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Cost Reduction with Environmentally Correct Destination of Liquid Waste in Machining Processes

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Abstract**—***Machining processes use synthetic oils, either cutting or soluble, for the heavy processing stage, generating a liquid residue, composed largely of heavy metals, which are highly polluting and can not be disposed of without adequate treatment. This paper presents an already successful and successful case study of a renowned company located in the PIM - Manaus industrial pole, pointing out an economically viable alternative, with support in the available technologies and meeting the requirements of the applicable laws, as well as describing the whole learning process in the co urse of activities.*

Keywords**—** ***Synthetic oils, Destination, Liquid waste, Applicable law requirements.***

I. INTRODUCTION

The continuous and constant disregard for the environment by the human being, either individually or through highly polluting productive processes, is increasingly evident as one of the greatest threats to the renewal of existing natural resources, especially water resources and, for that matter, continuity of life. Through this reality, urgent measures need to be taken to minimize the inconsequential use of natural resources and favoring sustainable development, ensuring the proper use of these resources without jeopardizing the progress or danger to the continuity of the human race.

Among all available natural resources, water is undoubtedly the most important element for the continuity of our species on the planet. Debates on preservation and conservation of water resources and on the environmental issue are a reality, being part of the agenda of major sanitation companies and government agencies in general. The study of water, its composition, availability and scarcity in some areas, is the subject of several pedagogical projects related to environmental education.

Machining is the operation that gives the part: shape, dimensions or surface finish, or a combination of these, through the removal of material in the form of chips [1].

In this sense, it is sought through this case study, to demonstrate how the effects of the application of liquid waste treatment to the reduction of the cost of production in machining processes in a company of our Industrial Pole of Manaus, from the obtaining of water in nature until its processing and return to the receiving body or other uses, such as reuse processes.

II. BIBLIOGRAPHIC REFERENCE

In the available literature, there are several concepts, ranging from author to author. According to [2], there are many different names and they designate the same substance (oil or cutting fluid), making it difficult to discern the performance of each one in the process in which it is applied. If it is necessary to standardize this nomenclature for the correct distinction of its individual characteristics and applicability.

Another application, [3] addresses the Technological Aspects of dry machining with minimal amount of cutting fluid.

2.1 Synthetic Oils and Cutting Fluids

We will use the following concepts:

Cutting fluid - It is said about any fluid used for the cutting or machining of metals or other materials [4].

Cutting oil - It can be originated as mineral (petroleum), animal or vegetal, pure or associated [2] and is used as a supply, with no mixing with water, also called pure or integral [4].

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Emulsifiable oil - It is a cutting fluid based on mineral oil mixed with emulsifying agents [2], its use is mixed with water in the form of an emulsion, at any oil content [4]. Usually called water-soluble oil or emulsifiable cutting fluid [2].

Synthetic fluid - Also known as chemical fluid. Refers to the chemical solution composed of inorganic materials and / or other materials dissolved in the water and which does not contain mineral oil [2].

Semi-synthetic fluid - Commonly found as a semi-chemical fluid, it is a cutting fluid containing a small part of mineral oil mixed in water, forming a fine emulsion, similar to a common solution [4]. It can be said that it is a combination of the synthetic fluid with a very small part of emulsifiable oil with a high emulsifier content [2].

It can be said that synthetic cutting oils or cutting fluids are extremely complex compositions found in large-scale machining processes, whose structure of chemical agents will depend on the production dynamics and the metals with which they will be worked [1], as well as to the environment [5].

This project gains significance to the extent that the identification of research objects in liquid waste disposal can contribute to standardize and obtain references on the authentication of the research in the scenario in which it is proposed. It is known that due to the interdisciplinarity, characteristic of research in contemporary society, scientific production is often dispersed in publications of various fields and not only in the publications of the area.

Some factors are considered as delimiters for this research: first refers to the constant cycle of technological development that makes the methodologies applied to the treatment of liquid waste and an infinite range of other processes, obsolete every second. Besides addressing topics that, due to their interdisciplinarity, are inserted in the most diverse areas of scientific production. Secondly, it will be important to consider the fact that Portuguese is not the language commonly found in international research, causing arduous work to develop search strategies, as well as the correct and strict interpretation of data collected

2.2 Water as a Primal Resource for the Machining Process

Some preliminary information is relevant to the understanding of what is proposed in the article. In the world, according to statistics provided by the WHO (World Health Organization) and published by Marcos Von Sperling, in his book "Introduction to Water Quality and Sewage Treatment", water is distributed as follows, in the world sea water : 97%; Glaciers: 2.2%; Freshwater: 0.8% groundwater: 97%, Surface water: 3%.

