I. PRELIMINARY

Cafes or coffee shops are one of the places that have mushroomed in Indonesia in recent years. Factors in the development of lifestyle and necessities of life are balanced with creativity and innovation for cafe business owners(Priawan, 2016). The prospect of coffee shops is currently very bright, where every year coffee shops are mushrooming and increasing by 10-15 percent. It can be seen that the number of coffee shops in Indonesia in the last three years has tripled, from 1,083 outlets in 2016 to 3,000 outlets in 2019.

The problem with the development of coffee shops cannot be separated from how easy it is for the community to open this business, where previously opening a coffee shop required a large investment and is now accessible to the community.(Prasetyo, 2020). Until 2019 the development of coffee shops is expected to increase by 15% - 20% compared to 2018. Meanwhile, the contribution of cafe shops to breakfast coffee has increased by 25% to 30%.(Pradika, 2019).The growth of coffee consumption in

Indonesia from year to year has increased in the last 4 years (2015-2018). So it will show the growth of coffee consumption in Indonesia (Figure 1)

Fig.1: Consumption Growth

The growth of coffee consumption in the last 4 years has increased from year to year, an increase in people who consume coffee in Indonesia has caused the café business to experience very rapid development. This is marked by the proliferation of business people involved in the café business, causing the level of competition in the café business to become increasingly stringent. Efforts made by café business people are preparing coffee quality with

different tastes and preparing all café facilities so that they can compete with other cafés. Then another factor in order to maintain the sustainability of the café business is paying attention to customer loyalty, which is a manifestation and continuation of consumer satisfaction through the use of facilities and services provided by the business owner.(Lusiah, 2018)

Customer loyalty is very important in maintaining business continuity, because loyal consumers are consumers who are satisfied with the service they get from business owners. Loyalty is a customer's deep commitment to resubscribe or repurchase selected products/services consistently in the future, even though situational influences and marketing efforts have the potential to cause behavior changes (Hurriyati, 2019: 129). The opinion expressed by Hasan (2014: 120) that customer loyalty is the key to success, not only in the long term but also sustainable competitive advantage. One way that is done by business owners to increase loyalty is customer satisfaction (Customer Satisfaction).

According to Wijaya (2018: 153), customer satisfaction is the level of one's feelings after comparing the performance (results) that he feels compared to his expectations. Satisfied customers will increase customer loyalty in making repeat purchases. Findings made by previous researchers found differences or inconsistent. So that there is a research gap found. Then in increasing customer satisfaction and customer loyalty, there are a number of determining factors, namely service quality and price. Service quality according to Tjiptono and Chandra (2017:59) is the quality of service. Service quality is the expected level of excellence and control over that level of excellence to meet consumer desires.

Then price or price according to Sudaryono (2016: 216) is an exchange rate that can be equated with money or other goods for the benefits obtained from an item or service for a person or group at a certain time and a certain place. Affordable prices provide satisfaction for customers so that it has an impact on customer loyalty for the services offered.

Based on the theory, the results of previous research and gap research, research questions will be presented, namely:

a) Does service quality affect customer satisfaction

b) Does price affect customer satisfaction

c) Does service quality affect customer loyalty

d) Does the price affect customer loyalty

e) Can customer satisfaction mediate the effect of service quality on customer loyalty

f) Can customer satisfaction mediate the effect of price on

customer loyalty

II. RESEARCH METHODS

This research is a quantitative research, which according to Arikunto (2017: 10) is defined as an approach that requires a lot of numbers, starting from data collection, interpretation of the data, as well as the appearance and results. The type of research using the explanatory method is research conducted by explaining the symptoms that arise from the subject of this study. Judging from the objective, it is a causal study that explains the causal relationship regarding the effect of service quality and price on customer loyalty with customer satisfaction as an intervening variable. This research was conducted at grind & pull cafes in Makassar City. The reason for choosing Café in this study is that it is often visited by young and old people.

This study used 187 samples, where the sampling technique used was a purposive sampling technique, which according to Sugiyono (2019: 138) namely determining the sample based on certain criteria or considerations, namely customers who have members and have visited the café more than 2 times. Ferdinand (2014: 109) stated that the sample size that must be met in Amos' SEM modeling is a minimum of 100 and uses a comparison of 5-10 observations for each estimated parameter. In this study using 14 indicators, so the ideal sample size is 140 samples (10 observations x14). However, to obtain a representative sample, researchers determined 187 samples to be used as respondents.

To find out the relationship between service quality and price on customer loyalty through customer satisfaction can be visualized in the form of Figure 2 below:
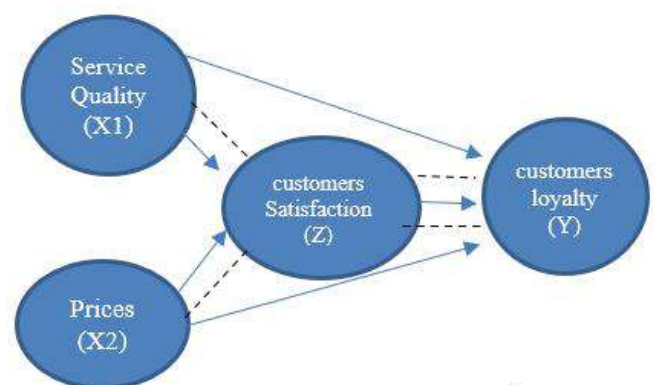
Fig.2. Framework of Mind

Then the indicators of each latent variable in this study are according to Tjiptono (2017: 159) service quality is measured by 5 indicators namely reliability, responsiveness, assurance, empathy, tangibles.). Kotler & Lane (2009:83) explains that there are 3 indicators in

measuring price (price), namely price affordability, price compatibility with benefits, price according to ability or price competitiveness. Then the endogenous variable in this study is customer satisfaction as measured by 3 research indicators namely price suitability, intention to return, willingness to recommend (Tjiptono, 2017: 101). While Kotler & Lane (2009:101) explains that there are 3 indicators in measuring customer loyalty, namely Repeat Purchase, Retention, Referral.

III.   ANALYSIS AND DISCUSSION

Statistical analysis explains the description or description of research variables which may include service quality, price, customer satisfaction, customer loyalty. (Table 1)

Table 1. Descriptive Statistics of Research Variables

Latent variable	Means	Standard Deviation	range actual	range theoretical
Service quality	16,87	4,18	10-24	5-25
Price	10.01	2,41	6-14	3-15
Customer Satisfaction	10,19	2.64	6-15	3-15
Customer Loyalty	11.08	2.35	7-15	3-15

Source: Data processed, 2022

Descriptive statistics on each latent variable, namely service quality, has a score of respondents' answers with an actual range of 10-24 while a theoretical range of 5-25. This shows that the respondents' answers related to the actual range are higher when compared to the theoretical range. This indicates that the service quality at Grind & Pull in Makassar can already be categorized as good. The same goes for prices with an actual range of 6-14 and a theoretical range of 3-15 which indicates that the price set by Grind & Pull Café is competitive, when compared to other cafes.

Then descriptive statistics namely customer satisfaction with respondents' answers having an actual range of 6-15 and a theoretical range of 3-15, so that it can be said that customer satisfaction on grind & pull is already high. Respondents' answer scores on customer loyalty with an actual range of 7-15 and a theoretical range of 3-15, this indicates that customer loyalty is already high, which means that the application of service quality and price has increased customer satisfaction. In the analysis of descriptive statistics, before analyzing the research data using the Amos SEM method, a confirmatory test will be carried out first

Confirmatory factor analysis is a multivariate analysis

whose role is to confirm whether the measurement model built is in accordance with the hypothesis. Before conducting a confirmatory test (CFA) on latent variables, a model feasibility test will be presented first which aims to find out whether the confirmatory model to be used can be said to have a fit model or not (Table 2).

Table 2: Confirmatory model feasibility in Amos's SEM

Information	cut off Value	Model Test Results Beginning	Model Test Results After repair	Conclusion
$\lambda2$	88.25	102.60	84,220	Fit Models
CMIN/DF	≤ 2.0	1.445	1,239	Fit Models
ρ	0.05	0.008	0.089	Fit Models
GFI	≤ 0.90	0.927	0.940	Fit Models
AGFI	≤ 0.90	0.893	0.907	Fit Models
IFI	≥ 0.95	0.983	0.991	Fit Models
CFI	≥ 0.95	0.978	0.988	Fit Models

Source: Data processed, 2022

The results of the feasibility of the confirmatory model in Amos' SEM analysis, that the confirmatory model has a goodness fit of index is in accordance with the requirements in Amos's SEM analysis. For more details, the value of loading factor (λ) and construct reliability, average variance extracted (AVE) will be presented (Table 3).

Table 3 : Analysis of loading factor values, Construct reliability and average variance extracted

Latent variable	Indicator	loading factor(λ)	construct reliability	AVE
Service Quality	X1.1	0.904		
	X1.2	0.742		
	X1.3	0.862	0.911	0.672
	X1.4	0.720		
	X1.5	0.856		
Price	X2.1	0.666		
	X2.2	0.885	0.781	0.548
	X2.3	0.647		
customers Satisfaction	Z. 1	0.853		
	Z. 2	0.837	0.864	0.680
	Z. 3	0.782		
customers Loyalty	Y. 1	0.878		
	Y.2	0.885	0.906	0.763
	Y.3	0.878		

Source: Data processed, 2022

The results of the convergent validity test on indicators on latent variables, namely for service quality have a value of the loading factor range of 0.742-0.904 which is greater than 0.50, so that it can be said that the five indicators of service quality already have good convergent validity. Then the price variable with 3 indicators, which has a loading factor value of 0.647-0.837 which is greater than 0.50 so that it can be said that the three indicators already have good convergent validity. In addition, the customer satisfaction variable has 3 indicators with a loading factor value of 0.782-0.853, as well with customer loyalty there are 3 indicators with a loading range of 0.878-0.885 which is greater than 0. Then seen from the results of the construct reliability test, where all construct reliability, namely service quality, price, customer satisfaction and customer loyalty, is greater than 0.70, besides that the AVE value is already greater than 0.50. So that it can be said that all the indicators used in testing the research hypothesis are reliable. Before testing the hypothesis in this study, a normality test will be carried out in Amos' SEM first, where the results of the normality test show that multivariate normality has a critical ratio (CR) of 0.018 which is smaller than 2.58. This shows that the data in the SEM analysis Amos is normally distributed. Then the results of the outlier test from SEM Amos (Table 4) are as follows:

Table 4: Outlier Test Results in Amos' SEM

Observations number	Mahalanobis d squared	p1	p2
35	34,245	,002	,299
50	30,288	,007	,374
48	26,657	,021	,763
174	25,375	.031	,835
55	25.104	.034	,755
170	24,925	.035	,650
26	24,303	.042	,676
1	24,006	.046	,626
169	23,684	.050	,594
63	23,605	.051	,487
158	23,216	,057	,498
173	22,376	,071	,686

Source: Data processed, 2022

The highest d-squared mahalanobis value is at observation number 34 with a d-squared mahalanobis value of 34,295 which is smaller than the chisquare table (p=0.001; df 14) of 36,125 which means that the data in Amos' SEM did not find any outlier data.

After the Amos SEM test, the research hypothesis will be tested, but previously the feasibility test of the model will be presented in testing the hypothesis based on the value of the goodness of fit index (Table 5), namely:

Table 5: The results of testing the feasibility of the testing model research hypothesis

Information	Cut of Value	Test results Model	Conclusion
λ^2	88.25	0.089	Fit Models
CMIN/DF	≤ 2.0	1,239	Fit Models
ρ	0.05	0.089	Fit Models
GFI	≤ 0.90	0.940	Fit Models
AGFI	≤ 0.90	0.907	Fit Models
IFI	≥ 0.95	0.991	Fit Models
CFI	≥ 0.95	0.991	Fit Models

Source: Data processed, 2022

The results of the model feasibility test in testing the research hypothesis show that all goodness of fit index values are in accordance with the requirements in Amos' SEM. This indicates that the model used in testing the research hypothesis already has a fit model, so that the regression weight will be presented in Amos's SEM for testing the research hypothesis, namely:

a) The effect of service quality on customer satisfaction, with a standardized regression weights coefficient of 0.374 and a pvalue = 0.005 <0.05. This shows that service quality has a positive and significant impact on customer satisfaction. This indicates that providing good service to café customers will make customers feel satisfied, so as to increase customer interest in visiting the Grind & Pull Makassar café again.

b) The effect of price on customer satisfaction shows that with a standardized regression weight coefficient value of 0.359 with a value $\rho value$ of 0.001 < 0.05, indicating that the price (price) can have a positive and significant influence on café customer satisfaction (customer satisfaction)

c) The influence of service quality on customer loyalty, which obtained a standardized regression weight value of 0.428 with a value of $\rho value$ = 0.000 <0.05, this shows that service quality has a positive and significant influence on customer loyalty. This indicates that service quality has a real influence in increasing customer loyalty.

d) The effect of price on customer loyalty, with a standardized regression weight value of 0.310, and besides that a pvalue = 0.002 <0.05, this shows that

price has a positive and significant influence on customer loyalty. These findings indicate that price can significantly increase customer loyalty.

e) The effect of customer satisfaction on customer loyalty obtained by a standardized regression weight value of 0.262 besides that with a pvalue = 0.000 <0.05, it can be said that customer satisfaction has a significant influence on customer loyalty. These findings may indicate that customer satisfaction can significantly increase customer loyalty.

Then seen from the indirect effect of service quality and price on customer loyalty mediated by customer satisfaction and customer loyalty which shows that the magnitude of the indirect effect of service quality on customer loyalty through customer satisfaction is 0.098 or 9.80%. While valueρvalue = 0.016 <0.05, it can be said that customer satisfaction can mediate the effect of service quality on customer loyalty. In addition, the indirect effect of price on customer loyalty through customer satisfaction is 0.094 or 9.40%, whereas a pvalue = 0.016 <0.05 indicates that customer satisfaction can mediate the effect of price on customer loyalty at Grind & Pull in Makassar.

IV. CONCLUSION

The results of this study indicate that the direct effect of service quality and price has a positive and significant effect on customer satisfaction and customer loyalty at Grind & Pull in Makassar. These findings indicate that empirically service quality will be able to increase customer satisfaction and customer loyalty at Grind & Pull. Then seen from the results of the mediation test through the bootstrapping process in SEM Amos which shows that customer satisfaction can mediate the effect of service quality on customer loyalty at the Grind & Pull café in Makassar. This can be indicated that d service quality can increase customer satisfaction so that it has an impact on customer satisfaction. The results of the mediation test, namely the effect of price on customer satisfaction on customer loyalty, indicate that competitive prices when compared to other cafes will increase customer satisfaction. So that it has an impact on customer loyalty.

The implications of this study show that the practical implications of this research are that this research can be used as input for the owners of Café Grind & Pull, Makassar in increasing customer satisfaction and customer loyalty through improving service quality. satisfying and set competitive prices when compared to other cafes. Then the theoretical implication of this research is that it can provide the development of marketing knowledge such as service quality, price, customer satisfaction and customer loyalty to those who will conduct research in the same field in the future.

Limitations in the study, where the researcher only chose one café and did not examine other cafes as a comparison. This is due to limited time and costs of researchers. Apart from that, another limitation is that the researcher only distributed questionnaires to customers who have members and besides that, choosing customers to be respondents were customers who visited the Grind & Pull café 2 times. So it is necessary for future research to make observations of more than 1 café and increase the number of research samples, in order to provide representative information.

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Formulation study for the development of a gel/cream produced with Mauritia flexuosa (buriti oil)

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Abstract— *Mauritia flexuosa, known as 'buriti', is an excellent source of bioactive compounds with antioxidant, hypolipidaemic, sun protection, antiplatelet, antithrombotic, hypoglycaemic, antimicrobial and antitumour properties. Considering these properties, it could be used as a therapeutic for conditions that affect the mouth, such as ulcerations and erythema. Among the oral conditions, we can mention oral mucositis, which is characterised by erythema, atrophy and ulceration of the mucous membrane. Thus, this work aimed to develop a phytotherapeutic pharmaceutical formulation for oral application that contains 5% buriti oil as the active ingredient. Five formulations were developed, and one (F5) of the formulations was chosen and subjected to organoleptic and physicochemical analysis (pH, density, and high-performance liquid crhromatography - HPLC), and later to a 3-month stability study in an accelerated climactic chamber. The initially obtained gel/cream was stable according to the tests to which it was submitted. However, after storage for 3 months, it showed a markedly reduced density, indicating the loss of volatile compounds, possibly vitamins A and E. Overall, the gel/cream formulated with buriti oil displays characteristics that make it potentially suitable for the treatment of oral ulcerations such as oral mucositis.*

I. INTRODUCTION

Mauritia flexuosa, known as 'buriti', belongs to the *Arecaceae family* and subfamily *Lepidocarycideae* and is a popular fruit found throughout South America. It is found in the Brazilian Cerrado, most commonly in the states of Pará, Amazonas, Maranhão, Piauí, Bahia, Ceará and Tocantins (Canuto *et al*., 2010). This fruit is an excellent source of bioactive compounds with antioxidant, hypolipemic, sun protection, antiplatelet, antithrombotic, hypoglycaemic, antimicrobial and antitumour properties (Freire *et al*., 2016). Methanolic extracts of various buriti parts show antimicrobial potential against *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli,*

Micrococcus luteus and *Bacillus cereus* (Koolen *et al*., 2013).

This fruit has macro- and micronutrients of great relevance for the development of new products in the food, therapeutic and pharmaceutical sectors (Freire *et al*., 2016). Considering its properties, it could be used as a therapeutic for ulcerative conditions in the mouth, such as oral mucositis (OM). OM is a common complication of cancer treatment, characterised by erythema, atrophy and ulceration of the mucous membrane of the mouth, leading to ulcer formation (Alhussain *et al*., 2021). It is painful due to exposure of the connective tissue, elevating the adhesiveness of fungi and colonisation of bacteria (such as

Staphylococcus), which exacerbates the pain and risk of infection (Souza & Viana, 2019). Thus, several adverse effects occur, such as intense pain, odynophagia, ulcerations and difficulty eating (Bowen & Wardill, 2017).

Although there are forms of treatment and prevention (oral hygiene, laser therapy and oral cryotherapy) and resources that relieve the symptoms of OM (analgesics and anti-inflammatory drugs, among others), there is still not an effective, specific treatment of OM that completely covers all its manifestations (Lima *et al*., 2021). The use of phytotherapy, along with multi-professional action, could have an indication for use and reduce intercurrences during antineoplastic treatment in individuals with cancer (Souza & Viana, 2019). Therefore, the search for new therapies that promote symptom relief and act to reduce and prevent OM is crucial (Lima *et al*., 2021). In this context, the purpose of this project was to develop an alternative phytotherapeutic pharmaceutical formulation containing buriti oil as a natural, low-cost active ingredient for oral topical use. The physicochemical characteristics of the gel/cream formulation were determined be measuring the pH and density and performing a centrifugation test, and the stability of vitamins A and E, which are present in buriti oil, was evaluated.

II. METHODOLOGY

2.1 Obtaining the raw material

The raw material was obtained from Engetec Engenharia das Essências, a Brazilian supplier of Amazonian buriti oil located in São Paulo, SP. According to the supplier, the vegetable oil is obtained by cold pressing the pulp, without refining, and it is 100% pure. It is non-volatile and has a strong colour and odour.

2.2 Physicochemical tests

A specified procedure (Brasil, 2008) was used to examined the physicochemical properties of the gel/cream. The physicochemical tests adopted for oil characterisation were appearance (viscous liquid), colour (reddish), odour (characteristic), density (0.910 g/mL), acidity index (9.4%), the iodine index (74.36 cg l/1002 g), the peroxide index (3.19 mEq O/kg2), the saponification index (197 mg KOH/kg) and the refractive index (1.46980) (Silva, 2019).

2.3 Chromatographic assay

Chromatography is one of the most versatile techniques for separating mixtures of substances. There is differential migration of substances in a chromatographic system that comprises the mixture to be separated, the mobile phase (gas or liquid) and the stationary phase. HPLC differs from other liquid chromatography techniques because of its ability to reduce the size of particles, allowing more efficient separation (Andrei *et al*., 2011).

