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Determination of Thermal Conductivity and Porosity of Composite Panels from Fibers, Bagasse Powder and Polypropylene (PP) Plastic Waste

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Abstract: Global warming causes temperatures on the earth's surface to increase. High temperatures during the day will make the temperature in the room of the residential house increase. The impact will affect the warmth of residents. One of the causes of the increase in indoor temperature is due to the absorption of solar heat by the components of the walls and roof. One alternative that can be done is the manufacture of composite panels that act as heat insulators using bagasse fibers, bagasse powder and the matrix of polypropylene plastic waste with low thermal conductivity, and high porosity. The composition of the composite varies the percentage of fibers and powders with a fixed percentage of polypropylene plastic waste of 90%. The percentage variation of polypropylene plastic waste of bagasse fiber and powder used is 100%:0%:0%, 90%:10%:0%, 90%:8%:2%, 90%:6%:4%, 90%:4%:6%, 90%:2%:8%, and 90%:0%:10%. Based on the test results, successive thermal conductivity values were 0.226715 W/m°C, 0.16241 W/m°C, 0.13543 W/m°C, 0.09582 W/m°C, 0.11457 W/m°C, 0.15351 W/m°C, 0.18276 W/m°C. The porosity values of successive samples were 0.63116%, 2.84024%, 3.36151%, 3.85179%, 3.24880%, 3.09383%, 2.65145%. From the test results, it was obtained that variation 4 had the highest thermal conductivity value with a value of 0.09582 W / m°C. while the highest porosity value was obtained in variation 4 with a value of 3.85179%. Composite panels with a variation of 4, and a variation of 5 are optimum variations that can be used as a good heat insulation material.

Keywords: Composite Panels, Polypropylene Waste, Bagasse Fibers, Bagasse Powder, Thermal Properties.

1. Introduction

Global warming is an event of increasing temperature in the atmosphere caused by trapping sunlight radiation in the earth's atmosphere. One of the consequences of global warming is the

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increasing temperature in residential buildings. The heat of the sun entering the room causes the indoor temperature to be high, coupled with the high humidity of the air as well, making the room uncomfortable. The high temperature of the room during the day will affect the comfort of residents, the increase in temperature in this room can be due to the absence of adequate air circulation, but also caused by the absorption of solar heat by the components of the walls and roof. The impact of this will certainly interfere with comfort, so a heat insulation board is needed to inhibit heat from outside the room [1].

Heat insulation boards are being used in various fields such as modern architecture and other industries, and these insulation boards are produced and used in various forms. However, most of the insulating materials are synthetic insulation in the foam type, where porosity is made inside the product, fiber-type insulation that uses glass wool or mineral wool in a type of nonwoven fabric made of fabric material and board products that use inorganic binders such as cement with perlite and ceramic balls [2]. Mineral wool includes a variety of inorganic insulation materials such as stone wool, glass wool, and slag wool. The average thermal conductivity range for mineral wool is between 0.03 and 0.04 W/(m.K) and the typical values of glass wool and rock wool are 0.03–0.046 W/(m.K) and 0.033–0.046 W/(m.K). These materials have low thermal conductivity values, are non-flammable, and are highly resistant to moisture damage [3]. Materials that can be used as heat inhibitors are vacuum insulation panels (VIPs), gas-filled panels (FP), airgels, and phase-changing materials (PCM). Among them, VIPs show one of the lowest thermal conductivity values (lower than 0.004 W/(m.K)) [4]. However, the use of these heat insulation materials has a fairly expensive price and their installation requires an expert workforce in their fields so that not everyone can buy them, using materials that are not environmentally friendly and can have an impact on health problems, such as skin and lung irritation. Therefore, alternative materials that are cheap and environmentally friendly are needed.

