Design and Fabrication Forced Convection Fish Smoking Kiln

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Abstract- A combination of smoke, salt, and drying is one of the earliest recorded methods of food preservation. These procedures, loosely known as "Smoking" or "Smoke Preservation," are successful because they kill food spoilage bacteria or render them harmless by altering the chemistry of the food these spoilage organisms need to grow. Traditional methods of smoked food preservation typically produced high salt and low moisture content products that are not desirable to most modern consumers. In this research, we have designed a unit of fish smoke of forced convection type. Convection air flowed using a fan is expected to keep the temperature and heat evenly distributed in the evaporating chamber. This is to maintain the quality of fish is characterized by the level of maturity evenly. The fish-smoking apparatus has dimensions of 154 cm long, 60 cm wide, 110 cm high, equipped with an air fan of 20 cm x 20 cm. Test results on tuna samples weighing 20 kg, fish smokers can reduce the water content in fish 58% within 2 hours.

Keywords-component- *fish, smoker, moisture content, convection.*

INTRODUCTION

Aceh is one of the areas in western Indonesia which has a marine resources of tuna fish. The catch of tuna fish by fishermen reached 600 tons a day with the fishermen as many as 4.140 people spread in several sub districts [1].

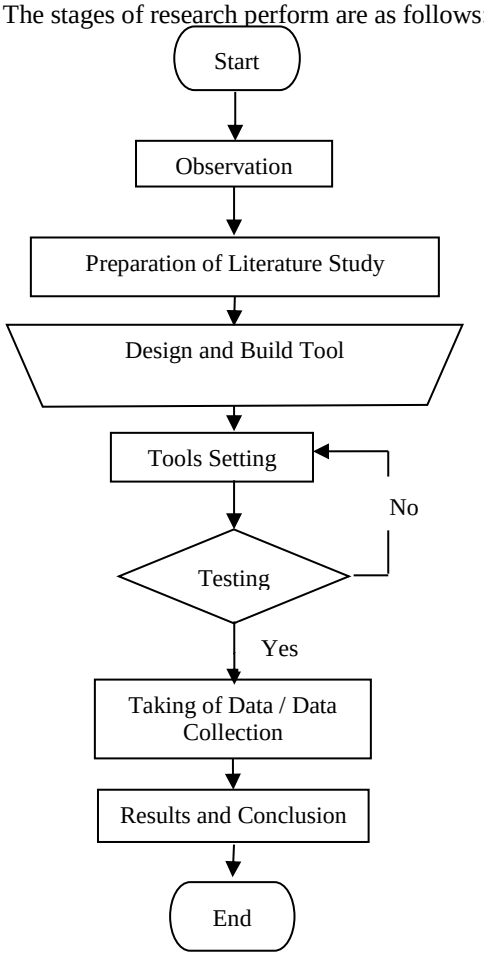
Potential of tuna fish catch is utilized by people to make fish curing technique with smoked method. The result of smoked fish is known as wooden fish. The smoked method of fish aims to reduce the water content in it. The amount of water loss for smoked fish according to SNI is a maximum of 60% [2].

To achieve the level of decreasing the water content of the fish in accordance with SNI standards, fish farmers in Aceh City make a traditional tool i.e. a house for smoked method of fish. The traditional smoked fish technique has several problems i.e., the need for extensive land, air pollution such as smoke, the need for a lot of fuel, requires a lot of workers, less hygienic, the potential of waste generated, and other problems. This causes the traditional smoked fish process to be less effective and efficient.

In this research, we made a portable fish curing tool use smoked method with a capacity of 20 kg / process [3]. It has a dimension of 154 cm long, 60 cm wide and 110 cm high equipped with an external fan with constant speed to keep the heat and air circulation in the tool [4].

