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Chilling System Insulation Hatch Design Using Refrigeration For 3GT Sized Vessels

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Abstract*— *A fast cooling process is needed to maintain the quality of the fish caught. In this research, the chilling system insulated hatch using refrigerant with a capacity of 80-100 kg for a 3 GT sized vessels. The insulation hatch is bolted from fiber material where the walls are cast with polyurethane material. Polyurethane consists of 2 (two) types, namely A and B, where when the two materials are mixed it will expand and form insulation. This hatch making research uses a trial and learn system. To be able to draw heat from the cooling room, the evaporator with a coil length of 30 meters is specially designed, that is, it is wrapped around the shape of the hatch and attached to the aluminum plate. The length of the capillary pipe used is 3.00 cm with a diameter of 0.26 to produce a load temperature of 2^0C - 4.4^0C. The test of the chilling system insulation using refrigerant was carried out at the cooling workshop SUPM Waiheru Ambon. The test materials used were sea water as much as 84 kg / L and whole tuna fish with a size of 28 kilograms. The design of this chilling hatch uses a 1/3 HP hermatic compressor with the factory standard Freon R134a. The condenser used is a copper tube type 19U aluminum fin. Based on the test results, the cooling component works well.

I. INTRODUCTION

Seafood products are high perusable food which is more prone to spoilage. The high content of osmoregulatory in the form of nitrogen protein makes fishery products very susceptible to bacterial growth. In addition, the average habitat for fishery products is in cold water temperatures, so that bacterial flora will be very difficult to inhibit compared to animal and plant flora using cold temperature treatment. This condition has an impact on the decreasing selling value of fish received by fishermen.

The system of storing fish into the hold, especially on traditional fishing vessels, often does not pay attention to the value of the Stowage Rate or storage level according to good quality standards of cargo. Due to this kind of action, it can reduce the quality of the fish. (Amiruddin at.al 2013)[1]. Insulated hatches can be a solution to fish quality problems. An insulated cooler box can be used to preserve fish using low temperatures (Susanti, M. T et.al 2008)[2].

One alternative effort to increase fish handling on ships is the application of a refrigeration system on board to increase the storage capacity of fish caught by fishermen (Ahmad Fauzi, 2017)[3]. The chilling system or cooling seawater in the cooling process of fishery products has several advantages such as relatively small physical damage to fish, temperatures that can drop quickly, and being stable and evenly distributed (Ahmat Fauzi, at.al 2018)[4].

The process of absorbing heat from an airtight-closed room and then moving the heat out of the room is called the refrigeration principle. This refrigeration principle will work in a system called a cooling engine. The refrigeration system of this cooling machine is developing very rapidly. According to Dossat (1961)[5] apart from being a support as well as for the production process and as a requirement for Air Conditioning (AC), a cooling machine can also function as a refrigerator, freezer or chiller.

The results of the research conducted (Rifki Efendi et.al, SINTEK) that the impact of refrigeration is divided by the compression work, the COP value is 4.5708. Untung B, et.al (2013)[6] tested using R22 on the design of the Sea Water Refrigerant system, the COP value was 4.5708 within 30 minutes. Refrigerant will absorb heat at lower temperature and pressure and release it at higher temperature and pressure (Wang, 2005)[7].

Research on the design of the chilling system insulation hatch using refrigerant aims to determine the effect of cooling load on the work of the cooling system. The performance of this cooling system includes refrigeration capacity, compressed power, Coofisient of Performance (COP) and the time required for cooling in the cold room. This research is expected that the chilling system insulation hatch can work properly and efficiently.

II. RESEARCH METHODS

There are two methods used in this research, namely: (a). comparative method, where the theoretical comparisons are made and the realities in the field, (b). The trial and learn method is that after the tool is made or assembled, then calculations are carried out to ensure the design results are appropriate or not. From the Trial and Learn results, the desired hatch design results will be obtained.

