

# Design of a Rotary System for Fish Smoking Equipment to Improve Smoking Efficiency with Smoke Filtration Method Using Cyclone Separator in Sorong West Papua

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**Keywords** — Design, Cyclone Separator,  
Rotary, Fumigation Equipment.

**Abstract**— The design of the smoking device made in this study is 120 cm long, 60 cm in diameter, the material used is iron plate (Fe) with a thickness of 2 mm, the smoking rack is made of stainless steel stirrups with a size of 8 mm with a capacity of 15 kg of fish that can be accommodated smoked and the fumigation device is portable. LxPxT (40x40X50) cm fuel furnace equipped with a 2" (inch) exhaust fan to push hot steam from the combustion furnace into the smoking chamber, 45 cm high cyclone, 11 cm diameter, liquid smoke distillation pipe using 1 inch Stainless steel. Roller module as a rack player automatically every 30 minutes, 2 minutes of rotation is connected to an electric motor HP (1400 RPM) 300 watts, 220 Volts, Gear-Box as a rotation reducer with a rotation ratio of 1:50 rpm. In testing the instrument, the parameters observed were the temperature of the smoking furnace, the temperature of the cyclone separator, the temperature of the smoking room, and the smoking time. The heat used to raise the temperature is 2.898 kj/kg, the heat used to evaporate the product water (fish), is 33.8904 kj/kg, the heat used to raise the product temperature (fish) is 21.942 kj/kg °C, the total energy consumed is used by the product is 58,704 kj/kg.

## I. INTRODUCTION

Fish is one of the food products that has a fairly high water content of around 60 to 70%, therefore fish undergoes the process of decay very quickly. So good handling is needed so that the quality of fish is maintained until it reaches consumers, one of which is through smoking which has the aim of obtaining a long-lasting fish storage time, giving a distinctive brownish aroma and color to smoked fish (Wibowo, 1996). Smoking is a process of penetrating volatile compounds in fish produced from burning wood and producing products with specific tastes and aromas. Isamu Kobajashi, (2012).

Processing of smoked fish in Sorong is generally still done traditionally, namely with an open smoking system in which the fish to be smoked is placed on racks arranged above the furnace with a distance of  $\pm 40$  to 50 cm, The process of processing smoked fish, which is still traditional, has to turn the fish over the stove so that the fish cooks evenly, and of course it produces hot steam and a large volume of smoke that can disturb the business actors themselves such as sore eyes and interfere with breathing, so that over time it can lead to respiratory tract infections and disrupt the environment and cause air pollution. Fumigation tools with a closed system are more effective than open systems (Maripul, 2004).

The development of fish smoking equipment technology is currently very much needed along with the times and the increasing need for environmentally friendly, safe, comfortable, easy to use, inexpensive, and affordable smoking equipment. with various factors supporting the availability of local material sources that can be utilized, and can be combined with technology that can be applied to the local community. Based on previous studies, various kinds of smoking devices have been made such as the performance test of the "Effhilink" smoking device (maritaikajoesidawati, et al 2018), Integrated Design of Furnaces, Heat Exchangers, Cyclone Separators and Material Rooms for Fish Smoking (Muh.Tahir 2018) , Smofim: Solar Photovoltaic-Based Fish Smoke Machine (MahdaEnja Al Hudha et al 2018),

The fish smoking device made in this study is a Rotary System Fish Smoker With Smoke Filtration Method Using Cyclone Separator, 120 cm long, 60 cm in diameter, the material used is iron plate (Fe) with a thickness of 2 mm, the smoking rack is made of 8 mm stainless steel, and uses a 1/4 HP motor with 220 V electric power, 1400 RPM motor rotation, and is connected to the Gear-Box as a reducer. motor rotation with a rotation ratio of 1:50 rpm, and connected to the Pulley and V-belt to rotate the smoking rack slowly (Low Speed) every 30 minutes and the rotation time is 2 minutes, so there is no need to flip the fish in the smoking room. The fumigation device has a cyclone separator with a height of 45 cm, a diameter of 11 cm, which functions to separate particles such as tar, ash, and soot from the furnace before entering the fumigation chamber.

## II. RESEARCH METHODS

The research method used is the experimental method, namely conducting trials on the performance of the rotary system fumigation device with smoke filtration using a cyclone separator, referring to the modified Tahir (2018). Implementation of this experimental research was carried out in the machine workshop owned by the Sorong Middle School of Fisheries Business. The research includes the design and manufacture and assembly of tools as well as testing the performance of fumigation tools.