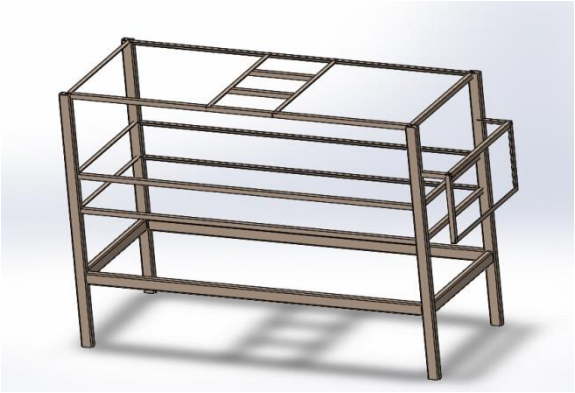
RESEARCH METHOD

The stages of research perform are as follows:

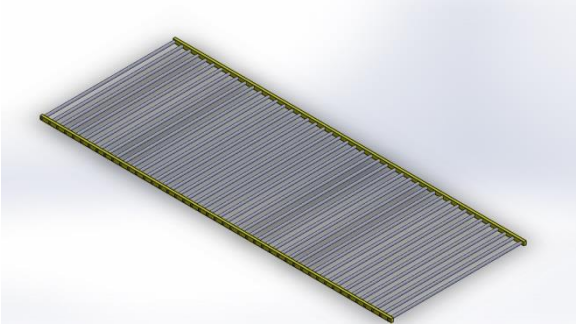


Before designing the tool, we made observations to the place traditional curing of fish with smoked method in Aceh City. Based on some of these locations obtained data as preliminary and consideration data in the design of a smoked fish machine. The design of smoked fish machine is done using CAD software as follows:

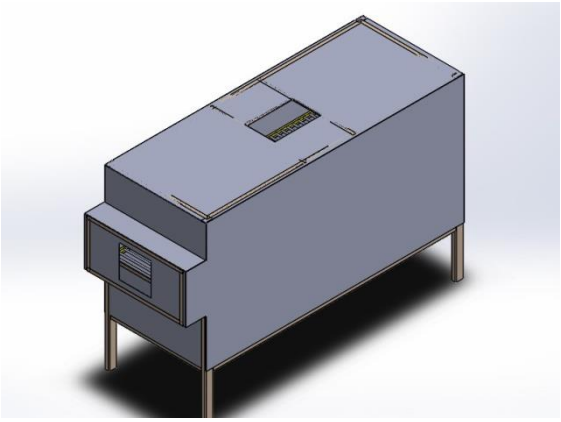
1. Design Frame of Machine



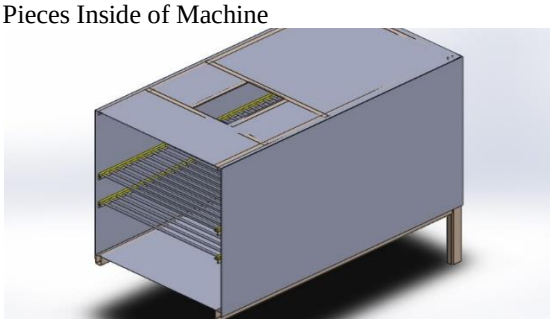
2. Design of Tray to Put Fish



3. Design of Overall Machine



4. Pieces Inside of Machine



After the engine design is made, the next step is to calculate the temperature flow rate by external force convection method with the assumption of smoke in the form of plate with dimension length 154 cm, width 60 cm and heat produced by 60°C. The outer air stream coming from the fan is 1m / s with a temperature of 30°C. the assumption of the flowing air is the ideal gas and there is no radiation effect with the steady state conditions shown in Figure 1.

