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DESIGN AND DEVELOP FRESH FISH TABLE WATER MACHINE

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Abstract
A research has been carried out on the design of a machine for cooling water displaying fresh fish with the aim of being able to replace the hygienic fish trade patterns in the traditional market. This research uses trials and learning method where the evaporator is specifically designed, namely Shell and tube so that it can collect water and pump it to a fresh fish display table with a capillary pipe length of 3.80 cm and a diameter of 0.52 inch to produce cold water temperatures of 2 ºC - 5 ºC. Based on the results of the experiment, it can be concluded that the cooling water table display system of fresh fish works well, the total cooling load of the water cooler engine is 125.9 watts, producing 4 °C cold water with an average power of 349 Watts. COP 3.9 refers to SNI 03-6572-2001 concerning refrigeration where the minimum COP is between 2.3 to 5.20.

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1. Preliminary

A cooling machine is a series of units that can operate to produce temperatures or cold temperatures Nowadays the cooling system plays an important role in everyday human life, especially for food storage especially fish. Fish is a very good animal, has a high protein value but has a high water activity (Aw) too so that bacteria easily develop (Tamputubun and Savitri, 2016). There are several ways to maintain the freshness of fish, namely with ice (impression), with cold air (refrigeration) and with cold water (chiller) (Ilyas, 1983).

In general, fish traders display their wares in an open place on the table so that the quality and quality of fish is very low. And there are also traders only to maintain the freshness of fish using preservatives which are very dangerous because of the limitations of ice. The use of formalin as an additional ingredient in food has been banned by the ministry of health and listed in the Regulation of the Minister of Health of the Republic of Indonesia No.722 / MenKes / Per / IV / 88. Along with the development of technology in the field of cooling engineering provides convenience, comfort, economical, environmentally friendly and so on. In general, the cooling process in fish cannot prevent total decay, but can reduce the activity of bacteria and enzymes. The principle of cooling is to reduce the temperature of the fish as low as possible, but not until it becomes frozen. From research conducted by Prasetya and Putra, (2013) the refrigerant mass flow rate of cooling capacity increases when the cooling of the condenser gets higher. The cooling value can be determined from the pressure ratio between the condenser and the evaporator by flowing the evaporator refrigerant through capillary pipes with diameter variations (Soegeng, 2009).

Therefore this study aims to design a fresh fish table water cooling machine that can replace the hygienic fish trade patterns. (Sjarif, *et al*, 2010) stated that the way to handle fish after catching until fishing is very low so that it affects the quality of fish.

The advantage of a fresh fish counter water cooling machine is that it can produce cold water up to 2 ºC - 5 ºC using a shale and tube evaporator and a specially designed capillary tube length. According to Homzah et al (2017), Heru Dwi Cahyono, (2017), Anwar *et al*., (2010) the temperature of capillary pipes through the cooling process, influences the refrigerant conditions in the engine coolant cycle, in this case the enthalpy value. In the research conducted (Taukhid *et al*., 2014) the results obtained in the design of a table for the needs of the fish market in the port of Central Lombok are planned to have a capacity of one cubic meter and can accommodate 250 kg of fish with a power of 3 KW

2. Methodology

This study used an experimental method based on the results of the experiment of the specially designed evaporator component and the diameter and length of capillary pipes to produce cold water temperatures of 2 ºC - 5 ºC and calculate the production loads (water and fish), wall construction loads and heat loads of water reservoirs. Input parameters used include data input water temperature, room temperature, evaporator inlet gas temperature, condenser inlet gas temperature, cooling energy and type of refrigerant**.**

Tools and materials used in the manufacture of fresh fish table coolers are Hermatic 1/2 PK compressors, 220-240 Volts, 15 fin Aluminum Copper Condenser tubes, Filter Dryers, Expansion Tools, Shell and tube evaporators, Tubbing cutters , Swaging and Flaring, Tube Bandding Spring, Pliers, Welding Equipment, Vacuum Pump, Keys, Manifold Gauge, Water Circulation Pump, Measuring Instrument, Freon R-134 a, Brass / Silver Welding Wire , Methyl Liquid, 0.5 mm stainless steel plate, 5 mm stainless steel elbow, Kettle, Acrylic Cover, Pipe insulation, PVC pipe ½ inch, 6 inch pipe and pipe cover, Thermostat control.

