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WATER CONDITIONING REFRIGERATION SYSTEM DESIGN AND CONSTRUCTION FOR LOBSTER CULTIVATION

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This research is to determine the cooling burden of the water conditioning system for lobster conditioning, where water must be conditioned to its temperature by its 21°C conditioning. This device uses steam compression systems precisely by utilizing water conditioning systems to condition water to stay awake at a temperature of 21°C. The method used in this study was to determine the volume of the water tank and its cooling capacity by calculating the cooling load calculating the heat load through the walls of the water tank and other heat generated. For lobster cultivation, an air conditioning machine with a capacity of 0.5 PK was used. Following a 3-hour test of the performance of the system, the following results were obtained: evaporation temperature of 15.2 °C and a product temperature of 21 °C obtained a Carnot COP of 7.11, an actual COP of 5.87, and an efficiency of 82.55%. This is in accordance with Design Carnot COP 8, actual COP design of 6.7, and design efficiency of 83%.

Kata kunci : Lobster, Cooling Load, COP, Efficiency, Refrigeration

1. INTRODUCTION

Freshwater lobster is a freshwater fishery commodity that has the potential to be developed as a cultivation commodity. In addition, this freshwater crayfish has a fairly high nutritional content, especially protein, and has a character that is not easily stressed and is not easily attacked by disease if the feed requirements and water quality are good. In good freshwater crayfish cultivation, the water quality is usually around 21°C to 28°C. With a degree of acidity (pH) in the range of 6–8, the maximum ammonia content in the water is 1.2 ppm, and the turbidity level is 30–40 cm [1]. In research (Hiwari 2018), it is also stated that water quality is also an important factor that must be investigated for the suitability of this lobster cultivation for the survival of the lobster to be cultivated [2]. Specifically, to maintain the quality of the water temperature between 21°C and 28°C. Research (Kurniasih 2008) states that freshwater crayfish (Cherax) habitats are shallow water flows and fresh water, such as lakes, swamps, and rivers. If the depth is less than 0.8 meters, it will cause death due to changes in temperature during the summer. The optimum growth of freshwater crayfish (Cherax) is in the temperature range of 21°C to 29°C Temperatures that are too low or too high will interfere with growth, with a tendency to immerse themselves in mud or become inactive [3]. In research (Roskiana et al. 2018), researchers conducted research on the use of a refrigeration system to cool water for hydroponic media because farmers experienced obstacles caused by the air temperature in Indonesia, which was too high so that it affected the results of hydroponic plant growth and resulted in good engine performance [4]. Therefore, this research will also utilize the air-conditioning (AC) refrigeration system for conditioning the water temperature in lobster cultivation.

Refrigeration is a process of absorbing heat in an object where each object will have a heat content whose amount depends on the temperature of the object [5]. The vapor compression refrigeration system is basically a system with an energy balance where the energy absorbed by the evaporator comes from the product discharged by the condenser through water or other cooling media in the system. This system has four main components, where each component has an important role in the running of the system. The 4 main components of the refrigeration system are the compressor, condenser, expansion, and evaporator [9].

Pressure-enthalpy diagram for a standard vapor-compression cycle

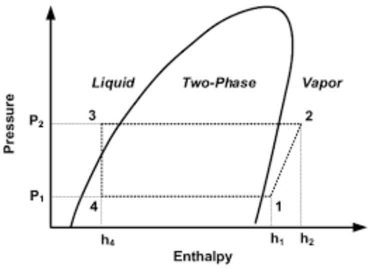

Figure 1 Vapor Compression Cycle P-h Diagram [10]

Based on Figure 1 Pressure-enthalpy diagram for a standard vapor-compression cycle, this vapor compression system also has 4 cycles where refrigerant vapor (freon) is compressed in the compressor and then condensed into a liquid in the condenser. The refrigerant liquid pressure is lowered in the expansion device (capillary pipe or expansion valve) so that the refrigerant is in liquid form and can then evaporate in the evaporator [6].

So, in this study, the air conditioning (AC) refrigeration system is no longer a food conditioning device but will be applied as a tool that will help condition water temperature in freshwater crayfish cultivation.