Man's interference, either directly or indirectly, such as the use of organic waste in the soil, contributes to the introduction of new elements that alter the quality of this precious liquid in nature.

In industry, the versatility of water, due to its property as a solvent and its ability to transport particles, among a multitude of uses, makes it a fundamental resource for good process progress.

Therefore, especially in industries, understanding all the relevance of this resource for sustaining processes, and for economic or even cultural issues and in the face of an aggressive immediacy imposed by technological advances, we are constantly seeking ways to reuse this resource, recycling processes, investing in reuse methods, increasingly effective and in awareness campaigns aiming at the maximum extension of the useful life and the reduction of the cost of manufacture. The importance of the treatment and the consequent destination, economically viable, according to the parameters of sustainability, becomes even more evident if we take into account the recent events related to the climatic and water crises in the planet.

2.3 Viable Environmental Alternative

Placing as the main topic of discussion the concept or idea of sustainable treatment and showing how it can directly affect how humans and companies currently dispose of natural resources and dispose of waste can be a crucial point in how the dynamics of natural resources is treated in the most diverse fields. discuss the consequences of misuse of this resource and its link with rational consumption reverberates directly in the establishment of sustainable industrial actions.

In this way, companies expand their horizons on sustainable competitiveness, without depleting resources and reducing markets, bringing benefits to society, reducing pollutants released, either in the atmosphere or in receiving bodies and minimizing the harmful impacts of productive activity on the environment. Communities as a whole, industries, markets, as well as governments can be favored over the discussion of sustainable treatment and its effects. However, issues related to sustainability are urgent and need to be the focus of the discussion, such as social, economic and social entrepreneurship, and can, in the short and medium term, cause resource depletion, political backwardness regarding incentives for technological development and to

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the research, being the commitment of the very survival of some of the specific social groups.

The scientific production aims, in a clear way, to harmonize the knowledge acquired in the research sphere with reality, in order to optimize its analysis and, consequently, to produce transformations. The impact of the systematic adoption of the appropriate and environmentally correct treatment of this precious resource, consists of a very relevant practical effect, is of particular importance in reducing the costs of production and destination in industries.

III. METHODOLOGY

For a correct and efficient data analysis, we made use of quality tools considered essential to the project: Brainstorming, Histogram, Pareto Diagram and Ishikawa Diagram.

3.1 Quality Tools Used

a) Brainstorming. The brainstorm is a term coined by Alex Osborn in 1953 [6], brainstorming or brainstorming session is carried out in a group consisting of a leader and about five regular members and five other guests. Regular members serve to keep pace with the process, and five other guests can be experts [7].

What is important in this method is that ideas flow spontaneously and "without brakes" or pre-judgments.

b) Histogram. "It's a very important quality tool for statistical analysis. It is a graph that shows the distribution of recorded events across the spectrum. These recorded events are called samples and are data collected from a process that wants to analyze behavior [8].

c) Pareto diagram. "Also known as Rule 80/20, Curve ABC or even Pareto Diagram, Pareto Analysis is a scheme, usually in the form of a column chart, that groups and orders the frequency of certain occurrences. Everything is done based on a very simple idea: that 80% of the consequences come from 20% of the causes [8].

d) Ishikawa diagram. "The Ishikawa diagram, of fishbone, of cause and effect or 6M, helps managers to investigate causes of problems for further resolution. The method is to organize causes into groups - labor, environment, materials, machines, measurement and methods - and study their effects [9].

3.2 Emergency Vulnerabilities

In the case of a case study of a project already implemented and successful in a renowned company, located in the Industrial Pole of Manaus, it was necessary to carry out the study on the emergency vulnerabilities at the time and the feasibility in the treatment of each one, hence, opt for the most relevant.