Machine unit design and table material selection

To design a refrigeration system must first be calculated the energy requirements to cool the load, namely media and materials, to the components used. The design of the cooling machine unit in selecting table material is adjusted to the situation and market conditions, the cooling machine unit is designed and designed using Cinema 4D Application while the table material uses Stainless steel and the table legs use holo iron because it is resistant to corrosion.

Media calculation

The design of a cooling system to cool the water that is on the table of fresh fish, the water to be cooled from a temperature of 25 ºC to 5 ºC, designed for 10 hours using chilling time for 2 hours. In this study, 35 liters of water were used with an initial temperature of 25 ºC. Physical properties of water at a temperature of 25 ºC, namely

Cp_{water} = 1870 J/kg ºC
ρ = 997.0 Kg/m^3
μ = 0,891 x 10^{-3} kg/m.s
K = 0,607 W/m ºC
Pr = 6,14

With the same method can be seen the properties of water at a temperature of 5ºC, namely:

Cp_{water} = 1857 J/kg ºC
ρ = 999,9 Kg/m^3
μ = 1,519 x 10^{-4} kg/m.s
K = 0,571 W/m ºC
Pr = 11,2
V = 0,014 m/s

Water mass calculation

To determine the load of water to be produced can be done by the equation (Incopera, 1981). as follows:

$$Qwater = \frac{m \,.\, Cp \,.\, \Delta T\,(J)}{Cooling\ time\ \ (s)} \qquad (1)$$

Where :
Q = Product Load (W)
m = mass (kg)
Cp = Specific heat ingredients (J/kg ºC)
ΔT = Difference in Water Temperature(ºC)

= 1857 . 35
= 64,995 kg
= 65 kg
10 hours of operation

$$Qwater = \frac{65 .1870 .(25-5)}{10 .3600}$$

Q_{air} = 67,52 watt

Fish mass calculation

$$Qfish = \frac{m . Cp . \Delta T(J)}{Cooling\ time\ (s)} \qquad (2)$$

$$Qfish = \frac{20 .3516 . (25.5)}{10 .3600}$$

Q_{fish} = 39 watt

Calculation of wall construction loads

Wall construction load parameters for various materials can be determined by the table equation (Roy J Dossat, 1978) as follows:

Table 1. Wall Construction Parameters for Various Materials.

No	Material Name	Thick (m)	Thermal Conductivity ($W/m^{2o}C$)
1	Moving Air		22,7 (F0)
2	*Polyurethane*	0,02 (X2)	0,026 (K2)
3	*Stailess Stell* 0.5	0,0005 (X1)	15 (K1)
4	Water		0,56 (F1)

The load through the wall can be calculated by the equation:

$$Q = U\ x A\ x \Delta T \qquad (3)$$

Where:
Q = Heat flow rate in (Watt)
U = Overall Heat Transfer Coefficient
(N / m^2 K)

ΔT= Different temperatures through the inner wall (°C)

A = Area of the Wall (outside) in m^2

U value can be determined:

$$\frac{1}{U} + \frac{1}{F1} + \frac{X1}{K1} + \frac{X2}{K2} + \frac{1}{F0} \qquad (4)$$

From the results of data retrieval from various materials used in cold water reservoirs, the calculation is done to get the U value.

$$\frac{1}{U} + \frac{1}{0,59} + \frac{0,0005}{15} + \frac{0,02}{0,026} + \frac{1}{22,7}$$

$$\frac{1}{U} + 1,69 + 3,33 + 0,76 + 0,044$$

$$\frac{1}{5,824} = 0,17\ \mathrm{N/m^2}\ K$$

Total heat load like a water reservoir

$$Q = U \, x \, A \, x \, \Delta T \qquad (5)$$

Left and right side load

Q = 0,17 x (1,2 x 2) x (25-5)

Q = 0,17 x 2,4 x 20

Q = 8,16 watt

Front and back wall loads

Q = 0,17 x (0,75 x 2) x (25-5)

Q = 0,17 x 1,5 x 20

Q = 5,1 watt

Upper and lower wall loads

Q = 0,17 x (0,90 x 2) x (25-5)

