

# Application of Waste Sawdust as Mixed Polyurethane Insulation in Traditional Cold Storage of Fishing Vessel

Sutopo Purwono Fitri<sup>1</sup>, M. Badrus Zaman<sup>2</sup>, Dwi Priyanta<sup>3</sup>, Mochamad Hidayat<sup>4</sup>

**Abstract**—in the process of fishing it takes some supplies such as fishing equipment, instrumentation and storage of fish. The traditional fishermen of their fishing days fishing usually only bring ice cubes. Solid plastic polyurethane foam is a mixture solution of polyols and isocyanates, commonly used as an insulating material storage. From the observation waste generated being sawmill sawdust per spindle with diameter of 30 cm and a length of 1 m with 5 times sawmill, Saws 0.8 cm thick produced 0.0088 m<sup>3</sup> / burnable logs only discarded. Therefore takes thermal conductivity test to review mixture of sawdust and polyurethane comparison with variations different dosing. Maximum disposals sawdust can be done is 40% of the total volume of material mixture, polyurethane and sawdust because composite material (sawdust-polyurethane) can not be bond with good so easy slab separately from origin form. Thermal Conductivity insulating good and economical on disposals 40% wood flour (0.05252 W / m<sup>2</sup>C) and is able to maintain a 2 kg of ice crystals melt up perfect on 34 hours. Operating profits economical from 4,8 m<sup>3</sup>insulation composite application with obtained Rp 4.486.000 compared with 100% Polyurethane Insulation Manufacture.

**Keywords**—sawdust, composites, polyurethane, insulation and thermal conductivity

## I. INTRODUCTION

In the process of fishing It takes some supplies such as fishing gear, fishing fleets, instrumentation and storage of fish. The fisherman-old traditional fishermen of their fishing days fishing usually only bring ice blocks as differences boat handling of fish in order to fish quality when arriving at the fish landing site to keep fresh.

The quality of fish storage is highly dependent on the quality of the heat insulating material (insulator) is used. The use of insulated hatch it can save ice delivered during fishing operations. The amount of ice left on landing and the demolition was still quite a lot, which is between 20-30% and even up to 50% [8].

Polyurethane is a material used as insulation retaining the temperature in the hold fish storage. But today, the constraints are felt particularly by fishermen is the problem of insulating material costs continue to rise, this limitation due to the high price of raw materials insulation.

From sawmills, wood waste are produced in the form of sawdust and pieces of wood. From the results of field observations sawmill waste generated per logs into wood powder with diameter of 30 cm and a length of 1 m to 5 times the mills, saws 0.8 cm thick produced 0.0088 m<sup>3</sup> / spindle just thrown away or burned [5]. These powders have the potential to be used as a substitute raw material insulator. With special handling will find the composition that allows for the use of sawdust as raw

material or a mixture of an insulating material on a fishing boat hatch.

Therefore, the thermal conductivity test is required for a mixture of sawdust and polyurethane with a variety of dosage ratio of 10% to 90%. With this research is expected sawdust (waste wood factory) will be used as raw materials or mixtures insulator cheaper, but still had a good insulator properties and can be made by the traditional fishermen.

## II. METHODOLOGY

Before performing composite manufacturing steps being taken in the implementation of this research are:

### A. Specimen Preparation

1. Determination comparison inflate (expand) the weight of the polyurethane mixture to form a solid foam volume by mixing a solution of polyol and isocyanate (1:1) are applied to the volume manufacturing of specimen with size 250x250x25mm
2. Sawdust sifted separated from the cut pieces of wood. Drying is done with dried under the sun for a day. As well as doing specific gravity measurements.
3. Beginning with the creation of 100% polyurethane specimen in the mold 250x250x25mm. The use of a mixture of polyol and isocyanate based measurement of the expansion ratio by weight solution. Then the composition of polyurethane and wood powder made by adding sawdust 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% on the specimens 250x250x25mm.

