Thermic Characteristics of Rice Husk and Polyurethane Composite Material as Insulation in Fish Cold Storage

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ABSTRACT

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The process of freezing fish always requires a cooler as a temporary storage place for fish. The ability of the storage to maintain cold temperatures is a serious problem to be considered so that the freshness of the fish can be maintained. Therefore, an appropriate technology is required to support the cold chain system so that fish quality can be maintained. The purpose of this study was to test the thermal conductivity of composite materials for fish storage insulation from a mixture of rice husks and polyurethane so that the price of the box can be reduced but still maintain the quality of the fish. The composition of the composite material was made with a volume ratio of 1:0.5, 1:1, 1:1.5, and 1:2. The thermal conductivity test of the material uses the ASTM E1225-99 standard. All test results were compared with 100% polyurethane material. The results of testing the thermal conductivity of 100% polyurethane material obtained 0.023 W/m.C. From all the test results, the material that is most likely to be applied to fish cooler box insulation is a 1:1 composition having a thermal conductivity value of 0.067W/m.C. Materials with this composition do not affect the expansion of the polyol and isocyanate reactions. This composition is the most economical to be used as insulation for fish storage boxes which can save the use of polyurethane by 50%.

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I. Introduction

The marine and fisheries sector is one of the supporting sectors for national development because of its large potential, it needs to be managed optimally in order to obtain maximum results. However, in reality there are still many catches that have not been able to meet expectations in terms of quality because the catch has decreased in quality by up to 30% after landing.

Polyurethane is one of the materials commonly used as thermal insulation in fish storage [1] [2]. When viewed from the current conditions, the traders really feel the problem, especially the problem of the cost of insulation materials which continues to increase, this limitation is due to the high price of insulation raw materials [3].

At the rice mill, various wastes are produced, one of which is rice husk. This rice husk has the potential to be used as a raw material to replace insulators because it can affect temperature. In addition, rice husks can also maintain polyurethane deformation [4].

Thus we need an appropriate technology to support the cooling system so that the quality of fish can be maintained. The purpose of this study was to determine the thermal characteristics of the composite material as an insulation material from a mixture of rice husk powder with polyurethane, so that the price of the cooler can be reduced but still maintain quality.

II. Method

2.1 Preparation of Specimen

Before making a specimen, the preparation of materials and the manufacture of prints are carried out first specimen. Preparation of materials in the form of powdered rice husk powder that has been cleaned and drying. Another material is polyurethane which consists of polyol and isocyanate in a ratio of 2:3. The printing press is made of multiplex coated with a cube-shaped iron plate with dimensions of 20x20x20 cm.

The manufacture of the material is carried out in stages according to the composition that has been determined between: polyurethane and cocopeat powder, namely 1:0.5, 1:1, 1:1.5, and 1:2 as shown in table 1. The composition ratio was measured by volume. The printed material is in the form of a cube according to the dimensions of the printing tool. This material is then shaped according to the size and shape of the material following ASTM E 1225-99 [5] for thermal conductivity testing and ASTM D 1621 [6] for compressive testing.

Table 1. Specimen Composition

No	Specimen Composition		
	Ratio	<i>Polyurethane (%)</i>	<i>Rice husk (%)</i>
1	1:0,5	66.67	33.3
2	1:1	50	50
3	1:1,5	40	60
4	1:2	33.3	66.67

The process of making specimens is printed with several compositions as planned in the proposal. The results of the specimens that have been printed are as shown in Figure 1.

Figure 1. The Process of Composing Specimen

III. Thermal Conductivity Test

Before carrying out the test, each specimen with a different composition was formed with dimensions of 52x35 mm, 3 (three) specimens were taken for each composition for testing. Each specimen must have a flat surface because the entire surface must be in contact with the reference

material (brass and stainless steel). The specimens were made a hole for the temperature sensor with a distance of 10 mm from the top surface and a second hole 25 mm apart as shown in Figure 2a. Specimens to be tested as shown in Figure 2b.

Figure 2. Test Specimen
(a) Position sensor hole. (b) Specimens with composition variations

The specimens will be tested on a thermal conductivity tester as shown in Figure 3a. This test equipment is designed in accordance with ASTM C 1225-99 (Standard Practice for Calculating Thermal Transmission Properties Under Steady State Conditions for specimens. The test equipment is equipped with real time data acquisition with output data that can be exported to Excel and processed in graphical form.