Q = 0,17 x 1.8 x 20

Q = 6,12 watt

The total heat load of a water reservoir is = 19.38 Watt

The overall total production load and load on a fresh fish counter water tank is 125.9 watts

3. Discussion and Result

As a fresh fish table cooling machine design in producing cold water, the design was determined by using the Cinema 4D program as shown below:

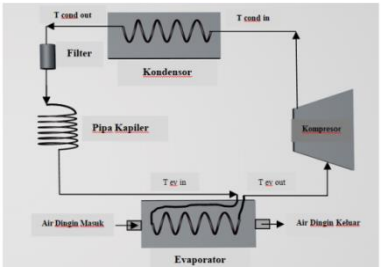

Figure 1. Schematic of the Cooling Machine Unit.

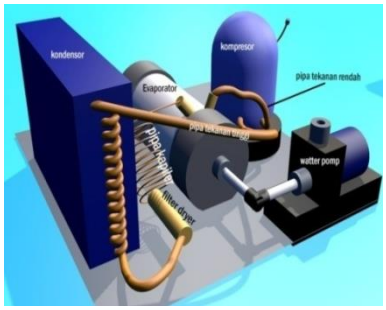

Figure 2. Engine Cooling Unit

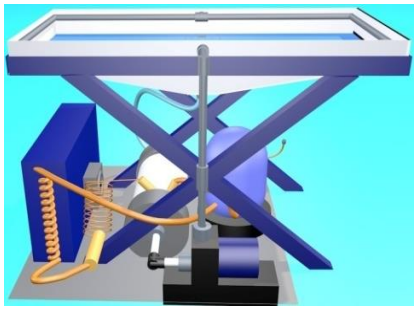

Figure 3. Side table cross section

- **Specifications of fresh water table display fish cooler machine unit.**

Compressor
The compressor functions to reduce the pressure in the evaporator and suck the coolant gas from the evaporator and then increase the pressure and temperature of the coolant to the condenser (Whitman, Bill. 2009, p. 448). The compressor used for the cooling water table display system for fresh fish is the Hermetic ½ PK compressor. The capacity of the compressor is determined from the calculation of the cooling load (Radha, *et al*, 2012).
The ½ HP compressor specifications are used for cooling the fresh fish table machine:

Merk	: Kulthorn
Model	: AE2415Y
Voltage	: 220-240 Volt
Frekuensi	: 50HZ
Freon	: R 134 a
½ HP	: 373 Watts

Figure 4. Compressors

Condenser
The condenser is the same heat exchanger as the Evaporator (Whitman, Bill. 2009, p. 420). The specifications of the condenser for ½ HP capacity are used for cooling the fresh fish table machine using factory standards, namely:
Condenser length : 92.5 cm
Pipe diameter : 0.375 cm
Pipe material : Brass
Fin Material : Aluminum
Amount of U : 15 U

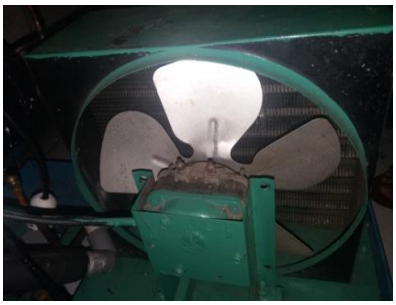

Figure 5. Condenser

Evaporator

Evaporator used is a type of shell and tube that is specially designed in the form of a spiral and uses a 6 inch diameter PVC pipe with a length of 0.5 meter PVC pipe. The length of the evaporator pipe is 15 meters with a diameter of 0.375 mm.

Figure 6. Shell and Tube Evaporator

Capillary pipe

Capillary pipe is one of the expansion tools that has two uses, namely reducing the pressure before entering the evaporator, and regulating the flow of refrigerant to the evaporator. Capillary pipes are used in refrigeration systems with a small capacity of 10 kw, capillary pipes reaching 1 to 6 meters in length with a diameter of 0.5 to 2 mm (Stoeccker, 1982)

Capillary pipes used in the manufacture of fresh fish table cooling machines to reach 2 ^{0}C to 5 ^{0}C are 3.80 cm long with a diameter of 0.052 inch.