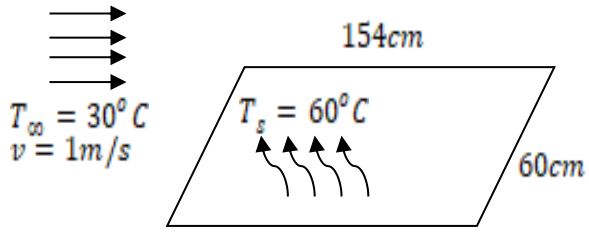


Figure 1. Assumption of Heating Conditions

Having known the initial conditions in the process of making smoked fish, it could be calculated properties of air used at the temperature. The calculation of air properties is as follows.

$$T = \frac{T_\infty + T_s}{2} = \frac{60^o C + 30^o C}{2} = 45^o C$$

Based on these temperatures it can be known the value of $k, P_r, \propto$ according to table properties [1]. Based on table properties can be obtained value:

$k = 0.02699 \frac{W}{m} \quad ^o C$,

$P_r = 0.7241$,

$\propto = 2.416\ x\ 10^{-5} \frac{m^2}{s}$.

The value of the Renault number [2]:

$$Re_L = \frac{vL}{\propto} = \frac{\left(1 \frac{m}{s}\right) x (154\ x\ 10^{-2} m)}{2.416\ x\ 10^{-5} m^2/s}$$

$Re_L = 6.374\ x\ 10^4$……..(1)

The value of the Nusselt number:

$Nu_L = (0.037\ Re_L^{4/5} - A) Pr^{1/3}$…….(2)

it caused,

$(0.6 \leq Pr \leq 60)$

wherein,

$A = 0.037\ Re_{x,c}^{4/5} - 0.664\ Re_{x,c}^{1/2}$……(3)

for the Renault Number Transition:

$Re_{x,c} = 5\ x\ 10^5$……..(4)

then the value of A: 871

$$Nu_L = (0.037\ Re_L^{4/5} - A)Pr^{1/3}$$
$$Nu_L = \left\{(0.037)\ x\ (6.374\ x\ 10^4)^{\frac{4}{5}} - 871\right\} 0.7241^{1/3}$$
$$Nu_L = 550.40$$

the value of h :

$$h = \frac{k}{L} x Nu_L \text{.....(5)}$$
$$h = \frac{0.02699}{154\ x\ 10^{-2}}\ x\ 550.40$$

$$h = 9.65 \frac{W}{m^2}.C$$

heat flow rate $\dot{q}$ could be calculated:

$$\dot{q} = hAs(T_\infty - T_s) \text{.....(6)}$$
$$\dot{q} = \{(9.65)\ x\ (1.54\ x\ 0.60)\}\ (45)$$
$$\dot{q} = 267.5\ W$$

The next step is make a smoked fish machine. The process of making the machine is done at the University of Samudra Mechanical Engineering Laboratory.

Figure 2. Process of Making Smoked Fish Machine

Testing process of machine is done at the University of Samudra Mechanical Engineering Laboratory using coconut shells as its fuel, and the fish as a sample.

Figure 3. Testing Process of Smoked Fish Machine

RESULTS AND DISCUSSION

Based on the results of tests that have been done could be obtained results as in Figure 4.

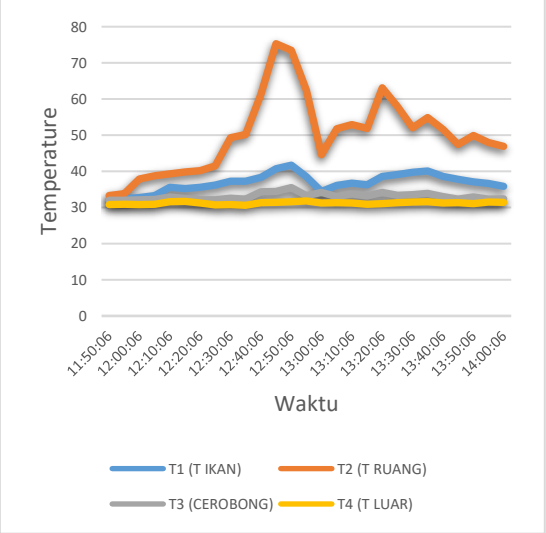


Figure 4. Data Testing Results

On Testing process is used smoke vapor from coconut shell combustion, and the mangrove test is carried out for 2 (two) hours 10 (ten) minutes, starting at 11.50 WIB - 14.00 wib. Retrieval of data per 10 (ten) minutes.