One alternative that can be taken is the manufacture of composite panels (boards) that can be used as heat-inhibiting materials. Composite materials are materials consisting of two or more materials that remain separate and different at the macroscopic level while forming one component to produce composite materials with different mechanical properties from the constituent materials of composite materials. Heterogeneous composites on a macroscopic scale. Each of such composites has different properties, and when combined in a certain composition will be formed new properties according to the desired. The shape (size) and structure of the composite will affect the properties of the composite, and in the event of interaction between components it will improve the composite properties of synthetic materials. Composites consist of several materials and are designed to obtain the best combination of properties of each of its components. Compared with conventional materials, composite materials have many advantages, including adjustable strength, lighter weight, superior strength and toughness, resistance to corrosion and wear resistance. Composite panel is a common designation for boards made of lignocellulose materials or other particles bonded with adhesive through a pressing process at a certain pressure and temperature. In simple terms, composites are a combination of two elements, namely fiber (fiber) as a filler or support and a matrix as an adhesive. Composite panels are the right choice as heat inhibitors because they can use organic fiber materials as the use of renewable and recycled resources to reduce waste [5].

Polymers that are often used as matrix materials in composites are of two kinds, namely thermoplastic and thermoset. The matrix used in this study is *Polypropylene* plastic waste which is included in the thermoplastic category, *Polypropylene* has very rigid properties, low specific gravity, resistant to chemicals and acid-bases, resistant to heat, and not easy to crack, but has low impact resistance [6]. *Polypropylene* is classified as thermoplastic because it has linear intermolecular bonds that can change shape, that is, it melts when exposed to heat, polypropylene has a melting point at a temperature of 160ºC. *Polypropylene* plastics are formed from a combination of many small molecules or monomers to form macromolecules called polymers. The manufacturing process involves thermal energy and catalysts that separate bonds in a molecule so that bonds can occur with other similar molecules. The most widely used plastic to date is a synthetic polymer, made from petroleum (non-renewable) which cannot be degraded by microorganisms in the environment. *Polypropylene* also has good insulation properties, is easy to work with, and is very waterproof because it absorbs little water and has high rigidity. Like other polyolefins, *polypropylene* is also resistant to non-oxidizing inorganic chemicals, detergents, and alcohols. However, *polypropylene* can be degraded by oxidizing agents such as nitric acid and hydrogen peroxide. Its highly crystalline nature produces high tensile strength, rigidity and hardness [7]. *Polypropylene* is a type of plastic that is often used because it has the property of being resistant to physical treatment and chemical treatment because it has high mechanical strength causing *polypropylene* plastic cannot be degraded by the environment, to overcome this problem, the manufacture of composite panels is carried out by making composite panels using plastic waste as adhesive materials or matrices. In this research, the material used for the matrix is polypropylene (PP) plastic waste which is used to reduce waste thrown into the environment by recycling it. This action is part of *zero waste* action which is the basis for various efforts to reduce waste and optimize the waste production process based on recycling activities (Recycle) [8].

Fiber is the main material in the manufacture of fiber composites. The fibers used can be both natural fibers and artificial fibers (synthesis). Natural fiber is a fiber derived from plants or animals that are tendrils such as yarn. To obtain the shape of the fibers, several stages of processing are required depending on the character of the base material. Fibers from plants include cotton, banana fronds, water hyacinth, and flax. While fibers from animals such as wool, silk, and bird feathers [9]. Natural fibers are fibers that come from nature (not artificial or human-engineered). Natural fiber or can be regarded as this natural fiber which is usually obtained from plant fibers (trees) such as bamboo trees, coconut trees, banana trees and other plants that have fibers on the trunk and leaves. Natural fibers derived from animals include silk, ilama, and wool. Research and use of natural fibers is developing very quickly until recently because natural fibers have many advantages compared to artificial (engineered) fibers, the advantages of natural fibers such as lighter loads, materials are easy to get, relatively low prices and most importantly is environment friendly. The use of natural fibers has now penetrated various fields of human life, just like artificial fibers, natural fibers can also be used as modifications of artificial fibers [10].

