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# Slurry Ice Machine Design Production Capacity of 1.3 Tons

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**Abstract**

Handling of fresh fish after harvest, in fish landing sites and fish processing units still uses conventional methods, so there are still many shortcomings and weaknesses that have an impact on the quality of the fish that is stored. The purpose of this study is to produce a slurry ice machine design with an evaporator temperature reaching -5°C, a production capacity of 1.3 tons according to the standard and put forward an ergonomic, safety factor as well. The results showed that the target temperature of the slurry ice machine evaporator reached -5°C was reached, with a temperature achievement of -5.8°C without using sea water reservoirs. Slurry ice production in one hour is 58.2 kg, without using water/salt reservoirs. The total slurry ice production without using sea water/salt water reservoirs, for 24 hours as many as 1,396.8 kg is converted to tons which is 1,3968 tons. Slurry ice production uses seawater/salt reservoirs, reaching an average temperature of -2.5°C. Slurry ice production in one hour is 123.6 kg, Total slurry ice production uses seawater/salt water reservoirs, for 24 hours is 2,966.4 kg converted to tons of 2.96 tons. Making this slurry ice machine with a capacity of 1.3 tons, takes approximately 45 days with the number of people making 4 people.

**Keywords :** Design, Slurry ice production, Enthalpy

## 1. INTRODUCTION

Handling of fresh fish after harvest, at the fish landing area and in the fish processing unit is still using conventional methods, namely using ice blocks that have been crushed into pieces of ice. This method still has some weaknesses, such as the length of time for fish to cool down to 0°C and in addition, the ice chips that are formed will hurt the fish, causing a decrease in fish quality faster, [6]. Besides that, the impact of the increase in the basic electricity tariff also caused the price of ice cubes to increase. Thus reducing the margin of fishing fishermen who use ice cubes as the main raw material for preserving fish they catch.

Slurry ice is the best solution, for slurry ice performance is better than ice blocks to maintain the quality of fish. Slurry ice is ice consisting of water mixed with ice crystals, slurry ice is produced by mixing water with freezing point suppressing additives, then the mixture is cooled so ice crystals are formed. Additives used to suppress freezing generally are salt, sugar, glycol and alcohol. The most commonly used additive is salt. There is a lot of salt in sea water, the raw material is very abundant and very cheap compared to fresh water which is used as the main raw material for making ice blocks. Sea water is also not disturbed by the dry season as in fresh water, when the dry season is very difficult to find and the price is also much more expensive.

In slurry ice as a fish cooler there is no air between the fish and ice, so that the cooling of the fish becomes faster because of direct contact with the surface and cavities in the fish is larger and slower bacterial growth makes an extension of the freshness of the fish. Another advantage of the slurry ice cooler is the fish's cooling time is three times faster than ice cubes to reduce the temperature to -2°C. Sea water is the basic ingredient of ice slurry which is very good for maintaining fish endurance because it contains the element chlorine (Cl), which can kill bacteria that cause spoilage [1]. In tropical countries with high environmental temperatures, the growth of microorganisms and deteriorating fish occurs very quickly [3]. The use of slurry ice increases the quality of microbiology and chemistry and reduces post-harvest losses [5]. The faster the lower temperature is reached during cold fish, the more effective decay activity is inhibited [8]. Market demand wants products that are maintained freshness and quality, is one of the challenges of the fishing business. To answer this market demand, slurry ice is a promising technique for keeping products at temperatures below freezing [2] [4]. The advantages of using slurry ice include lower temperatures, faster cooling, lower physical damage to the product and better heat exchange power. Direct contact with slurry ice with the surface of the fish provides better protection from oxidation and dehydration events [7].

## 2. METHOD

The study was conducted at the Jakarta Fisheries University Engineering Workshop, the time given to conduct the research was 2.5 months. Data taken by quantitative data types, aims to calculate (COP), refrigerant capacity (Q), refrigeration effects, refrigerant flow rate, volume flow rate, compressor work (WComp), heat released by the condenser and heat absorbed by the refrigerant in the evaporator. The calculation uses data from measurements of the condenser temperature, compressor pressure. Sources of data collection are taken from secondary data, namely literature studies (journals) related to previous research. While the primary data is taken from the engine performance test data in the slurry ice maker.

**Tools and Materials**

The equipment and materials needed during the design and manufacture of the slurry ice machine are as follows.

**Table 1.** Tools and materials

| No | Tools and materials |
|---|---|
| 1 | Large cutting burrs |
| 2 | Electric welding machine |
| 3 | Bending plate |
| 4 | Frais machine |
| 5 | Lathe |
| 6 | Gas welding |
| 7 | Flaring swaging |
| 8 | Tubing Cutter |
| 9 | Hand drill |
| 10 | Hand grinding |
| 11 | Gauge manifold |
| 12 | Vacuum pump |
| 13 | Divider valve 12 holes |
| 14 | Refrigeration Copper Pipe |
| 15 | Stainless steel 304 and stainless steel plate 316 |
| 16 | Polyurethane |
| 17 | Pulley |
| 18 | Refrigerant |

**Analysis Method**

The system designed must get a size that is in accordance with the components that will be used so that the design created can produce output in accordance with the wishes and does not require a lot of experiments, then at this stage will be calculated as a basis/reference for the selection of system components.