Figure 7. Capillary pipes

Filter Drier

Filter drier used in making fresh fish table cooling machine is type EK-053. Filter drier can be seen in the following image.

Figure 8. Filter Drier

Temperature Controller

The temperature controller functions as a regulator in accordance with the temperature we want to turn off and turn on the compressor. The temperature controller used is the Elitech STC-9200 brand, as shown in figure 8 as follows.

Figure 9. Temperature Controller

Water pump

The water pump used to flow cold water from the evaporator to the fresh fish display table is Resun SP-6000 40 W. The water pump can be seen in Figure 10.

Figure 10. Cold Water Pump

Coolant unit assembly

The steps undertaken in assembling the engine cooler unit on a fresh fish table are as follows:

- Preparing a table from an iron plate as a cooling machine holder fresh wet fish table.
- Installing 1/2 HP Compressor on a plate table.
- Set the condenser on the plate holder.
- Install the fan on the condenser.
- Installing an evaporator that has been assembled using PVC (Poly Vinyl Chloride) Diameter 6 inch Shell and Tube models.
- Connect by welding interconnected pipes, High Pressure Pipes from Compressor to Condensers, Filter Dryers, Capillary Pipes, Evaporators and back to Low Pressure Pipes on Compressors.
- Installing a PVC pipe (Poly Vinyl Chloride) Diameter ½ inch from the Evaporator to the water pump and flow it to the display table.
- Refrigeration units and fresh fish display tables can be seen in Figure 11 and Figure 12 as follows.

Figure 11. Water Cooling Machine Unit

Figure 12. Fresh Fish Display Table

After assembling a fresh fish table cooling machine unit, then retrieve data and simulate the COP using the Coolpack program by entering the following parameters:

- Total load : 879 Watt
- Ambient temperature : 37 ^{0}C
- Product type : Cold Water
- Raw material : Freshwater
- Initial temperature Laughter water : 25 ^{0}C.
- Temperature to be reached : 50C
- Evaporation Temperature : - 25 ^{0}C
- Condensation Temperature : 35 ^{0}C
- Refrigerant used : R 134 a

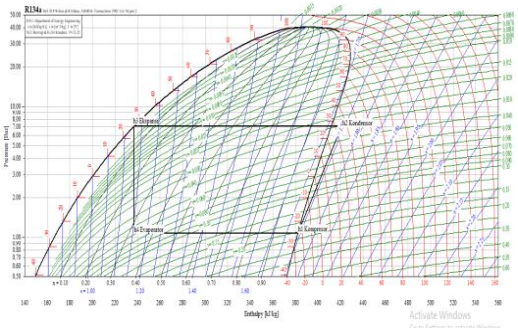

Figure 13. P-h diagram

The process of the p-h diagram is as follows:

- The h1-h2 process: a superheating dry compression that takes place inside the compressor. The work that takes place on the refrigerant during the compression step is the result of an increase in the enthalpy of the refrigerant in the compressor and the refrigerant flow rate.
- h2-h3 process: changing the shape of the gas to liquid, this process occurs in the condenser heat exchanger. The heat discharged into the environment depends on the rate of refrigerant flow and latent heat from the refrigerant.
- Process h3-h4: refrigerant in the form of saturated liquid flows through the expansion valve.
- Process h4-h1: refrigerant in the liquid vapor mixture phase through the evaporator. The heat absorbed by the evaporator depends on the rate of refrigerant flow and latent heat from the refrigerant.

The value at the point in the refrigerant cycle R134a in testing the cooling water table display fresh fish at the final evaporation temperature -25 ^{0}C and condensation temperature 35 ^{0}C can be seen in table 2.

Table.2. The value at the point in the refrigerant cycle 134a in testing the freshwater display table water cooling machine.