The entire discussion, illustrative figure 1, focused on the environmental equipment of responsibility and operation of the Utilities Sector of that company, where based on the data collected from official documents, such as monthly costs, quarterly costs, annual costs, operational quantitative, environmental liabilities, the destination of the waste and etc., it was possible to reach the object to which this article refers.

The performance of the following equipments was evaluated through brainstorm:

• Boiler House; • Power Generator;

• Effluent Treatment Station: in particular, we include liquid waste from the company's entire cooling network composed of more cooling towers, cold water plants and wells;

• Incineration Plant: here it is only the process that uses the liquid waste incinerator, since this, as we will see later, corresponds to the higher demand of this equipment.

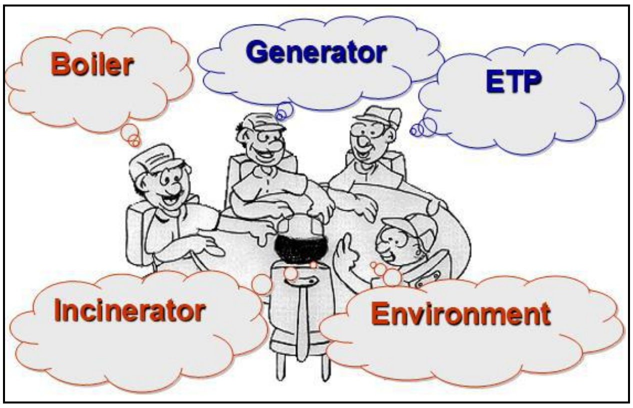

Fig. 1: Evaluation of the cost of environmental equipment

It was verified that the Boiler House and Incineration Plant were the equipment that demanded the highest monthly cost for the maintenance of its infrastructure and it was decided to dissect the reasons why this was a reality.

Some conclusions have been reached about which vulnerability to address first.

Several factors have been taken into account, such as:

Technology available at the time; Supply of inputs; Local alternatives to the energy matrix used until then; Cost with fuel; Economic viability; Current legislation; Logistics.

Figure 2 shows the flow chart of the liquid and solid waste path from its source to the incineration plant.

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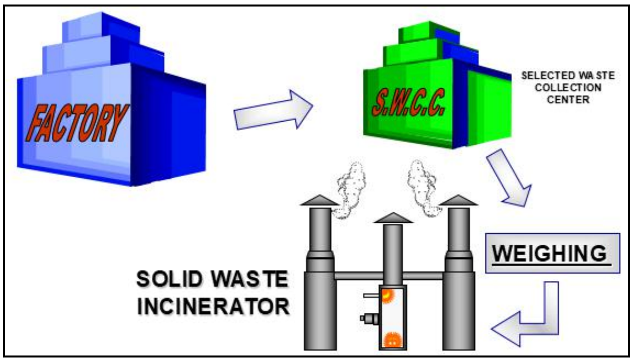

Fig. 2: Liquid waste flowchart

The liquid waste incinerator operates in the incineration of cutting oil (95.73%) and oil release agent (4.27%). It uses as fuel kerosene and has an incineration capacity of 1,000 liters per hour, at a working temperature ranging from 800 ºC to 900 ºC in a 13-hour work regime.

3.3 Comparison of costs of incineration SOLID x LIQUID

The graph of figure 3 shows the monthly average during the year of the cost of solid incineration x liquid.

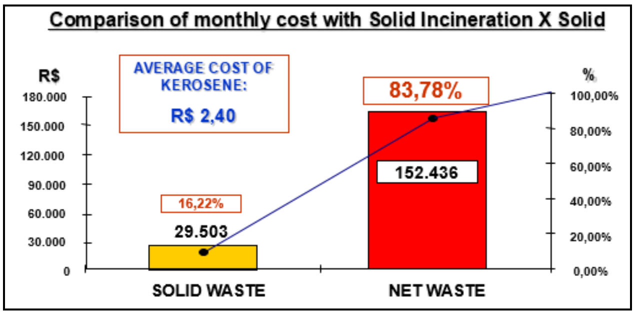

Fig. 3: Liquid waste flowchart

The average kerosene cost of 2.4 reais represented 16.225 of the total cost, while the cutting oil residue in the incineration process in question corresponds to 83.78% of the demand that came for processing.