### B. Apparatus

Thermal conductivity measurement based on ASTM C177. Tests performed on the specimen by placing the specimen on the hot and cold plates are then measured using a thermocouple on both sides of the inside of the second plate. Conductivity measurement is done by attaching a thermocouple probe on the inside of the plate and put the thermocouple probe into the center of the

Sutopo Purwono Fitri, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. Email: [sutopopf@gmail.com](mailto:sutopopf@gmail.com)

M. Badrus Zaman, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. Email: [drus\\_zaman@yahoo.com](mailto:drus_zaman@yahoo.com)

Dwi Priyanta, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. Email: [priyanta@gmail.com](mailto:priyanta@gmail.com)

M. Hidayat, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. Email: -

specimen sandwiched between the two plates. Recording of temperature is done in 60 minutes on each specimen.

1. Heating plate of copper with a thick 250x250x1mm size suction onto the heater. Heating plate which generates heat flux wrapped in aluminum foil to minimize heat losses while measuring.
2. The cooling plate is also of copper with a size 250x250x1mm affixed with copper pipe to drain the water so that the cooling plate can decrease the environmental temperature.

Heating plate is placed on the bottom that has been affixed to one side ditengan thermocouple probe in the plate, and next to the cooling plate on which is also attached a thermocouple probe on the inside. The specimen is clamped between the two plates of hot and cold with the meeting, all parts wrapped in aluminum foil wrapped to avoid loss of heat at the time of measurement.

#### C. Coolbox

Two crates insulated coolers (Coolbox) made of a composite material of 100% and most optimal powder with a size of 15x15x15cm inner and 2.5cm thick and coated with fiberglass on the inside and outside of 1mm thick. On the inside is filled with ice crystals amounting to 2 kg. measurements were carried out every hour for 40 hours which begins when the condition of full ice until the ice melts perfectly whole. Measurements carried out on specimens and specimen 100% polyurethane-polyurethane composite wood powder which meets the characteristics most excellent insulator material with consideration of sawdust most.

The comparative tests intended to determine the ability of the composite to the conductivity which still meets the characteristics as the insulator material on the addition of a mixture of wood flour maximum. The test is applied to the ability of composite insulators in

maintaining the temperature inside the coolbox to time, the condition of the ice melted at the temperature of melting ice is perfect (total) compared with the use of polyurethane insulation capability of 100%.

#### D. Economic

Comparison of economic benefit is done by comparing data obtained polyurethane material needs of field observations in the manufacture of insulation 30GT hold a fishing boat in the area Paciran, Lamongan with the use of wood-polyurethane composite powder in accordance with previous measurements performed. Observations were made to obtain data - data is as follows:

- The need for insulation in the hold space (volume)
- Price per kilogram Polyurethane A and B
- The price of waste sawdust

### III. RESULTS AND DISCUSSION

#### A. Specimen

Making test specimen can only be made for the specimen number 1 (as in figure 1) to 5, or at 100% PU to PU mixing 60% and 40% of wood powder. Unable to mixing of the dough when mixing because of too little amount of PU so that uneven and imperfect specimen.

Polyurethane composite specimens with 50% or by adding a mixture of sawdust 50% or smaller, polyurethane solution can not be spread evenly throughout the side and penetrated the sidelines of sawdust. So that the specimen is not perfect, easily damaged and sawdust easily detached due to lack of binder (polyurethane) as shown in Figure 2. Therefore, in this study the characteristics of thermo physical measurements can only be performed on a specimen of composite polyurethane sawdust 60% and 40%.



Figure. 1. Specimen 100% Polyurethane



**Figure. 2.** Specimen Failure (50% PU,50% Sawdust)

### B. Thermal Conductivity

Measurements of thermal conductivity in this study to determine the ability to conduct heat from the heating plate which is based on electrical current of 5.28 watts at a room temperature of 29 °C. Here are shown the results of thermal conductivity measurements on each specimen-polyurethane composite wood dust in figure 3.