### Tools and Materials

The equipment used in the design and manufacture and assembling of fumigation tools is workshop work equipment such as: Welding machine and welding wire, grinding machine, drilling machine, tape measure, angle ruler, pliers, scraper, vise, wrench, and pin. Supporting equipment used are: timer roller module, 1 phase HP electric motor, gear box Type FC A50 Ratio 1: 50, 2 inch blower, pulley and V-belt. The materials used to make the

fumigation tool are: 2 mm iron plate (Fe), 4x4 galvanized hollow iron, 2 inch galvanized pipe, 19 mm stainless shaft/axle, 1 inch stainless steel pipe, 8 mm stainless iron, bearing pillow block. The raw materials used in this study were skipjack tuna and yellow fin tuna weighing 300 grams - 500 grams/per head, while the fuel used for smoking was biomass fuel, namely wood charcoal and coconut shell.

### Design

Pressman, (2002). Design is a process of creating a new system or replacing an existing system in whole or in part. Whitten et al, (2004), build information systems and components based on design specifications.

Design Results in 3D Drawings Using the Google Sketch up Pro 8 Application

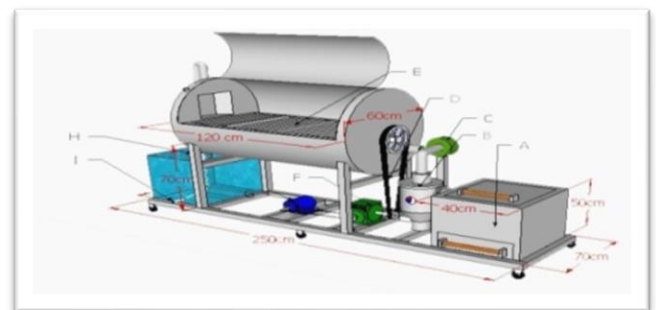


Fig.1: Fish Smoking Device Design Rotary System  
Cyclone Separator Method

Information :

- A. Combustion Furnace
- B. Cyclone Separator
- C. Blower
- D. V-Belt
- E. Smoking Rack
- F. Gear Box
- G. Electric Motor
- H. Liquid Smoke Distillation Pipe
- I. Liquid Smoke Output

## III. RESULTS AND DISCUSSION

The design of the rotary system of smoking fish using the smoke filtration method using a cyclone separator is carried out on the basis of consideration of input data in the form of literature studies obtained from books, journals and previous research results, and field observations are then analyzed and equipped with theoretical calculations. The results of the design of the rotary system of automatic

fish smoking using the smoke filtration method using a cyclone separator can be seen in Figure 2.



Fig.2: Fish Smoking Equipment with Smoke Filtration Using Cyclone Separator.

### Furnace

The combustion furnace functions as a place for the combustion process or the decomposition of fuel, namely charcoal and coconut shells to produce hot smoke through the combustion process. thus causing the decomposition process, namely the thermal decomposition of chemical elements, from the initial temperature in the first 30 minutes, namely at a temperature of 300°C to 360 minutes (6 hours) the fumigation process reaches a temperature of 470°C. The material used for the furnace is iron plate (FE) with a plate thickness of 2 mm. The furnace has a capacity of 19 kg of charcoal and coconut shell. Specifications of the fuel combustion furnace can be seen in table 1.

Table.1: Combustion Furnace Specification

Section	Dimension	Size
Furnace	Height	50 Cm
	Length	50 Cm
	Width	40 Cm

### Cyclone Separator

Cyclone Separator serves to separate tar, ash, and soot, so that the hot smoke that enters the smoking chamber and hits the fish's body is already clean smoke so that the smoke no longer contains these particles. This is in accordance with the function of the cyclone separator according to EkaMaulana et.al (2018) which states that the function of the cyclone separator is a particle separator from gas streams that is able to work over a wide operational range. In this cyclone separator, hot smoke from the furnace is processed or filtered before entering the smoking chamber by gravity system and particles such as tar ash and soot will not enter the smoking chamber but will fall to the bottom and be accommodated in the bottom container of the cyclone separator. The specifications of the cyclone separator can be seen in table 2.