The chromatographic profile in the raw material – to identify and quantify its fatty acids – was obtained by performing high-resolution gas chromatography using an HP 7820A gas chromatograph, with a Supelcowax-10 column (30 m × mm2 × 0.2 μm; Supelco). The column temperature was 150ºC, the injector temperature was 250°C and the flame ionisation detector was 260°C. The sample (1 μL) was injected with a 1:20 split ratio. The column temperature was increased up to 250°C at 10ºC/min. The following fatty acids were found in the raw material: palmitic acid (17.69%); oleic acid (74.03%); linoleic acid (2.14%); linolenic acid (1.24%); and stearic acid, gondoic acid and other compounds that were not quantified.

2.4 Location and equipment for bioproduct handling

The gel/cream was formulated in collaboration with companies located in the city of Floriano, PI. The equipment for physicochemical tests – pH, density, centrifugation and chromatography (HPLC and column) (Figure 1) – were duly calibrated and qualified before being used.
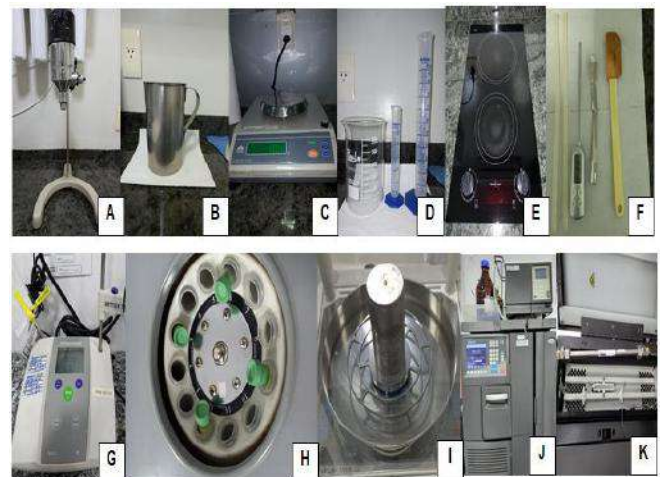
Fig.1. Equipment used for the physicochemical tests. A Fisatom model 713 mechanical stirrer; B stainless steel beaker; C Gehaka BG 4000 balance; D glassware; E hotplate; F plastic rod, digital thermometer, spatula and breadboard; G digital pH meter; H model 80-2 B centrifuge; I metal pycnometer; J HPLC; and K column.

2.5 Stability study

The raw materials that made up the formulation (Table 1) are suitable for use when stored properly and used before the expiration date. The stability study was performed by using a Mecalor stability chamber, equipped

with precision temperature and humidity control in accordance with the standards and conditions of the Brazilian Health Regulatory Agency (Anvisa). The climatic chamber was previously calibrated and its maintenance programme was up to date. The study was conducted at 40°C ± 2°C 75% ± 5% relative humidity (RH); these conditions allow for expected and tolerated variations due to climatic chamber openings. This study is designed to accelerate the chemical degradation and/or physical changes of a pharmaceutical product under forced storage conditions (Brasil, 2019a).

Table 1. Pharmaceutical excipients used in the development and characterisation of the orabase pharmaceutical formulation produced with buriti oil (Mauritia flexuosa) and their respective applications and registration numbers.

EXCIPIENT	CAS NO.	APPLICATIONS[1]
Aspartame	22839-47-0	Sweetening agent
Mint essence	-	Flavouring
Cetyl Alcohol	36653-82-4	Coating, emulsifying and hardening agent
BHT	128-37-0	Antioxidant
CMC	9004-32-4	Stabilising, suspending, viscosity-increasing and water-absorbing agent
EDTA	6381-92-6	Chelating agent
Glycerine	56-81-5	Antimicrobial preservative; co-solvent; emollient; humectant; plasticiser; solvent; sweetening and tonicity agent
Xanthan gum	11138-66-2	Gelling, stabilising, suspending, sustained-release and viscosity-enhancing agent
PEG 4000	25322-68-3	Ointment base; plasticiser; solvent; suppository base; tablet and capsule lubricant
PEG 400		
Nipagin	99-76-3	Antimicrobial preservative
Nipazol	94-13-3	
Solid petroleum jelly	8009-03-8	Emollient; ointment base
Ollivem 1000®	85116-80-9/92202-01-2	Emulsifier

[1]According to Rower et al. (2009). Abbreviations: BHT, butylated hydroxytoluene; CMC, carboxymethyl cellulose;

EDTA, ethylenediaminetetraacetic acid; PEG, polyethylene glycol.

2.6 Bioproduct development

During the development of the gel/cream, five formulations were produced in an attempt to stabilise the product. The raw materials and concentrations used in each formulation are shown as percentages in Table 2.

Table 2. Raw materials and their respective concentrations used in the five formulations (F1–F5).

RAW MATERIAL	F1	F2	F3	F4	F5
EDTA	0.05%	0.05%	0.05%	0.05%	0.05%
Glycerine	5.0%	5.0%	5.0%	5.0%	5.0%
Xanthan gum	0.2%	0.2%	0.2%	0.2%	0.2%
CMC	0.3%	0.3%	0.3%	0.3%	0.3%
Distilled water	37.9%	36.9%	32.4%	35.3%	35.3%
PEG 4000	8.0%	8.0%	8.0%	8.0%	8.0%
PEG 400	20%	20%	20%	20%	20%
Solid Vaseline	20%	20%	20%	20%	20%
Cetyl Alcohol	3.0%	3.0%	3.0%	3.0%	3.0%
BHT	0.05%	0.05%	0.05%	0.05%	0.05%
Phenonip®	0.5%	-	0.5%	-	-
Mint essence	-	-	2.0%	1.5%	1.5%
Simulgel®	-	0.5%	-	-	-
Cetiol V®	-	-	3.0%	-	-
Ollivem®1000	-	-	-	6.0%	1.0%
Aspartame®	-	0.5%	0.5%	0.5%	0.5%
Buriti Oil	5%	5%	5%	5%	5%
Optiphen®	-	0.5%	-	-	-
Nipagin	-	-	-	0.05%	0.05%
Nipazol	-	-	-	0.05%	0.05%
Total (%)	100%	100%	100%	100%	100%

Abbreviations: -, not included in the formulation; BHT, butylated hydroxytoluene; CMC, carboxymethyl cellulose;

EDTA, ethylenediaminetetraacetic acid; PEG, polyethylene glycol.

Except for formulation F5, after solubilisation the raw materials that composed the aqueous phase were poured into the raw materials that composed the oily phase that had also been solubilised; both phases were at 60°C. At the end, the active ingredient and the other adjuvants were added.

To prepare the final formulation (F5), distilled water was measured in a plastic beaker and then added to a stainless-steel beaker. Ethylenediaminetetraacetic acid (EDTA) and glycerine were then weighed and added separately to the beaker; the mixture was stirred by hand until completely solubilised, and then heated to 80°C. Next, nipagin was added and the mixture was stirred until completely solubilised. Carboxymethyl cellulose (CMC) was sprayed and stirred until completely solubilised; subsequently, the xanthan gum added and the mixture was stirred, always maintaining the temperature at 80°C, thus creating the aqueous phase (phase 1).

In a separate glass beaker, the raw materials of the oil phase were weighed: PEG 4000, PEG 400, solid Vaseline, cetyl alcohol, butylated hydroxytoluene (BHT) and nipazol. They were then dissolved 80°C and under constant stirring to produce the oily phase (phase 02).

Immediately after heating, with both phases at approximately 60°C, the oily phase was slowly poured over the aqueous phase under agitation in the Fisatom Mod. 713 mechanical stirrers at 200 rpm. The stirring was maintained until room temperature was reached. The Olivem® 1000 was partly heated to complete dissolution and added to the beaker under stirring. Aspartame® was also partly dissolved in water (approximately 5 mL) and added to the beaker under stirring. In the final step at 40°C, buriti oil was added and stirred constantly. Finally, the mint essence was added and the mixture was stirred for approximately 20 min (Brasil, 2019b).

After the preparation of the product, quality control analyses were performed to evaluate the physical and chemical stability of the gel/cream obtained. The centrifugation, density in a metal pycnometer and pH tests were performed; the last two were performed in triplicate to evaluate the reproducibility of the results. All procedures were carried out as specified in Farmacopéia Brasileira, 6th edition (Brasil, 2019b) and the Cosmetic Products Stability Guide (Brasil, 2004).

The product was kept at room temperature (25 ± 2°C) for 48 h and then analysed. Part of the product was distributed in a petri dish for evaluation of the organoleptic characteristics colour, taste, odour and the presence or absence of lumps (clumps of particles). These parameters were evaluated through smell, sight, taste and touch. Subsequently, the gel/cream was subjected to the centrifugation test. Equal amounts of the product were separated in three test tubes, placed in a centrifuge (Centribio model 80-2 B) and centrifuged at 3,000 rpm for 30 min (Brasil, 2004). The relative density was determined by using a metal pycnometer. The pH was determined at room temperature (25.0 ± 2.0°C) by using a Mettler Toledo benchtop digital pH meter that had been calibrated with pH 4.0–7.0 buffer solutions. The sample was also subjected to analysis for identification of the bioactive compounds of vitamin A (retinol) and vitamin E (tocopherol) (Monograph, 2017; Food Chemicals Codex, 2020). Additional details of the analyses are presented in section 2.7.

2.7 Physicochemical assay of the bioproduct

2.7.1 Density

After weighing the empty metal pycnometer and taring the balance, the sample was inserted into the metal pycnometer and then weighed. The formula below was used to determine the density. The weight of the empty pycnometer was 148.3779 g/mL and the weight difference of the pycnometer with water and the empty pycnometer was 25.0475 g/mL.

$$(d_{20}^{20}) = \frac{\text{pycnometer weight with sample – empty pycnometer}}{\text{Weight difference of the pycnometer with water and the empty pycnometer}}$$

2.7.2 pH

The pH of the sample was measured in a Mettler Toledo benchtop digital pH meter by inserting the electrode directly into the sample. The electrode was removed from the resting solution (water), washed and placed inside the product. After allowing the reading to stabilise, the measurement was recorded.

2.7.3 Identification of vitamins A and E

For vitamin A identification, 6 µg of the sample was weighed in a glass beaker and dissolved in 1 mL of chloroform. Next, 10 mL of antimony trichloride working solution was added to the solution. For vitamin E identification, 50 µg of the sample was dissolved in 10 mL of absolute alcohol. Two millilitres of nitric acid was added under stirring and the solution was heated.

The chromatographic analysis was performed with fresh solutions following the principles of the European Pharmacopoeia 9th edition (European Directorate for the Quality of Medicines, 2017) with some adaptations. One millilitre of the sample solution was pipetted into 10 mL of dichloromethane and dissolved. The stationary phase was octadecylsilyl silica gel for chromatography reagent (5 µm). The mobile phase was water reagente and methanol reagent (5:95 v/v). An ultraviolet (UV) spectrophotometer was used to detect vitamins A and E, with 10 µL of the sample and standard solution injected.

After completing the initial analysis of the formulation, nine aluminium tubes (60 g capacity) were filled with the product. After being identified with an adhesive label, the samples were submitted to the accelerated stability study. Storage in the accelerated climactic chamber lasted for 3 months at 40 ± 2°C and 75% ± 5% RH (Brasil, 2019b). The sample was analysed again to determine its stability.

2.8 Statistical analysis

The sample results were analysed by means of descriptive statistics (obtained from MATLAB) and organised in a Microsoft Excel spreadsheet. The statistical variables used are: mean, variance, standard deviation, minimum and maximum. Student's t-test was performed to evaluate the stability and pH changes after 3 months of storage. A p value < 0.05 was considered to indicate a significant difference.

III. RESULTS

The gel/cream obtained had the typical characteristics of a viscous gel, had no lumps and had a yellow colour, from the buriti oil. Overall, it was a uniform product, had a pleasant texture, was easily spread and had a characteristic mint odour/flavour that lasted even after 3 months of incubation in the accelerated climactic chamber (Figure 2). There was no phase separation in the initial sample subjected to centrifugation, making the formulation suitable for the stability study in the accelerated climactic chamber.
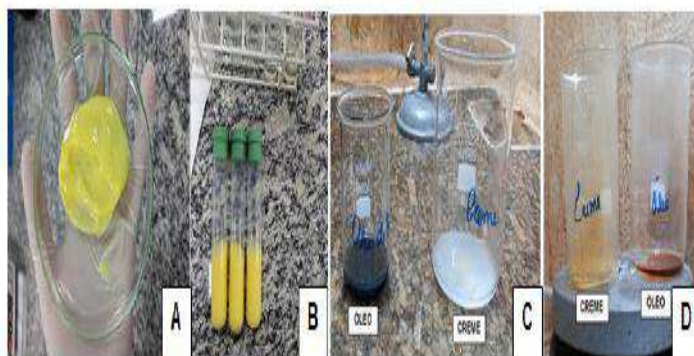
Fig.2. A Appearance of the gel/cream obtained with 5% buriti oil; B the appearance after the initial centrifugation (before stability testing); C colourimetric identification of vitamin A; and D colourimetric identification of vitamin E.

The pH and density analyses of the gel/cream were performed in triplicate. The values before and after the stability study in the accelerated climatic chamber are presented in Table 3.

Table 3. The pH and density of the formulated gel/cream before and after the stability study in an accelerated climatic chamber for 3 months (n = 3 for each time point, presented separately).

DESCRIPTIVE STATISTICAL ANALYSIS

Parameters	Analysis 1	Analysis 2	Analysis 3	Initial average
pH	6.16	5.99	5.97	6.04
Density (g/mL)	2.5221	2.5721	2.5555	2.5499

Parameters	Analysis 4	Analysis 5	Analysis 6	Final average	Standard deviation	Variance
pH	6.46	6.39	6.06	6.30	0.21	0.04
Density (g/mL)	0.9703	0.9703	0.9735	0.9714	1.12	1.25

In the colourimetric identification of vitamin A before and after the stability study, the desirable confirmation of retinol (vitamin A) in the sample would be the immediate appearance of a transient blue colour. In the analysed sample it was not possible to clearly observe the colour transition because of the whitish colouration from the solution extracted for analysis (Figure 2). However, using high-performance liquid chromatography (HPLC), there

was a peak in the retention time of about 4 min in the initial sample, indicating the presence of the vitamin A in the product. The peak was no long present in the sample after 3 months of storage in the accelerated climactic chamber (Figure 3). Before and after the stability study, vitamin E was successfully identified based on the colourimetric assay: a bright red to orange colour developed upon heating, confirming the presence of tocopherol (vitamin E) in the product.
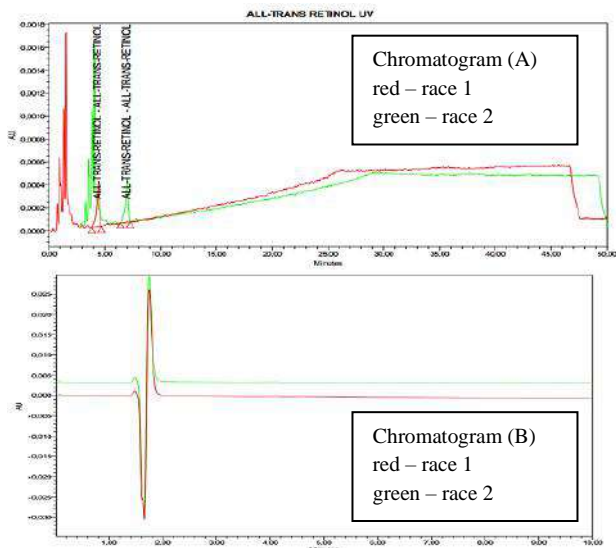
Fig.3 UV-HPLC Chromatogram (A) obtained before the accelerated stability study identifying the presence of the vitamin A precursor all-trans retinol in the bioproduct sample. Chromatogram (B) obtained after an accelerated stability study identifying the absence of the vitamin A precursor all-trans retinol in a sample of the bioproduct.

Abbreviations: UV, ultraviolet; HPLC, high-performance liquid chromatography.

All the results for the product analysed prior to long-term storage were satisfactory. There was no difference in the pH of the product before and after the stability study ($p > 0.12$). However, after the accelerated stability study, the density had dropped significantly ($p < 0.12$), which indicates a loss of volatile components. This reduction is probably related to a loss of vitamin A, because the associated chromatographic peaks no longer appeared after storage for 3 months.

IV. DISCUSSION

A gel-type semisolid pharmaceutical form is composed of one or more active ingredients containing a gelling agent. The cream consists of an emulsion, formed by a lipophilic phase and a hydrophilic phase (Brasil, 2019b). The product produced in this study had the characteristics of both a gel and a cream, and these characteristics were maintained before and after the stability study.

Centrifugation analysis is a primary test performed before a stability study to anticipate possible instability. Phase separation could occur in semi-solid forms (Brasil, 2004). In this test, the product did not show any sign of instability; hence, the product was submitted to the stability study.

The density of a liquid or semi-solid form can indicate the incorporation of air or the loss of volatile ingredients (Brasil, 2004). The gel/cream formulated with buriti oil had an initial average density of 2.5499 g/mL. After 3 months of storage in the accelerated climactic chamber, the density had dropped markedly to 0.9714 g/mL; this difference was significant ($p < 0.12$). This change indicates that there was a loss of volatile ingredients in the formulation.

The pH represents the acidity or alkalinity of a given solution, measured from 1 (acidic medium) to 14 (alkaline medium), with 7 being considered a neutral pH (Brasil, 2004). The normal pH of saliva in the mouth is around 7 (RizqI et al., 2013). The pH of the product was close to the neutral pH of saliva, which indicates a good indication for oral use. The pH of the formulated gel/cream did not change after 3 months of storage in the accelerated climactic chamber.

Vitamin A deserves special attention for its importance in combating oxidative stress and its potential chemoprotective effect (Matos *et al.*, 2014). The colourimetric identification of vitamin A was not clear, probably due to interference from the colour of the sample. Specifically, after extraction with chloroform, the sample solution had a whitish colour, which could have caused interference, making the analysis impossible, because it is visual. When the test is performed using buriti oil, the blue colour is clearly visible, confirming the presence of vitamin A in the oil used in the product.

The sample was then subjected to a more effective analysis via HPLC, obtaining satisfactory results in the initial analysis, with a vitamin A identified at 4 min at 325 nm. The time differs from that specified by the European Pharmacopoeia 9th edition (Monograph, 2017) due to the column used, which was of a different size (Zorbax Eclipse C18 150 m × 4 mm). Because it was longer in length, the run time varied, but did not exceed the acceptable limits for variations in chromatographic parameters (column diameter ± 25%) (Brasil, 2019b). However, in the chromatogram obtained after the stability study, no peak was observed. The vitamin A had probably degraded, which is consistent with the considerably reduced density of the formulation after long-term storage.

Alpha-tocopherol is the main component of the vitamin E breakdown group. It is a powerful antioxidant and the main fat-soluble vitamin responsible for protecting cell membranes from peroxidation (Lima *et al.*, 2014). The colorimetric identification of vitamin E was fully satisfactory and as expected: both before and after the stability study, the product contained vitamin E.

Vitamins A and E are relatively stable but can exhibit significant losses due to thermal degradation during storage and because they are easily oxidised in the presence of oxygen (Prado *et al.*, 2011). Thus, it is suggested that further studies be conducted to better ascertain the stability of these compounds and to verify the antimicrobial and antifungal properties of the new formulation produced with buriti oil.

V. CONCLUSION

Based on the results obtained, the orabase gel/cream formulated with buriti oil showed initial stability and the expected physicochemical properties. That is, there was no visible instability observed in the product such as phase separation and it was possible to detect the presence of vitamins A and E, bioactive compounds with important antioxidant activity. After 90 days of storage in the accelerated climactic chamber, although the formulation did not present phase separation, there was a marked drop in the density compared with the initial analysis. This reduction indicated the loss of volatile compounds, a fact confirmed later by the absence of the vitamin A chromatographic peak. The absence of vitamins does not disqualify the product as a good candidate for the treatment of OM, because it maintained its fatty acid composition, including linoleic (omega or 6n-6) and linolenic acid (omega 3 or n-3) acids, which are essential for normal cellular functions of the skin. Additional studies should be carried out to improve the stability of especially vitamin A and to explore the antimicrobial and antifungal properties of the bioproduct developed in this research. Other improvements could also be made, such as changing the flavour. The mint essence could be replaced by any other flavour that is pleasant to the target audience.