Point	**T** [^{0}C]	**P** [bar]	**v** [M$^-$3/kg]	**h** [kJ/kg]	**s** [kJ/(kg K)]
1	-25.000	1.067	0.180299	382.208	1.7410
2	35.581	7.058	0.030499	421.119	1.7410
3	35.581	7.058	0.030499	421.119	1.7410
4	27.000	7.058	N/A	237.148	N/A

Information:
P : Pressure
Q : Temperature
V : Volume
H : Vapor enthalpy
s : Liquid entrop

The nature of the R134a gas in the ph diagram shows that what is used in the design of a fresh cooling table machine results that, the final temperature of the evaporator is -25 ^{0}C without water load and with a water load of 35 liters reaching a temperature of 4 ^{0}C according to the desired temperature of 2 ^{0}C to 5 ^{0}C to cool fresh fish. The enthalpy at point 4 decreases along with the process of expansion in the capillary pipe (process 3-4). Capillary pipe length of 3.80 meters, can still be extended so that the enthalal value shifts to the left. That the lower the temperature that must be lowered, the COP system will also increase. Changes in capillary length affect the COP in the cooling machine (Homzah *et al*., 2017).

From the results of testing the cooling machine water table displaying fresh fish, that this unit uses a steam compression refrigeration system to produce a capacity of 0.373 KW, uses refrigerant 134a and works at condensation temperature of 35 °C and the maximum evaporation temperature on the evaporator is -25 °C, producing water cold circulated with a temperature of 4 °C to cool fish as much as 20 kilograms and 35 liters of water simultaneously within 2 hours.

Conclusion

After designing the construction of a fresh water display table water cooling machine, it can be concluded that the water cooling table display system of fresh fish works well and can be applied by fish traders both in traditional markets, fish auction places, fresh grilled fish huts and super markets. The total cooling load of the fresh fish counter water cooling machine is 125.9 watts, producing 4 °C cold water to cool the fish as test material as much as 20 kilograms and 35 liters of water within 2 hours with an average power of 349 Watts. Evaporator is specially designed namely Shell and tube so that it can hold water and can be pumped to a fresh fish display table. Capillary pipe length 3.80 cm in diameter 0.52 inch. COP 3.9 refers to SNI 03-6572-2001 concerning refrigeration where the minimum COP is between 2.3 to 5.20. Then the design of this refrigeration system can be used.

Suggestion

Fresh fish display tables must be insulated to minimize heat losses from the walls of the display table.

References

Anwar, K., Arif, E., Piarah, W.H., 2010. Effects of Capillary Pipe Temperature on Cooling Engine Performance 1, 10.
National Standardization Agency. (2001). Procedures for Designing Ventilation and Air Conditioning Systems in Buildings. SNI 03-6572-2001. Jakarta.
Dossat, R. J. (1961). Principles of Refrigeration. Toppan Company, Tokyo.
Heru Dwi Cahyono, 2017. Analysis of the Effect of Length and Diameter of Pipe.pdf. Muria holy university.
Homzah, O.F., hendradinata, Beta Akui, 2017. the effect of capillary length variation.pdf.
Ilyas. (1983). Refrigeration Technology Fisheries Products Volume 1 Fish Cooling Techniques. Agricultural Research and Development Agency. Plenary: Jakarta
Incopera, D.W. (1981). Fundamental of Heat Transfer. New York: John Willey dan Sons inc.
Radha, K.K, Sarada, S.N, dan Rajagopal, K. (2012). Development of a chest freezer – optimum design of an evaporator coil. International Journal of Automotive and Mechanical Engineering (IJAME), Vol. 5, 597-611.
Prasetya, B.H.P., dan Putra, A.B.K. (2013). An experimental study of the variation of the condenser cooling rate on the R22-DMF defuse absorbi cooling machine. Pomits Engineering Journal, 2 (1), 2337-3539
.Roy J Dossat, 1978. Principles Of Refrigeration, second. ed.
Sjarif, B., Suwardiyono dan Gautama, S.D. (2010). Catching and Handling of Fresh Tuna in Rawai Tuna Ship. Semarang: Center for the Development of Fishing.
Soegeng, W. (2009). Cooling machine performance test using LPG refrigerant. Austenite Journal, (1) 2, 63-69.
Stoecker, W.F, Jones, W.,N. 1982. *Refrigeretion and Air Conditioning.* The McGaw-Hill, Inc: New York
Taukhid, I., Pamungkas, A., Sianturi, D.S., Daniel, D., 2014. Hygienic Fish Table Design for Fish Market in Awang Harbor, Central Lombok. National Marine Journal 9, 59–64.
Whitman, B, and all. 2009. *Refrigeration & Air Conditioning Technology 6Th*Edition. Delmar Cengage Learning: Clifton Park, USA.