In this study, the authors will collect experimental data regarding system design and system performance, time, the value of COP (Coefficient of Performance), and to determine the cost of using a water conditioning system for lobster cultivation.

Thus, it is possible to determine the effectiveness of the air conditioning (AC) system in the lobster cultivation water conditioning system, as well as to determine the feasibility of system performance in terms of system performance, including the COP value, and the success of system design in lobster cultivation.

Based on research (Effendi and Setiawan 2016) entitled "Design of Refrigerated Sea Water (RSW) Dry System on 58 GT Fiber Plywood Fishing Vessel with 45 M3 Hatch Capacity" states that Refrigerated Sea Water (RSW) has several pipes that function to suck seawater to be processed into cold water and then connected to the fish storage hatch. In this study, RSW uses a capacity of 40 HP with refrigerant type R22. The results obtained from this study are that it takes 2 hours to reduce the temperature to 0°C and to reach the hold temperature of -23°C it takes 3 hours. The high pressure reaches 140 Psi while the low pressure reaches -10 Psi. and obtained a COP value of 4.5708 [7].

Based on research (Education et al., 2014), in a study entitled "Increasing COP (Coefficient of Performance) Car AC System Using Condensed Water," it states that coefficient of performance (COP) is one of the indicators in the refrigeration system that determines the work of the system. COP itself is a comparison between refrigeration capacity and compressor power. Performance (COP) can also be defined as the ratio between the refrigeration effect and the compression work required to compress the refrigerant in the compressor. Therefore, the greater the performance value (COP), the better the performance of the refrigeration system. The greater the performance value (COP), the more efficient the refrigeration machine. Factors that affect the COP value include the impact of refrigeration and changes in compression work [8].

2. METHODS

This research uses the design method. The design method was carried out to obtain design data, machine manufacture, and performance testing of the water conditioning refrigeration system for lobster cultivation. The following is a flowchart of this research, which is shown in Figure 2.

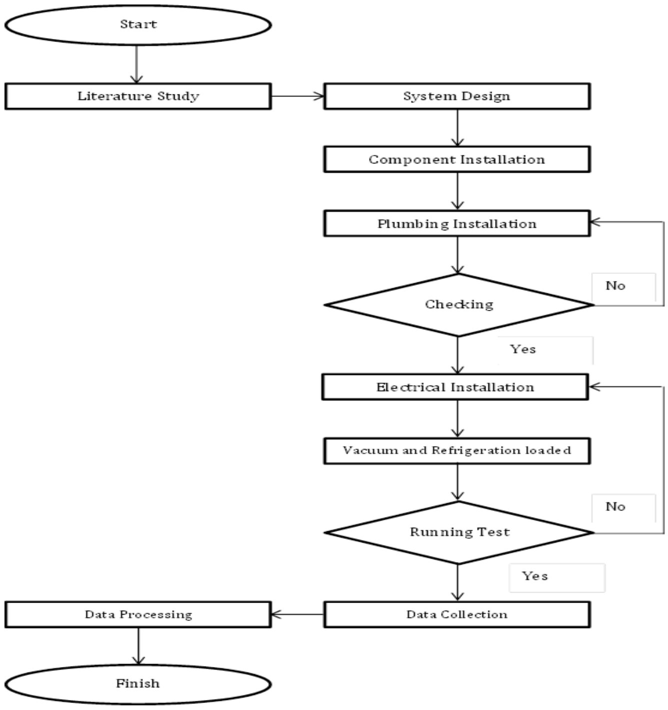

Figure 2 *Implementation Flow Chart*

The design carried out in this study started with making lobster racks with a height of 1.5 meters, a length of 83 cm, and a width of 63 cm for lobster storage of 1 package lobster/pond, then continued with the manufacture of two loser ponds made of plastic with The size is 55 cm in diameter, 87 cm in length and 27 cm in depth, so that in two ponds the number of lobsters is 20. In addition, in this study, using a compressor with a capacity of 0.5 PK and one evaporator, and adjusting the size of the evaporator to the suction pipe, the condenser used is a type of air-cooled condenser with a fan whose capacity is equal to the capacity of the compressor, while the expansion device uses a capillary tube with a length and diameter are adjusted to the compressor capacity.