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A Review on design and analysis of steel bridge with identification of load bearing capacity

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Abstract— Strengthening old bridges is an increasingly relevant strategy for risk prevention and operation continuity in management of infrastructures. Transportation networks are subjected to progressively stricter environmental and load conditions, leading to a growing number of deficient structures, also due to aging and deterioration. However, employable resources are finite, from both economic and environmental points of view. For these reasons, strengthening opportunities should be considered as a viable option, improving bridges with low economic and environmental impact. With this perspective, a selection of some of the most interesting strengthening techniques for old truss steel bridges is presented. To address effective solutions, the most frequent problems in old truss railway bridges are first presented. Literature analysis and experts' interviews were conducted and compared to results obtained from a representative bridge cluster. Different solutions addressing highlighted problems are then collected and qualitatively evaluated, in terms of efficacy on structural and typical construction requirements. Finally, general remarks and recommendations based on collected evidence are presented.

I. INTRODUCTION

A bridge is a means by which a road, railway or other service is carried over an obstacle such as a river, valley, and other road or railway line, either with no intermediate support or with only a limited number of supports at convenient locations. Bridges range in size from very modest short spans over, say, a small river to the extreme examples of suspension bridges crossing wide estuaries. Appearance is naturally less crucial for the smaller bridges, but in all cases the designer will consider the appearance of the basic elements, which make up his bridge, the superstructure and the substructure, and choose proportions which are appropriate to the particular circumstances considered. The use of steel often helps the designer to select proportions that are aesthetically pleasing. Bridges are an essential part of the transport infrastructure [1].

II. BACKGROUND

Steel is widely used in building as material. Because of steel have many factors affecting in mechanical properties, availability in a variety of useful and practical shapes, more economy, design simplicity, and ease and speed of construction. In another hand Steel can be produced with a variety of properties by adding many enhancements to suit our different requirements. The principle requirements are strength, ductility, weld ability, and corrosion resistance. Steel design, or more specifically, structural steel design, is an area of knowledge of structural engineering used to design steel structures. The structures can range from towers to homes to bridges. There are currently two common methods of steel design: The first and older method is the Allowable Strength Design (ASD) method. The second and newer is the Load and Resistance Factor Design (LRFD) method.

III.   LOADS ON STEEL BRIDGE TRUSSES

Trusses are used in bridges to transfer the gravity load of moving vehicles to supporting piers. Depending upon the site conditions and the span length of the bridge, the truss may be either through type or deck type. In the through type, the carriage way is supported at the bottom chord of trusses. In the deck type bridge, the carriage way is supported at the top chord of trusses. Usually, the structural framing supporting the carriage way is designed such that the loads from the carriage way are transferred to the nodal points of the vertical bridge trusses.
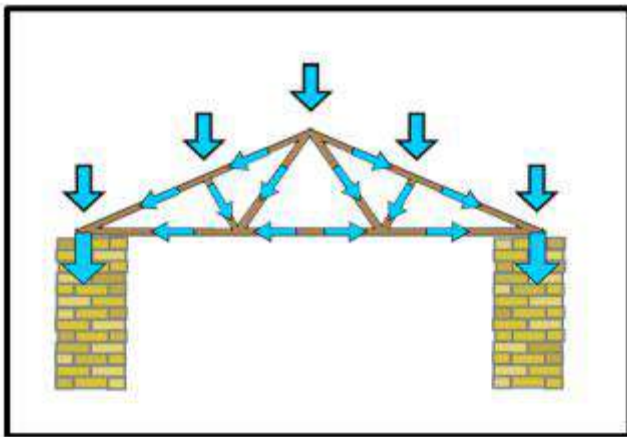
Fig.1: load distribution over a steel truss bridge.

IV.   LOADS

1. Dead Loads: The dead load represents the weight of structure itself and any other immovable loads (equipment) that are constant in magnitude and permanently attached to the structure. It consists of the weight of the main supporting trusses or girder the floor beams and stringer of the floor system. Structural design is that the true dead load of the structure that cannot be determined until the bridge is designed and a final design cannot be accomplished unless the true dead load is known. The dead load acting on a member must be assumed before the member is designed; one should design the member of a structure in such a sequence that to as great an extent as practicable the weight of each member being designed is a portion of the dead load carried by the next member to be designed.

2. Live load: The live load for highway bridges consists of weight of the applied moving load of vehicles and pedestrians. Highway bridges should be designed to safely support all vehicles that might pass over them during the life of the structure actually; the traffic over Highway Bridge will consist of multitude of different types of vehicle. It's not possible for the designer to know what vehicles will be use the structure or what the required life of the bridge will be to ensure the safety of the structure. Some form of the

control must be maintained so that the designer has to provide sufficient strength in the structure to carry present and future predicated loads.

3. Wind Loads: Wind loads are caused by the pressure of wind acting on the bridge members. They are dynamic loads that depend on such factors as the size and shape of the structure, the velocity and angle of the wind. For design purposes, AASHTO specifications give wind loads as uniformly distributed static loads. This simplified loading is intended for rigid structures that are not dynamically sensitive to wind; that is, structural design is not controlled by wind loads. It applied as horizontal loads acting on the superstructure and substructure and as vertical loads acting upward on the deck underside. The magnitude of the loads depends on the component of the structure and the base wind velocity used for design.

V.   STRUCTURAL ELEMENTS

Truss bridges usually present different features in terms of static scheme, spans, overall length, geometry and so forth. However, they are assembled by the same structural elements such as main trusses, deck elements and connections. As a matter of fact, these are the references for bridge inspection manuals [11-12]. For this reason, the encountered problems for the truss bridge type are organized and presented according to the mentioned scheme. Attention is focused on main trusses, deck elements, connections, in association with the strengthening interventions presented. However, it is good to remember that bracings and bearings may also require strengthening.

VI.   LITERATURE REVIEW

YongjianLiu, Advances in the application and research of steel bridge deck pavement: The common diseases of orthotropic steel deck pavement have seriously affected the service life and safe operation of long-span steel bridges. This paper presents an overview on current application and research status of steel bridge deck pavement. Comparations were made on the design requirements of steel bridge deck pavement in several specifications of China, USA, and Japan. The pavement structures, deck stiffnesses and corresponding environmental temperatures were collected from 119 steel bridges around the world. Based on the information collected, the material performance, combination mechanism, technical characteristics and application prospects of various pavement structures were analyzed. Finally, comparison was made on different calculation methods of bridge deck stiffness. Results show that double-layer *EAM*, *GAM + SMAM* and *ERS* are the most commonly used pavement

structures of steel deck presently. However, for most of application cases, the actual life cannot reach the design service life of 15 years. Rigid base can significantly improve the stress condition of surface pavement and steel top plate [1].

ChaoJiang, Fatigue assessment of fillet weld in steel bridge towers considering corrosion effects: Field inspection shows that the fillet weld in steel bridge towers may be subjected to corrosion and fatigue loading simultaneously. To ensure the structural safety in the service life, corrosion effects on the fatigue life of the fillet weld in steel towers were investigated in this study. A prediction procedure of the fatigue life of the weld was firstly proposed based on the fracture mechanics method and verified by the test results. Three types of corrosion effects, pitting corrosion at the initial crack, pitting corrosion near the initial crack, and the corrosion fatigue crack growth were considered. Three corrosion levels were also defined under different corrosive environments. By taking the Third Nanjing Yangtze River Bridge as an example, a modified finite element (FE) model integrated with the local shell model was established to analyze the stress variation of the fillet weld in steel towers. Based on the stress influence lines, the maximum stress range was obtained under the vehicle load [2].

ZheZhang, Fatigue performance and optimal design of corrugated steel–concrete composite bridge deck: Orthotropic steel bridge deck (OSD) has been widely used in long and medium span bridges. However, traditional OSD with U-ribs is prone to fatigue cracking at the deck-to-rib welded joint. Corrugated steel–concrete composite bridge deck (CSCCBD) composed of corrugated steel plate, concrete layer and perforated plate shear connectors was proposed recently to improve the fatigue performance of the bridge deck. In this paper, comparing of the fatigue performance of OSD and CSCCBD was conducted through finite element (FE) analysis. The results showed that the stress amplitude of deck-to-rib welded joint of CSCCBD was reduced by more than 90 % compared with OSD. The fatigue problem of deck-to-rib welded joints can be solved fundamentally. It is further studied that distribution of fatigue vulnerability details of CSCCBD. The most unfavorable fatigue vulnerability details are located around the diaphragm-to-rib weld. The fatigue life of CSCCBD was evaluated based on the linear cumulative damage theory [3].

ShuailingLi, Ultra-low cycle fatigue fracture initiation life evaluation of thick-walled steel bridge piers with microscopic damage index under bidirectional cyclic loading: Strong earthquakes can cause ultra-low cycle fatigue (ULCF) fracture in steel bridge piers. This paper examined the fracture behavior of two thick-walled square section steel bridge piers subjecting to horizontal bidirectional cyclic loading. In addition, a microscope damage index for evaluating ULCF fracture initiation life of steel bridge piers was proposed. The findings show that ductile cracking firstly appeared at the junction between the stiffened base plate and bottom weld at the corner position of steel bridge piers under bidirectional cyclic loading, and that initial crack growth did not reduce the strength capacity [4].

HuiyunXia, Preparation and performance of durable waterproof adhesive layer for steel bridge deck based on self-stratification effect: In view of the shortcomings of the existing steel bridge deck waterproof adhesive layer (WAL), such as poor durability, high construction cost and long construction period, a new preparation method of waterproof coating with self-stratification effect is proposed. In this paper, poly butyl acrylate-methyl methacrylate–styrene block copolymer with lower glass transition temperature was synthesized by free radical solution polymerization, and 5 kinds of self-stratification coatings were obtained by mixing it with epoxy resin at different mass ratios. The glass transition temperature, thermal stability and chemical composition of acrylic resin were characterized by DSC, TGA, and FT-IR. The self-stratification behavior of the coatings was confirmed by FT-IR, SEM, and water contact angle test. The basic performance and road performance of above self-stratifying waterproof coatings were tested according to specific standards [5].

JiaSun, Structural optimization of steel bridge deck pavement based on mixture performance and mechanical simulation: The upper layer of modified SMA mixture (SMAM) and the lower layer of epoxy asphalt mixture (EAM) is a steel bridge deck pavement (SBDP) structure with application potential, but there is a lack of systematic research on it. In this study, the pavement material and structure of SMAM + EAM were optimized using mixture performance tests and finite element analysis, which provided guidance to facilitate its promotion and application. Firstly, the pavement performance and dynamic properties of SMAMs and EAMs prepared with different binders were compared to preferably select the appropriate SBDP material. Secondly, the dynamic modulus master curves of the mixtures were established to provide material parameters for pavement structure design. Finally, the FEA method was applied to comparatively analyze the dynamic mechanical response of the pavement structure for different structures, thickness combinations, and temperatures to optimize the SBDP structure purposefully. The results demonstrated that EAM had better high-temperature rutting resistance than SMAM, while SMAM had superior moisture damage and skid resistance [6].

Qing-ChenTang, Hybrid control of steel-concrete composite girder bridges considering the slip and shear-lag effects with MR–TMD based on train-bridge interactions: With the speed of trains higher and bridge structures towards larger spans with lighter weight, the train-bridge resonance will become fairly pronounced. Therefore, to ensure the safety of bridge structures, research on vibration control is of far-reaching significance, especially for steel–concrete composite girder bridges with mechanical properties, such as slip, and shear lag. Therefore, based on a magnetorheological tuned mass damper (MR–TMD), this paper proposes a hybrid control strategy for the steel–concrete composite girder bridge considering whether the trains are either on or off the bridge, and applies it to a numerical example, reducing vertical dynamic responses of a railway steel–concrete composite girder bridge based on train-bridge interactions [7].

O.Bouzas, A holistic methodology for the non-destructive experimental characterization and reliability-based structural assessment of historical steel bridges: Nowadays, several historical steel structures present damage and an advanced deterioration state induced by human or natural actions, causing fluctuations in geometrical, physical, and mechanical properties that dramatically affect their mechanical behavior. Due to the economic, cultural, and heritage value, these constructions must be comprehensively assessed to verify their current condition state. This work presents a holistic methodology aimed at the non-destructive experimental characterization and reliability-based structural assessment of historical steel bridges. It comprehends from the experimental data acquisition to the finite element model updating and the probabilistic-based structural assessment to obtain the reliability indexes of serviceability and ultimate limit states. Several sources of information are considered in the evaluation process, thus, results are more realistic and accurate and can be used for optimal decision-making related to maintenance and retrofitting actions. The feasibility of the methodology has been tested on O Barqueiro Bridge, an aging riveted bridge located in Galicia, Spain. The study first involved a comprehensive experimental campaign to characterize the bridge effectively at multiple levels: geometry, material, and structural system by the synergetic combination of different tools and methods: in-depth visual inspection, terrestrial laser scanner survey, ultrasonic testing, and ambient vibration test [8].

Tadesse G.Wakjira, Explainable machine learning based efficient prediction tool for lateral cyclic response of post-tensioned base rocking steel bridge piers: This study presents a novel explainable machine learning (ML) based predictive model for the lateral cyclic response of post-

tensioned (PT) base rocking steel bridge piers. The PT rocking steel bridge pier comprises a circular tube with welded circular base plate that is pre-compressed to its base by means of gravity loads and/or a PT tendon. The input factors were column diameter, column diameter-to-thickness ratio, column height-to-diameter ratio, cross-sectional area of tendon-to-column ratio, tendon initial post-tensioning ratio, dead load ratio, base plate thickness, and base plate extension. Response variables were column residual drift, column shortening, ratio of degraded stiffness to initial stiffness, maximum lateral strength to uplift force ratio, and lateral strength reduction ratio. Nine ML techniques that range from the simplest to advanced techniques were used to generate the predictive models [9].

TomaszMaleska, Effect of the soil cover depth on the seismic response in a large-span thin-walled corrugated steel plate bridge: The common use of corrugated steel plate (CSP) bridges and culverts has been increasing in recent years. Despite the growing popularity of these objects, there is very scarce research concerned with the response of such structures to seismic excitation. Therefore, the aim of the study is to determine the effect of seismic excitation on a CSP bridge with span exceeding 17 m and a variable depth of the soil cover above the steel shell (from 1.0 to 5.0 m). The obtained results demonstrate that the depth of the soil cover has a significant impact on the response of the bridge [10].

DaoyunYuan, Fatigue damage evaluation of welded joints in steel bridge based on meso-damage mechanics: Welding is a rapid and flexible connection that facilitates the use of a broad range of steel bridge. However, fatigue cracks initiating from various welded connection details are common problems in steel bridges. Therefore, it is vital to accurately evaluate the fatigue damage evolution and fatigue life of welded joints in steel bridge. In this study, a fatigue damage evolution model based on the *meso*-damage mechanics was proposed to evaluate the fatigue damage of welded joints in steel bridge. The number density of micro-cracks was adopted as the damage variable in the fatigue evolution model. Finite element modelling and user material subroutine (UMAT) in ABAQUS were combined to simulate fatigue damage evolution of welded joints in steel bridge. The fatigue damage evolution model was embedded in UMAT while the UMAT was coupled with the finite element model of the welded joints under cyclic loading [11].

OskarSkoglund, A numerical evaluation of new structural details for an improved fatigue strength of steel bridges: Fatigue is often the decisive design factor when designing steel bridges and improving the fatigue strength of critical details can reduce the amount of steel material

used. In this paper, the fatigue strength of four different structural detail solutions are investigated and compared through numerical simulations. Two of the evaluated structural details have not been used before in bridge construction. The most promising structural detail managed to improve the fatigue strength by more than 25% compared to the conventional solutions used today. The numerical studies were performed as a preparation for future testing [12].

AlirezaGhiasi, Damage detection of in-service steel railway bridges using a fine k-nearest neighbor machine learning classifier: Minor areas of surface corrosion in steel railway bridges can grow progressively and lead to localized section losses and structural failure over time. This paper proposes a novel combined damage detection approach for the classification of various extents and degrees of cross section losses due to damages like corrosion using a k-Nearest Neighbor (kNN) machine learning classifier. A Finite Element (FE) model of an in-service railway bridge is developed and validated using vibration data from field testing and these combined FE-field data are trained and tested to classify various corrosion cases following the Australian Standard AS7636 [13].

JeonghwaLee, Improved design of intermediate diaphragm spacing in horizontally curved steel box bridges: Eccentric live loading acting on the steel box girders induces cross-sectional distortion in the steel box sections. In particular, the distortional behavior in horizontally curved steel box bridges can be significant compared to that in straight ones; the reason is that the curvature effects of horizontally curved steel box bridges can provide additional distortional behavior due to gravity and live loads even without eccentricity of the applied loadings for every construction sequence (self-weight for non-composite and live loads for composite box sections). Therefore, to control the distortional warping normal stresses induced by the distortional behavior, it is necessary to install intermediate diaphragms in the box sections for straight and horizontally curved box bridges [14].

DorinRadu, Residual life of a historic riveted steel bridge - engineering critical assessment approach: Sustainability has become an increasingly important component of requirements for the rehabilitation of bridge structures. Responsible use of our limited natural resources is essential for future generations, so the whole bridge rehabilitation process must be taken into account, in terms of structural integrity. The environmental impact for these types of structures is major – demolition and reconsideration of e.g. reinforced concrete structure being examples of poor management of resources and energy. On the existing roads and railways network steel bridges with more than 100 years

in service lifetime are numerous. The in-service safety assessment of these structures is a complex problem. This article emphasizes the importance of rehabilitating the structure of existing steel bridges, considering the historical monument character of these structures, as well as the reuse of existing structures, part of sustainable development. The paper is presenting a study case for an historical riveted steel bridge build in the beginning of twentieth century, with an assessment method considering the structural integrity by means of fracture mechanics [15].

VII. CONCLUSIONS

In this paper, different possible strengthening solutions for old steel truss Steel bridges have been proposed. Their choice is generally motivated by different aspects, such as structural efficacy, construction times, required traffic interruptions and maintenance ease. First, the analysis of material and structural features has outlined that strengthening requirements: (1) are related to brittleness and low-redundancy characteristics of truss steel bridges; (2) are mainly associated to problems localized in deck elements, namely stringers, cross beams, and connections. Literature review, interviews and direct examination of a target bridge cluster also suggest that often problems are not present on a single element only but interest a whole class of structural components. For this reason, it is opportune to assess whether a global strengthening solution can be more effective that a set of local interventions. Being the latter better known and more extensively adopted, an examination of global strengthening strategies is conducted and presented through real case studies. The overview highlights that: (1) load bearing capacity for main trusses is generally not a problem, however a global intervention can reduce fatigue sensitivity in main trusses connections and increase the overall structural robustness and safety; (2) extensive interventions on the deck can not only solve the phenomena localized in single problematic elements, but improve the overall behaviour of the structure, in terms of deformations, sensitivity to brittle failures, vibrations and maintenance. We believe that there are many more smart, innovative solutions that have been used, but they are not always reported in the literature, since bridge designers and bridge owners are normally not so interested in producing papers for conferences and journals. Thereof, strengthening may not always be the best solution for deficient old truss railway bridges. However, an updated knowledge of available techniques and a creative approach can expand the upgrade possibilities for existing bridges, increase their lifetime and safety with low economical and environmental impact, while preserving our historical heritage.

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Production Growth Response of Two Sugar Cane Varieties (*Saccharum officinarum L.*) At Available Various Water Levels

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Abstract— This study on available water content aims to determine the ability of sugarcane plants to grow and produce under water-stressed conditions. This research is expected to be used as one of the references in making decisions to use water efficiently in the Takalar sugar factory's sugarcane plantations. The study used two varieties of sugar cane namely PS. 61 and Q 81. The two varieties were planted at various moisture content levels, namely 25-50%, 50-75%, and 75-100%. The results showed that having 50-75% available water content had a better effect on sugarcane growth during the dry months of September and October. The Q 81 variety is better able to utilize the limited water supply for growth and production. The amount of available water and the variety of growth and sugarcane production have a significant interaction.

I. INTRODUCTION

Sugarcane (Saccharum officinarum L.) is a major sugar-producing plant. Sugar cane sugar is an important commodity because it is one of society's nine basic needs. The growing population necessitates an increase in the community's need for sugar consumption. This increase must be accompanied by an increase in sugar cane cultivation in order to meet the community's sugar needs. Takalar sugar factory has a large sugar cane cultivation area. Water availability is a major issue in this plantation area. From November to April, rainfall is uneven and concentrated, with a long and distinct dry season from May to October.

