Cooling System Design for Cold Storage of Traditional Fishing Boat Using Insulation from Rice Husk

Muhammad Abidin[1], Alam Baheramsyah[2], Ede Mehta Wardhana[3]

Abstract- Quality of fish is an important factor and determines the high selling price of fish in the market. In achieving that it will require proper handling in the process of cooling the fish before it is sold. To keep the freshness of the fish, fishermen usually use Styrofoam-based coolbox as its isolation. In this study modify coolbox using rice husk which serves as insulation on coolbox. This study aims to determine the effect of insulation using rice husk over time and temperature which will be compared with Styrofoam coolbox. Before the experiment, the first thing to do is to test the composition of rice husk with white cement. What is the best composition to be used as insulation on coolbox? The tests are thermal conductivity, density, and flexural strength tests. From the test results obtained the best composition of rice husk and white cement is 1: 1 which has a thermal conductivity (0.746 W / mK) and density (0.32 gr / cm3) better than other compositions. In the experiments performed using 3 kg of wet ice, it was found that in 24 hours cooling time, the rice husk coolbox had the lowest temperature of 13.5 ° C and the lowest Styrofoam coolbox temperature was 10.6 ° C.

Keywords: Insulation technology, Coolbox, and Fish Refrigeration

I. INTRODUCTION

Fish has a high source of protein and nutrients that are being needed by everyone. The sea fish is captured by fishermen who are then kept in the boatload space for days until the ship docks on the ground. The high protein in fish makes the fish will be quick to experience decay, not immediately wake up then the fish will experience rotting for 6-7 hours after containment of fish. This happens because of the conditions in the storage space of the fish. The situation in the fish load space very influences the quality of fish and the impact to fishermen from fishermen because only good quality fish that have high prices and fish that have low quality has a low price but not denied also if the state of fish that has rotten then the fish will also be removed

In general, the way that fishermen deal with this problem is with the cooling system. The medium used by fishermen in this way is to use wet ice or commonly known as ice beams. However, cooling using this medium is not very effective where wet ice has a weight that can reduce the fish load on the vessel and wet ice is also rapidly melting. In addition to using wet ice as a cooling, fishermen also add salt to wet ice and fish to preserve fish longer but this way can also change the taste of the fish that has been caught becomes saltier.

Another way that can be used is to combine ice wet with dry ice. The use of a mixture of dry ice and wet ice can sustain cold for 52 hours and within 2 hours to reach the lowest temperature of -2^{O}C with a 95 kg fish load.

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The dried ice here serves as a cooling system in the boat's fishing boats where the dry ice will also cool the wet ice that cools the fish. Dry ice has a temperature lower than wet ice that is -78.5 ° C (-109.3 ° F) at atmospheric pressure [1]. The use of insulation in fish storage boxes can maintain cold for 75 hours with the best temperature of -2ºC - 5ºC where the results of this study are better than previous research. The insulation used herein is the use of Insulation using Freon [3]. So from the results of his research can be said that with the insulation with Freon affect the time and temperature of cooling.

Innovation that can be done by the researcher is by utilization of insulation using rice husk. Currently, rice husks are still not utilized optimally by the community. Rice husk has the ability as a heat insulator one of them is as ice preservation of the environment so that the heat from the environment does not enter into the ice, which can make the ice quickly melt [4]. So it is expected that with the addition of this insulation on the cooling system can increase the cooling time in the room fit.

Research on this thesis aims to design a prototype cooling system by adding insulation using rice husks in the fishing boat space. The use of this insulation is expected to keep the temperature cool so that the fish will have good quality and have a high selling value.

II. METHODOLOGY

Before the manufacture of coolbox, the authors did some tests on the insulation of rice husks. Some of the tests carried out on rice husk insulation are thermal conductivity, density, and strength (Bending Strength Test).

A. Preparation of Specimens

The collected rice husk particles will be mixed with water and white cement with the composition of the rice husk: white cement: water is 1: 1: 2.5, 1: 2: 2.5, 1: 3: 2.5

and 1: 4: 2.5. Which is made on each test is different, for testing the density has a size of 5cm x 5cm x 1.5cm for thermal conductivity testing made with 5cm height and 4cm diameter and for bending test have a specimen size of 20cm x 5cm x 1cm.

B. Specimen TestingDensity Test

Mass type is the mass measurement of each unit volume of objects. The higher the mass of the type of an object, the greater the mass of each volume. The average mass of each object is the total mass divided by its total volume. An object with a higher density (eg iron) will have a lower volume than the same mass having a lower density (eg water). After getting the result of weighing it will be calculated based on the following formula:

$$\rho = \frac{m}{V}$$

Dimana:
P = Density (gr/cm^3)
m = Mass (gr)
V = Volume (cm^3)

Weighing of finished specimens using analog scales. After getting the result it will be calculated based on the above formula.