A. Calculate product mass in kg:

$$m = \rho.V$$

ρ sea water : 1.03 x $10^3$ kg/$m^3$

m : 56.52 liter

V : 58.2 kg (product mass)

B. Calculate Cooling Loads

1. Decrease in product temperature from initial temperature to freezing temperature. (cooling), is 6,680 kJ

$$Q1 = m\ (T1 - Tb)\ Cp$$

2. Freezing of the product at the freezing temperature is 141,420 kJ with the equation

$$Q2 = m\ x\ hif$$

3. Decrease in product temperature (sea water) from freezing temperature to harvest temperature (becoming slurry ice) is 787,026 kJ the equation is:

$$Q3 = m\ (Tb - T2)\ Cp$$

4. So the total removal of the sum of the product (seawater) heat load (Qtot) can be calculated by the equation:

$$Qtot = Q1 + Q2 + Q3$$

The removal of Qtot heat is 10,823 kW

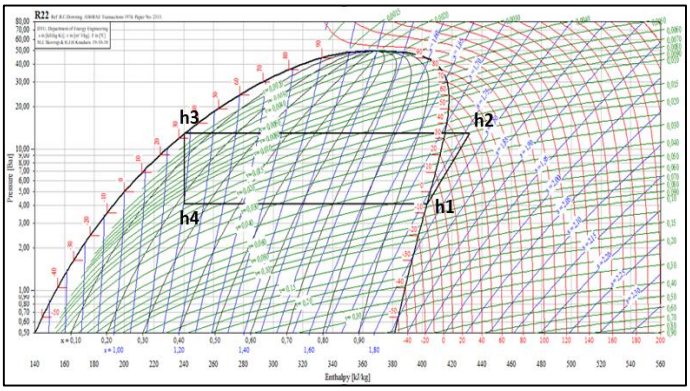


**Figure 1.** Diagram enthalpy

From Figure 1 it is obtained :

T evaporator : -5°C

T condenser : 40°C

P evaporator : 4.277 Bar

P condenser : 15.296 Bar

h1 : 404.06 kJ/kg

h2 : 435.25 kJ/kg

h3 : 249.50 kJ/kg

h4 : 249.50 kJ/kg

Calculate the effects of refrigeration:

The refrigeration effect can be obtained from the enthalpy difference: 154.56 kJ

Calculate Refrigerant Flow:

The refrigerant mass flow rate is: 0.07 kg/s

## 3. RESULTS AND DISCUSSION

**Design Specifications**

As a limitation of the slurry ice machine design in producing slurry ice, the design is determined as follows:

A. Production Capacity

Evaporator Dimension :

High : 80 cm

Inside Diameter : 30 cm

Is known : 1 liter = 100 mili liter = 1000 $cm^3$

Calculate Volume :

$V = {}^{1}/_{4}\ x\ \pi d^2\ x\ t$

$V = {}^{1}/_{4}\ x\ {}^{22}/_{7}\ x\ 30^2\ x\ 80$

$V = 56520$

$V = {}^{56520}/_{1000\ cm^3}$

$V = 56.52\ liter$

Calculate product mass in kg:

$m = \rho . V$

$m = 1.03\ x\ 10^3\ kg/m^3\ .\ 56.52\ liter$

$m = \frac{1030\ kg/m^3}{1000\ liter}\ x\ 56.52\ liter$

$m = 1.03\ kg\ x\ 56.52$

$m = 58.2\ kg$

Production target in 24 hours :

$= 58.2\ kg\ x\ 24$

$= 1396.8\ kg$

$= \mathbf{1.3\ ton\ (in\ 24\ hours)}$

B. Dimensions of the slurry ice machine :

Length : 160 cm

Width : 90 cm

High : 110 cm

C. Slurry ice cooling system :

Ambient temperature : 32°C

Types of products : slurry ice

Slurry ice raw material : sea/salt water

Salinity of sea water : 30 ppt

Initial sea water temperature/salt water : 27.8°C

Temperature to be achieved : -5°C

Evaporator loading capacity : 56.52 liter

Refrigerant used : R22

**Design Results**

The results of the design are set forth in the application in the form of 3D images in the 4D Cinema program, as follows:

