Eco. Env. & Cons. 26 (November Suppl. Issue) : 2020; pp. (S135-S139)
Copyright@ EM International
ISSN 0971–765X

Utilization of bagasse and sawdust as bio-based insulation on the walls of the ship's accommodation ceiling

Tristiandinda Permata[1]*, D. Hikmawati[2]*, Aurista Miftahatul Ilmah[3] and Jailani[3]

[1]Ship Building Engineering, State Polytechnic of Madura, Indonesia
[2]Department of Physics, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia
[3]Ship Building Engineering, State Polytechnic of Madura, Indonesia

(Received 27 February, 2020; Accepted 23 June, 2020)

ABSTRACT

Bagasse has been widely used as an addition of insulation material, it is caused that bagasse contains a lot of lignocellulose which can be processed into artificial boards, in addition to bagasse material which is widely used as an alternative material supporting the artificial board is sawdust so that if the bagasse waste and sawdust used as insulation material, its ability will be maximal as an alternative to making insulation. heat insulation materials are useful in reducing the rate of heat transfer, so the conductivity of these materials must be low. One of the places that use heat insulation is the ship's accommodation room. One of the ship's accommodation spaces is one of the parts is the ceiling (the top and bottom of the ship's accommodation room) is used as a resting place for the crew and as a storage area for goods on board the ship. The process of making insulation materials with the addition of baggase waste and sawdust waste by 40% of the total volume of the mixture consisting of polyurethane. Then the test is carried out to get the thermal conductivity value from each mixture of sawdust, bagasse, and polyurethane with various dosing ratios on wood powders, the cooling load calculation is then performed. The test results show the best conductivity value is the mixing of wood powder 0.2 g which is 2.65 W/mK which can withstand the rate of heat up to 311.22 KW.

Key words : *Bagasse, Sawdust, Thermal insulation, Thermal conductivity, Accommodation*

Introduction

Along with the development of time and technology, many natural materials are used as alternative and supporting materials in making insulation. One of them is bagasse and sawdust. Bagasse is residue in the sugarcane milling plant after extracting and taking it so that the remaining sugarcane fiber waste is commonly called bagasse or baggaGe. Bagasse has very good content to be processed again to support other materials. Bagasse contains lignocellulose which can meet the requirements to be processed into artificial boards (Yosephina, 2012).

Besides bagasse, another waste that is currently being used is sawdust. Sawdust is a lot of waste produced in the industrial world and has not been used optimally. Many who use sawdust as an alternative in making artificial boards, one of which has been done by Maiwita (2014), which utilizes bagasse and sawdust as particleboard and produces that the composition of bagasse and sawdust influences the conductivity of particleboard. From the experimental results obtained by the small composition of bagasse the greater the thermal conductivity value.

(Maiwita, 2014).

From the results of these experiments, it is known that Bagasse and sawdust can reduce heat well so that many researchers began to use bagasse and sawdust as an insulation material to reduce heat. Insulation is used as a protector or protects a series of things that are not desirable, there are several types of insulation one of the thermal insulation or insulation to reduce heat. Materials that have good conductivity can certainly be good insulation materials, along with several values of different thermal conductivity materials.

Table 1. Chemical Composition of Bagasse (Sudaryanto, *et al.*, 2002)

Content	Percentage (%)
Dush/Carbon	3
Lignin	22
Celulose	37
Extract	17
Pentosan	27
SiO_2	3

Thermal insulation is widely used in spaces that prioritize comfort and safety. One that uses a lot of insulation in the room is a ship. On the ship, there is a space that uses heat insulation. One of them is in the ship's accommodation room, this room is used as a storage place for goods on the ship so insulation is needed to withstand the propagation of heat on the ship. Several parts use heat insulation in the accommodation room, one of them is the upper and lower part of the accommodation or is called the accommodation ceiling. In the calculation of making insulation on ships adapted to ASTM C177 standards. Based on the above matters, it is necessary to study the extent to which bagasse and sawdust can be used as an alternative material. Therefore we need a thermal conductivity test for bagasse mix, sawdust, and polyurethane. By doing this research it is expected that bagasse waste and wood dust can be used as a mixture of insulators in the ceiling of ship accommodation.

Table 2. Value of the thermal conductivity of various materials (Holman, 2010)

Materials	Thermal Conductivity (W/mC^0)
Pure Silver	410
Pure Aluminum	202
Pure Nickle	93
Pure Iron	73
Wood	0.17
Raw Rubber	0.15
Wood Charcoal	0.084
Air	0.024

Materials and Methods

The steps used in the manufacture of bagasse-based insulation and sawdust waste.