Natural fibers are more economical than synthetic fibers because natural fibers are easy to obtain, have economic value and are biodegradable. In the manufacture of composites, natural fibers are used not only to increase strength and rigidity, but also to reduce the weight of the resulting composite material. Bagasse fiber is starting to be widely used because it can reduce waste in the environment to minimize environmental problems, is renewable and does not endanger health. Other than bagasse fiber there are other natural fibers used to make composites are coconut fiber, water hyacinth fiber and rice straw. In this study, bagasse fiber was chosen as a natural fiber in the manufacture of composite panels because bagasse fiber has cellulose which can act as a reinforcing fiber in composites, the cellulose content contained in bagasse powder can create an air cavity so that it acts as a filling material and is more environmentally friendly because sugarcane bagasse is an organic waste. Bagasse fiber contains 62.78% silica, which is an insulator ceramic material. The higher the bagasse content used, the lower the thermal conductivity of the particle board which means that the better the board's ability as a heat insulator [11]. In addition, bagasse also contains 32% cellulose. Cellulose contained in bagasse fibers can result in the formation of voids, so it can help reduce the transfer of heat energy to particles in the composite panel [12].

Thermal conductivity is a phenomenon where the temperature difference causes the transfer of thermal energy from one area of a hot object to another region of the same object at a lower temperature. Thermal conductivity can determine how well a composite board conducts heat. In this research the composite panel acts as a heat insulator, therefore the composite must have a low thermal conductivity value [13]. A good material to use as a heat insulator material is a material with a thermal conductivity value around 0,1 W/m°C [12].

Porosity can be defined as a comparison between the volume of pores to the total volume on a composite board. The amount of pore content in a composite is one of the factors that influences thermal conductivity. The greater the porosity value, the smaller the thermal conductivity [14]. Non-porous material is a material that has a porosity of less than 0.25 or 25% and porous materials usually have a porosity greater than 0.4 or 40% [15][16].

Several studies have been conducted on composites made from bagasse, including by varying the bagasse, rice husk, and corn cobs with the highest conductivity value of 0.49425 W /mK with a ratio of 25% rice husks, 50% corn cobs and 25% bagasse. The lowest thermal conductivity value is 0.23105 W/mK with a ratio of 60% rice husks, 20% corn cobs and 20% bagasse [17]. In another study using bagasse fibers with rice husk filler, the composite board tested had thermal conductivity values ranging from 0.029 W / m.K to 0.069 W / m.K. However, composite uses resin as a matrix which is not environmentally friendly and requires expensive costs. Therefore, the composites to be made using waste so that they are cheaper and more environment friendly. Based on the results of previous studies that have been described, bagasse fiber has been used as a heat insulator material, but in previous studies bagasse fiber combined with a resin matrix which is expensive and not environment friendly. there are also several studies that use bagasse, *polypropylene* plastic waste matrix using paper *sludge* filler where the use of Paper *sludge* filler material to increase the porosity value of composite panels as heat insulator composite, but paper *sludge* is included in category B3 waste, B3 waste is an abbreviation for Toxic and Hazardous Materials which contain substances or components that directly or indirectly pollute, damage or endanger the environment, health and survival of humans and other living creatures. B3 waste also contains heavy metals such as Cd, Cr, Pb, Ag and Zn which are very harmful to human health and the use of powder from bagasse can reduce waste from making composite panels which is part of the *Zero Waste concept*. Hence this research using powder from bagasse as a substitute for filler material for composite panels. Therefore, the author wants to develop a composite panel that act as insulation panel using bagasse fibers as a reinforcing material and the bagasse powder as a filling material using a *polypropylene* plastic waste matrix (PP). The purpose of this study is to determine the effect of the comparison of the amount of fiber and sugarcane bagasse powder with the *polypropylene* matrix on the testing of thermal properties and porosity of composite panels.

2. Materials and Method

This research was experimental research. Experimental research is carried out by providing treatment of the object of study, therefore a causal relationship will be known. The results of this study are in the form of thermal conductivity data of composite panels that have been tested using thermal conductivity tools and porosity value of composite panels. This study is using variations in the amount of bagasse fibers with bagasse powder filler on the thermal properties of panels and the porosity of composites with *polypropylene* (PP) plastic waste matrix. There are 7 variations of the bagasse fiber mass and the bagasse powder mass. Each variation consists of 3 samples as a comparison, with a total sample of 21 samples as can be seen at Table 1[18].