With the available data, the decision analysis was made of which relevant vulnerability we would attack, within which the diagram of Ishikawa. Figure 4 shows the illustration of the Ishikawa diagram, where the environment, machine, methods, employee, cost and safety were analyzed.

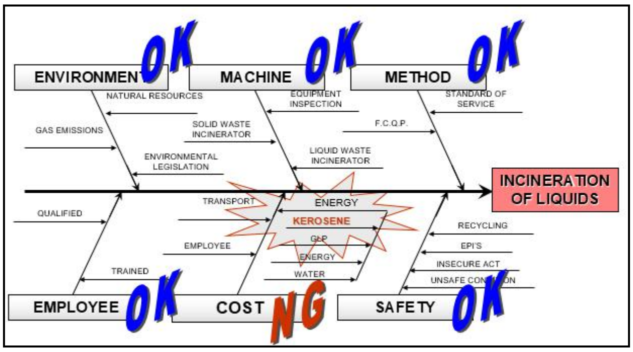

Fig. 4: Ishikawa diagram

As shown in Figure 4, the question of the energy matrix was the most urgent. It was necessary to reduce the cost with the consumption of kerosene.

Kerosene is one of the finest fossil fuels used in industry and, in addition to the generation of sulfur dioxide and carbon monoxide, still generates a huge amount of particulate matter and inevitably ends up reaching our atmosphere and causing, among other situations, health problems. "Studies point to several diseases caused by contamination of particulate matter, such as premature death of the heart, heart problems such as heart attacks and cardiac arrhythmia. There are also reports of development of asthma in children and other problems related to the respiratory system, such as irritation of the airways, coughing and difficulty breathing.

A detailed analysis of the cutting oil processing was made and the sampling was started in the sector where the operation occurred and the problem was identified as the quantity of contaminants present in the product, which made it unfeasible for reuse or recycling.

The contaminants in question were mostly: bush oil, microorganisms, filings, hydraulic oil, fabrics, polymer waste such as plastic pieces.

After analysis, it was concluded that the real cause of the high cost of incineration of the liquid residue (soluble oil) was in the large contaminated volume of this material, which was discarded.

We went to the research of: Current treatments for the product; Service providers (local or non-local); Economic viability of the project; Return on investment; Environmental legislation in force.

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Fig. 5: Cutting oil operation

The machining process uses the cutting oil to perform the process. Figure 5 shows an illustration on the cutting process and the use of cutting oil.

3.4 Making Possible Solutions

The possible solutions of the problem are the decontamination of the cutting oil in the generating source; Decontamination through the physical-chemical treatment of the effluent treatment plant; Decontamination through the centrifugation process for disposal at the effluent treatment plant; Decontamination through the centrifugation process followed by ultrafiltration for disposal at the effluent treatment plant.

3.4.1 Decontamination of cutting oil at the generating source (machines)

As a fundamental part of the machining process, the use of cutting oil is shown in figure 6.

Fig. 6: Cutting machine oil operation

The options are:

a. Placement of screens at each outlet and oil in the equipment to contain contaminants. is economically viable and some machines already have output screens, but would only solve the problem of solid particles, such as filings. Discarded hypothesis;

b. Placing of rails for containment of the busbar oil. The buses were internal and the very systematics of the processes caused drag of the contaminants. Discarded hypothesis;

c. Local sterilization of each equipment to avoid microbiological contamination by exposure and contact. Need of sterilization of all the machines, not only of the cutting oil coming from the reservoirs. As the environment was open, even sterilizing, the microbiological contamination would occur again. Hypothesis discarded.

3.4.2 Decontamination through the physical-chemical treatment of the ETS (Effluent Treatment Station)

The treatment of industrial effluents generates as by-products, the quantity and nature of the by-product depends on the characteristics of the initial effluent. Figure 7 shows a treatment plant

Fig. 7: Effluent treatment plant

The options are:

a. Critical variables of the above specified process: BOD (biochemical oxygen demand), COD (chemical oxygen demand). Discarded hypothesis;

b. Oils and greases of cutting oil above specified in relation to the effluent from the manufacturing process. Discarded hypothesis;

c. Death of the colonies of microorganisms essential for the treatment of the effluent. Discarded hypothesis;

d. Reducing the efficiency of the treatment process.