Making Specimens

Bagasse is dried by drying it naturally using the help of the sun's heat. Bagasse is dried for approximately two to five days depending on weather conditions to dry. Bagasse that has been dried and then cut into small pieces with a length of 5-10 mm and then milled into bagasse powder. The sawdust is dried using the help of the sun's heat until the sawdust is completely dry. In determining the ratio of expansion (expansion) weight of polyurethane mixture to volume by forming a solid foam by mixing a solution of polyol and isocyanate (1: 1) as has been done by Nasution(2014), to form a 1 ml volume of each solution (Polyol and Isocynite), with a weight of 1.4123 grams of polyol solution and 1.8598 grams of Isocynite in the total weight of both solutions after mixing 3.2721 grams. The two solutions are then stirred evenly and experience a maximum expansion for 6 '28 '' seconds to form a solid volume of 14 cm3 polyurethane weighing 15.5902 grams. This means that. The mixed solution expands by volume 14 times the volume of the initial solution and forms 0.2337 gr/cm^3 (Nasution, 2014). Furthermore, for variations in the composition of the specimen making for polyurethane and bagasse made fixed, while for wood powder varied as seen. in Table 3.

Measurement of Thermal Characteristics Properties

Measurement of thermal conductivity based on ASTM C 177. Tests are carried out on specimens by

Table 3. Variation of specimens

Sample	Weight			Weight of sawdust (gr)	Bagasse weight
	PU A	PU B	PUA+ B		
1	2.5	2.5	5	0.2	0.4
2	2.5	2.5	5	0.4	0.4
3	2.5	2.5	5	0.6	0.4
4	2.5	2.5	5	0.8	0.4

placing specimens on hot and cold plates which are then measured using thermocouples on both the inner sides of both plates. Conductivity measurements are carried out by attaching the thermocouple probe to the inside of the two plates and inserting the thermocouple probe into the center of the specimen flanked by the two plates. Temperature recording is performed at the 150th minute on each specimen.

Results and Discussion

Making a Sample

The test begins with the making of a cylindrical test specimen with a size of 40x50mm and has a volume of 62.8 cm^3 by mixing wood dust and bagasse as a composite at a ratio of 60% Polyurethane and 40% composite, where for the composition of Polyurethane and bagasse made the same for each specimen, while sawdust is varied. mixing 50% polyurethane and 50% composite or greater cannot be carried out due to lack of polyurethane liquid which causes clumping of the composite so that the process of perfect expansion does not occur.

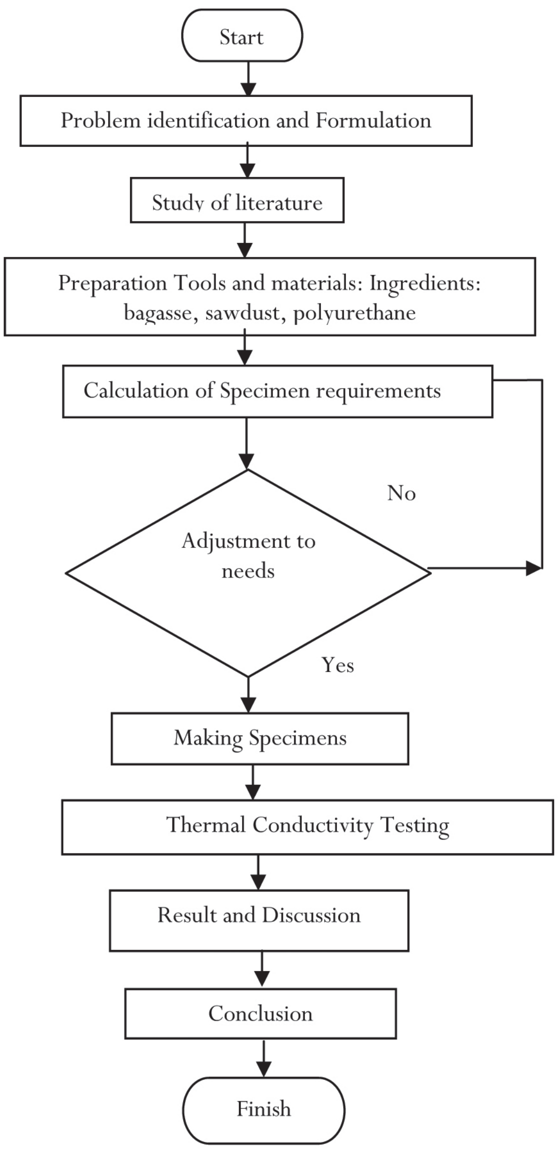

Fig. 1. Research Flow

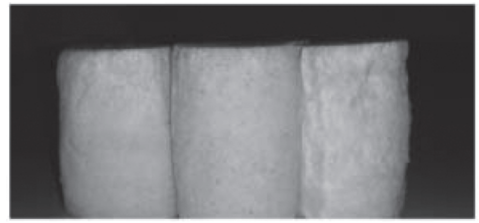

Fig. 2. Sample

Thermal Conductivity Testing

Thermal conductivity testing refers to ASTM C 177. The test is carried out by wrapping the specimen between the two copper, hot and cold copper. The copper is then affixed with thermocouple probe sensors on both sides inside. The temperature measurements produced on hot and cold copper are carried out by inserting a thermocouple in the middle of the specimen flanked by the two plates.