Table 1. The mass percentage of each sample variation

NO	Matrix	Fiber	Powder
1	*Polypropylene* (100 gram)	0 gram	0 gram
2	*Polypropylene* (90 gram)	10 gram	0 gram
3	*Polypropylene* (90 gram)	8 gram	2 gram
4	*Polypropylene* (90 gram)	6 gram	4 gram
5	*Polypropylene* (90 gram)	4 gram	6 gram
6	*Polypropylene* (90 gram)	2 gram	8 gram
7	*Polypropylene* (90 gram)	0 gram	10 gram

Based on the table 1, we can find out the composition of *polypropylene* plastic waste used permanently for each sample variation, the variation of each test sample lies in the mass of bagasse fibers and bagasse powder with the 1st variation as a comparison. In this study, the tools used in the study were digital scales, beakers, spatulas, stoves, filters, infrared thermometers, pans, molds, iron saw, basins, crossbars, scissors, calipers, stopwatches, and thermal conductivity tools. The research materials used are bagasse fiber, *polypropylene* plastic waste, bagasse powder, NaOH and aquades.

The stages used in the manufacture of this composite have several stages. The first stage is preparation, which begins with the preparation of bagasse fibers obtained from sugarcane ice traders around the Padang State University campus environment. The sugar content in the bagasse is removed by soaking the bagasse that has been obtained for 1 day, after which it is dried in the sun until it is dry. After drying, the bagasse is combed with a wire brush to separate the fibers and cork. Furthermore, the bagasse fibers that have been separated by cork are cut into pieces 3 cm long [19]. After the fiber is cut, an alkalization process is carried out to remove lignin from the fiber. Alkalization treatment is carried out by soaking fibers using chemicals in the form of 5% NaOH within 2 hours [20]. After the alkalization process, the fibers are washed using clean water, then the fibers are dried by drying in the sun to dry [21]. Next is the preparation of bagasse powder which is used as a filler in composites. Bagasse powder is obtained from the result of the separation between the fibers and the cork of the bagasse, then the powder is mashed with a blender and then sifted using a 30 mesh sieve (0.6 mm). The next stage is the preparation of *polypropylene* plastic waste that serves as a matrix in the composite. The *polypropylene* plastic waste used in this study was obtained from a plastic collector in Tabing, Padang City. The plastic obtained is in the form of plastic that has been chopped, cleaned and dried until dry.

The second stage is the process of making samples. The obtained *polypropylene* plastic waste is melted at a temperature of 160 ºC. When heated, the plastic waste is stirred continuously until melted [22]. After the plastic waste melts, it is then mixed with bagasse fibers that have been cut 3 cm long and the bagasse powder is then stirred until homogeneous. Furthermore, if the dough is homogeneous, it is put into a mold measuring 13 cm x 13 cm x 0.7 cm. Each sample variation there are 3 test samples. The size of each test sample is adjusted to the test equipment, which is 13 cm x 13 cm x 0.7 cm.

The third stage is the testing of test samples. The tests carried out in this study are thermal conductivity tests and porosity tests. Thermal conductivity testing is carried out using the Thermal Conductivity Apparatus, which aimsto find the thermal conductivity value of the composite panel sample. Here are the thermal conductivity testing steps using the Thermal Conductivity Apparatus: 1) Fill the ice bucket with water, then freeze it in the freezer. This step is carried out before the research activities are carried out. 2) Measure the thickness (h) of each sample used in the study. 3) Installing the composite panel sample on the steam chamber tube. 4) The measurement of the diameter of the ice that has been frozen inside the container is denoted by (d1). Then put the ice on top of the composite panel. 5) Let the ice sit on the composite panel for a few minutes so that the ice begins to melt and full contact between the ice and the surface of the composite panel occurs. 6) Determine the mass of the tube used to hold the melted ice denoted by (Mt). 7) The storage of melting ice in a tube with a measurement time (t), which in this study was carried out for 3 minutes. 8) Determine the mass of the melted ice-filled tube (Mta). 9) Determine the mass of melted ice denoted by (Ma). 10) Drain steam into the steam chamber. Let the steam flow for a few minutes until the temperature stabilizes so that the heat flow is in a state of disrepair, or it can be said that the temperature at a point does not change with time. 11) Empty the jar used to collect the melted ice. Repeat Steps 6 to 9 with the steam delivery time to the steam room for 3 minutes (tau). Measurement of the mass of melted ice (Mau). 12) Re-measure the diameter of the ice denoted by (d2). 13) Perform the same activity on the sample with variations in the amount of fiber and other bagasse powder.