Figure 3. Thermal conductivity test equipment
(a) Test Equipment (b) Arrangement of conductivity tests

This test equipment has a data logger that can record the temperature that passes through the material every 30 seconds. The data is sent to the computer and displayed in Microsoft Excel in real time through the PLX_DAQ for Excel application. This application functions as a connection software between computer devices and thermal conductivity test equipment. This test kit has 6 heat measuring sensors called T1, T2, T3, T4, T5 and T6 respectively. Channels T1 and T2 are placed on a stainless steel reference material which has a conductivity value of 0.24 W/m.oC which is given a heater plate as a heater. For channels T3 and T4 are implanted in the specimen and T5 and T6 are placed on a brass reference material which has a known thermal conductivity value of 1.09 W/m.oC. After compiling and installing the sensor, all of it is inserted in the tube so that the

temperature reading is not affected by the outside temperature. The arrangement of the test equipment can be seen in Figure 3b.

The heat conductivity value is calculated based on ASTM E1225-99. The conductivity calculation is carried out on the reference material for Stainless Steel ($k_T = 0,24 \text{ W/m.}^\circ\text{C}$) and brass ($k_B = 1,09 \text{ W/m.}^\circ\text{C}$), including the following specimens.

Stainless Steel Heat Rate

$$q'_T = k_T \cdot \frac{T_2 - T_1}{Z_2 - Z_1}$$

Brass Heat Rate

$$q'_B = k_B \cdot \frac{T_6 - T_5}{Z_6 - Z_5}$$

The temperature reading distance for each material is:

$T_1 - T_2$ = Stainless Steel

$Z_2 - Z_1$ = 15 mm

$T_3 - T_4$ = Test Material

$Z_4 - Z_3$ = 15 mm

$T_5 - T_6$ = Brass

$Z_6 - Z_5$ = 15 mm

Thermal conductivity

$$k'_s = \frac{(q'_T + q'_B)(Z_4 + Z_5)}{2(T_4 - T_5)}$$

IV. Results and Discussion

The heat conductivity test for each composition is 1:0.5; 1:1; 1:1,5 and 1:2. Each composition was tested 3 times with the aim of getting the average conductivity value for each specimen.

4.1 Specimen of Composition 1:0.5

The results of the heat conductivity test for the composite material of a mixture of Polyurethane and rice husks at 1:0.5 Each test specimen was named 1:0.5a, 1:0.5b and 1:0.5c. The test data was taken for 60 minutes at a temperature of up to 200 °C.

The highest thermal conductivity value of the 1:0.5a mixture of polyurethane specimens reached 0.4084922 W/m.°C occurred in the first 3 (three) minutes of testing while the lowest value was - 0.22497 W/m.°C occurred in to 6 (six). Overall, in the next second there was a decrease in the value of the thermal conductivity and continued to reach a stable conductivity value until the end of the test time with an average value of 0.01508 W/m.°C. In testing the second specimen with the same composition, specimen 1:0.5b, the thermal conductivity values that occur with many variations are generally still in the positive area. The highest thermal conductivity value in this specimen was 0.8764 W/m.°C at 150 seconds and the lowest was 0.008795 W/m.°C occurred in 2010. So the average conductivity value for 60 minutes of testing was 0. ,08293 W/m.°C. Further testing was carried out on the third specimen (1:0.5c) showing the highest conductivity value of 0.9964 W/m.°C occurred also in the early minutes of the test while the lowest conductivity was - 0.041083 W/m.°C occurred at last minute so that the average conductivity value of this specimen is 0.06712 W/m.°C. From these three tests, the average conductivity value of the 1:0.5 polyurethane-rice husk ratio composition is 0.05504 W/m.°C. Comparison of test data on this specimen can be seen in Figure 4.

Figure 4. Comparison graph of the conductivity value of the composition specimen 1:0.5

4.2 Specimen of Composition 1:1

The results of the heat conductivity test on composite material specimens with a composition of Polyurethane-rice husk in a ratio of 1:1 are shown in Figure 11. Comparison of the composition between polyurethane and rice husk in this specimen is based on the measurement volume. Specimens were named 1:1a, 1:1b and 1:1c in each test with the aim of facilitating data storage and processing. The conductivity test on the 1:1a specimen can be explained that the highest thermal conductivity value is 0.69819 W/m.°C, while the lowest conductivity value is -1.95167 W/m.°C. The heat given by the heater causes the flow rate in the specimen to be unstable starting from 0-1710 seconds, but in the next seconds the conductivity value reaches a stable condition. During 60 minutes of testing, the average conductivity value was 0.09196 W/m.°C. The results of subsequent tests on the same specimen with the name 1:1b, the highest thermal conductivity value in the 1:1b specimen was 0.6366 W/m.°C and the lowest was -0.5705 W/m.°C. In this second test, the conductivity value is more stable than the first test (1:1a specimen) so that the average conductivity value is 0.05939 W/m.°C, which is lower than the results of the first test. In the third test (1:1c) the highest conductivity value is 1.31521 W/m.°C while the lowest conductivity is -1.7625 W/m.°C so that the average conductivity value in this specimen is 0.05217 W/m. °C. Based on the results of the three tests, the average conductivity value of the specimens at a 1:1 composition ratio between polyurethane and rice husk was 0.067847 W/m.°C. Comparison of test data on this specimen can be seen in Figure 5. When compared with the results of testing specimens with a composition of 1:0.5 between polyurethane and rice husk, it can be explained that the addition of 0.5 times the volume of rice husk from the total volume of polyurethane can affect the conductivity value, namely of 0.0128 W/m.°C.