The main issue in efforts to increase sugarcane productivity in the Takalar sugar factory's sugarcane plantation area is the short rainy season with strict dry months, combined with soil conditions with low water holding capacity. Sugarcane productivity has averaged 49.24 t/ha since 1987, with a crystal content of 3.99 t/ha and a yield of 9.43%.

This low productivity is due to the fact that plants' water requirements are solely met by rainfall. Because the new plants (plant cane) had to be cut down before they gotten older, the weight and yield of the cane were relatively low.

To avoid this, the plants are planted at the appropriate time. The accuracy with which the time of planting and harvesting is determined defines the high or low weight of sugarcane and its yield. Because of this, approximately 70% of the sugar cane planting in the Takalar sugar factory plantations occurred in August, September, and October, despite the fact that water availability was extremely limited at the time.

So far, most research has concentrated on the use of water resources in dry-land sugarcane plants with irrigation systems, with little emphasis on the efficient use

of water during dry months for sugar cane growth and production. Given the condition of the Takalar sugar factory land, which ranges from flat to undulating with quite high rainfall during the rainy season, the rain water that flows on the surface (run off) in Lampung is used as irrigation water through dams to be used during the dry season. However, the amount of water that can be accommodated has not been able to meet the needs of plants during the dry season, making it difficult to cultivate plants.

PS 61 and Q 81 sugarcane varieties were developed at the Takalar sugar factory. Both varieties have adapted well to their surroundings. This ability can be capitalized on by creating favorable conditions for growth and production.

II.   RESEARCH PURPOUSES

This study on available water content aims to determine the ability of sugarcane plants to respond to limited water availability in determining their growth and production.

III.   RESEARCH METHODS

This research was conducted in Parangpungata Village, Polong Bengeng Utara District, Talakar Regency. This research was carried out in the form of an experiment arranged according to a Split Plot Design in a random group pattern. The main plot consisted of two varieties, namely PS 61 and Q 81 (V_2). Subplots are available concentration levels that consist of three levels, namely the 25-50% available concentration level (K_1). 50-75% (K_2) and 75-100% (K3). The main and sub-plot combinations are:

V₁K₁ V2K1

IN1K₂ V2K2

IN1K3 IN2K3

Each combination was divided into three groups, yielding a total of 18 experimental plots. Each unit is 12x10 meters in size, or 120 m2. Water requirements are calculated using field capacity of 40%, permanent wilting point of 27%, and soil density of 1.39 cm3.

As a result, the water available for sugarcane crops ranges between 27 and 40%. The water contains four levels of water content, which are as follows:

a.   25% of the water is available, then the soil water level is 0.25 x 13 =3.25%

b.   50% of the available water, then the soil water content is 0.50 x 13 = 6.50%

c.   75% of the available water, then the soil water content is 0.75 x 13 = 9.75%

d.   100% of the water is available, then the soil water content is 0.25 x 13 = 13.00%

The supplied water is calculated using the following equation:

$$W_{SI} = 0,1 \times hi \frac{\sum SI}{W} \times WWI$$

W_{SI} = Soil sleeve expressed in units of water deviation from the 1st layer (mm)

Hi   = Thickness of the 1st layer of soil (cm)

$\sum SI$ = Density or dry weight of soil volume from the 1st field (9cm³)

WWI = Soil sleeve from the 1st layer (% by weight).

The amount of water for each level of water content is calculated using this equation as follows:

a.   25% of available water, = 3.9 x 3.25 =12.675 mm/m² or 1521 1/plot

b.   50% of available water, = 3.9 x 6.50 = 25.350 mm/m² or 3042 1/plot

c.   75% of available water, = 3.9 x 9.75 = 38.250 mm/m² or 4563 l/plot

d.   100% of available water, = 3.9 x 13.00 = 50,700 mm/m² or 6084 l/plot

As a result, the amount of water required for each treatment can be calculated. Since the increase (%), the number of tillers, stem height, stem diameter, number and length of internodes, stem length, number of stems, sugarcane weight per stalk, and sugarcane yield (%) have all been observed.

IV.   RESULT AND DISSCUSSION

The experimental results revealed that the amount of available water content and its interaction with varieties had a significant effect on the number of tillers at 30 HST, plant height at 30 HST, stem diameter at harvest, and number of internodes, but only had a minor effect on internode length and sugarcane yield. The analysis revealed that the highest number of tillers and plant height for both varieties occurred at water availability levels of 50-75% and 75-100%. At the same moisture content levels of 50-75% and 75-100%, stem diameter and internode length showed the same interaction results (Tables 1 and 4). Cane internode length and yield showed varying tendencies. For segment length, water content levels of 25-50% and 50-75% outperform moisture content levels of 75-100%, whereas for sugarcane yield, available water content levels of 25-50% and 75-100% have

a negative effect. superior to 50-75% water content (Tables 5 and 6).

The two sugarcane varieties tested yielded varying growth and production results. The components of tiller number, plant height, and internode length (Tables 1, 2, and 5) revealed that the PS 61 variety outperformed the Q 81 variety. In terms of stem diameter, internode number, and sugarcane yield, the Q 81 variety performed better than the PS 61 variety (Tables 3,4, 6).

Table 1. Average number of tillers per meter at 30 HST

Variety	Level of water		
	K_1	K_2	K_3
V_1	$4,19^b{}_x$	$4,60^a{}_x$	$4,66^a{}_x$
V_2	$4,19^c{}_x$	$4,36^b{}_y$	$4,50^a{}_y$
BNJ α = 0,05		V= 0,014	K= 0,060

In the BNJ test, numbers followed by letters that are not the same are significantly different in rows (a, b) and columns (x, y) = 0.05

Table 2. Average Total Plant Height (cm) Age 30 DAP

Variety	Level of water		
	K_1	K_2	K_3
V_1	$17,84^c{}_x$	$21,18^b{}_x$	$26,21^a{}_x$
V_2	$18,96^a{}_x$	$19,51^a{}_y$	$20,14^a{}_y$
BNJ α = 0,01		V=1,90	K= 1,26

Numbers followed by letters that are not the same are significantly different in rows (a, b) and columns (x, y) in the BNJ test α = 0.01

Table 3. Average Stem Diameter (cm)

Variety	Level of water		
	K_1	K_2	K_3
V_1	$2,75^a{}_x$	$2,77^b{}_x$	$2,73^c{}_x$
V_2	$2,79^a{}_y$	$2,81^b{}_y$	$2,82^c{}_y$
BNJ α = 0,05		V= 0,007	K= 0,0015

Numbers followed by letters that are not the same are significantly different in rows (a, b) and columns (x, y) in the BNJ test α = 0.05

Table 4. Average Number of Segments at Various Levels of Available Moisture Content

Variety	Level of water		
	K_1	K_2	K_3
V_1	$19,73^a{}_x$	$19,93^a{}_x$	$20,30^a{}_x$
V_2	$21,56^a{}_x$	$21,20^a{}_x$	$2,40^b{}_y$
BNJ α = 0,01		V=1,1	K= 1,85

Numbers followed by letters that are not the same are significantly different in rows (a, b) and columns (x, y) in the BNJ test α = 0.01

Table 5. Average Segment Length of Two Sugar Cane Varieties (cm)

Variety	Level of water		
	K_1	K_2	K_3
V_1	13,15	13,25	12,43
V_2	11,65	12,19	11,01
	$12,40^a$	$12,72^a$	$11,72^b$
BNJ α = 0,01		NP= 0,50	

Numbers followed by letters that are not the same differ greatly in the BNJ test α = 0.01

Table 6. Average Yield of Two Sugar Cane Varieties (%) at Various Levels of Available Moisture Content

Variety	Level of water		
	K_1	K_2	K_3
V_1	10,20	8,76	10,02
V_2	8,33	9,26	10,46
	$9,265^c$	$9,010^b$	$10,24^a$
BNJ α = 0,01		NP= 0,9	

Numbers followed by letters that are not the same differ greatly in the BNJ test α = 0.01

Sugarcane requires a lot of water to grow. Water availability in sufficient quantities can assist plant metabolic processes in meeting the needs for optimum growth.

The experimental results show that 50-75 percent available water and 75-100 percent available water are adequate amounts to aid plant metabolic processes. A water content of 25-50 percent produces better results for shoot formation and plant height in early growth. According to Barnes (1974), sugar cane grows optimally when the

moisture content is between 50 and 75 percent of the field capacity. Water availability in sufficient quantities in plant tissues where cell division occurs will promote plant growth. Ambo Ala, 1995, also mentioned that having enough water available at the start of germination will help the sprouts grow faster.

At a moisture content of 25-50 percent of available water, initial growth is inhibited. It is suspected that the scarcity of water inhibits metabolic processes, affecting plant growth. Sugarcane plant growth and development are determined by the availability of water in the soil. When soil water content is low, water moves more slowly into plant cells, limiting the amount of food reserves that can be translocated (Rahman, 1997).

Variety and the level of available moisture content have a significant influence on production components. The effect, however, differs widely. The effect is less favorable during the rainy season because the limited availability of water at the start of growth is no longer significant for production components.

At various levels of available moisture content, the PS 61 variety was more volatile in growth and production. In terms of the number of tillers and plant height, the higher the water content, the better the growth, whereas the stem diameter, internode length, and yield of Q81 experienced growth and production improvements at each available water content level. The higher the water content, the better and more rapid the growth. This variety can survive in environments with limited water availability, and when water availability is optimal, it will be optimally utilized to spur growth and production. As a result, the two species have different abilities in utilizing water availability to spur growth and production.

V. CONCLUSION

1. The level of available water content of 50-75 percent can have a good effect on the growth of sugarcane plants.
2. 2. The Q81 variety is better suited to utilizing the limited water supply for sugarcane growth and production.
3. The level of available water content and variety have a significant impact on sugar cane growth and production.

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Analysis of Clean Water Distribution System in Nuruwe Village, West Kairatu District, Seram West Regency using Epanet Software 2.0

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Abstract— Water is one of the natural elements that more or less influences every important role in the life of humans and other creatures in this nature which is a basic need for humans so that it becomes the main thing if the clean water sector gets priority in handling and fulfilling it. Water demand is the amount of water needed for household, industrial and other needs. Population Projection is a scientific calculation of population in the future based on assumptions about the components of population growth at a certain level, the results of which will show the characteristics of the population, births, deaths and migration. EPANET is a computer program that provides hydraulic simulations and trends in the quality of water flowing in pipelines. The network itself consists of Pipes, The method of data collection and analysis used in this study was to conduct a survey at the research location to review and see directly the conditions of the research location, then create a piping system that is suitable for the research location, after that calculate the projected population and clean water distribution system in Nuruwe village by using the Epanet 2.0 Software to analyze the feasibility of the piping system based on the number of residents and water needs it can be concluded that the clean water requirement needed by the residents of Nuruwe Village is 2.44 liters/second, with this amount of water demand, a network system distribution model is made piping using Epanet 2.0 software, and the results obtained are Run Successful, which means the distribution of the piping system runs 100%.

I. INTRODUCTION

Water is one of the natural elements that more or less influences every important role in the life of humans and other creatures in this nature which is a basic need for humans so that it becomes the main thing if the clean water sector gets priority in handling and fulfilling it. It is expected to be able to distribute and meet the community's clean water needs properly and evenly, with the existing pipe distribution system. If the distribution system that occurs is not good, it will cause various kinds of problems including a lack of water pressure so that the water flow is not distributed evenly, with the existing pipe distribution system. (Rusdina, 2015)

The clean water supply system that is implemented in the PAMSIMAS program in obtaining clean water will produce better quality and quantity of services different from one city/regency to another. This is also the case in West Seram District, Maluku Province, where the distribution of clean water from this program has not been maximized in each area. If the distribution system that

occurs is not good, it will cause various kinds of problems including lack of water pressure so that the water flow is not distributed evenly.One of the villages in West Seram Regency which is also affected by the less than optimal distribution of water is Nuruwe Village, Kairatu Barat District. This area also experiences the same thing, where water distribution is not optimal even though there is already a pipe network system in this area (batosamma, 2018).

Thus, to anticipate the clean water problem in Nuruwe Village, West Kairatu District, it is necessary to review it so that the clean water problem in the village can be properly resolved. In this study the authors propose an alternative solution to clean water problems by re-analyzing the clean water distribution system assisted by Epanet 2.0 software. The distribution system will be modeled in EPANET 2.0 software to find out whether water sources can meet community needs in a sustainable manner until the planned year.

With this the author conducts research on the Analysis of the Clean Water Distribution System in Nuruwe Village, Kairatu Barat District, West Seram Regency Using Epanet 2.0 Software

II.   LITERATURE REVIEW

2.1   Definition of Water

Water is a natural resource that is absolutely used for life and human life and in the environmental management system, water is an element of the environment.

Clean water is water that is used for daily needs and will become drinking water after being boiled first. As a limit, clean water is water that meets the requirements for a drinking water supply system. The requirements in question are requirements in terms of water quality which include physical, chemical, biological and radiological quality, so that when consumed it does not cause side effects (General Provisions of Permenkes no. 416/Menkes/PER/IX/1990). In the General Description Module of Drinking Water Provision and Treatment, March 2003 Edition, p. 3 of 41 (Makawimbang et al., 2017).

2.2   Water Needs

Water demand is the amount of water needed for household, industrial and other needs. The priority of water needs includes domestic, industrial, and public service water needs (Pramono & Andana, 2019). The water requirement determines the size of the system and is determined based on water usage

1.   Clean Water Requirements Standard

Water needs will be categorized into domestic and non-domestic water needs. Domestic water needs are water needs that are used for household needs, namely for drinking, cooking, bathing, washing clothes and other needs, while non-domestic water needs are used for commercial activities such as industry, offices, and social activities such as schools, hospitals, places of worship and commerce. (Suheri et al., 2019). The average water consumption unit for non-domestic facilities and infrastructure in the evaluation is adjusted to the DPU standards of the Directorate General of Cipta Karya, 1996 in Table.1 and also domestic facilities and infrastructure are listed in Table.2 as follows:

Table.1: Non-domestic water needs

No.	Sarana dan prasarana	UnitKebutuhan KonsumsiAir (liter/hari)
1	masjid	30 untuk 100 orang
2	gereja	10 untuk 100 orang
3	toko	10 untuk 20 orang
4	pasar	10 untuk 20 orang
5	hotel	25 untuk 300 tempat tidur
6	rumah makan	2000 untuk 1 rumah makan
7	industri	2000 untuk 1 industr
8	rumah sakit	240 untuk 300
9	puskesmas	25 untuk 10 orang
10	apotek	10 untuk 20 orang
11	sekolah	25 untuk 250 orang
12	kantor	30 untuk 25 orang
13	bioskop	25 untuk 200 tempat duduk

Table.2: Domestic water demand

URAIAN	KATEGORI KOTA BERDASARKAN JUMLAH PENDUDUK (JIWA)				
	> 1.000.000	500.001 s/d 1.000.000	100.000 s/d 500.000	20.000 s/d 100.000	< 20.000
	Kota Metropolitan	Kota Besar	Kota Sedang	Kota Kecil	Desa
1	2	3	4	5	6
1. Konsumsi Unit Sambungan Rumah (SR) (liter/org/hari)	> 150	150 - 120	90 - 120	80 - 120	60 - 80
2. Konsumsi Unit Hidran (HU) (liter/org/hari)	20 - 40	20 - 40	20 - 40	20 - 40	20 - 40
3. Konsumsi unit non domestik					
a. Niaga Kecil (liter/unit/hari)	600 - 900	600 - 900		600	
b. Niaga Besar (liter/unit/hari)	1000 - 5000	1000 - 5000		1500	
c. Industri Besar (liter/detik/ha)	0.2 - 0.8	0.2 - 0.8		0.2 - 0.8	
d. Pariwisata (liter/detik/ha)	0.1 - 0.3	0.1 - 0.3		0.1 - 0.3	
4. Kehilangan Air (%)	20 - 30	20 - 30	20 - 30	20 - 30	20 - 30
5. Faktor Hari Maksimum	1.15 - 1.25 * harian	1.15 - 1.25 * harian	1.15 - 1.25 * harian	1.15 - 1.25 * harian	1.15 - 1.25 * harian
6. Faktor Jam Puncak	1.75 - 2.0 * hari maks	1.75 - 2.0 * hari maks	1.75 - 2.0 * hari maks	1.75 *hari maks	1.75 *hari maks
7. Jumlah Jiwa Per SR (Jiwa)	5	5	5	5	5
8. Jumlah Jiwa Per HU (Jiwa)	100	100	100	100 - 200	200
9. Sisa Tekan Di penyediaan Distribusi (Meter)	10	10	10	10	10
10. Jam Operasi (jam)	24	24	24	24	24
11. Volume Reservoir (% Max Day Demand)	15 - 25	15 - 25	15 - 25	15 - 25	15 - 25
12. SR : HU	50 : 50 s/d 80 : 20	50 : 50 s/d 80 : 20	80 : 20	70 : 30	70 : 30
13. Cakupan Pelayanan (%)	90	90	90	90	70

Information :

*) depending on the socio-economic survey

**) 60 % piping, 30 % non piping

***) 25 % piping, 45 % non piping

The feasibility standard for clean water needs is 49.5 is 2.5 liters per day. Standard water requirements in humans usually follow the formula of 30 cc per kilogram of body weight per day. That is, if someone with a body weight of 60 kg, then the need for water per day is 1,800 cc or 1.8 liters. The UNESCO world body itself in 2002 has established the basic human right to water, which is 60 ltr/person/day. The Directorate General of Human Settlement, Ministry of Public Works, subdivides the standards for drinking water according to regional locations as follows:

1) Rural areas with a need of 60 liters / per capita / day

2) Small City with a need of 90 liters / per capita / day.

3) Medium City with a need of 110 liters / per capita / day.

4) Metropolitan City with a need of 130 liters / per capita / day.

2. Clean Water Requirements

In planning a clean water distribution system, of course there are water requirements (Boekoesoe, 2010). these are:

1) Quantity

The quantity requirement in the supply of clean water is in terms of the amount of raw water available. This means that raw water can be used to meet regional needs and the number of people to be served.

2) Continuity

Raw water for clean water must be taken continuously with relatively constant debit fluctuations, both during the dry and rainy seasons. Continuity can also mean that clean water must be available 24 hours per day, or whenever needed, water needs are available. However, these ideal conditions can hardly be met in every region in Indonesia, so to determine the level of continuity of water use can be done by approaching consumer activities towards priority water use. The priority for water use is for a minimum of 12 hours per day, namely during the hours of life activities, namely at 06.00 – 18.00.

2.3 Population Projection

Predictions of population in the future are based on the rate of urban development and trends, land use directions and the availability of land to accommodate population growth. It is necessary to know the prediction of the population in the 20-year planning period to determine the clean water needs of the planning area (Asrorudin, 2020). By taking into account the rate of development of the population in the past, the statistical method is the closest method for estimating the population in the future. The method used is:

• **Geometric Method**

This method is considered good for a short period of time equal to the period of data acquisition. The equation used is:

$$Pn = Po\ (\ 1 + r\ )n \quad .... (2.1)$$

With :

Pn = Number of Population in Year n

Po = Total population in the base year

r = Population Growth Ratio

n = Year Projection

2.4 Hydraulic Analysis

Flow in a pipe or flow in which the entire pipe section is filled with water. If water flows in a pipe but there is a free water surface in the pipe, then the flow is not included in the definition of flow in a pipe (Amin, 2011).

1) Main Energy Loss (major)

There are several empirical equations that are used each with its own advantages and disadvantages. The Darcy Weisbach equation is most widely used in fluid flow in general. For flows with relatively unchanged viscosity, the Hazen Williams equation is used. The following shows the following two equations:

a) Darcy Weisbach equation

Darcy Weisbach's mathematical equation is:

$$Hf = (L.v2\ /\ D.2g) \quad .... (2.2)$$

With :

hf = loss of energy or pressure (major or main)(m)

v = discharge of water in the pipe (m³/s)

f = friction coefficient (DarcyWeisbach)

L = pipe length (m)

D = pipe diameter (m)

g = acceleration due to gravity (m/s²)

b) The Hazen Williams equation

The Hazen-William equation is the most commonly used, this equation is more suitable for calculating pressure loss for pipes with large diameters, namely above 100 mm.

In addition, this formula is often used because it is easy to use. The Hazen Williams equation empirically states that the discharge flowing in the pipe is proportional to the pipe diameter.

$$S = hS/L \quad .... (2.3)$$

With :

S = hydraulic tilt

hL = pressure loss

L = pipe length

Besides that there is a factor C which describes the physical condition of the pipe such as the smoothness

of the inner wall of the pipe which describes the type of pipe and its age.