The data obtained from the thermal conductivity test are the diameter of the ice before and after it is flowed with steam carried out for 3 minutes, and the mass of ice that melts before and after flowing with steam which is carried out for 3 minutes. The thermal conductivity equation is to measure of how far a material supports (conducts) or resists (insulates) the flow of heat. The value of the thermal conductivity of the sample is calculated using the equation (1):

$$K = \frac{(R_O)(\,L + c\,\Delta t\,)(h)}{(A\,)(\,\Delta T)} \quad (1)$$

Based on equation (1) k is thermal conductivity, R_0 is the rate of melting ice, L is the heat of ice melting, c is a water-type heat, Δt is temperature difference of ice freezes into melting ice, h is the thickness of the sample, A is the surface area of the sample and ΔT is the temperature difference [23].

In the porosity test, all samples were weighed under dry conditions using digital scales. Next all samples are immersed in the same container for 24 hours. Furthermore, the sample that have been soaked for 24 hours are weighed again using digital scales. The data obtained from the porosity test are in the form of masses of dry samples and wet samples. The porosity value of the sample is calculated using the equation (2):

$$P = \frac{M_b - M_k}{V_b} \times \frac{1}{\rho_a} \times 100\% \quad (2)$$

Based on equations (2) P is porosity, Mb is the wet mass of the sample after soaking, Mk is the dry mass of the sample before soaking, Vb is the sample volume and ρair is the density of water [24].

3. Results and Discussion

The results of this study are in the form of thermal conductivity data of composite panels that have been tested using thermal conductivity tools and porosity of composite panels. The data obtained are indirect data, where to obtain the value of thermal conductivity and porosity of the sample is processed using the equation. The results of the thermal conductivity test data that have been obtained are processed using equation (1) to obtain the thermal conductivity value of the test sample. Test sample can be seen in Figure 1.

Figure 1. The Samples

Each sample variation there are 3 test samples. The size of each test sample is adjusted to the test equipment, which is 13 cm x 13 cm x 0.7 cm. Thermal conductivity indicates the ability of a material to conduct heat. The following are the thermal conductivity values of each sample and the average thermal conductivity values of each sample variation can be seen in Table 2.

Table 2. Average value of thermal conductivity

Variations Sample	Thermal Conductivity (W/m°C)			Average grades Thermal Conductivity (W/m°C)
	Sample 1	Sample 2	Sample 3	
Variation 1	0,22949	0,2278	0,22285	0,22672
Variation 2	0,16055	0,16374	0,16294	0,16241
Variation 3	0,13192	0,13638	0,13798	0,13543
Variation 4	0,09569	0,09586	0,09593	0,09582
Variation 5	0,11204	0,11337	0,11831	0,11457
Variation 6	0,15083	0,15128	0,15843	0,15351
Variation 7	0,18016	0,18428	0,18384	0,18276

In Table 2 there is a thermal conductivity value in each sample variation, where each sample variation consists of three samples. Table 2 also contains the average thermal conductivity values for each sample variation. If plotted in the graph, it can be seen the value of thermal conductivity of composite panels. The relationship between each variation in the composition of the sample against the average thermal conductivity value can be seen in Figure 2.