Of the four components that are already available, the assembly process is carried out with the equipment and materials that have been provided to form a unit according to the design. This tool will be used for research, so it will be designed and built in such a way that it can be used as research for all of you. This unit will be designed to produce water at a temperature of 21°C, and this cooling system will use refrigerant type R32.

The calculation of the cooling load is divided into several parts, namely the calculation of the wall cooling load and the calculation of the product cooling load. Count the burden of cooling the wall, that is:

Qwall = U x A x Δt (Equation 1.1) [9].

Where:

Qwall	= Heat Load on the Wall (Watt)
U	= Heat Transfer Coefficient on The Wall (Watt/m^2. K)
A	= Room wall surface area. (m^2)
ΔT	= The difference between the ambient temperature and the room (K)

To get the value of U, obtained by the following equation,

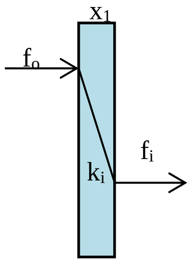

Figure 3 Cabin Material

$$U = \frac{1}{\frac{1}{f1}+\frac{x1}{k1}+\frac{1}{fo}} \quad \text{(Equation 1.2)}$$

Where:

f_o = The coefficient of convection in the environment (Watt/m^2. K)
k_1 = The thermal conductivity of the nth wall layer (Watt/m.K)
x_1 = The thickness of the nth wall layer (m)
f_1 = The coefficient of convection in space (Watt/m^{2}K)

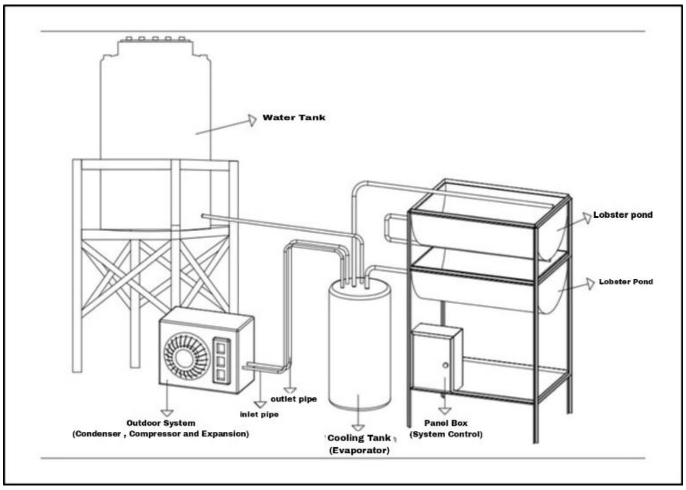

Figure 4 Lobster Cultivation Water Conditioning Device Design.

Table 1 Cooling tank wall material

Cabin Construction	Thickness (m)	Conductivity (W/m.K)	Thermal Conductance (W/m^2.K)
Inside air (f_{in})	-	-	9.37
Plastic	0.002	0.15	-
Outside air (f_{out})	-	-	22.7

By using equation 1.2,

$$U = \frac{1}{\frac{1}{f1}+\frac{x1}{k1}+\frac{1}{fo}} \quad \text{(Equation 1.2)}$$

Then the resulting wall load of 6,12 W/m^{2}K.
To calculate the heat load generated by the walls in the cabin, namely:

Q = U x A x ΔT
= 6.12 W/m^2. K x 1.25m^2 x 11 K
= 84.15 watt

3. RESULTS AND DISCUSSION

Table 2 System Performance Comparison

Variable	System Test	System Design
The Cooling Tank Temperature (°C)	21	21
Evaporation Temperature (°C)	15.2	10
Condensing Temperature (°C)	55.7	40
Discharge Pressure (bar)	36	30
Suction Pressure (bar)	13,5	11
qw (kJ/kg)	40	35
qc (kJ/kg)	275	270
qe (kJ/kg)	235	235
Rate of Refrigerant Mass Flow ṁ (kg/s)	0.0093	0.0108
Qw (kW)	0.34	0.378
Qc (kW)	2.37	2.9
Qe (kW)	2.03	2.5
COP actual	5.87	6.7
COP carnot	7.11	8
Efficiency (%)	82.55	83
Current (A)	1.2	1.7
Real Power (watt)	244.64	299.2

The results from the data above show that the design with the test results is not much different in value, so that the design of the water conditioning system for lobster cultivation can run well. From the results of electricity consumption for one month, it is more efficient than other freeze dryer designs. The results of this study can be distributed to public services because electricity consumption is very efficient and this design is very easy to use for the general public and has used very sophisticated technology to regulate water temperature conditions for lobster cultivation.