In general Hazen William's formula is as follows:

$$Q = 0.2785 . C . d2.63 . S0.54 \quad ....(2.4)$$

With :

    Q = water discharge in the pipe (m³/s)

    C = pipe roughness

    d = pipe diameter

    S = hydraulic tilt

If the pressure loss or hL is to be calculated then:

$$hl = (Q /(0.2785.C.d2.63))L............................ (2.5)$$

With :

    Q = water discharge in the pipe (m³/s)

    C = pipe roughness

    d = pipe diameter

    L = is the length of the pipe from node 1 to node 2

C is (Hazen William coefficient) different for various types of pipes while for High Density Poly Ethylene (HDPE) pipes the value of C (Hazen William coefficient) is 130. The following is C in Hazen William which can be seen in Table .3.

Table.3: Hazen William's C Score (DPU Directorate General of Cipta Karya)

Pipe Type	Grade C Planning
Asbestos Cement (ACP)	120
UPVC	120
Medium DPE	130
High HDPE	130
Ductile (DCIP)	110
Cast iron (CIP)	110
GIP	110
Steel	110
Pre-streams (PSC)	120

2) Secondary Energy Loss

Local energy loss due to cross-section enlargement, cross-section reduction, diaphragms and pipe bends. Minor energy loss in mathematical language is written as follows:

$$hf = k (v2 / 2g) .... (2.7)$$

With :

    k = loss of energy

    k = coefficient of minor loss

    v = speed

    g = gravity

In general, this pressure loss is much smaller than the loss due to friction in the pipe, therefore this pressure loss is commonly referred to as a minor loss or minor loss. (Dharmasetiawan, 2004: page II-12).

2.5 Water Pressure Requirements

According to the DPU (Department of Public Works) standards, water that is channeled to consumers through transmission and distribution pipes is designed to be able to serve consumers to the farthest with a drinking water pressure of 10 mka or 1 atm. This pressure figure must be maintained, ideally evenly distributed on each distribution pipe. If the pressure is too high, it will cause the pipe to burst and damage the plumbing tools. The pressure is also kept not too low, because if the pressure is too low it will cause water contamination during flow in the distribution pipe (Mahardhika, 2018).

1) Brocaptering (Spring Catcher Tub)

Protecting and capturing water from springs to be collected and channeled using transmission pipes to reservoirs.

2) Reservoir (Reservoir) The function of the reservoir is:

- As a reserve of clean water in the event of damage or repair of the distribution network.
- As a reserve to meet usage fluctuations.
- Can function as a pressure relief tub.
- As a water reserve for fire fighting.

The dimensions of the power depending on the service reservoir generally range between 17.5% - 20% of the average daily water demand. The greater the tamping capacity of the service reservoir, the safer the system is against system damage/repair and fire fighting.

2.6 Epanet 2.0 application

1) Introduction to EPANET 2.0 Software

Epanet is a computer programwhich describes the hydraulic simulation and the trend of the quality of water flowing in the pipeline. The network itself consists of Pipes, Nodes (pipe connection points), pumps, valves, and water tanks or reservoirs. EPANET tracks the flow of water in each pipe, the condition of the water pressure at each point and the condition of the concentration of chemicals flowing in the pipe during the flow period. In addition, water age and source tracking can also be simulated (Safitri et al., 2021).

EPAnet can assist in setting strategies to realize water quality in a system. These include:

1) Alternative use of sources in various sources in one system.

2) Alternative pumping in scheduling filling or tank filling.

3) Use of treatment, for example chlorination in storage tanks.

4) Targeting pipe cleaning and replacement.

Running in a windows environment, Epanet can be integrated to perform editing in data entry, running simulations and viewing running results in various formats. It also includes color codes on maps, data tables, graphs, and contour images.

For example for designing, calibrating hydraulic models, residual chlorine analysis, and customer analysis. EPANET can assist in managing strategies for realizing water quality in a system.
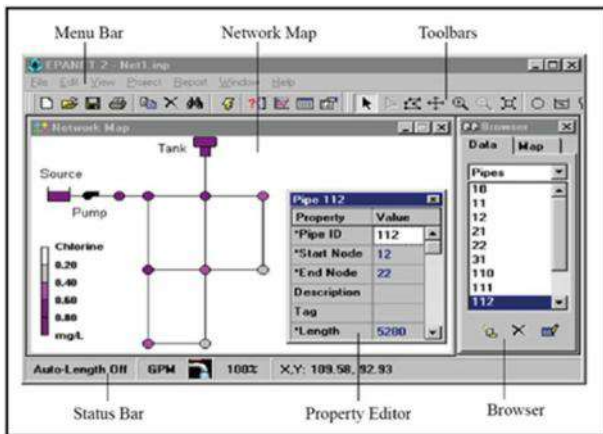
Fig.1: Display (source: Epanet 2.0 Application)

The use of software tools makes it easier to analyze the condition of the existing clean water pipelines so that it helps in rearranging the existing clean water pipelines.

2) How to use Epanet 2.0 Software
- Installing Apps

EPANET version 2.0 is designed for a Windows 95/98/NT operating system environment that is compatible with IBM/Intel PCs (Asrorudin, 2020). It consists of one file, en2setup.exe, which contains the self-extraction setup program. To install Epanet:

a) Select Run from the Windows Start menu.
b) Enter the full path and file name en2setup.exe or click the browse button to locate it on your computer.
c) click the OK button to start the process.

The Setup Program will ask for the choice of the folder (directory) where the Epanet files will be placed. The default folder is c:\program files\Epanet 2.0. After the file is installed, the Start Menu will have a new Epanet 2.0 menu. To easily log out of Epanet, select the inactive item on the Star Menu, then select Epanet 2.0 from the submenu that appears. (The executable file name of Epanet under windows is epanet2w.exe)

Likewise, if you want to remove Epanet from your computer, you can follow the following procedure:

a) Select Settings from the Start Menu

b) Select Control Panel from the Settings menu
c) Double click on the add/remove programs item
d) Select Epanet 2.0 from the list of programs that appears
e) Click the Add/Remove button

- Bar Menu

The menu bar located at the top of the EPANET work area contains a group of menus used to control EPANET programs consisting of:

a) File Menu

The file menu contains commands for opening and saving data files and for printing.

b) Edit Menus

The Edit menu contains commands for editing and copying.

c) View Menu

On the View Menu there are commands to control the display of the network map.

d) Project Menu

Project Menu   in it there are commands related to the analysis being carried out on the project menu.

e) Menu Reports

The Report menu has commands that are used to display analysis data in different formats.

f) Window Menus

The menu window contains commands Rearranges all the smaller windows to match the main window

g) Help Menu

The Help Menu contains commands for getting help in using EPANET. Help can also be obtained by pressing the F1 function key.

3) Open Program and Program Settings
a) Run the epanet program Start – Program – Epanet 2.0
b) After the Epanet program appears, then click File then click New or click Open then double click the file name if the file already exists.
c) Create an image file for the base map that will be made into the existing pipeline with a "BMP" file (if it is still in JPG format, it must be converted to BMP) which will be made to load the image on epanet.
d) Enter the map image in BMP form, namely click View – Backdroop – Load – press the plan drawing file
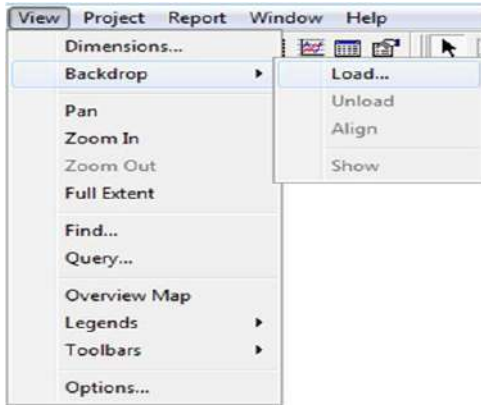
Fig.2: Display BMP file creation

e) Before creating a system network, first equalize the size of the discharge unit and determine the head loss formula, namely click on the Browser Toolbar:

➤ Hydraulic Data
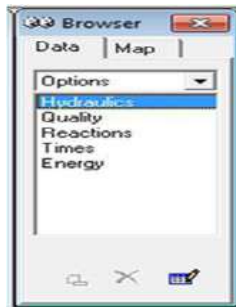
Fig.3: View Data generation

➤ Flow unit (LPS) head loss
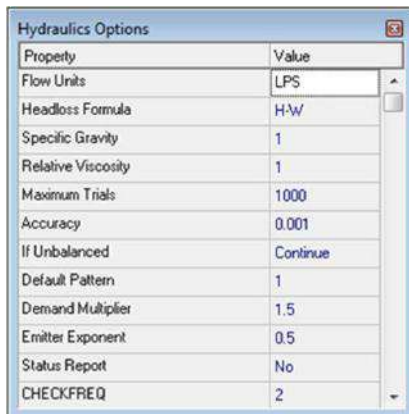
Fig.4: Display of making a headloss flow unit

➤ Data Options time

Fig.5: Display of making total duration data

4)   Create a Network Model Drawing

Create a distribution system network according to the existing system, using the Toolbars Map available in the epanet program (SIREGAR, 2021).

❖ Click the Reservoir Toolbar and place it on the plans.

❖ Click the Node/Junction Toolbar and place it on the plans.

❖ Click Pipe Toolbar b connect between junctions (press junctions for nodes then place them on the plan drawing).

❖ Then forwarded to Tank, Valves, Pump, etc.

5)   Enter Data

❖ After creating the system network, then filling in each data on junctions, pipes, reservoirs, pumps, tanks, etc. The data is filled according to the existing system.

❖ Create Time Patterns. The time pattern contains the peak hour factor for fluctuations in water usage per hour.

Data – Patterns – Add

In the patterns editor, the data that must be filled in includes:

a) Pattern Name (Pattern ID) → eg 1

b) The multiplier is filled with the peak hour factor. Peak hour factor (peak factor) is filled based on fluctuations in water usage.
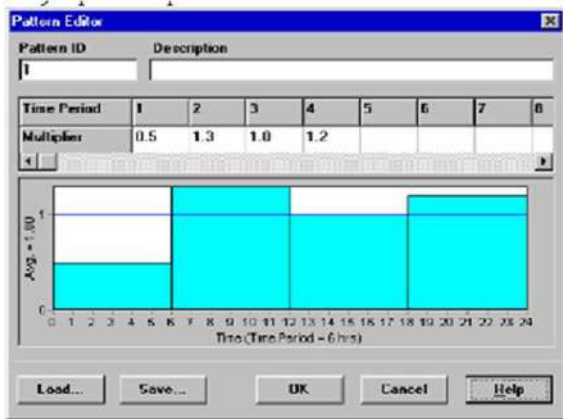
Fig.6: Data entry display (Pattern Editor)
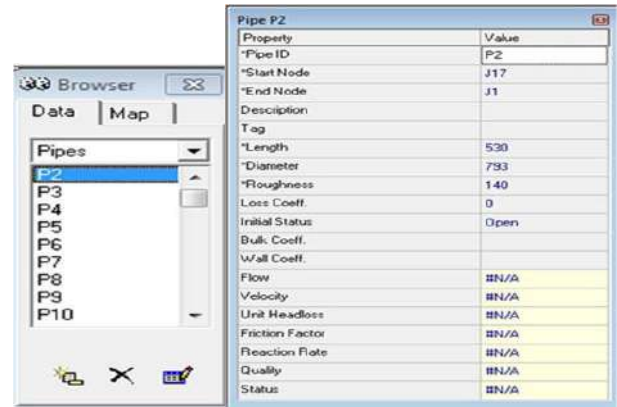
Apart from using the time pattern, the peak factor/peak hour factor can also be entered in the Demand Multiplier. Option – Hydraulic Option – Demand Multiplier (peak hour factor 1.5 – 1.75).

❖ Fill in Junctions data. In the Junction properties that must be filled include:
  a) Junction Name (Junction ID)
  b) Elevation (Elevation) → in meters
  c) Debit (Base Demand) → in L/s
  d) Demand pattern → Fill in the name of the pattern that has been made, for example 1
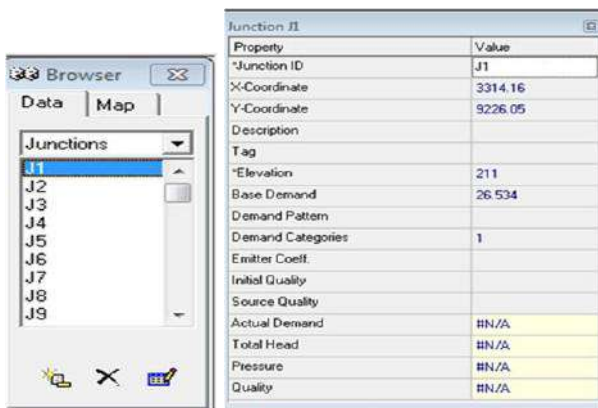
Fig.7: Display Junction Id

❖ Fill in Pipe data. The Pipe properties that must be filled include:
  a) Pipe name (Pipe ID) → eg P-1
  b) Pipe length (Length) → in meters
  c) Pipe diameter → in mm
  d) Pipe roughness coefficient (roughness) → 110 – 120 for plastic

Fig.8 Display Pipe Id

❖ Fill Reservoir data. The Reservoirs properties that must be filled include:
  a) Reservoir Name (Reservoir ID) → eg R-1
  b) Head Total (Total Head) → in
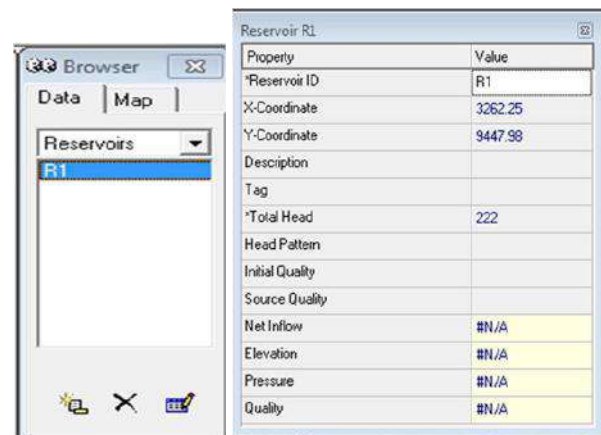
Fig.9: Reservoir filling display Id

❖ If pumping is required in a system, before filling in the pump data, first make a pump curve.
  Data – Curves – Add In the Curve editor fill in:
  a) Curve Name (Curve ID) → eg p-1
  b) The type of curve that will be made, because it makes a pump curve, then fill in the pump type (curve type: pump)
  c) Fill in the discharge (flow) with L/s and pressure in meters
  d) Click OK
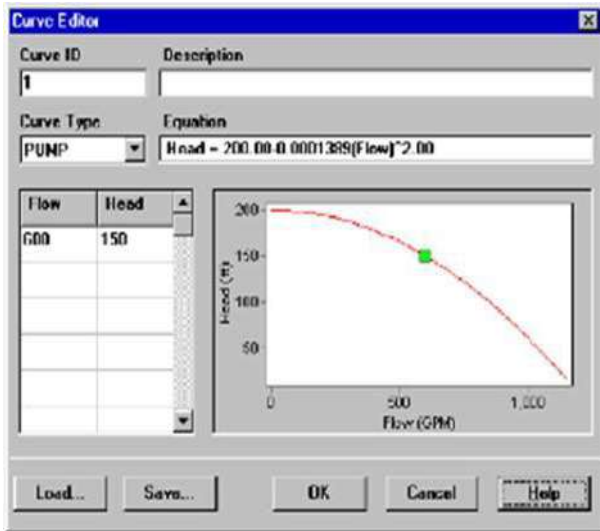
Fig.10: Display of the pump editor Curve

Fill in the data Pump (Pump). The Pump properties that must be filled include:

a) Pump Name (Pump ID) → eg Pump-1
b) Pump curve (Pump curve) → filled in accordance with the pump curve that has been made, for example p-1
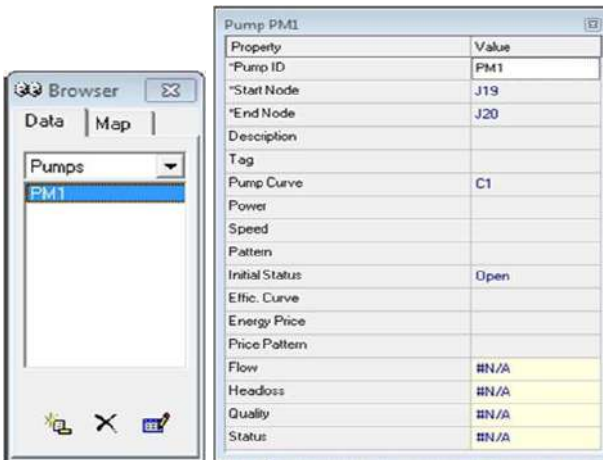
Fig.11: Display Pump Id

6) **Run Data and Models**
   a) After all done press Run ⚡ (shape of lightning)
   b) If RUN is SUCCESSFULL then proceed with the appearance of the data and checking the data whether it is in accordance with the standards set.
   c) Display of entry results in tabular form.

III. METHODOLOGY

Research Flow Chart
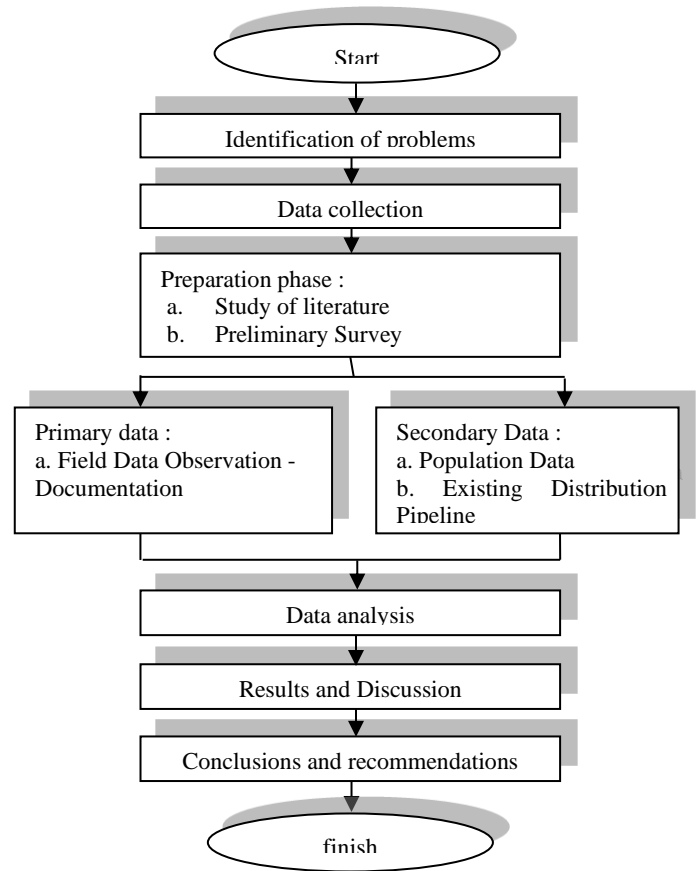
Fig.12: Research Flowchart

3.1. Research sites

In the research conducted by the author, the location was in Nuruwe Village, Kairatu Barat District, West Seram Regency.

Fig.13: Research Locations

3.2. Tools and Materials

Materials used to meet the needs of this research include: research permits, maps of research locations, and pictures of village maps

The tools used in this research are: Camera. Stationery, and Meter rolls

3.3. Data collection technique

The data collection method used for this purpose includes two parts, namely:

1) Primary data collection, which consists of:

Observation, namely data collection by observing the research location directly. Data taken directly at the research location, among others, Existing Pipeline data.

2) Secondary data collection, which consists of:

Secondary data, namely data obtained at the village office in the form of population data for the last five years, village maps and other data that supports the research process.

3.4. Data Analysis Techniques

Data analysis was carried out by utilizing methods obtained from literature studies. The steps taken are as follows:

1) Process population data.
2) Analyze the large demand for clean water that must be met by springs in the next 15 years.
3) Calculating the existing water needs
4) After the necessary data has been collected, we can perform the analysis. This analysis was performed with Epanet 2.0.