Table.2: Cyclone Separator Specification

Section	Dimension	Size
Cyclone Separator	Height	45 Cm
	Diameters	11 inch

### Fumigation Room

The fumigation chamber unit is in the form of a tube or cylinder with a horizontal position having a connecting line and an air outlet that is directly connected to the liquid smoke distillation, so that the smoke that comes out is not wasted into the environment but can be converted into other products in the form of liquid smoke. The dimensions of the smoking chamber are 120 cm long with a diameter of 60 cm and a fish smoking rack length of 113 cm and a width of 57 cm. The smoking rack is made of food-safe stainless steel material with a size of 8 mm. This smoking rack is also supported by stainless steel axles with a size of 19 mm so that the fish rack does not bend when loaded with fish weighing up to 15 kg. The material used for the fumigation chamber is iron plate (FE) with a plate thickness of 2 mm. fish rack made of stainless steel with a size of 8 mm Specifications for smoking rack space can be seen in table 3.

Table.3: Specification of Fumigation Room And Rack

Section	Dimension	Size
Fumigation room	Diameters	60 Cm
	Length	120 Cm
smoking rack	Width	57 Cm
	Length	113 cm

### Liquid Smoke Distillation

Distillation is a process of changing the form of gas from direct or indirect combustion into a liquid form by lowering its temperature through a device called a condenser. The condensation process helps the water vapor molecules become liquid, so that the hot smoke from the burning process of charcoal and coconut shells is not wasted into the environment but can be converted into other products in the form of liquid smoke. The material used in the distillation container is iron plate (FE) with a thickness of 1.5 mm. for the distillation pipe made of spiral stainless steel pipe with a spiral diameter of 30 cm. the distillation container can accommodate 50 liters of cooling water which serves to absorb heat from the distillation pipe which is flowed by hot smoke/fumigation gas coming out of the fumigation chamber. The specifications for the container and distillation pipe can be seen in table 4.

Table.4: Product Specification Liquid Smoke Distillation Containers and Pipe

Section	Dimension	Size
<b>Distillation Container</b>	Height	50 Cm
	Length	50 Cm
	Width	40 Cm
<b>Distillation Pipe</b>	Diameters	1 Inchi
	Length	300 Cm

### Heat energy calculation analysis

Initial weight of fish ( $m_{mib}$ ) = 15 kg

Temperature of smoking room temperature ( $T_m$ ) = 75 °c

Temperature Outdoor temperature ( $T_s$ ) = 29 °c

Initial water content ( $K_{aib}$ ) = 68.18% = 0.68

Total charcoal fuel ( $m_t$ ) = 19 kg

The calorific value of merbau fuel (charcoal) ( $Q$ ) = 19,526728 kJ/kg

Smoking time ( $T$ ) = 6 jam

Hot type of water ( $C_p \text{ air}$ ) = 4,2 kJ/kg°C

latent heat of water vapor ( $L_w$ ) = 2.260 kJ/kg

The initial water mass of the fish ( $m_c$ ) can be determined by calculating using the following equation:

$$m_c = m_{mib} \times k_{aib}$$

Where :

$m_c$  = initial mass of fish water, kg

$m_{mib}$  = initial mass of fish, kg = 15 kg

$k_{aib}$  = Initial water content of fish, kg = 68.18% = 0.68

Then obtained:

$$\begin{aligned} m_c &= 15 \times 68.18\% \\ &= 15 \times 0,68 \\ &= 10.2 \text{ kg} \end{aligned}$$

The heat used to raise the temperature of the water content ( $m_{air}$ ) can be calculated by:

$$m_{air} = m_c \times C_p \text{ air} \times \Delta T$$

Where :

$m_{air}$  = temperature of water content

$m_c$  = initial water mass of fish = 10.2 kg

$C_p \text{ air}$  = specific heat of water = 4.2 kJ/kg

$\Delta T$  = temperature difference = 46 °c

Then obtained:

$$\begin{aligned} m_{air} &= m_c \times C_p \text{ air} \times \Delta T \\ &= 10,2 \times 4,2 \times 46 \\ &= 1,970.64 \text{ kJ/kg} \end{aligned}$$

The mass of water evaporated during the drying process ( $m_e$ ) can be calculated by:

$$m_e = m_{mib} - m_{ik}$$

Where :

$m_e$  = mass of water evaporated during the smoking process, kg;