Measurement of thermal conductivity in this study was conducted to determine the ability to conduct heat from heating plates sourced from an electric current of 5.53 Watts at room temperature of 29^{0}C. The following are the results of the measurement of thermal conductivity in each polyurethane-wood dust-bagasse composite specimen in Table 4.

Fig. 3. Sample testing process

Based on the measurement results obtained from the test specimen. Obtained the temperature of each point can be seen in Figure 4.

From Figure 4. It can be concluded that each sample will decrease in temperature with the fastest temperature to experience a decrease in sample 4. In the calculation of thermal conductivity as shown in Table 4. Comparison of thermal conductivity of each polyurethane composite specimen - wood powder - Bagasse, more details can be shown in Figure 5.

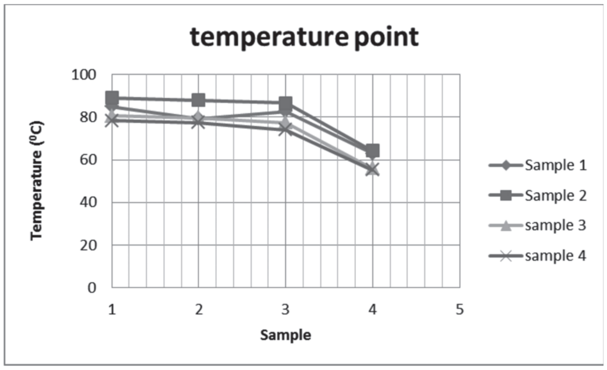

Fig. 4. Temperature of each point

The higher percentage of wood sawdust added to the composite specimen, the thermal conductivity value increases. So that the lowest conductivity value is obtained from the mixing of 0.2 g sawdust which is 2.65 W/mK. The conductivity value of each specimen is high due to the use of copper as a conductor of heat which has a high conductivity value of 385 W/mK, whereas according to the application for insulation on ships it should use carbon steel which has a much lower conductivity value than copper which is 50 W/mK. This can be seen from the Conductivity coefficient in Table 4.

Load Calculation

Load Heat Transmission (Qtr)

After obtaining the lowest thermal conductivity

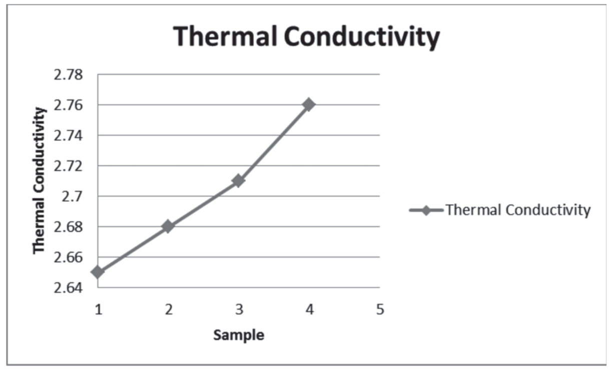

Fig. 5. Thermal conductivity of polyurethane - wood dust – Bagasse

value in the experiment, which is mixing 0.2 gr sawdust with a conductivity value of 2.65 W/mK, then the cooling load calculation is performed to determine the cooling load that can be held by the insulation of the captain's room in the ship's accommodation room. Based on Indian Standart (First Revision) 14754: 2008 heat transmission:

Transmission load (Heat Transmission) in the ship's accommodation room:

$$\phi = \Delta T(KvAv) + (KgAg) \quad .. (1)$$

ϕ = *Transmission Load*

ΔT = Differences in outside and inside temperaments (K)

K_v = Heat transfer coefficient (W/m^{2}k)

A_v = Area (m^2) does not include windows (glass +20mm)

K_g = Heat transfer coefficient (W/m^{2}k)

A_v = Window area (m^2) (glass + 20 mm)

There are several parts in calculating transmission load, including up, down, front, back, right, left. So that the calculation of transmission can be shown in Table 5.