The following is a data graph of the performance of the air conditioning system for water conditioning in lobster cultivation.

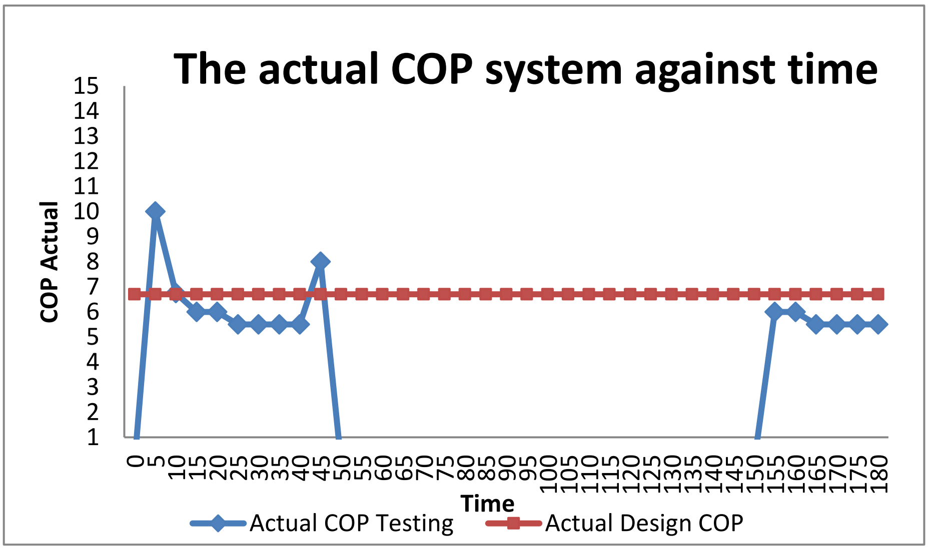

Figure 5 Actual COP of the system

Figure 5 above explains that the actual COP of the test results has an actual COP value of 5.87 while the actual COP of the design results has a value of 6.7. This happens due to the influence of the value of the refrigeration effect and compression work at the time of testing but does not have a very large difference so that the system can run properly according to the design.