Figure 5. Comparison graph of the conductivity value of the composition specimen 1:1

4.3 Specimen of Composition 1:1,5

The conductivity test on the 1:1.5a specimen can be explained that the highest thermal conductivity value is 2.064672 W/m.°C. As the heat supplied by the heater increases, the temperature sensor reads the heat flow rate in the specimen which is more stable. The lowest thermal conductivity value is -2.8631 W/m.oC so that the average conductivity value is 0.1475 W/m.oC. In the next test with the same composition (1:1.5b) the highest thermal conductivity value in this specimen was 1.430344 W/m.°C and the lowest was -1.6029 W/m.°C so that the average conductivity value was obtained. the average value of 0.070568 W/m.oC, when compared with the test on the specimen composition 1:1.5a there was a decrease in the average conductivity value, but the heat flow rate in the specimen was still in a stable condition. The third test, specimen 1:1.5c, can explain that the highest conductivity value is 1.36698W/m.°C while the lowest conductivity is -2.05602 W/m.°C so that the average conductivity value in this specimen is 0.14566 W/m.°C the results of the three tests obtained the average conductivity value of the specimen with a composition of 1:1.5 the ratio of polyurethane and rice husk was 0.11089 W/m.°C. Comparison of test data on this specimen can be seen in Figure 6. When compared with the results of testing specimens of 1,0.5 and 1:1 composition of polyurethane-rice husk, it can be explained that the composition of 1.1.5 has a higher conductivity value than the two specimens. In terms of the heat flow rate that occurs in the specimen has a more stable condition.

Figure 6. Comparison graph of the conductivity value of the composition specimen 1:1.5

4.4 Specimen of Composition 1:2

Thermal conductivity testing on composite material specimens with a mixture of Polyurethane and rice husk composition 1:2a showed the highest thermal conductivity value reached 1.219366 W/m.°C. As the heat supplied increases, the rate of heat flow in the material becomes more and more stable. The lowest thermal conductivity value is -0.92546 W/m.°C, during the 60 minute test the average conductivity value is 0.2912366 W/m.°C. In specimen 1:2b the highest thermal conductivity value in this specimen is 1.49526 W/m.°C and the lowest is -0.6778 W/m.°C so that the average conductivity value is 0.1009 W/m.°C, lower than the results of the first test. In the third test (1:2c) it can be explained that the highest conductivity value is 1.7489W/m.°C while the lowest conductivity is -0.86887 W/m.°C so that the average conductivity value in this specimen is 0.093509 W/m.°C, lower than the test on specimens 1:2a and 1:2b. Based on the results of the three tests, the average conductivity value of the specimen with the ratio composition of polyurethane with rice husk 1:2 is 0.138022 W/m.°C. Comparison of test data on this specimen can be seen in Figure 7.

Figure 7. Comparison graph of the conductivity value of 1:2 composition specimens

The test data on all compositions obtained different results as shown in Figure 8. The thermal conductivity value of 100% polyurethane was used as a comparison data on the composition of the specimen mixed with polyurethane. The polyurethane used in this study is non-CFC material with a ratio of polyol and isocyanate of 2:3 with a thermal conductivity value of 0.023 W/m.°C [7].

Figure 8. Comparison of specimen conductivity values

When viewed from all test results, the specimen with a composition of 1:1 is the most likely material to be applied to pending box insulation with a conductivity value of 0.067 W/m.°C, the test results are close to the recommended insulation material limit of 0.023-0, 04 W/m.°C [8]. This composition did not significantly affect the thermal conductivity value between polyol and isocyanate, very different from the 1:1.5 and 1:2 compositions which greatly affected the conductivity of the material. If a 1:0.5 material is used, the use of husks in the insulation still looks too little so that this composition will not reduce the use of polyurethane.

V. Conclusion

Related to all test results, the specimen with a composition 1:1 is the most likely material to be applied to cold storage insulation with a conductivity value of 0.067 W/m.°C, the test results are close to the recommended insulation material limit of 0.023-0.04 W/m.°C [8]. This composition did not significantly affect the thermal conductivity value between polyol and isocyanate, very different from the 1:1.5 and 1:2 processes which greatly affected the conductivity of the material. If a 1:0.5 material is used, the use of husks in the insulation still looks too little so that this composition will not reduce the use of polyurethane.

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