It appears that the temperatures at points T1, T2, T3, and T4 are unstable or unconditioned, between the four points, the temperature at T2 point is extreme, it is caused by :

1. The temperature seems to decrease drastically, it is caused by the addition of fuel, then the door on the burning furnace

and the curing room is opened in order to reduce the smoke of the curing room when it will be weighed on the fish.

2. Temperature is very high, it is caused by too much fuel that is incorporated into the furnace, and when the fuel in the furnace burns entirely, there is a rise in high temperature and look extreme.
3. Visible unstable temperatures caused by the temperature entering the curing room cannot be conditioned.
4. The temperature is very high, it's because too much fuel is put into the furnace, and when the fuel in the furnace is completely burned, there's a high temperature rise and extreme visibility.
5. Visible unstable temperatures caused by the temperature entering the curing room cannot be conditioned.

Testing Result Data of Weighing Fish

Taking the test data on the fish weight is done for 2 (two) hours 10 (ten) minutes, then weighing for 1 (one) hour time, and the results of the data could be seen in Figure 5.

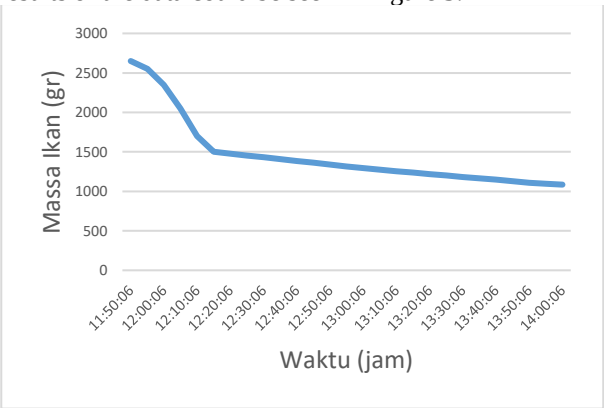


Figure 5. Graph Data Result of Weight Fish Lossing

Seen on the graph of the decrease in water content in the first hour is only 1.3 kg, it is caused the fish is still too wet and still a lot of water content in the body of the fish, and the temperature into the curing room is not too high, and the reduction of water levels i.e. at the second hour to reach 2 Kg.

ANALYSIS AND DISCUSSION

The heat flow rate of 267.5 W by utilizing the fan with a constant speed of 1 m / s with the outside temperature of 30ºC obtained that the process of curing fish takes only 2 hours 10 minutes. Maturity level of the fish is also more evenly with the decrease in water content up to 2Kg.

To find the calculation of water loss in fish using equation (1):

wherein:

$$Wb = 2{,}65 \text{ Kg}$$
$$Wk = 1{,}11 \text{ Kg}$$

$$KA = \frac{Wb - Wk}{Wb} \; x \; 100\ \%$$

$$KA = \frac{2{,}65 - 1{,}11}{2{,}65} \; x \; 100\ \%$$
$$KA = 58\ \%$$

Thus, the loss of water content in fish after it is smoked is 58%. Standardized value of water content in smoked fish based on SNI is a maximum of 60%. Smoke fish products using smoking cabinet and furnace. With a water content reduction of 58%

CONCLUSION

Based on the above research it could be concluded that the use of fan with constant speed as an external force in the process of making smoked fish could be used as an alternative in the process of curing fish to obtain a level of fish maturity more evenly with the process is shorter.

REFERENCES

[1] Cengel. A. "Heat Transfer (A Practical Approach) Second Edision". Appendix 1.

[2] Bergman, Lavine, Incroperra, Dewitt, "Fundamentals of Heat and Mass Transfer (Seventh Edition)". John and Willey Press.

[3] Doe. PE. "Fish drying and smoking: Production and quality" 1998.

[4] AA Fagge, AO Lawal. "Development and Testing of an Improved Fish Smoking Kiln"