1. Thermal Conductivity Test

The thermal properties of the composites using the ASTM E 1225-13 standard, this test method describes the steady technique to find the value of thermal conductivity. The thermal conductivity test is performed by placing specimens between hot and cold copper metal bars. Then the thermocouple probe is mounted on every hot metal part, specimen and cold metal. After the thermocouple is mounted on the conduction test equipment, close the insulator assembly.

Thermal conductivity (k) is an intensive quantity of material which indicates its ability to conduct heat. Thermal conduction is a transport phenomenon where temperature differences cause the transfer of thermal energy from one hot body region to the same region at a lower temperature. A good thermal conductivity value is between 0.034 - 0.21 W / mK [4]. The scheme of the testing process can be seen in Figure 1.

According to ASTM E 1225-13 calculate the heat rate in the reference material as follows:

- On top meter reference material (top bar) :

$$q'_T = \lambda_M . \frac{T_2 - T_1}{Z_2 - Z_1}$$

- On the bottom meter reference material (bottom bar):

$$q'_B = \lambda_M . \frac{T_6 - T_5}{Z_6 - Z_5}$$

- Based on the above two equations, to calculate the thermal conductivity value of the specimen using the following formula:

$$\lambda'_S = \frac{(q'_T + q'_B)(Z_4 - Z_3)}{2\,(T_4 - T_3)}$$

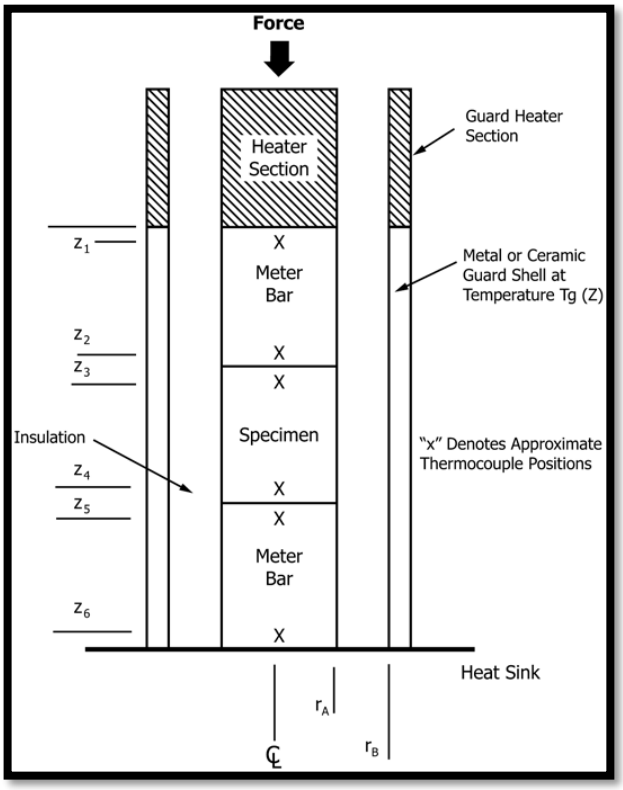

Figure 1 Scheme of Specimen Testing

2. Bending Strength Test

The tests were conducted using the standard JIS A 5908 (2003). The test specimens are 5 cm x 20 cm x 1 cm in dry air condition which is spread with the buffer 15 times the nominal thickness but not less than 15 cm and then the loading is done in the middle of the jark buffer. In this test, loading until the state is broken with a loading speed of 10 mm/min. Bending Strength Test Value can be calculated by the formula:

$$\textit{Bending Strength Test}\ (\text{N/mm}^2) = \frac{3PL}{2bt^2}$$

Where,
P : Maximum Load (N)
L : Span (mm)
b : width of Specimen (mm)
t : Thicness of Specimen (mm)

C. Coolbox

Coolbox made with size 34cm x 24cm x 27cm with a thickness of 2 cm adjust to the size of Styrofoam coolbox sold in the market and coated with plywood and fiberglass on the inside and outside. The composition of rice husk and white cement selected is by the best composition chosen after doing some testing. On the inside will be filled with wet ice of 3 kg and measured for 24 hours. This test to determine the ability of isolation in maintaining the temperature inside the coolbox against time. Then the second coolbox rice husk will be compared with Styrofoam coolbox.