Based on the measurement results as shown in figure 3, on the fifth specimen thermal conductivity composites still qualify thermal characteristics is used as an insulator (in terms of thermal conductivity of 0.02 W / m ° C to 0.06 W / m ° C) [8] is a specimen by mixing sawdust 10%, 20%, 30% and 40%.

### C. Coolbox

Coolbox is made from 100% polyurethane and composite then each filled with 2 kg of ice crystals. Measurements were made every hour and thawing of ice every two hours for 40 hours. The measurement results as shown in the figure 4.

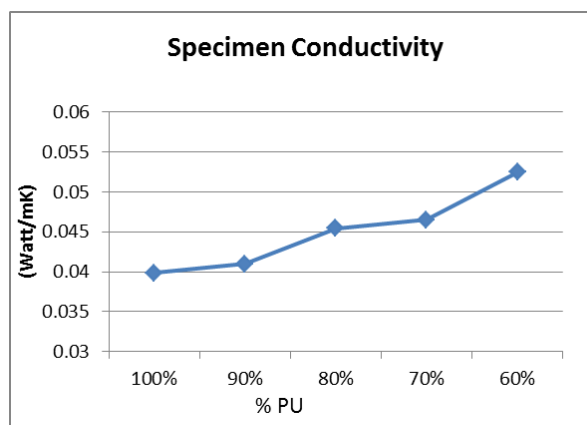
The use of composite insulators 60% polyurethane and 40% wood flour lowered resistance to maintain the condition of the ice in a coolbox than using 100% polyurethane, within 34 hours of the start of the ice had melted completely. The use of composite mixture of

40% of wood powder able to maintain a temperature below 10 ° C for 17 hours. While the use of 100% polyurethane capable of maintaining a temperature below 10 ° C for 24 hours. However, 60% polyurethane composites can be used as an insulator in particular for vessels operating hatch one day fishing, because they can maintain the ice up to 34 hours, is sufficient for all operational needs. In addition, the composite can save up to 40% the use of polyurethane.

### D. Economic

From the observation hatch insulation manufacturing of fishing vessels Paciran, Lamongan. It takes 420 kg of a mixture of PU A and PU B for insulation of 4.8 m<sup>3</sup> at a price of Rp 32,000 per kilogram PU.

On the application of a composite mixture of 60% polyurethane and 40% sawdust, a reduction in the cost of consumption of polyurethane as much as 40%, but there is an additional cost of Rp 390,000 for the purchase of sawdust. Total cost of the need for insulation composite head is Rp 8.954 million. With the use of this composite, gain an initial investment of Rp 4.486 million.