The tools and materials used in the manufacture of chilling hatches are fiber and mat, resin, catalyst, 5 x 3 wood, dye, polyurethane, nails, plywood, grinder, saws. Meanwhile, the tools and materials for the cooling component are 1/3 HP hermatic compressor, 19U aluminum fin copper tube condenser, Ø 0.26 capillary tube, astn pipe ¼ x 0.55 in x 15 m for evaporator, filter dryer, 0.5 aluminum plate. mm, pipe bender (tube bedding spring), pipe widen (swaging and flaring), pipe cutter (tubbing cutter), welding tool, toolkit, vacuum pump, measuring tool, freon 134a, manifold, brass welding wire, cable, MCB 10A, thermostate control and temperature measuring instrument

Insulation Hatch Design

Based on preliminary field data, the box or sterofoam box measuring 120 x 40 x 32 with ice cubes is still the main choice for traditional tuna fishermen. The weakness of using this sterofoam box is that fishermen cannot regulate the temperature so that before arriving at the auction site, the quality has deteriorated. The tools and materials for making the insulation hold consist of fiber mat, resin, catalyst, dye, 3 mm multiples, wood glue, saw, drill, hammer, pliers. As for the insulation using polyurethane material.

Polyurethane is usually used in various forms. Apart from being a coating, polyurethane is also used as an adhesive because it has fiber and foam and is easily formed in a variety of components (Kim S. H et.al 2010)[8].

This research, an insulation hatch will be made using polyurethane as the insulation material. As for the size of the manufacture of this insulation hatch, namely :

Table 1. Size of the hatch

Dimension	Size
Long	100 cm
Wide	100 cm
High	80 cm
Cavity thickness	10 cm
Hatch capacity	0,384 cm^3

Table 2. Size the insulation Space

Dimension	Size
Inner length	80 cm
Outer length	100 cm
Inner width	80 cm
Outherwidtg	100 cm
Inner height	60 cm
Outher height	80 cm
Insulation thickness	10 cm

Table 3. Ukuran ruang pendingin

Dimension	Size
Long	80 cm
Wide	80 cm
High	60 cm

Hatch Assembly Proses

a. Coating or laminating the fiber glass layer after the gel coat has dried on the mold
b. Remove the hatch from the mold when it dries
c. Place the aluminum plate in the middle of the box according to the specified size, and make sure it is in the center position before casting using polyurethane

d. check gradually on the results of work if there are defects

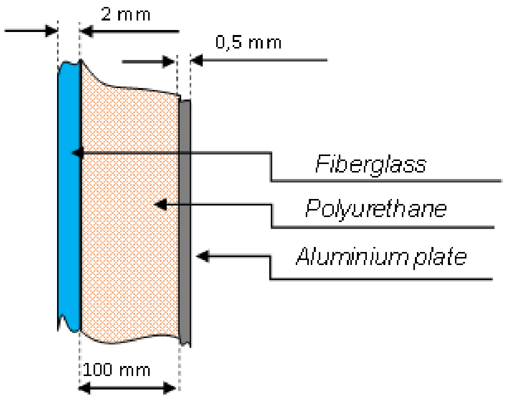

Fig. 1: Hatch material

heat load on the hold use formula :

$$Q = U \cdot A \cdot \Delta T \tag{1}$$

By :

Q : load wall (watt)

U : Overall heat transfer coefficient

A : Difference temperature through the walls (^{0}C)

ΔT : Outer wall area in m^2

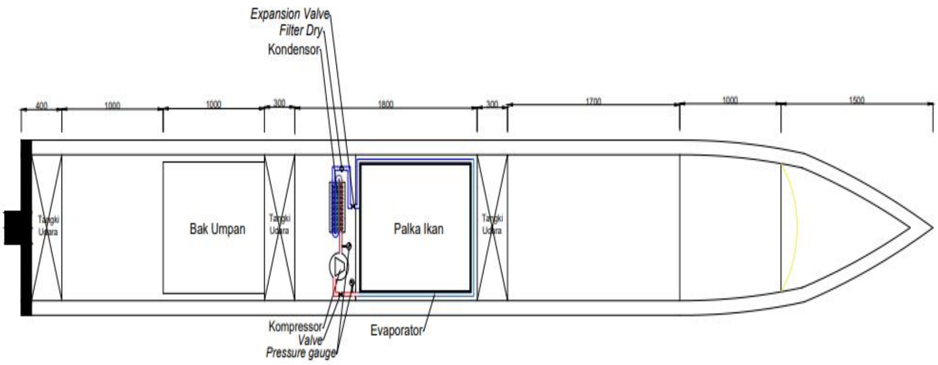

Fig. 2. Placement of insulating hatches and cooling component on vessels

To calculate load product, use formula :

$$Q_p = \frac{m \cdot cp \cdot \Delta t}{long\ cooling\ time} \tag{2}$$

Q_p : load cool of product

m : mass (kg)

cp : specific heat of material (kJ/kg)