3.5. Epanet 2.0 Analysis Flowchart

```
        ┌──────────────┐
        │    Start     │
        └──────────────┘
               ↓
     ┌────────────────────┐
     │ New Project Creation│
     └────────────────────┘
               ↓
     ┌────────────────────┐
     │  Program Settings   │
     └────────────────────┘
               ↓
 ┌──────────────────────────────────┐
 │ Depiction of Water Network       │
 │ Distribution Scheme              │
 └──────────────────────────────────┘
               ↓
 ┌──────────────────────────────────┐
 │ Data Input of Clean Water        │
 │ Distribution Network Components  │
 └──────────────────────────────────┘
               ↓
 ┌──────────────────────────────────┐
 │ Water Demand Pattern Data Input  │
 └──────────────────────────────────┘
               ↓
     ┌────────────────────┐
     │ Program Simulation  │
     └────────────────────┘
               ↓
 ┌──────────────────────────────────┐
 │ Interpretation of Simulation     │
 │ Results                          │
 └──────────────────────────────────┘
               ↓
        ┌──────────────┐
        │   Finished   │
        └──────────────┘
```
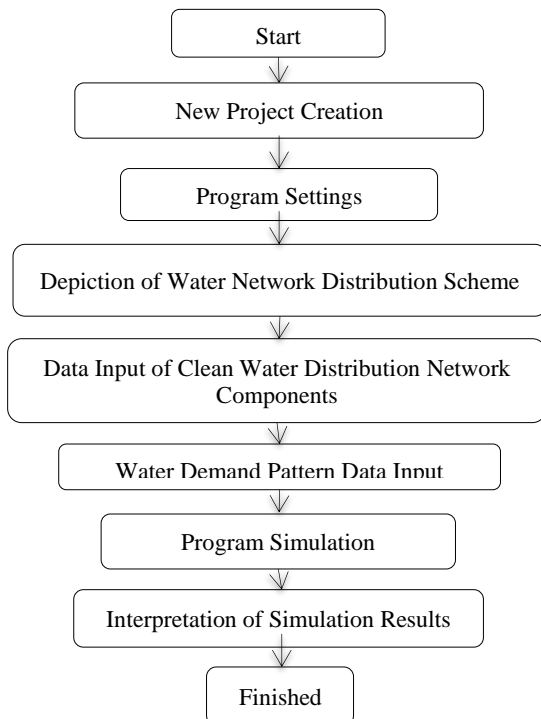
Fig.14: EPANET 2.0 Analysis Flowchart

IV. ANALYSIS AND DISCUSSION

4.1 Pipeline Network Map

Piping Network Is a map of the pipeline network carrying water from the reservoir reservoir to the service network. The following is a map of the pipeline network from Nuruwe Village, Kairatu Barat District, West Seram Regency.
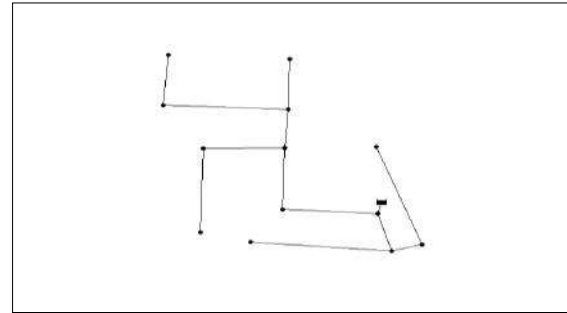
Fig.15: Pipeline Network Map of Nuruwe Village

As seen in Figure 15 above the piping network system in Waisamu Village has 2 piping network systems namely, the one in red is the old piping network, while the one in yellow and blue is a piping network system that has been added recently .

4.2 Water Demand Analysis

Water requirements for socio-economic facilities must be differentiated according to PDAM regulations and taking into account the production capacity of existing sources, level of leakage and service. The main factor in the water demand analysis is the population in the study area. To analyze projections for the following years, Arithmetic and Geometric methods can be used. From this projection, the amount of water demand from the domestic and non-domestic sectors is calculated based on the criteria of the 1996 Directorate General of Cipta Karya.

4.3 Population Projection

The method used to calculate the projected population for the next 15 years uses the geometric method. The geometric method formula is as follows:

The geometric method formula

$$Mr = Po\,(\,1 + r\,)n$$

Information :

Po   = Total Population Served (Soul)

r   = Population Growth Ratio (2 % = 0.02)

n   = Design Period (15 Years)

Table.4: Population Data for 2016 – 2021

No	Year	Number of Souls	Number of families
1	2016	1533	348
2	2017	1564	355
3	2018	1569	357
4	2019	1628	370
5	2020	1661	378
6	2021	1730	393

Table.5: Population Growth Projections for 5, 10, and 15 Years

No	Point	Population Projection $P_0(1+r)^n$			
		Year 2021	5 years	10 years	15 years
1	MA.A - DE	526	581	641	708
2	A.A1 - A.A4	407	449	496	548

3	C.C1 - C.C2	361	399	440	486
4	D.D1 - D.D2	445	491	542	599
5	Amount	1739	1920	2120	2340

Example of Calculation of Population Needs Projection 5, 10, and 15 Years of Nuruwe Village using the geometric method:

Line No. 1. Example of Calculation of Population Growth Projection for 5 Years MA.A – DE Pipeline

$P_n = P_o \times (1 + r)^n$

$P_n = 526 \times (1 + 0.02)^5$

$P_N = 581$

Line No. 1. Example of Calculation of Population Growth Projection for 10 Years MA.A – DE Pipeline

$P_n = P_o \times (1 + r)^n$

$P_n = 526 \times (1 + 0.02)^{10}$

$P_n = 641$

Line No. 1. Example of Calculation of Population Growth Projection for 15 Years MA.A – DE Pipeline

$P_n = P_o \times (1 + r)^n$

$P_n = 526 \times (1 + 0.02)^{15}$

$P_n = 708$

Table.6: 15 Year Population Calculation Projection Nuruwe Village for Each Pipeline and Node

No	Track Pipe	nodes	Number of population served (soul)	Population Projection 15 yrs (soul)
		MA		
1	MA-A	A	0	0
2	AB	B	67	90
3	BC	C	89	120
4	CD	D	156	210
5	DE	E	214	288
			Total = 526	Total = 708
		A		
1	A-A1	A1	41	55
2	A1-A2	A2	52	70
3	A-A3	A3	79	106
4	A-A4	A4	235	316
			Total = 407	Total = 548
		C		
1	C-C1	C1	127	171

2	C1-C2	C2	234	315
			Total = 361	Total = 486
		D		
1	D-D1	D1	256	345
2	D1-D2	D2	189	254
			445	599
			Total Number = 1739	Total Number = 2340

Line No 1. Example of calculating the projected population for 15 years: Pipeline MA – A, Pipeline A

Pn = Po (1 + r)n

Pn = 67 (1 + 0.02)15

Pn = 90

So the population increase for the MA-A pipeline, Pipe A is 90 people

4.4 Calculation of Water Needs

Water demand is the amount of water needed for household, industrial and other needs. Priority water needs include domestic water needs, industry, public services. Water demand is the amount of water that is reasonably needed for basic human (domestic) activities and other activities that require water. The water requirement determines the size of the system and is determined based on water usage.

In calculating the demand for domestic and non-domestic water, peak hour water demand, and the planned volume of the reservoir for the 15th year, you can see the calculation example below:

Table.7: Calculation of Projection of Clean Water Needs in Nuruwe Village

No	Uraian	Satuan	Tahun 2021	5 Tahun (2026)	10 tahun (2031)	15 Tahun (2036)	Kode	Cara Hitung	Keterangan
1	Jumlah penduduk	jiwa	1.739	1.920	2.120	2.340	1		rata2 kenaikan 2% pertahun
	Pelayanan penduduk	%	100	100	100	100	2		juklak 100% pelayanan
		jiwa	1.739	1.920	2.120	2.340	3		
2	Pelayanan SR	%	90	100	100	100	4		juklak / survei
		jiwa	1.565	1.920	2.120	2.340	5	(5)= ((4)*(3))/100	
		jiwa/sb	5	5	5	5	6		juklak
		Jmlh. Sb	313	384	424	468	7	(7)= (5) / (6)	
	Pemakaian Air	Lt/org/hr	90	90	90	90	8		juklak
		Lt/sb/hr	450	450	450	450	9	(9)= (8) x (6)	
		Lt/det	1,63	2,00	2,21	2,44	10	(10)=(5)x(8)/86400	
3	Pelayanan KU / HU	%	10	-	-	-	11	(11)= 100 - (4)	
		jiwa	174	-	-	-	12	(12)=(11)/100*(3)	
		jiwa/HU	100	100	100	100	13		juklak
		Jmlh. HU	2	-	-	-	14	(14)=(12)/(13)	
	Pemakaian Air	Lt/org/hr	60	60	60	60	15		juklak
		Lt/HU/hr	6.000	6.000	6.000	6.000	16	(16)=(13)*(15)	
		Lt/det	0,12	-	-	-	17	(17)=(12)*(15)/86400	
4	Total Domestik	Lt/det	1,75	2,00	2,21	2,44	18	(18)=(10)+(17)	
5	Total Non Domestik	%	0	0	0	0	19		
		Lt/det	-	-	-	-	20		
6	Total Kebutuhan Air	Lt/det	1,75	2,00	2,21	2,44	21	(21)=(18) + (20)	
7	Kehilangan Air	%	20	20	20	20	22		juklak
		Lt/det	0,39	0,44	0,49	0,54	23	(23)=(21)*(22)/90	
8	Kebutuhan Air								
	- Rata-rata	Lt/det	2,14	2,44	2,70	2,98	24	(24)=(21)+ 23)	
	- Harian Puncak	Faktor	1,1	1,1	1,1	1,1	25		juklak
		Lt/det	2,35	2,69	2,97	3,28	26	(26)=(24)* (25)	
		M³/hari	8,48	9,68	10,69	11,80	27	(27)=(26)x3600/1000	
		M³/hari	203,41	232,32	256,50	283,20	28	(28)=(27)*24	
	- Jam Puncak	Faktor	1,5	1,5	1,5	1,5	29		juklak (minimum)
		Lt/det	3,21	3,67	4,05	4,47	30	(30)=(24)*(27)	
9	Kebutuhan Air Baku	Faktor	3,0	3,0	3,0	3,0	31		faktor keamanan
		Lt/det	7,06	8,07	8,91	9,83	32	(32)=(26)*(31)	Besarnya debit perencanaan
									3X kebutuhan air baku
10	Volume Resevoir	M³	40,68	46,46	51,30	56,64	33	(30)=(0.2)*(28)	Minimum 20% harian Maks
									Kriteria perencanaan

Example of Calculation: Calculation of Water Needs in Nuruwe Village Pipeline D – E, Node E for Year 0 and Year 15

Column. 5 Row 10.

An example of calculating the water demand for year 0 Pipeline D – E, Node E

Water requirement = (90 x 214) / 86400

Water requirement = 0.22 liter/sec

Information :

Average water requirement   =
90lt/0rg/sec

Number of people served = 214 souls

1 day   = 86400 seconds

Column.7 Row 10.

An example of calculating the water demand for the 15th year Pipeline D – E, Node E

Water requirement = (90 x 288) / 86400

Water requirement = 0.30 lt/sec

Information :

Average water requirement   =
90l/0rg/sec The number of people served   = 288 souls

1 day   = 86400 seconds

For the calculation of other pipelines can be seen in Table.16 below.

Table.16: Water Needs in Nuruwe Village

No	Track Pipe	nodes	NODE LOAD			
			Number of population served	Water Needs	Total population 15 yr projection	Water Needs Projection 15 yrs
			(soul)	(lt/d)	(soul)	(lt/s)
		MA				
1	MA-A	A	0	0.00	0	0.00
2	AB	B	67	0.07	90	0.09
3	BC	C	89	0.09	120	0.12
4	CD	D	156	0.16	210	0.22
5	DE	E	214	0.22	288	0.30
			Total = 526		Total = 708	0.74
		A				
1	A-A1	A1	41	0.04	55	0.06
2	A1-A2	A2	52	0.05	70	0.07
3	A-A3	A3	79	0.08	106	0.11
4	A-A4	A4	235	0.24	316	0.33
			Total = 407		Total = 548	0.57
		C				
1	C-C1	C1	127	0.13	171	0.18
2	C1-C2	C2	234	0.24	315	0.33
			Total = 361		Total = 486	0.51
		D				
1	D-D1	D1	256	0.27	345	0.36
2	D1-D2	D2	189	0.20	254	0.26
			Total = 445		Total = 599	0.62
			Total Number = 1739	Total Number = 1.81	Total Number = 2340	Total Number = 2.44

4.5 Hydrolysis Calculation

Hydraulic calculations in this case calculate node loads, pipe loads, and head loss calculations in the Nuruwe Village piping system.

Column. 8 Rows. 9

An example of calculating the number of people supplied by the MA – A Pipeline, Node A:

Total population supplied = total population served by points MA - A, D - E– total population of MA - A

Number of population supplied = 526 – 0

Number of population in supply = 526

Column.10 Row.9

An example of calculating the projected number of people supplied for 15 years in the MA – A Pipeline, Node A:

$Pn = Po (1+ r)n$

$Pn = 526 (1 + (0.02))15$

$Pn = 708$ souls

Column.11 Row.9

Example of calculation of Flow projection on MA – A Pipeline, Node A:

Flow = (15 year population projection x average water demand) / 86400

Flow = (708 x 90) / 86400

Flow = 0.74 liter/sec

Column.12 Row.9

An example of calculating peak flow hour projections on the MA – A Pipeline, Node A:

Peak hour flow = Flow x peak hour factor

Peak hour flow = 0.74 x 1.5

Peak flow hour = 1.11 lt/sec

Column.18 Row.3

An example of calculating the theoretical pipe diameter in the MA – A Pipeline, Node A:

D. Theoretical Pipeline = (3.59 x Peak hour flow x 106) / (Slope0.54 x HW Coefficient)0.38

D. Theoretical Pipe = (3.59 x 1.11 x 106)/(35,290,54 x 120)0.38

D. Theoretical Pipe = 25.11 mm = 63.00 (Design pipe diameter)

Columns.20 Rows.3

Example of calculating head loss per 100 m on the MA – A Pipeline, Node A:

H.loss = (3.59 x Peak hour flow x 106)/(Design pipe D.2.63 x HW coefficient)1.85

H.loss = (3.59 x 1.07 x 106)/(63.002.63 x 120)1.85

H.loss = 0.38 m

Columns.20 Rows.3

Example of calculating Total Head loss + 10% minor in the MA – A Pipeline, Node A:

Total H.loss +10% = H.loss x (pipe length/100) x (1+ (minor loss/100)

Total H.loss +10% = 0.38 x (17/100) x (1+ (10/100)

Total H.loss +10% = 0.07 m

Column.21 Row.3

Example of calculating HGL on the MA–A Pipeline, Node A:

HGL = Reservoir elevation – Total H.loss+10%

HGL = 12 – 0.07

HL = 11.93

Column.22 Row.3

Example of calculating the Residual Pressure in the MA – A Pipeline, Node A:

Residual Pressure = Reservoir Elevation – Total H.loss+10%

Residual Pressure = 12 – 0.07

Residual Pressure = 11.93 m

Column.23 Row.3

Example of calculating Flow Velocity (V) in the MA – A Pipeline, Node A:

V = ((4 x Peak hour flow)/1000)) / (((3.14 x D. design pipe))/1000)2)

V = ((4 x1.07)/1000)) / (((3.14 x 63.00))/1000)2)

V = 0.34 m/s

Table.17: Hydraulic Calculation of Pipe Load, Headloss, Residual Pressure, Nuruwe Village

BEBAN NODE					BEBAN PIPA				Koeff HW	PERHITUNGAN HEAD LOSS					
Jmlh. Pddk	Kebutuhan	Jmlh. Pddk	Kebut. Air	Kebut air	Jmlh. Pddk	Jmlh. Pddk	Flow	Flow		Diam. Pipa	Diam. Pipa	Hloss	Total Hloss	HGL	Sisa
yg dilayani	Air	Proy 15 thn	Proy 15 thn	jam puncak	yg disuplai	Proy 15 thn		Jam Puncak	C	D teoritis	D desain	per 100 m	(+10% minor)		Tekan
(jiwa)	(lt/d)	(jiwa)	(lt/dt)	(l/dt)	(jiwa)	(jiwa)	(lt/dt)	(lt/dt)		(mm)	(mm)	(m)	(m)	(m)	(m)
														12.00	
0	0.00	0	0.00	0.00	526	684	0.71	1.07	120	24.78	63.00	0.38	0.07	11.93	11.93
67	0.07	90	0.09	0.14	459	597	0.62	0.93	120	50.76	63.00	0.29	0.39	11.54	11.54
89	0.09	120	0.12	0.19	437	568	0.59	0.89	120	47.49	63.00	0.27	0.28	11.26	11.26
156	0.16	210	0.22	0.33	370	481	0.50	0.75	120	40.84	63.00	0.20	0.13	11.12	11.12
214	0.22	288	0.30	0.45	312	406	0.42	0.63	120	40.13	50.00	0.44	0.38	10.74	10.74
526		708	0.74	1.11											
														11.54	
41	0.04	55	0.06	0.09	366	476	0.50	0.74	130	39.19	63.00	0.17	0.11	11.43	7.43
52	0.05	70	0.07	0.11	355	462	0.48	0.72	130	35.65	50.00	0.49	0.21	11.22	6.22
79	0.08	106	0.11	0.17	328	426	0.44	0.67	130	46.09	50.00	0.42	0.75	10.47	6.47
235	0.24	316	0.33	0.49	172	224	0.23	0.35	130	36.73	50.00	0.13	0.25	10.22	7.22
407		548	0.57												
														11.54	
127	0.13	171	0.18	0.27	234	304	0.32	0.48	130	36.94	63.00	0.07	0.08	11.46	8.46
234	0.24	315	0.33	0.49	127	165	0.17	0.26	130	30.72	50.00	0.07	0.10	11.35	7.35
361		486	0.51												
														11.54	
256	0.27	345	0.36	0.54	189	246	0.26	0.38	130	37.24	63.00	0.05	0.09	11.27	9.27
189	0.20	254	0.26	0.40	256	333	0.35	0.52	130	36.29	50.00	0.27	0.23	11.03	10.03
445		599	0.62												
1739	1.81	2340	2.44	4.76											

4.6 Piping Network Modeling With E-PANET 2.0 Software

The output generated from the EPANET program includes debit flowing in the pipe (lt/s), water pressure from each point/node/junction which can be used as an analysis in determining installation, pump and reservoir operations.

The stages of piping network modeling with EPANET 2.0 software are:

1. Open the Google Earth Pro software to draw a piping system. Place the location point first to determine the coordinate point.
2. Take a picture of the piping network from Google Earth Pro then input it in Ms. Visio, then cut the image and adjust it according to the workbook in Ms. Visio.

3. After successfully getting the image that has been cropped on Ms. Visio, then open the EPANET software then enter the image by pressing the file menu at the top left of the display then pressing the open file menu and entering the image that has been cut from Ms. Visio into the EPANET software .

4. Enter the previously recorded Coordinate Points into the EPANET software in order to minimize distance errors in the EPANET software by pressing the view menu then selecting a dimension and then entering the coordinates in the four dimension columns, namely X and Y.
5. After entering the coordinates, then determine the location of the reservoir according to the piping system data or the piping system plan that has been determined by pressing the add reservoir menu. in the upper center of the EPANET menu display.
6. After entering the coordinates, then in the top center menu you will see the add junction menu circular shape, press the menu then mark each point of the pipeline using the menu.
7. Then connect each of these junctions by pressing the add pipe menu which is shaped like an inverted capital I to connect each junction point that has been previously marked.
8. After connecting each piping system using the add pipe menu, then placing the elevation of each location point at each junction point by pressing the junction point and entering the elevation according to the elevation on google earth pro at each junction point,

for example the elevation of point E on goggle earth pro by 4 m then enter the same elevation at point E in the EPANET software. Do the same thing at each junction point as in method no.8 to be able to provide elevation at each junction point of the piping network.

9. After that, enter the previously calculated water requirement at each piping junction point by pressing the piping junction point where you want to enter the water requirement, then enter the water requirement in the base demand section according to the calculation. For example, at the junction point of pipe E, enter the water requirement based on the calculation results.

10. Do the same for all existing junction points so that all junction points in the piping system have the required amount of water according to the calculation results.

11. After that, enter the design pipe diameter for each pipe connection, and also input the roughness value according to the calculation results according to the calculation results obtained. For example, in the D - E pipe connection, the design pipe diameter is 50 mm with a roughness value of 120.