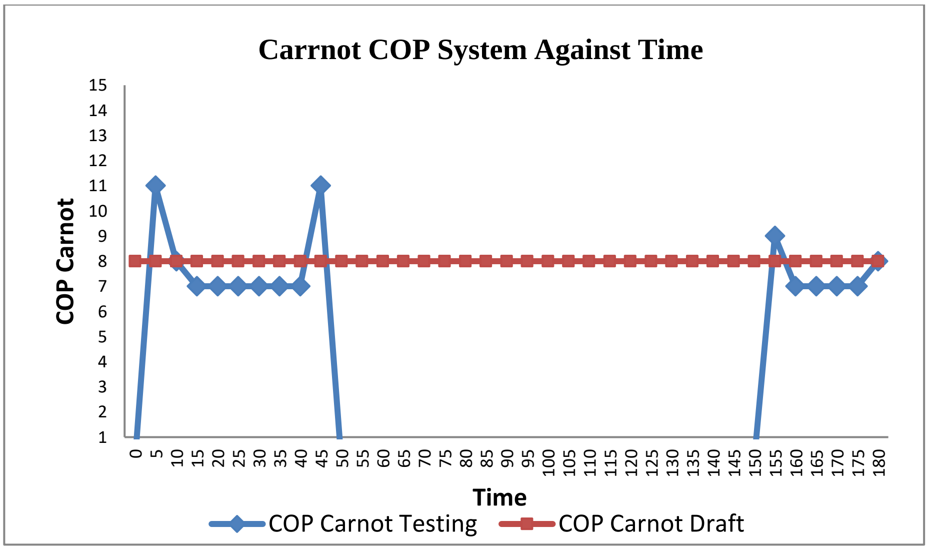

Figure 6 COP Carnot System

Figure 6 above explains that the Carnot COP from the test and design has a different COP Carnot value, namely the Carnot COP in the design is 8, while the Carnot COP from the test is 7.11. This proves that the design that has been made has a good performance value because at working temperatures, or saturation temperatures, both condensation and evaporation occur, the maximum COP that can be obtained for the system is COP Carnot. So it can be said that the larger the coefficient value, the more efficiently the system will work.

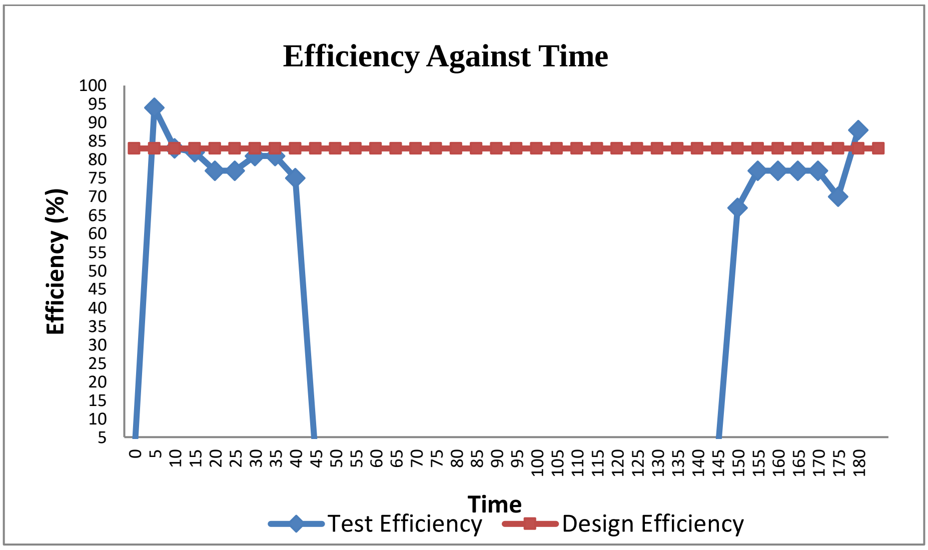

Figure 7 System Efficiency

In charts, the performance value of test systems has a smaller average of 82.55% than the design system's average of 83%. his can happen because it is influenced by several factors, ranging from ambient temperature to the mass of the refrigerant used. Based on the data in table 2, it is also shown that the refrigerant mass flow rate at the time of testing is lower than the refrigerant mass flow rate in the design, which affects the performance value of the air conditioning system for water conditioning in lobster cultivation. However, the overall performance value of this system at the time of testing did not experience a very large difference from the design performance value, so that the system continued to run well.

4. CONCLUSION

After all the processes are completed, starting from the design, the system installation process, the testing process, and the data retrieval process, So it can be concluded:

1. System cooling load or cooling load based on calculation results of 381.7 watts: in this system, the compressor we use is 0.5 PK.
2. The engine cooling time can be said to be successful because when the temperature reaches 21°C after 45 minute, and within 3 hours, the system can reach 21°C twice, while the design data takes 3 hours, or 180 minutes. So it can be said that this system works well because it experiments with the time it takes to cool the water faster than the time to cool the water in the design.
3. The performance of the water conditioning system in lobster cultivation resulted in the actual COP value at the time of testing at 5.87 and the actual COP at the design being 6.7. The Carnot COP value at the time of testing obtained a value of 7.11 and the Carnot COP in the design of 8. While the efficiency value at the time of testing was obtained, the average value was 82.55%, and the design efficiency was 83%. So it can be said that this cooling system works well because the efficiency values at the time of the experiment and the efficiency values of the design do not have a significant difference in average values.
4. From the results of testing tools, it can be concluded that the application of the refrigeration system for conditioning lobster culture water is feasible to use because the system that works on it has good performance.

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