III. RESULTS AND DISCUSSION

A. Specimen

After doing some testing above then the next step is making Coolbox. In the manufacture of coolbox should be based on the above test results. From table 1 it can be seen that good composition used as isolation in coolbox is in composition 1: 1. In a 1: 1 composition having a low thermal conductivity value that is good as an insulation with a value of 0.746 W / mK also has an advantage in low density. However, the comparison of 1: 1 composition has a weakness in the low flexural load value. The flexible load generated from the test shows different values on each specimen. The highest bending load value is obtained by a 1: 4 specimen with an average of 3 N / mm2. The addition of white cement affects the value of its thermal conductivity, where the more white cement is added the thermal conductivity gets worse but the higher the strength. Therefore, the most important thing in the selection of insulation on the coolant is the thermal conductivity value so that the composition taken is with a good thermal conductivity value. To anticipate the low power it will be given additional strength from plywood used as a wall on this coolbox.

Table 1. Test Results

Composition (Rice Husk: Cement)	Test		
	Density (gr/cm3)	Thermal Conductivity (W/mK)	Bending Strenght Test (N/mm²)
1 : 1	0.32	0.746	0.21
1 : 2	0.667	0.802	1.56
1 : 3	0.8	1.113	2.91
1 : 4	1.013	1.157	3.00

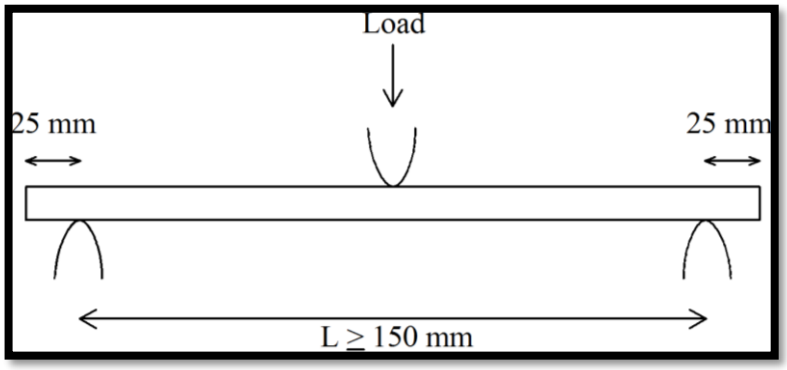

Figure 2 Testing Bending Strength Test

B. Coolbox

Coolbox insulated rice husk and Styrofoam coolbox filled with 3 kg each wet ice. In the measurement and observation for 24 hours with the average room temperature is 29 ° C. After the results obtained from both experiments it will do a comparison of data obtained from experiments coolbox rice husk and coolbox Styrofoam. So it can be analyzed the effect of rice husk insulation on time and cooling temperature will also be known better coolbox using rice husk insulation or Styrofoam coolbox.

From the graph in figure 4 it can be analyzed that in experiments using Styrofoam coolbox and wet ice as a cooling medium of 3 kg, with a cooling time of 1440 minutes (24 hours) the lowest resulting temperature was 10.6 ° C at 70 minutes 1hour 10 minutes). The highest temperature produced in the coolbox was 19 ° C at 1440 min (24h).

In the experiment using rice husk as insulation on coolbox with cooling media in the form of wet ice as much as 3 kg, in cooling time for 24 hours produced the lowest temperature 13,5 ° C at minute 70 (1 hour 10 minute) which is higher than experiment Using Styrofoam. The temperature stability inside the coolbox occurs at 350 minutes (5 hours 50 minutes) to 970 minutes (16 hours 10 minutes) ranging from 21.1 ° C. From both experiments we have seen that experiments using insulation from rice husks are no better than experiments using the Styrofoam coolbox.

As we know beforehand that the smaller the thermal conductivity value the longer the heat transfer process and the better the cooling process. Based on the thermal conductivity test result, the thermal conductivity value of rice husk and cement composition selected is 0.746 W / mK which is bigger than the thermal conductivity of Styrofoam which is 0,03 W / mK. In ASTM standard E 1225-13 states that the range of conductivity values that can be calculated is 0.2 W / mK to 200 W / mK.

Some other things that cause the high value of thermal conductivity that is not a good effect of coolbox experiment is a mixture of isolation consisting of rice husk, white cement, and water. From the mixture, it can be seen that the thermal conductivity value of white cement is 1.5 W / mK and the conductivity value of water is 0.58 W / mK so greatly affects the thermal conductivity value of rice husk mixture and white cement. Another possible cause is the presence of trapped water content in rice husk insulation so that from the aqueous sidelines it can conduct heat well and make the thermal conductivity value of the insulation higher and cause poor test results on the coolbox, the requirement for good cooling insulation is Has a low thermal conductivity value.

To overcome the above problems there are several ways that can be used to replace the adhesive used by the author of them is the use of PVAC glue as an adhesive. The use of glue is expected to be better than the use of white cement as adhesive. In the application of glue, pvac does not use water as a mixture that is different from cement that requires water. And it is hoped that the use of pvac glue as an adhesive on rice husk isolation can make coolbox can maintain cold longer than Styrofoam.