$m_{mib}$  = initial mass of fish = 15 kg

$m_{ik}$  = mass of dry/final fish = 10.2 kg

Then obtained:

$$\begin{aligned} m_e &= 15 - 10.2 \\ &= 4.8 \text{ Kg} \end{aligned}$$

The energy value for evaporating fish water ( $Q_t$ ), using the equation:

$$Q_t = m_e \times L_w$$

Where :

$Q_t$  = energy value for fish water vapor

$m_e$  = mass of water evaporated = 4.8 kg

$L_w$  = latent heat of water vapor = 2.260 kJ/kg

Then obtained:

$$\begin{aligned} Q_t &= m_e \times L_w \\ &= 4.8 \times 2.260 \text{ kJ/kg} \\ &= 10.848 \text{ kJ/kg} \end{aligned}$$

The heat used to raise the temperature, using the equation:

$$Q_{air} = m_{mib} \times c_{pair} \times \Delta T$$

Where :

$Q_{air}$  = heat energy to raise the temperature (kJ)

$m_{mib}$  = Mass of fish (Kg) = 15 kg

$C_p \text{ air}$  = Specific heat of water (kJ/Kg°C) = 4.2 kJ/Kg°C

$\Delta T$  = temperature difference (°C) = 46 °C

Then obtained:

$$\begin{aligned} Q_{air} &= m_{mib} \times C_p \text{ air} \times \Delta T \\ &= 15 \times 4.2 \text{ kJ/kg}^\circ \text{c} \times 46 \\ &= 2.898 \text{ kJ/kg} \end{aligned}$$

The heat used to evaporate the product water (fish), using the equation:

$$Q_{uap \text{ air}} = m_{mib} \times C_{uap \text{ air}}$$

Where :

$Q_{uap \text{ air}}$  = heat energy to evaporate water (kJ)

$m_{mib}$  = Mass of fish (kg)

$C_{uap\ air}$  = Heat of water vapor (kJ/Kg) = 540 Cal = 2.25936 kJ/kg.

Then obtained:

$$\begin{aligned} Q_{uap\ air} &= m_{mib} \times C_{uap\ air} \\ &= 15 \times 2,25936 \\ &= 33.8904 \text{ kJ/kg} \end{aligned}$$

Specific heat used to raise the temperature of the product (fish), the specific heat ( $C_p$ ) of fish is 3.18 kJ/kg°C. (Syamsulbahriwidodo, 2015)

The heat used to raise the temperature of the product (fish) using the equation:

$$Q_{ikan} = m_{mib} \times C_{p\ ikan} \times \Delta T$$

Where :

$Q_{ikan}$  = heat energy to raise the temperature of the product (kJ)

$m_{mib}$  = Fish Mass (Kg)

$C_{p\ ikan}$  = Specific heat of product (kJ/Kg°C)

$\Delta T$  = Change in temperature (°C)

Then obtained:

$$\begin{aligned} Q_{ikan} &= m_{mib} \times C_{p\ ikan} \times \Delta T \\ &= 15 \times 3.18 \times 46 \\ &= 21.942 \text{ kJ/kg}^\circ\text{C} \end{aligned}$$

So the total energy used by the product is:

$$Q_{total} = Q_{air} + Q_{uap\ air} + Q_{ikan}$$

Where :

$$Q_{total} = \text{Total energy used by the product}$$

Then obtained:

$$\begin{aligned} Q_{total} &= 2.898 \text{ kJ/kg} + 33.8904 \text{ kJ/kg} + \\ &\quad 21.942 \text{ kJ/kg}^\circ\text{C} \\ &= 58.7304 \text{ kJ/kg}^\circ\text{C} \end{aligned}$$

#### IV. CONCLUSION

With the design of a rotary system fish smoking device with a smoke filtration method using a cyclone separator with a fuel furnace specification of LxPxT (40x40X50) cm, exhaust-fan 2" (inch), cyclone height 45 cm, diameter 11 cm, liquid smoke distillation pipe using 1 inch Stenlist steel, rack player 30 minutes 2 minutes long, electric motor HP (1400 RPM) 300 watts of electric power, 220 Volts, Gear-Box rotation 1:50 rpm, heat obtained 2,898 kJ/kg, The heat used to evaporate the product water (fish), is 33.8904 kJ/kg, the heat used to raise the temperature of

the product (fish) is 21.942 kJ/kg °C, the total energy used by the product is 58.704 kJ/kg.

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