Hypothesis discarded.

3.4.3 Decontamination through the centrifugation process for disposal in the ETS (Effluent Treatment Station)

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Centrifugation involves the removal of solid particles and part of the heavier oil by density difference. Figure 8 shows the spinning process.

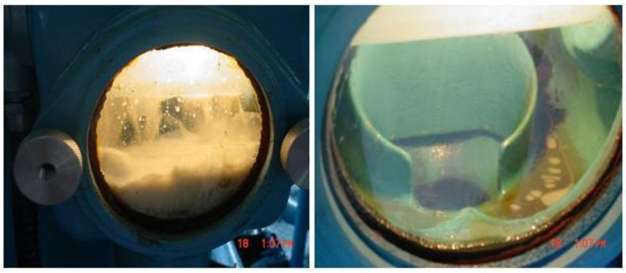

Fig. 8: Centrifugation process

The options are:

a. There is withdrawal of solid particles and removal of the lubricating and bushing oil, but the cutting oil remains. Discarded hypothesis;

b. Indexes of oils and greases, BOD, COD and heavy metals above that allowed in CONAMA 20/86, legislation in force at the time. Discarded hypothesis;

c. Death of colonies of essential microorganisms when discarded for ETS. Discarded hypothesis;

d. Reduction of the efficiency of the treatment process in the ETS. Hypothesis discarded.

3.4.3 Decontamination through the centrifugation process followed by ultrafiltration for disposal in the ETS

Ultrafiltration is the removal, at the molecular level, of particulate matter, colloidal, dissolved organic and microorganisms through the passage, through membranes, of the soluble oil, under high pressure and with low consumption of electric energy. Figure 9 shows an example of the result of the ultrafiltration process.

Fig. 9: Result of centrifugation followed by ultrafiltration

The options are:

a. There was a cost reduction with the destination of the liquid waste;

b. There was withdrawal of solid particles and removal of hydraulic oil, bus and cut oil;

c. BOD, COD, heavy metals in accordance with the standards of receipt for treatment in TES.

The centrifugation method followed by ultrafiltration was what demonstrated greater energy efficiency and greater efficiency in meeting the current environmental standards.

IV. RESULTS OBTAINED

4.1 Analytical Result

The analytical results are based on the specifications of the National Environmental Council, created by Federal Law No. 6.938 / 81, which is the Brazilian collegiate body responsible for adopting measures of an advisory and deliberative nature regarding the National Environmental System. All specifications have met CONAMA.

4.2 Return on Investment

With the implementation of the process, the cost of incineration of the liquid waste, which was R $ 0.80, was R$ 0,35.

Figure 10 show reduction.

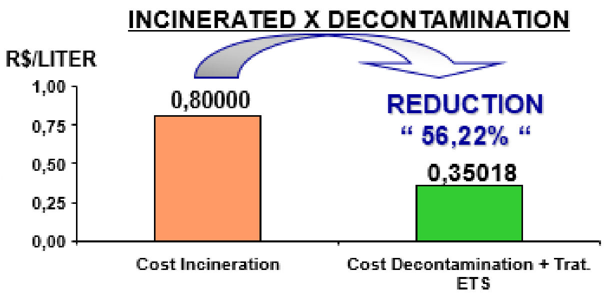

Fig. 10: Result reduction

Reduction of 56,22% of the cost of the destination of liquid residue and of 18,36% in cost with the "general" kerosene of the factory.

When applying the information to the consumption of kerosene x annual cost of the destination in the incineration plant, the very high number of R$ 1,948,752.00 is reached during the period of one year.

V. CONCLUSION

The aim of this project was to demonstrate, in a structured way, the importance of an environmentally correct destination, endorsed by good practices, a constant maturation of environmental awareness combined with the technological advances essential to the maintenance of the environment, which makes industrial

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production much more competitive and sustainable. In order to satisfy this purpose, a synthetic description of the solution found for optimization of the destination of the liquid residue generated in the machining process of the company in question was chosen.

The result obtained, exceeded expectations, brought with it an extensive and prolific attitude change in relation to the negotiations and possible environmental impacts resulting from the disposal of this material in an inadequate way, a considerable financial return, besides serving as an aid to future researches concerning the area.

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