Another way that can be used is to use adhesive technology without adhesives or called by the name of the binderless board where it is widely used in the manufacture of particleboard. Research with this method has been done using kenaf core, bagasse, coconut fiber, elephant grass, and spruce and pine. Non-wood raw materials are widely studied with the consideration that they contain hemicelluloses that have a very important role in the self-bonding process. The commonly used method is the heat forging method on the specimen. Adhesive technology without adhesive is still not widely developed in Indonesia. With this method, it is expected that the thermal conductivity value of rice husk is not affected by the presence of adhesive material. So the experimental results are better than experiments that use white cement as adhesive.

Figure 3 Coolbox with Insulation from Rice Husk

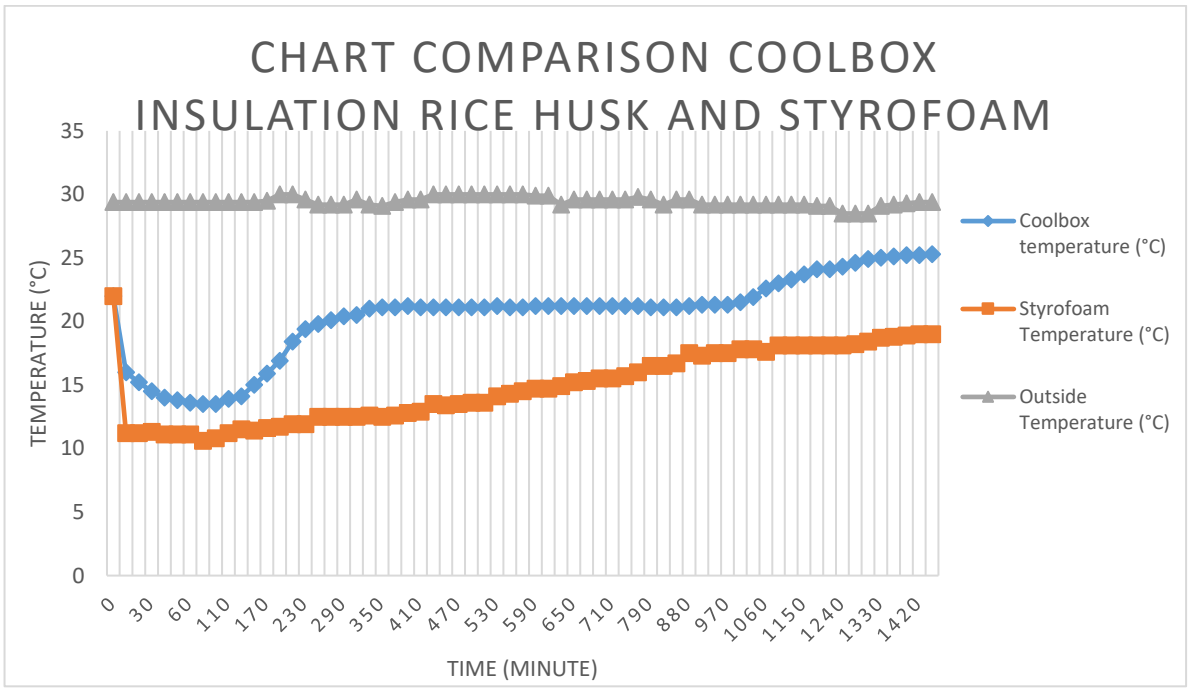

Figure 4 Chart temperature comparison Cool Box Rice husk with Cool Box Styrofoam

Figure 5 Coolbox Temperature Measurement

IV. CONCLUSION

Based on the results of experiments that have been done, it can be concluded as follows:

1) From the test results obtained the composition of the chaff and white cement is the best and the selected to isolate the coolbox with the composition of 1: 1. Because it has a low density of 0.32 g / cm^3 is better than other compositions and has a conductivity value Thermal is good compared to other compositions with a value of 0.746 W / mK but the value of thermal conductivity is not in accordance with the thermal characteristics as isolator characteristics ranging from 0.034 - 0.21 W / mK [4]. But it has a defect in its bending strength value of only 0.21 N / mm^2 where the composition of 1: 4 has a better value of 3 N / mm2. In anticipation of low power value then coolbox is given a wall made of plywood.
2) From the results of the study showed that the cement content gives effect to the quality of the insulation using rice husk. The more cement the husk's ability to isolate is lower.
3) Within 24 hours of cooling time, the lowest temperature of the experiments using an insulated coolbox of rice husk was 13.5 ° C. And in experiments using Styrofoam coolbox with the lowest temperature of 10.6 ° C. So it can be seen that the use of white cement as adhesive on the insulation of rice husk is not better than Styrofoam coolbox.

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