ΔT : range of temperature (^{0}C)

To find the overall heat coefficient, use formula :

$$U = \frac{1}{\frac{1}{f1} + \frac{X1}{K1} + \frac{X2}{K2} + \frac{X3}{K3} + \frac{1}{f0}} \tag{3}$$

$1/f_0$ = 22,7 W (m^2K)

$1/f_1$ = 0,56 W (m^2K)

U = 0,16 W (m^2K)

Total heat load through the wall is 19,3 Watt

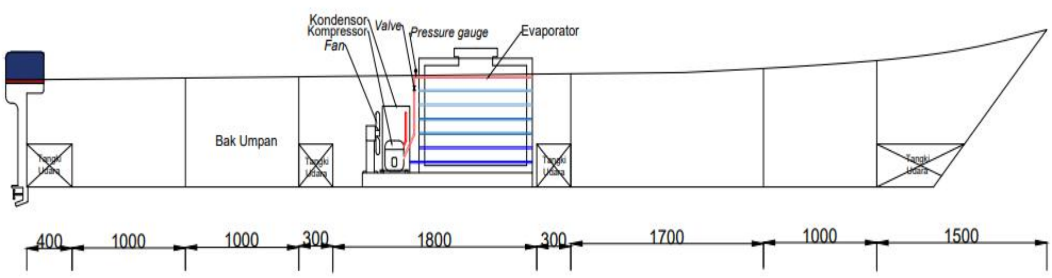

Fig. 3. Position of the hatch on the side view head

Refrigeration System

A. **Working principle of the chilling system insulation hatch**

The working principle of a cooling engine is basically the same as other cooling systems such as refrigerators, air conditioners, Frezzers, which draw heat on objects to reach the desired low temperature. The working principle of the chilling system insulation hatch is that the refrigerant is flowed to the evaporator through a capillary tube which functions to convert high pressure liquid refrigerant into low pressure liquid refrigerant by injecting it through a small hole.

Furthermore, the liquid refrigerant into the evaporator and take the heat out of saltwater, fish or air so refrigrant liquid turns into a gas. After the refrigerant has changed in the form of gas-temperature and low-pressure compressor and mengkompresikannya on to become refrigrant-temperature and high-pressure gas is then entered into a condenser and then refrigerant gas is converted into liquid, with water or air.

Refrigerated sea water in the hold space. The seawater used must be clean, which is not contaminated by toxic materials that can cause toxicity to humans. Sea water is cooled in the hold before the fish are put into the hold. The fish that have been caught are then put into the hold with the ratio of sea water to fish is 3: 1.

In this process, if the sea water mixed with fish becomes dirty, the sea water in the hold can be removed and replaced gradually with new sea water. And so on in order to maintain water quality which has an impact on the freshness of the fish itself.

B. **Cooling System Component**

Several cooling system components are used in the insulation hatch of the chilling system, among other :

- Compressor 1/3 HP,
- Aluminum fin condenser 19U,
- ASTN pipe 1/4 x 0.55 x 15,
- Capillary tube
- Filter

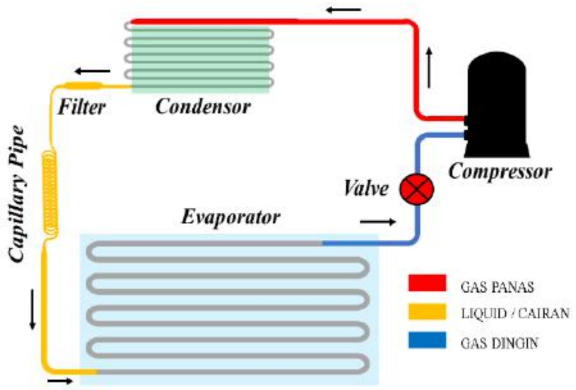

Fig. 4: Cooling system scheme

C. Basic Calculate of Compressor, Condensor and Evaporaor

- Compressor

The compression process occurs in the compressor where the refrigerant phase that enters the compressor is saturated vapor with low temperature and pressure. To calculated compression work, use formula :

$$Wk = h1 - h2 \quad (4)$$

By :