Heat Loads of People (Qp)

Based on Indian Standards (First Revision) 14754: 2008 heat issued by people there are two types,

Table 4. Measurement of Temperature and Conductivity of Specimens.

Sample	Set point thermo control	Voltage (V)	Current (I)	Point temperature (°C)				Thermal conductivity (W/Mk)
				T1	T2	T3	T4	
1	100	220	1.4	85	79.2	82.6	63	2.65
2	100	220	1.4	89	88	86.6	64.2	2.68
3	100	220	1.4	80.6	79.6	77.5	56	2.71
4	100	220	1.4	78.4	77.4	74	55.2	2.76

Table 5. Transmission Load of Setipa Ship Accommodation Space

No	Ship accommodation room	Transmission Load
1	Roof	0.053 watt
2	Floor	0.053 watt
	Q total of ceiling	0.106 watt

namely sensible heat and latent heat, and for large values of heat from people Based on Indian Standards (First Revision) 14754: 2008. which is 120 Watt or 0.12 kW.

Heat Load Lamp (Ql)

Based on Indian Standart (First Revision) 14754: 2008 explains that the heat load on the lamp can be ignored if the heat load calculation is done during the day, and for this final project the calculation of the load is calculated in daytime conditions so that the value of the heat load due to the lamp is 0.

a. Heat Load Sun
Based on Indian Standards (First Revision) 14754: 2008. Calculation of solar heat can be calculated with the formula:

$$\phi = \Sigma \text{ Av k } \Sigma Tr + \Sigma AgGs \quad .. (2)$$

ϕ = heat load sun.

A_v = The area is filled with heat (m^2).

K = heat coefficient based on (5.2.3) or (5.2.4) for ship structures in surface $A_{v.}$

ΣTr = Temperature more than 35 ^{0}C including window.

ΣTr = 12 K for vertical light surfaces.

A_g = Extent of glass exposed to sunlight (m^2)

G_s = heat the glass surface follows:

G_s = 240 W/m^2 for the extent of the glass with the interior

So based on calculations using these equations obtained as in Table 6.

Based on the calculations that have been done, the total cooling load obtained in the captain's bedroom in the accommodation room is:

Qtotal = Qtr+Qp+Qi+ Qs

= 0.160 kW + 0.12 kW+ 0+ 311 kW = 311.22 kW

Based on the results of these calculations it was found that the composite with 5 mL PU, Bagasse 0.4 gr, and wood powder 0.2 g, can withstand the rate of heat up to 311.22 kW

Table 6. Heat Load Each Section of Heat Accommodation.

No	Accommodation's Ship	Transmission Load
1	The back side	155,7 kW
2	The front side	155,7 kw
	Heat load total of sunlight	311 kW

Conclusion

The lowest conductivity was found in mixing 0.2 g sawdust at 2.65 W/mK. Based on the results of these calculations it was found that the composite with 5 mL PU, Bagasse 0.4 g, and wood powder 0.2 g, can withstand the rate of heat up to 311.22 kW.

Acknowledgment

The authors thank for Airlangga University and *State Polytechnic of Madura* for supporting the laboratory and space to do the research.

References

ASTM C 1045 – 97 "*Standard Practice for Calculating Thermal Transmission Properties Under Steady - State Conditions". Annual Book ASTM*

ASTM C 518 – 98 "*Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus". Annual Book ASTM*

IS 14754:2008. Ships and marine technology – Air- Conditioning and Ventilation of accommodation space – Design conditions and basic of calculations" Firt Revision

Holman, J.P. 2010. *"Heat Transfer"*. New York : McGraw-Hill Company (2010)

Maiwita, Fitria, Darvina. Yenni, Yulkifli., pengaruh variasi komposisi ampas tebu dan serbuk gergaji pada papan partikel terhadap konduktivitas termal. *Pillar of Physics.* 1. April 2014, 41-48

Nasution, P., Fitri, S. P. and Semin. 2014. *Karakteristik Sabut Kelapa Sebagai Insulator Palka Ikan, Berkala Perikanan Terubuk*. Hal 82-92 ISSN 0126 – 426I.

Sudaryanto, Y., Antaresti; Wibowo, H., Biopulping Ampas Tebu Menggunakan *Trichoderma viride* and *Fusarium solani, Prosiding Seminar Nasional Fundamental and Aplikasi Teknik Kimia, Surabaya*, 30 September 2002; hal. 163-171.

Yosephine., Alita, Gala,Victor, Aning Ayucitra1*, Ery Susiany Retnoningtyas2. 2012. Pemanfaatan Ampas Tebu dan Kulit Pisang Dalam Pembuatan Kertas Serat Campuran. *Jurnal Teknik Kimia Indonesia*. 11(2): 94-100.