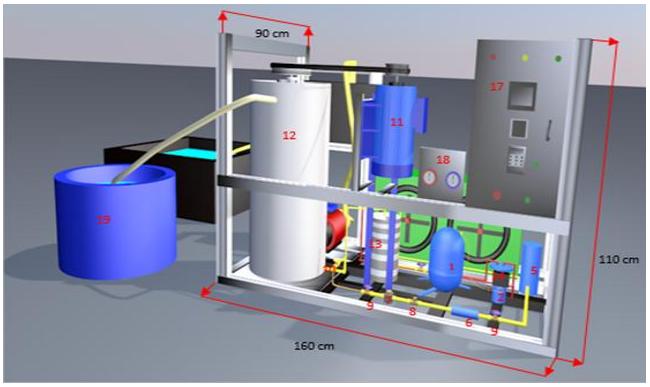


**Figure 2.** Front look

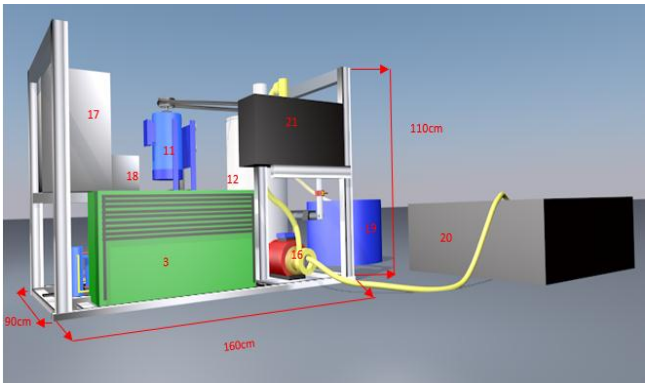


**Figure 3.** Back view

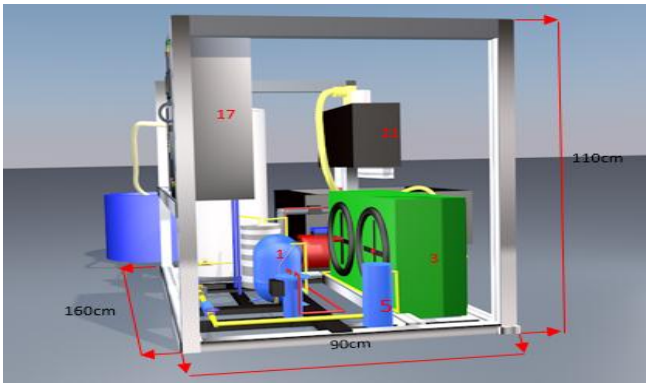


**Figure 4.** Right-side view

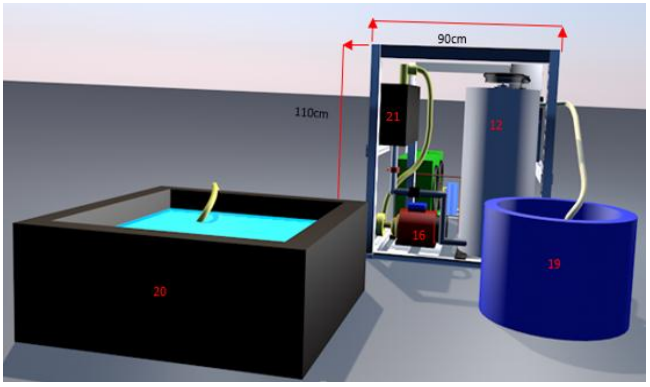


**Figure 5.** Left side view

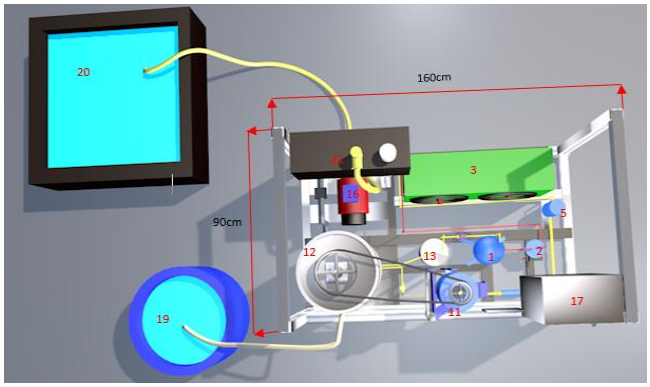


**Figure 6.** Top view

**Table 2.** Infomation Figure

| No | Information | No | Information |
|---|---|---|---|
| 1 | Compressor | 12 | SIG |
| 2 | Oil Separator | 13 | Suction Accumulator |
| 3 | Check Valve | 14 | Pressostat |
| 4 | Air Condenser | 15 | Solenoid Valve |
| 5 | Receiver | 16 | Pump |
| 6 | Filter and Drayer | 17 | Electrical Panel Box |
| 7 | Solenoid Valve | 18 | Manometer HP & LP |
| 8 | Side Glass | 19 | Storage Tank |
| 9 | Valve | 20 | Seawater Tank |
| 10 | Expansion Valve | 21 | Sea Water Reservoir |
| 11 | Electric Motor | | |

## 4. CONCLUSION

In accordance with the first objective which is to produce a slurry ice engine design with an evaporator temperature reaching -5°C, a production capacity of 1.3 tons according to the standard and put forward an ergonomic, safety factor as well. The target temperature of the slurry ice machine evaporator reaches -5°C is reached, with a temperature achievement of -5.8°C without using sea water reservoirs. Slurry ice production in one hour is 58.2 kg, without using water/salt reservoirs. The total slurry ice production without using sea water/salt water reservoirs, for 24 hours as many as 1,396.8 kg is converted to tons which is 1.3968 tons.

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