**Figure. 3.** Specimen Conductivity

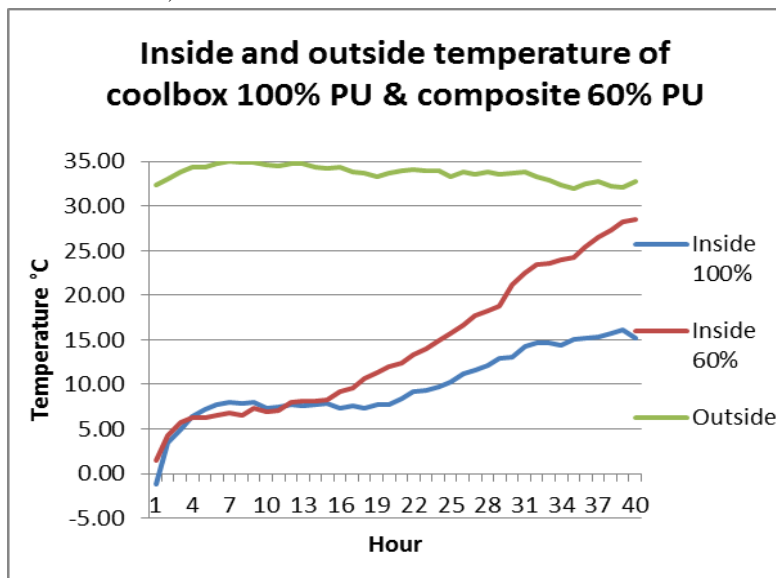


Figure. 4. Inside and outside temperature of coolbox specimen

TABLE 1.  
100% POLYURETHANE PRODUCTION

100% Polyurethane				
Volume (m <sup>3</sup> )	Weight (kg)		Price/kg	Rupiah
4,8	210 (A)	210 (B)	32.000	13.440.000
Total				13.440.000

TABLE 2.  
60% POLYURETHANE; 40% SAWDUST PRODUCTION

Composite 60% PU dan 40% Sawdust			
Item	Consump.	Price	Rp
Vol. 60% PU A+B	252 kg	32.000/kg	8.064.000
Vol. 40% Sawdust	576 (29 sack)	10.000/sack	390.000
Man power	1 Day, 5 Worker	100.000/day	500.000
Total			8.954.000

#### IV. CONCLUSION

##### A. Technical

The addition of wood shavings to do the maximum is 40% of the total volume of mixed material, namely polyurethane and wood. The addition of wood dust is more than 40% can not be done because the composite material (sawdust-polyurethane) can not bind to either because with the least amount of liquid polyurethane which can not penetrate the sidelines of sawdust so easily separated from its original slab form. The addition of sawdust 10, 20, 30, and 40% is a good thermal insulator according to standard ASTM. Good thermal insulator and economically in addition to 40% wood flour (conductivity of 0.05252 W / m ° C).

Applications coolbox insulator-polyurethane

composite wood powder able to maintain perfect ice to melt at 34 hours, faster than the 100% polyurethane applications that can sustain the ice for more than 40 hours.

##### B. Economic

Economic benefits in the manufacture of insulation hatch rate of 4.8 m<sup>3</sup> with the application of a composite of 60% PU and 40% wood powder obtained Rp 4.986 million compared with the manufacturing of 100% polyurethane insulation.

REFERENCES

- [1] Amiruddin, W., Iskandar H. B. 2014. Efisiensi Perubahan Kerapatan Material Polyurethane Terhadap Laju Penetrasi Panas Pada Palka Kapal Ikan Tradisional. S1 T. Perkapalan F. Teknik UNDIP., Semarang
- [2] ASTM C 177 (2004), “*Standart Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus*”, American Society Testing and Materials, United States
- [3] ASTM C 518 (1998), “*Standart Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*”, Annual Book of ASTM
- [4] ASTM C 1045 (1997), “*Standart Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions*”, Annual Book of ASTM
- [5] Badrawada, I, G, Gde., Susilo, A. 2009. Pengaruh Kepadatan Papan Partikel Dari Tiga Jenis Serbuk Kayu Terhadap Nilai Konduktivitas Panasnya. Jurusan Teknik Mesin, Fakultas Teknologi Industri, Institut Sains & Teknologi AKPRIND., Surabaya
- [6] Hasibuan, R, I., Supomo, H., Soejitno. 2013. Analisis Teknis dan Ekonomis Penggunaan Komposit Serabut Kelapa dan Serbuk Pohon Kelapa sebagai Isolasi Kotak Pendingin Ikan pada Kapal Ikan, Jurnal Teknik POMITS, Vol. 2, No.1, ISSN: 2337-3539 (2301-9271).
- [7] Kholis, M. N., Syofyan, I., Isnaniah. 2014. Study Use Powder As Raw Materials Manufacturing Saws Insulator Cooling Box Fish (Coolbox) Used Traditional Fisherman.
- [8] Nasution, P., Fitri, S, P., Semin. 2014. Karakteristik Sabut Kelapa Sebagai Insulator Palka Ikan, Berkala Perikanan Terubuk. Hal 82-92 ISSN 0126 – 4265