Wk : compression work (kJ/kg)

h1 : enthalpy refrigerant enters the compressor (kJ/kg)

h2 : entalphy refrigerant out of compressor (kJ/kg)

- Condenser

This process occurs in the condenser, where the refrigerant temperature is higher than ambient temperature, the heat of refrigerant Anas will be released through the condenser pipe wall to the surrounding environment. Condenser disposed heat calculated, use formula :

$$Qc = h2 - h3 \quad (5)$$

By :

Qc : Heat disposed condenser (kJ/kg)

h2 : entalphy refrigerant enter the condenser (kJ/kg)

h3 : entalphy refrigerant out of condenser

- Kapiler

This process occurs in the capillary tube, where after the refrigerant releases heat in the condenser, the liquid refrigerant will flow into the capillary tube to lower its pressure and temperature. The temperature that occurs is expected to be lower so that heat can be absorbed while in the evaporator. Because there is a process of receiving and releasing energy, the entaphy value becomes constant.

h3 = h4

- Evaporator

Process takes place in the evaporator, where the temperature of the refrigerant in the evaporator is made lower than the refrigeration room, so that the evaporation process takes heat. Heat absorbed by the evaporator is calculated use formula :

$$Q_e = h1 - h4 \quad (6)$$

By :

Qe : heat absorbed by the evaporator (kJ/kg)

h1 : entalphy refrigerant out of evaporator (kJ/kg)

h4 : entalphy refrigerant enter enterthe condenser (kJ/kg)

III. RESULT AND DISCUSSION

By using the coolpack application, the enthalpy point and pressure are determined on the p-h diagram, see *Fig. 5.*

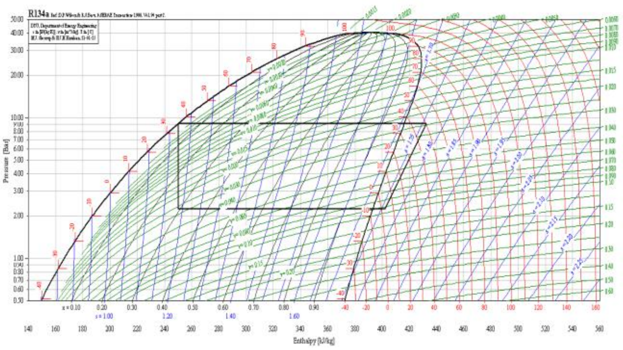

Fig. 5. P-h diagram

Enthalpy value obtained through the calculation is as follows, see *Table 4.*.

Table 4. Table of result entalphy

Point	T (^{0}C)	P (Bar)	v (m^{-3}/kg)	h (kJ/kg)	s (kJ/kg^{0}K)
1	2,800	2,238	0,093724	401,835	1,7590
2	51,354	9,371	0,023723	433,026	1,7590
3	51,354	9,371	0,023723	251,697	1,7590
4	37,00	9,371	N/A	251,697	N/A

The highest enthalpy value in the table above (h1) is 401,835 kJ/kg.

Coofisien of Performance

Calculate the value coofisien of performance used formula :

$$COP = \frac{h1-h4}{h2-h1} \; or \; \frac{Qe}{Wk} \quad (7)$$

Result of COP calculation is 4,81

Machine work efficiency

Value of the work efficiency of the machine is 80%

IV. CONCLUSION

The test results were carried out on the work of the refrigerant mass unit compressor (W) was 31.192 kJ / kg, the heat released by the condenser (Qc) was 181.329 kJ / kg and the heat that could be absorbed by the evaporator (Qe) was 150.138 kJ / kg. The COP value in the chilling system insulation hatch design using refrigerant after testing is 4.18, meaning that the COP value is included in the SNI COP Limits.

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