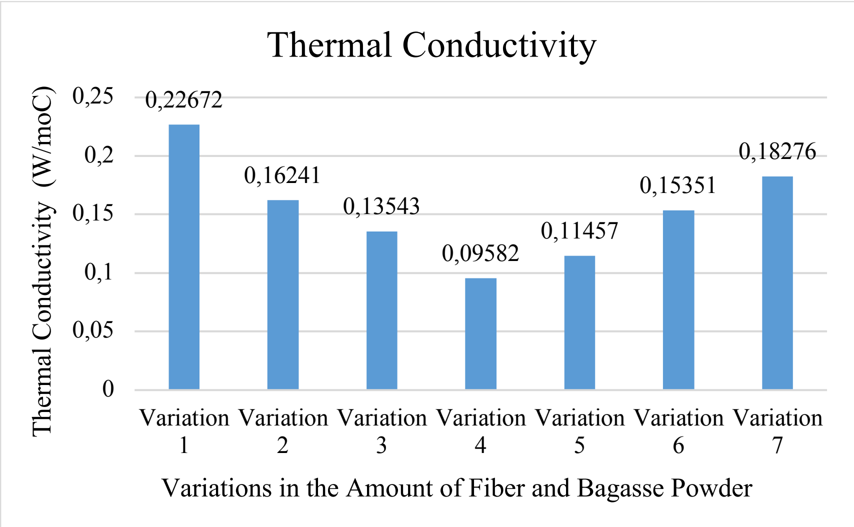

Figure 2. The relationship between each variation in the composition of the sample against the average thermal conductivity value

Based on the figure 2, it can be seen that the composite panel of variation 1 with a percentage of polypropylene matrix of 100% without fibers and powders has the highest average thermal conductivity value of 0.226715 W / m°C, followed by a variation in the percentage of fiber and bagasse powder in variation 2, variation 3, variation 4, variation 5, variation 6, and variation 7 resulting in an average thermal conductivity value of 0.16241 W / m°C, 0.13543 W/m°C, 0.09582 W/m°C, 0.11457 W/m°C, 0.15351 W/m°C, 0.18276 W/m°C. With the optimum percentage in variation 4 with an average thermal conductivity value of 0.09582 W/m°C, which indicates that the addition of fiber and bagasse powder affects the thermal conductivity value in the composite panel.

This is because bagasse contains silica which is an insulator ceramic material. Previous studies have stated that the decrease in thermal conductivity values is influenced by the greater percentage of the fiber content of bagasse. This is because silica in the bagasse has a role in resisting heat conduction [11][12].

The results of this study are also supported by previous studies which stated that bagasse contains the dominant cellulose, which is around 26%-43%. Cellulose in the bagasse fibers creates air cavities contained in the composite that can provide insulator properties, so as to reduce the transfer of heat energy to the particles in the composite panel [11][25][26].

Variation 5, variation 6, and variation 7 resulted in an increase in the average thermal conductivity value of 0.11457 W/m°C, 0.15351 W/m°C, 0.18276 W/m°C. Where the percentage of bagasse powder is greater than the percentage of bagasse fiber. The increase in the thermal conductivity value in variation 5, variation 6, and variation 7 is also due to the small particle size in the bagasse powder so as to create fewer cavities and make the composite panels denser, so the thermal conductivity value also increases. This is also supported by previous research which states that the particle size in small composite panels is not enough to create cavities which causes an increase in the thermal conductivity value of composite panels [27].

Previous research stated that a good material for use as a heat insulator material is a material with a thermal conductivity value around 0,1 W/m°C [12], therefore, it can be concluded that composite panels with variation 4 and variation 5 with average thermal conductivity values successively of 0.09582 W/m°C, and 0.11457 W/m°C meet the standard as composite panels with good heat insulators.

Another actor that affects the thermal conductivity of the material is porosity. The more holes in the sample, the lower the thermal conductivity. The pores contained in the sample contain gases. gases are poor conductors of heat compared to liquids and solids. Due to the heat conductivity of the air trapped inside the pore, the thermal conductivity value is low [28].

Based on the measurement data that has been obtained, the next step is to determine the porosity value of the test sample with the measurement data of the mass of the dry sample and the mass of the soaked wet sample and then calculated using the formula in equation (2). The following is the porosity of each sample and the average porosity value of each sample variation can be seen in Table 3.