12. After all the values have been entered, the next step is to see whether the water flow system is running smoothly or not, by clicking the Run menu on the top left of the EPANET display menu in the form of a lightning bolt. to see whether the water flow in the piping system runs smoothly or not.

13. If the EPANET menu display after finishing Run shows the Run Successful display, then it indicates that the drainage system in the piping network is flowing 100%.

14. After the Successful Run, it is continued by displaying data in the form of Network Link data, Network Nodes data that has been obtained in the EPANET software by pressing the table menu at the top left of the EPANET software display.

15. Display the data that has been obtained for later and then the data (Network Link, Network Nodes data) is entered on the Ms.Excel display for further input into

the results that have been obtained from the EPANET Software.

16. Then look at the graphical display recorded in the EPANET software by pressing the Graph menu at the top left of the EPANET Software display menu, and then pressing the Frequency plot on the Graph Type and pressing Links on the Object Type, then selecting Parameters to display on the graph.
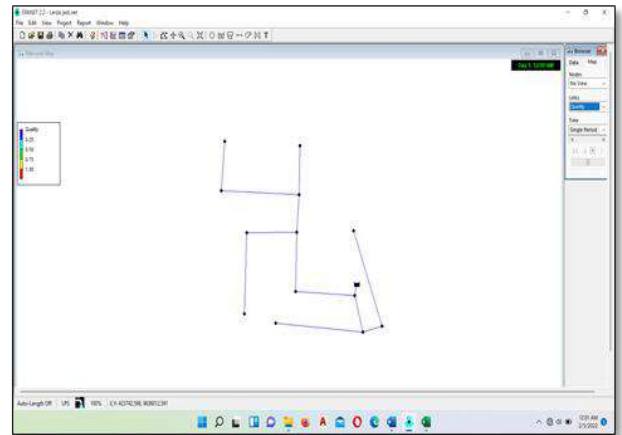
Fig.8: EPANET Menu Display

17. To view the Flow, Velocity, Unit HeadLoss, and Friction Factor graphs, select the Parameters section of the Graph Selection menu display in the Graph Menu.

18. Then look for the browser menu at the top right of the EPANET Software display with the browser name and select the Map menu to display directly the state of the existing piping system by pressing on Nodes and Links to select what parameters you want to display.

19. From the data that has been obtained, then enter these data into Ms. Excel to be the resulting data from EPANET Software.

20. From the data that has been obtained, then enter these data into Ms. Excel to be the resulting data from EPANET Software.

Table.18: Network Table Links

Network Table – Nodes							
ID nodes	elevation	Base Demand	Initial Quality	Requests	heads	pressure	Quality
	m	LPS		LPS	m	m	
Pipe Junctions 2	0	2.44	0	2.44	10.99	10.99	0
Pipe Junctions3	6	0.14	0	0.14	8.8	2.8	0
Pipe Junctions4	4	0.51	0	0.51	7.19	3.19	0
Pipe Junctions 5	3	0.62	0	0.62	6.78	3.78	0
Pipe Junctions 6	4	0.43	0	0.43	6.68	2.68	0

Pipe Junctions7	4	0.08	0	0.08	10.92	6.92	0
Pipe Junctions8	5	0.11	0	0.11	10.9	5.9	0
Pipe Junctions 9	4	0.16	0	0.16	10.87	6.87	0
Pipe Junctions10	3	0.48	0	0.48	10.68	7.68	0
Pipe Junctions11	3	0.26	0	0.26	7.09	4.09	0
Pipe Junctions12	4	0.48	0	0.48	6.92	2.92	0
Pipe Junctions13	2	0.52	0	0.52	6.56	4.56	0
Pipe Junctions14	1	0.38	0	0.38	6.49	5.49	0
Pipe Reservoir1	12	#N/A	0	-6.61	12	0	0

Table.19: Network Table Nodes

						1						
ID link	Length	Diameter	Roughness	Bulk Coef.	Wall Coef f.	Flow	Velocity	Head loss units	Friction Factor	Reaction Rate	Quality	Status
	m	mm				LPS	m/s	m/km		mg/l/d		
Pipes Pipes1	12.01	63	130	0	0	6.61	2.12	84.03	0.023	0	0	open
Pipes Pipes 2	79.56	63	120	0	0	3.34	1.07	27.53	0.03	0	0	open
Pipes Pipes3	63.35	63	120	0	0	3.2	1.03	25.43	0.03	0	0	open
Pipes Pipes4	40.19	63	120	0	0	1.95	0.63	10.16	0.032	0	0	open
Pipes Pipes5	52.1	50	120	0	0	0.43	0.22	1.9	0.039	0	0	open
Pipes Pipes6	40.32	63	130	0	0	0.83	0.27	1.8	0.031	0	0	open
Pipes Pipes7	26.53	50	130	0	0	0.27	0.14	0.69	0.036	0	0	open
Pipes Pipes8	108.62	50	130	0	0	0.16	0.08	0.26	0.039	0	0	open
Pipes Pipes9	117.89	50	130	0	0	0.48	0.24	2.01	0.033	0	0	open
Pipes Pipes10	68	63	130	0	0	0.74	0.24	1.46	0.032	0	0	open
Pipes Pipes11	86.78	50	130	0	0	0.48	0.24	2.01	0.033	0	0	open
Pipes Pipes12	104.89	63	130	0	0	0.9	0.29	2.09	0.031	0	0	open
Pipes Pipes13	52.53	50	130	0	0	0.38	0.19	1.31	0.034	0	0	open

From the results of the analysis of the distribution of piping networks using EPANET 2.0 software, the result is that the distribution of piping networks gets 100% results.

V.　CONCLUSION

1. The need for clean water needed by the residents of Nuruwe Village, West Kairatu District, West Seram Regency is 2.44 liters/second

2. The distribution of the piping system has been able to meet the needs of clean water in Nuruwe Village, Kairatu Barat District, West Seram Regency because it has met the water needs of the residents of Nuruwe Village.

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Evaluation of the development of competences in radiology and diagnostic imaging in a cross-sectional study in a medical graduation

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Abstract— To assess the development of skills by medical students in radiology and diagnostic imaging in a cross-sectional way in undergraduate medicine in an integrated and interdisciplinary curriculum. This is a quantitative, analytical, and expository cross-sectional study, through the application of a structured questionnaire on the radiological themes developed in the axis that has as practical support the Morphofunctional Laboratory, with students from the 1st, 5th and 8th semester of the medical course at the Centro Universitário Metropolitano da Amazônia (UNIFAMAZ), Belém, PA – Brazil. For the

elaboration of the result of the present study, the analysis of 93 applied questionnaires was used, respecting the selection criterion, in which the questionnaire should contain the Free and Informed Consent Term duly completed and signed, of which 15 already had a previous graduation. The students at each end of the application of the questionnaire were more confident during the semesters, represented by the increasing average of correct answers over the semesters, and, in this way, corroborating the evolution of the students in the resolution and reasoning of the proposed questions. The information obtained from the medical students evaluated in the study corroborate that problem-based learning facilitates and assists in the process of obtaining knowledge, through the morphofunctional components of the course used to approach radiology and diagnostic imaging with a view multidimensional in addition to the role of complementary examination methods.

I. INTRODUCTION

Radiology is a medical specialty that renews itself and advances every day, in a modernization process that, in addition to investments, requires continuous effort to update. Intrinsically linked to technological development, diagnostic imaging methods allow physicians to obtain information that could not have been imagined less than ten years ago, with a speed and efficiency that enhance Medicine as a whole. (Scatigno Neto, 2019).

It plays an important role in modern medicine, since imaging technologies have revolutionized the clinical practice of medicine in Brazil and worldwide, (Corr P, 2012), but many of the students are not properly prepared for the discipline during the early years of college or are presented with the discipline in a non-transversal way, a set of general personal skills that are useful and important in the context of the performance of different activities, interdisciplinary. (Branstetter BF et al., 2007).

The use of radiological images is a fundamental part of learning due to their availability and undeniable clinical relevance. Some studies indicate that the "early" insertion of this skill enriches the understanding of pathophysiological processes, as well as anatomy. This is due to rapid technological advances, the availability and use of alternative resources for teaching anatomy and clinical correlation (Kalami TR et al., 2016).

Since the advent of imaging tests, radiology and diagnostic imaging have made important advances in several areas. Therefore, it is essential that there are trained professionals to know the techniques and the appropriate use of these complementary exams (Corr P, 2012), since their inappropriate use implies damage both for the patient and for the health system (Silva et al., 2019).

Consequently, preparing medical students to become responsible users of medical images, including, for this purpose, the teaching of radiology and diagnostic imaging in the undergraduate medical curriculum, is the target of increasing attention (Lim-Dunham, 2016).

The National Curriculum Guidelines (NCGs) for the Undergraduate Medicine Course (Brasil, 2014) define the organization, development and evaluation of the course, within the scope of the higher education system in the country, and guide the promotion of integration and interdisciplinarity in coherence with the curriculum development axis, and the use of methodologies that privilege the active participation of the student in the construction of knowledge.

In this sense, some doubts emerged related to the model, the content and the ideal period to introduce the learning of radiology and imaging diagnosis, showing the need to develop an effective means for teaching this (Silva et al., 2019).

Al Qahtani et al (2014), points out that at the Al-Baha University Faculty of Medicine (ABUFM), in Al-Baha - Saudi Arabia – it should have been during the initial stages of curriculum development and these issues arose. Alternatives to answer this question were to approach radiology within other clinical disciplines through an "when indicated" approach, to allocate a distinct and specialized module or to integrate a related theme longitudinally into the curriculum during its 6 academic years (Al Qahtani et al, 2014).

The teaching of radiology and diagnostic imaging began to integrate the Axis Of Health Care and Education (AES), in the morphofunctional laboratory (LMF) (FAMAZ, 2017), developed in some periods, with active methodologies and favoring the teaching method in vertically integrated stages. The assimilation of content

through this means allows a lasting learning, relevant in the practical and real clinical work of the students (Lim-Dunham, 2016).

The evaluation of the development of competencies by the medical student in radiology and imaging diagnosis in a transversal way in the undergraduate course in medicine in an integrated and interdisciplinary curriculum, using active methodology, is significant for the training of the medical professional.

II. METHOD

The present study was carried out at the Metropolitan University Center of the Amazon (UNIFAMAZ), Belém, PA – Brazil, with students from the 1st, 5th and 8th semester of the medical course, between December 2021 and April 2022. This is a quantitative, analytical and expositive cross-sectional study. The inclusion criteria were: to be a student regularly enrolled in the medical course of the university center mentioned above, to be frequent in the curricular activities of the 1st, 5th or 8th semester of the course and to agree to participate in the study by signing the Free and Informed Consent Form proposed in the questionnaire applied.

The material proposed for the study was a structured questionnaire containing radiology and diagnostic imaging themes in the Morphofunctional Laboratory of the Metropolitan University Center of the Amazon, based on the curriculum for the teaching of radiology of the University Center, which lists the minimum contents for learning in each semester of medical graduation.

UNIFAMAZ presents in the medical course thematic axes subdivided into curricular units. In the Health Care and Education (AES) axis, one of the methodologies applied is Problem Based Learning (FAMAZ, 2017). For the development of the axis, practical support and an anatomical, physiological, histopathological and radiological basis, among others, are provided by the Morfofuncional Laboratory.

Considering that the semester to be attended by the student is a modifying factor of the degree of difficulty in answering the questions in the questionnaire and bearing in mind that the subject may not yet have been the subject of the interviewee's semester. Thus, the questionnaire was subdivided into the following subjects: Identification of the types of exams and their characteristics, Human anatomy in radiology, human pathology in radiology and diagnostic imaging.

The questionnaire had multiple-choice questions, with four items in each question, with only one of the alternatives being considered correct according to what is delimited by

the Brazilian Society of Radiology and Imaging Diagnosis and content worked in the institution.

In addition, another factor analyzed was the possibility of some previous training to verify if there was a difference that favored the completion of the questions presented. The research was developed in person without prior notice to the students that there would be the evaluation, but with authorization of the application by the institution and the teachers, at the end of the classes of the class to be addressed, using the list of regularly enrolled students who were approached to fill out the questionnaire and agreed to participate in the study.

The questionnaire was answered at the same time as delivery and returned immediately to the researchers after completion of the resolution. During the completion of the questionnaire, participants were not allowed to clarify doubts, consult books and other students and have access to the internet, cell phone or any electronic devices. Data were computed exclusively from participants who correctly completed and signed the Free and Informed Consent Form.

After data was used, after collection, the separation was performed by means of tables and spreadsheets, organizing them into three large groups indicating each semester evaluated, with the respective correct answers and general and individual errors of the participants, through analysis of the quantitative variables described through their absolute value, frequency distribution and occurrence rate. Subsequently, each group was subdivided into the individual characteristics of each question, as mentioned in the fourth paragraph of this item, in order to generate graphs that more easily show the research objectives.

Data were analyzed using Microsoft Excel using tables, graphs and numerical summary, which provided a demonstration of the collected data. Quantitative variables were described by means of their absolute value, frequency distribution and occurrence rate. For the methodological analysis of this article, as proposed by Yin, R.K. (2015), a methodological design is presented to understand the nature of a contemporary and social phenomenon applied in its context in the classroom, making the analysis more objective, over which the researchers had no control over what they want to clarify.

The research project followed the legal precepts recommended by Resolution 196 of the National Health Committee of Brazil - CNS-CONEP. The research was observed by the UNIFAMAZ Ethics Committee, upon submission to Pataforma Brasil, due to the need to use data collected from human beings in the research.

III.   RESULTS AND DISCUSSION

The analysis of 93 applied questionnaires were used to elaborate the result of the present study, respecting the selection criterion, in which the questionnaire should contain the Free and Informed Consent Form duly completed and signed, distributed as shown in figure 1. There were no students who opposed participating in the research.
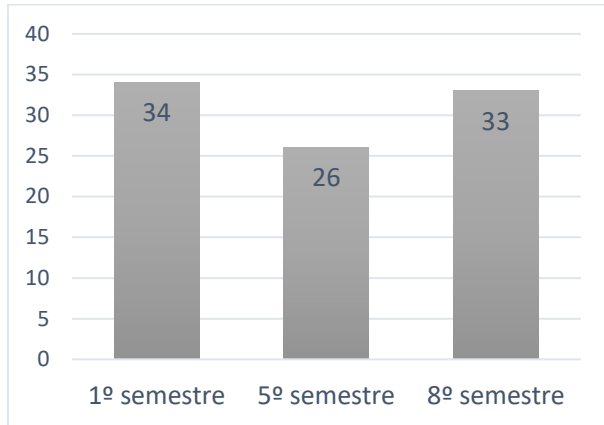

Fig.1. Distribution of students by semester.

Source: Own authorship. Belém (PA), Brasil, 2023.

The interviewees were asked about having completed some specialization before starting graduation. Therefore, among the 93 interviewees, 15 already had a previous graduation, which represent about 16% of the total. There were three specialists present among the academics of the 1st semester. Such data are then detailed as shown in table 1.

Table 1. Distribution of graduate students by specialty.

Previous graduation	1st semester	5th semester	8th semester
Nursing	0	2	0
Physiotherapy	0	0	1
Hospital Management	0	0	1
Biomedicine	0	0	1
Nutrition	0	0	2
Odontology	1	1	1
Biology	1	0	1
Electrical Engineering	1	0	0
Administration	0	1	0
Production engineering	0	1	0

Source: Own authorship. Belém (PA), Brasil, 2023.
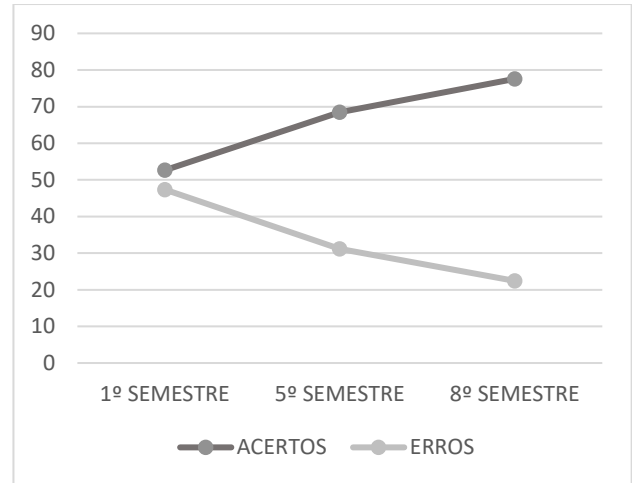
Fig.2. Distribution of students by semester.

Source: Own authorship. Belém (PA), Brasil, 2023.

Regarding the thematic axes presented, there was also a progressive increase as the semester progressed. The themes "Identification of the types of exams and their characteristics", "Radiological anatomy", "Radiology and diagnostic imaging" were renamed in figure 3 as Themes 1, 2 and 3 respectively, as well as presenting the correct rate in each one. of the topics addressed, presented both in the form of absolute and relative frequency of correct answers. Subsequently, the questions were grouped in table 2 containing the four questions related to theme 1, which represent the 1st, 2nd, 3rd, and 5th questions, three sentences related to theme 2, which include the 4th, 7th, and 9th questions and three sentences on theme 3, which correspond to the 6th, 8th and 10th, thus totaling the ten questions available in the survey.

Fig.3. Hit rate of respondents by thematic axis.

Source: Own authorship. Belém (PA), Brasil, 2023.

Table 2. Rate of correctness of respondents in each question.

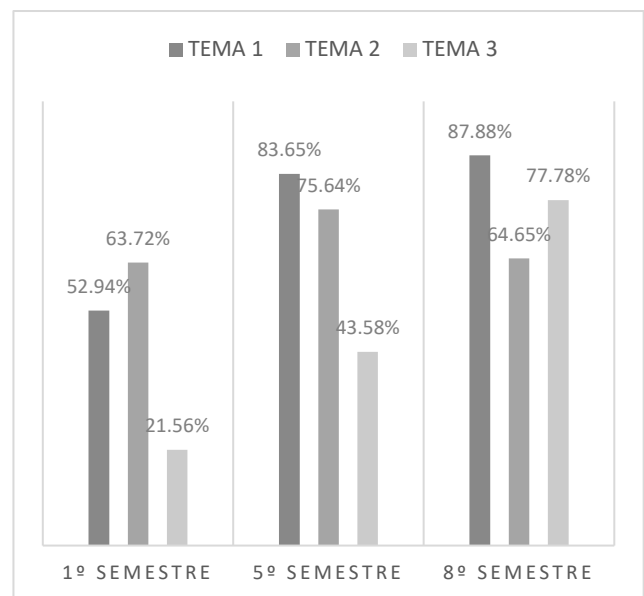| Questions	1st Semester		5th Semester		8th Semester	
	Absolute Frequency	Relative Frequency	Absolute Frequency	Relative Frequency	Absolute Frequency	Relative Frequency
1st	15	44,12%	18	69,23%	28	84,85%
2nd	18	52,94%	23	88,46%	23	69,70%
3rd	33	97,05%	26	100%	33	100%
4th	25	73,53%	22	84,61%	21	63,64%
5th	24	70,58%	20	76,92%	32	96,97%
6th	10	29,41%	4	15,38%	28	84,85%
7th	22	64,70%	24	92,30%	33	100%
8th	6	17,64%	14	53,84%	16	48,49%
9th	18	52,94%	13	50%	10	30,30%
10th	6	17,64%	16	61,53%	33	100%

Source: Own authorship. Belém (PA), Brasil, 2023.

In view of the completed questionnaires, the characteristics of the studied population are observed, consisting of 93 medical students, with samples being collected from the 1st, 5th and 8th year of the UNIFAMAZ, of which 34 belonged to the 1st year, 26 to the 5th year and 33 made up the class of the 8th semester of the Medical Course that use PBL as one of the study methodologies for the Morphofunctional axis that addresses imaging based on self-directed learning (Trullàs JC, et al., 2022).

In addition, among the total number of students interviewed in the survey, 15 already had a previous degree, which represent about 16% of the total and demonstrated a certain maturity when answering the proposed questionnaire, with reports that they had already studied or experienced some of the questions previously, either in training or professional performance, as well as, in daily life, through experience. Therefore, among the 10 specialists in health-related areas presented among the participants, such as nurse, dentist, physiotherapist, biomedical, nutritionist and hospital manager, only three were below the average for the semester they had attended, a value equivalent to 30% of undergraduate students in the health area, compared to 46.98% of the students who had not attended a previous specialization or attended but were not related to health.

Students at each end of the questionnaire application were more confident over the semesters, represented by the growing average of correct answers over the semesters, and thus corroborating the students' evolution in solving and reasoning the proposed questions. Thus, the need for early

introduction of radiology into the curricular component of morphofunctional is evident in the students' responses by increasing as the semester increases to be attended, thus, this serves as a support to recognize that the introduction of basic concepts of radiology in a transversal way in the thematic modules, make it possible to relate knowledge of the basic sciences, such as anatomy with basic and advanced concepts of imaging (Foltran et al., 2015).

In view of this, a meta-analysis was carried out which showed that the PBL teaching method had a positive effect in obtaining higher theoretical scores compared to the traditional teaching method in 16 studies. As well, thirteen studies provided sufficient data on skill scores, and a significant difference in favor of PBL was also observed. Questionnaire surveys were applied in most of the included studies and indicated positive effects of PBL on students' learning interest, scope of knowledge, team spirit and oral expression in radiology teaching (Zhang S, et al., 2018).

In line with early study adherence and radiology teaching methodology, Berger at al., 2019 compares the PBL study used in cardiopulmonary resuscitation (CPR) learning combined with high-fidelity simulation training leads to an increase in measurable short- and long-term learning at the beginning of sufficient CPR by medical students after training compared to classical education compared to classical education. As in the study by Rocha BC et al., (2021) demonstrated that the methodologies (traditional, hybrid, e-learning and problem-based learning) tested had similar performance; however, the traditional

methodology showed less acceptance by students when analyzed subjectively and comparatively.

Regarding the questionnaire, there was a variation in the correctness rates, in general, the first semester students were the ones with the lowest performance in all the thematic axes addressed in the questionnaire. In view of this, we highlight the evaluation of the third group of questions related to more advanced concepts of imaging, such as imaging diagnosis through pathological changes associated with the students of the first semester, which presented more difficulties, by observing the percentage of correct answers, with about 21.56%.

The question that showed the best domain of the interviewees was the 3rd question, having the highest percentages of correct answers from the participants in all semesters, 100% of correct answers in the 5th and 8th semesters and 97.05% in the first semester. Students in the third question should identify the alternative that was showing a chest X-ray, with the other alternatives being computed tomography, ultrasound and magnetic resonance imaging, all showing a chest image.

It is also worth paying attention to the question that presented a great variation in the correctness rate of the interviewees: The 10th question. The percentage of correct answers for students in the first semester was 17.64%; 61.53% in the fifth and 100% in the eighth semester, which may be a reflection of the impact of a contextualized question in the individual analysis of each participant. In this question, a clinical picture of a patient with changes in the menstrual cycle was presented, associated with an ultrasound image of the uterine region with an image suggestive of uterine myoma, with endometriosis, endometrial neoplasia and cervical neoplasia as other alternatives (Silva et al., 2019).

Teaching in the basic and clinical cycle of a medical course, from the 1st to the 4th year, is a period to acquire the knowledge of the subjects in the basic area necessary for the application during the period of the boarding school, from the 5th to the 6th year, whose objective is to prepare the student, providing him with security, knowledge and experience to obtain sufficient theoretical basis to solve the most frequent and recent problems in the professional environment. Therefore, the study by Matlala S. (2021) addresses issues such as tuberculosis, human immunodeficiency virus and acquired immunodeficiency syndrome (HIV and AIDS) and, more recently, the pandemic of coronavirus disease 2019 (COVID-19), in addition to the advancement of technology and the change of regulations and policies, demonstrating the effectiveness of teaching-learning also from the point of view of teachers.

Thus, much of the basic and clinical cycle occurs within the HEI with the objective of the students knowing not only the semiotechnique in health environments, but also having the theoretical support necessary for the construction of a quick clinical reasoning, an efficient request and interpretation of complementary exams and a correct conduct as a future physician (Al Qahtani et al., 2014).

IV. CONCLUSION

The information obtained from the medical students evaluated in the study corroborate that problem-based learning facilitates and helps in the process of obtaining knowledge, through the morphofunctional components of the course used to approach radiology and imaging diagnosis with a multidimensional view beyond the role of complementary examination methods.

Along with this, other knowledge, particularly anatomy and pathology, facilitate the study of radiology because they contextualize clinical situations in the way that would possibly be addressed if the student was in a similar situation professionally, so the means of complementary diagnosis should be approached multidimensionally from the beginning of the medical course until their training.

Diagnostic accuracy in radiology is a skill to be developed progressively between medical students and the graduate professional, but the mastery of technical vocabulary for understanding the reports of the requested tests, as well as the due use of diagnostic imaging mechanisms are fundamental points to medical education. Associated with this, teaching using the PBL proves to be an effective and satisfactory methodology for medical education, allowing medical students to acquire not only knowledge, but also other skills necessary for medical professionalism. (Trullàs JC, et al., 2022).

Through the significant informational and technological advances that allow exploring various anatomical, histological, physiological and pathological aspects, and due to the easy archiving of digitized images, allowing the formation of large collections, the proposal to use radiology as a learning tool since the beginning of the course is positive. Therefore, over time, it is avoided that many future physicians do not have real conditions to interpret tests and perform appropriate conducts, in addition to dealing with possible problems to which they are exposed (Branstetter IV et al., 2007).

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Development of a Convolutional Neural Network for Classification of Type of Vessels

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Abstract— In this paper, was used a method which use concepts of intelligence artificial, machine learning, deep learning for Classification of Type of Vessels. With a technique from deep learning called Convolutional Neural Network (CNN) was applied to recognize images to identify the type of ship and to use the same method to identify if the vessel. The CNN projected with determined 5 layers, the first layer containing 32 neurons, the second layer with 64 neurons, the third layer with 128 neurons, the fourth layer with 512 neurons. Activation functions for these specified layers contain the ReLU function. The fifth and last layer is the output layer is the output layer, so the number of neurons is equal to the number of vessel type. In our study six classes were used, which are the vessel types, in this layer the activation function was the Softmax. The CNN generate satisfactory results, where could get results of prediction with all corrects answers to identify the ship.

I. INTRODUCTION

The deep learning techniques will be used, which are called Convolutional Neural Networks (CNN). This programming technique is embedded within the Artificial Intelligence (AI) environment, which has been shown to be quite effective for image problems such as: Classification, pattern recognition [13], character extraction (OCR's) [11] and object detection [7], ship recognition using self-organizing distributed maps [9].

Based on the data provided by the Navy and the advancement of deep learning techniques, the objective is to develop a CNN code capable of classifying images of different type of vessels.

II. THEORETICAL REFERENCE

2.1. Types of Vessels according Normam

According Normas de Autoridade Marítima (NORMAM), there are many types of vessels, but in this paper, was used six of them. The types choosen was: canoe, Catamaran, Ferry Boat, Yatch, Military Ship, Sailboat. In Figure 1 shows a sailboat called "Cisne Branco", one example of the vessels.

Fig.1. Sailboat Cisne Branco

2.2. Intelligence Artificial, Machine Learning and Deep Learning

Siegel et. al. [14] explain the Artificial Intelligence is one of areas of computational science which focus on building machines and computers capable the simulate a type of intelligent behavior, making possible accomplish similar tasks the humans, like a recognizing voice, take decisions, visual perception, translating of languages. According of author Menezes [10], there are many areas where apply Artificial Intelligence.

For Bishop [4] and Almeida [1], Machine Learning is a type of system capable to get and accumulate knowledge and still yet improve the performance in specifics tasks. Are programs developed to learn to predict without have any supervision of programmer. This type of technique is applied in many areas, like processing images, recommendation songs, fraud detection.

Deep Learning (DL) built over neural network, being one type of machine learning, which is similar of human neurons. In Figure 2 show the artificial intelligence with subgroups [10].
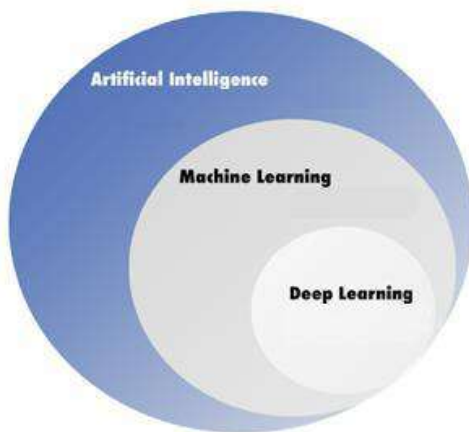

Fig.2. Subgroups of Artificial Intelligence

Anjos [2] declare that the deeper, or more levels, exist in the neural network, more is the quantity of operations and hence the need more computational power. The deep learning models are known too as neural networks because the first algorithms created to represent the biological learning, similar the brain.

2.3 Convolutional Neural Network

The great advantage of a convolutional neural network (CNN) on the other type of neural network it is your superior performance with the processing of image, speech, or audio signal inputs. The basic architecture consists of three types of layers, which are convolutional layer, pooling layer and fully connected layer.

Accord with IBM Cloud Education [8] The convolutional layer is the first layer of a CNN. While convolutional layers can be followed by additional convolutional layers or pooling layers, the fully connected layer is the final layer. With each layer, the CNN increases in its complexity, identifying greater portions of the image. Earlier layers focus on simple features, such as colors and edges. As the image data progresses through the layers of the CNN, it starts to recognize larger elements or shapes of the object until it finally identifies the intended object.

According to Almeida [1], one of the most important characteristics of CNN is the large number of architectures that can be configured, since networks have different layers that can be combined, including parameter variation.

For Bengio et. al. [3] the structure is composed of a series of consecutive layers convolution, pooling or variation, in the feature extraction phase. According to Anjos [2], the convolution layer the operation acts in 4 dimensions: filter width (x'), filter height (y'), filter channels (c) and number of filter (f):

$$Fout = \sum_{c=1}^{C} \sum_{x'=1}^{X} \sum_{y'=1}^{Y} Fin(c, x-x', y-y')W(c, x', y', f)$$

The output feature (Fout) of dimensions (Rx x Ry) are produced by the convolution of the filters (W), of dimensions (x' x y'), with the input feature (Fin), of dimensions (X x Y).

III. METHODOLOGY

The methodoly was separated in 5 steps. In step 1, images will be collected from many places, specific classes used on code, which are Military Ship, Ferry Boat, Canoe, Catamaran, Sailboat and Yacht, as seen previously. In step 2, a database will be created containing images from the internet, of the region.

All photographs are different for training and validation purposes, as it is important that the program can improve its parameters based or various points of view of the vessel type, without running the risk of training in a biased way.

After the elaboration of the database of images, proceeding to step 3, the development of the code for classification of images will be elaborated in the programming language python, which platform is considered open source, allowing users to use it free, in addition to of being able to use libraries, one of them being the TensorFlow (TF), created by the Google Brain team. TF is an open-source library for Machine Learning and there is an Application Programming Interface (API) that will be used for Deep Learning is Keras, which has a set of programming routines [6].

In this step, the process of the Convolutional Neural Network (CNN) will be discretized, including the number of neurons, layers, activation functions, Epoch and the form of displaying results on screen.

After setting the CNN and proceeding to step 4, the tool will run, where it will train and validate its parameters for classification, seeking to discard characteristics irrelevant features, for example the presence of water and prioritize specific contents, such as hull shape. For details about its accuracy, the percentage will be displayed on screen during all training periods.

Finally step 5, which consists of carrying out a test in which random images are presented, which are not included in the data base and generate a prediction of the results. In this case, if there is any non-conformity in the results, this error can lead to the interpretation that it may be related to the photographs in the dataset or the number of times generated.

This methos will be applied bot for the classification of the type of vessel and for the analysis of the vessel's freeboard.

IV.   RESULT ANALYSIS

Images of six types of vessels were collected, as seen previously, and a database created for CNN to use for training.

For the method mentioned, in setup 3, the setting of the classification is specified categorically, because there are more than two classes to be evaluated. The images are very large dimensions, requiring a high demand of time and computational effort to process the pixels, they were resized to dimensions of 200 pixels long and 200 pixels wide, acceptable sizes for conventional computer. It was also determined that 5 layers of neurons would be used, the first containing 32 neurons, the second with 64 neurons, the third with 128 neurons, the fourth with 512 neurons. Activation functions for these specified layers contain the ReLU function ([15],[5]).

The fifth and last layer is the output layer is the output layer, so the number of neurons is equal to the number of inputs. In this case, 6 classes were used, which are the vessel types, with the Softmax activation function [12].

For the loss function, the Categorical Cross Entropy was used, which collaborated with evaluation of the epochs, to determine if the results were converging. After the training, in the last step, random images of vessels that are not in the database will be provided to CNN so that it can classify.
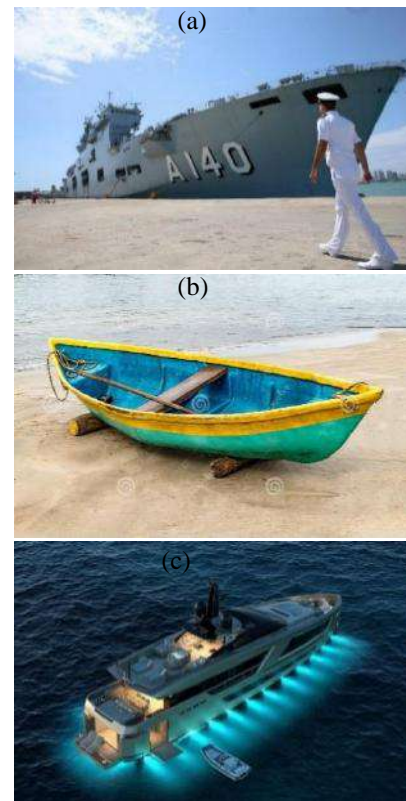
Fig.3. (a) War Ship; (b) Boat; (c) Yatch

The Convolutional Neural Network (CNN) was programmed to classify images according to the type of vessel. Currently the database consists of 120 photos, 60 for training and 60 for validation. Tests were performed with 30, 50 and 75 epochs. Was given to the CNN 6 photos in this order: War Ship (Figure 3-a), Boat (Figure 8-b), Yatch (Figure 3-c), Sailboat (Figure 9-a), Boat (Figure 9-b) and Catamaran (Figure 3-c).

At 30 epochs (Figure 5-a) the program get 4 of 5 correct answes, it had a mistake at last one picture. In this case, CNN answered Navio_Militar. At 50 epoch (Figure 5-b) was the same result at 30 epoch. For the last time, was executed with 75 epoch (Figure 5-c) which was showed the correct 5 of 5 answers.

It can be seen that there was an error in the last classification for training of 30 and 50 epochs. However, for 75 epochs, the network was correct in all its classifications
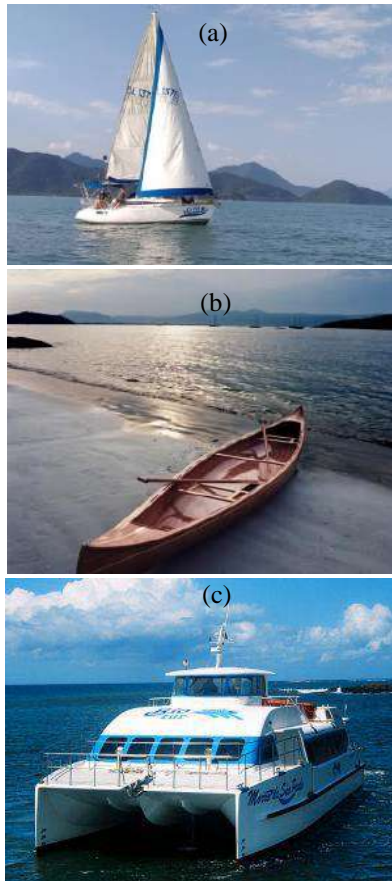
Fig.4. (a) Sailboat; (b) Boat; (c) Catamaran

V. CONCLUSION

Given the results presented, it can be seen that the neural network was successful in its first stage, which was to identify the types of vessels through images.

To increase the probability of correct predict in a low number of epochs it is necessary to increase the number of images in the database, since 120 photos is a very low number, and in some cases, there are databases with more than 5 thousand. From this, the database will be improved. Not only in relation to the number of existing photos, but also the increase in the types of vessels, in other words, CNN will be able to identify more classes.

In addition to identifying the type, it will also be enhanced with images of inclined vessels for the net to measure the freeboard.

With the expansion of the database, CNN will have an increase in accuracy in relation to its forecasts, being able to determine the type of stability risk in case the vessel is with low freeboard or inclined.

Fig.5. (a) 30 Epochs; (b) 50 Epochs; (c) 75 Epochs

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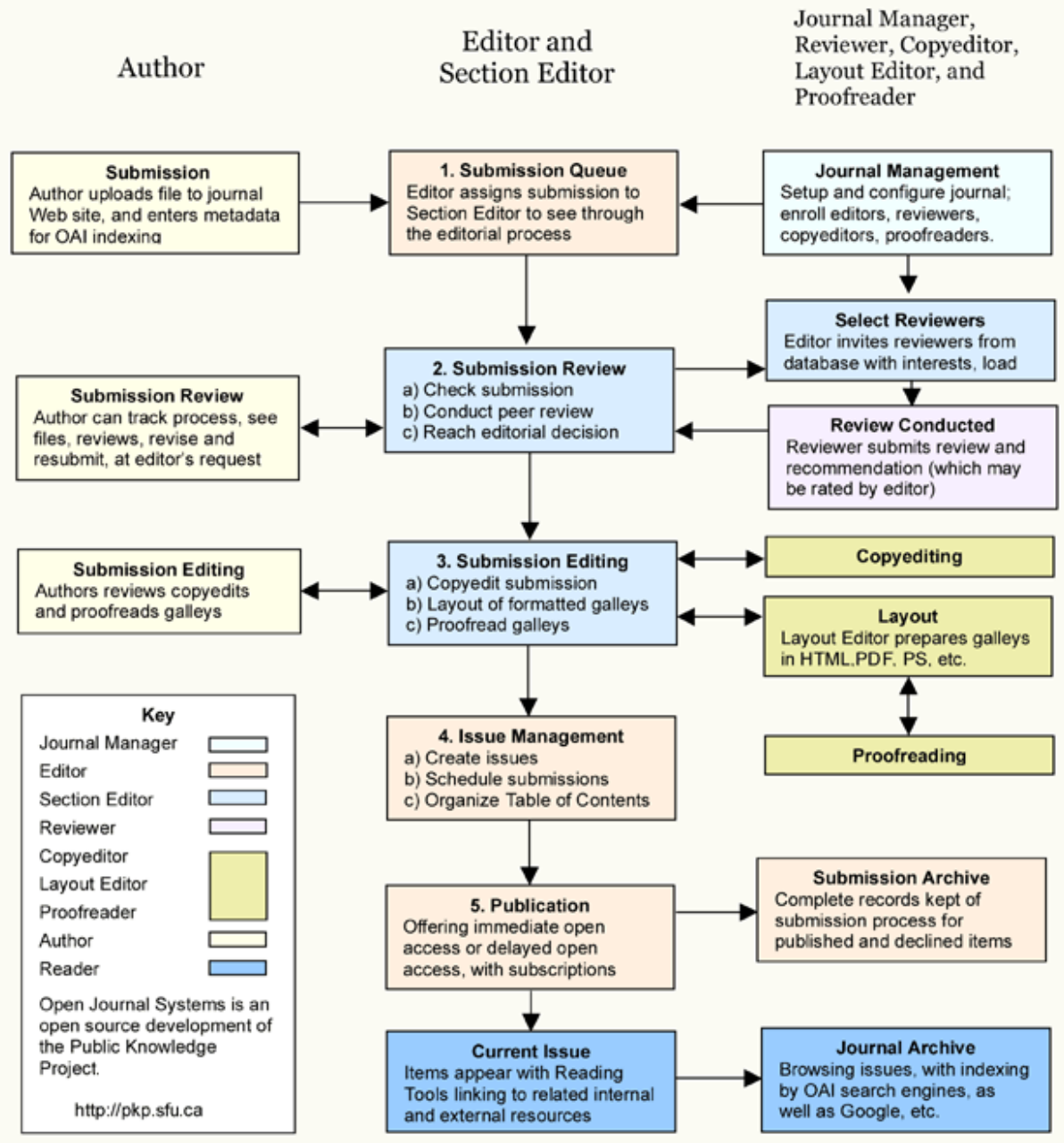
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