Table 3. Porosity Values of Each Sample Variation

Sample Variations	Porosity (%)			Average Porosity (%)
	Sample 1	Sample 2	Sample 3	
Variation 1	0,60862	0,52409	0,76078	0,63116
Variation 2	2,92477	2,78107	2,81488	2,84024
Variation 3	3,45731	3,41505	3,21217	3,36151
Variation 4	4,01522	3,71090	3,82925	3,85179
Variation 5	3,46577	3,12764	3,15300	3,24880
Variation 6	3,08538	3,11074	3,06002	3,09383
Variation 7	2,66272	2,78952	2,50211	2,65145

In Table 3 there is a porosity value in each sample variation, where each sample variation consists of three samples. Table 3 also contains the average porosity values for each sample variation. If plotted in the graph, you can see variations in the amount of fiber and bagasse powder and the porosity value of the composite board as shown in Figure 3.

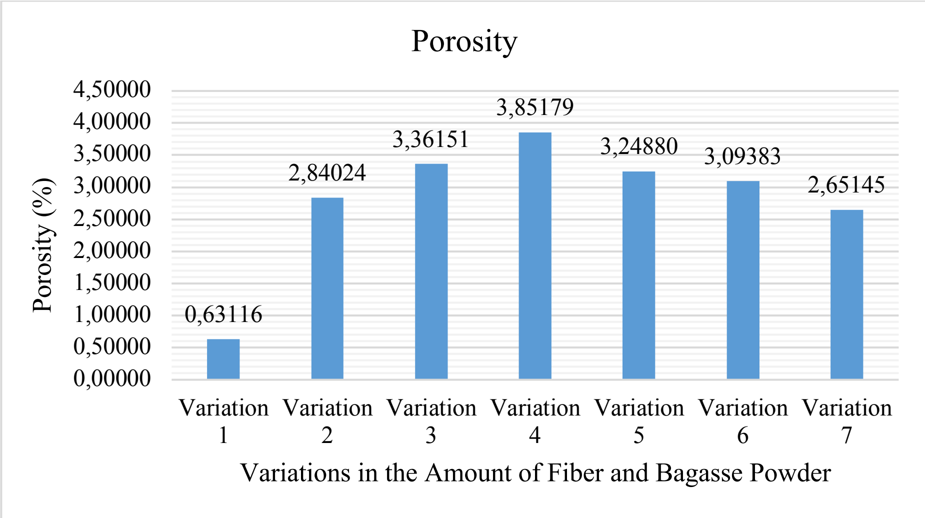

Figure 3. The relationship between each variation in the composition of the sample against the average porosity value

Based on the figure 3, it can be seen that the composite panel of variation 1 with a percentage of polypropylene matrix of 100% without fibers and powders has the lowest average porosity value of 0.63%, indicating that the constituent material is tighter which fills the cavities in the composite panel which results in its porosity becoming smaller. Followed by variations in fiber and bagasse powder in variation 2, variation 3, variation 4, variation 5, variation 6, and variation 7 resulted in an average porosity value of 2.84024%, 3.36151%, 3.85179%, 3.24880%, 3.09383%, 2.65145%. With the optimum percentage in variation 4 with an average porosity value of 3.85179%, which shows that the addition of fiber and bagasse powder affects the porosity value on the composite panel.

Composite panels with variation 2, variation 3, and variation 4 resulted in an increasing average porosity value with porosity values of 2.84024%, 3.36151%, 3.85179%. This is because bagasse contains cellulose which is dominant, which is around 26%-43% creating air cavities contained in the composite so that porosity increases. Cellulose in the board contains voids that can provide insulator properties as well, so it can help reduce the transfer of heat energy in the particles in the board [11][12][27].

The thing that causing the formation of voids on composite panels because the addition of fiber and bagasse powder with *a polypropylene* plastic waste matrix causes the mixture on the composite panels to be inhomogeneous, this has an impact on combining the fibers and bagasse powder with *polypropylene* plastic waste to be imperfect and create a cavity between the constituent components [29].

Another factor that causes the creation of voids in composite panels is the *polypropylene* matrix which has a high viscosity. This causes the matrix distribution in the composite panel to be uneven, the matrix distribution does not meet the entire sample evenly because from the characteristics of the fiber and the bagasse powder itself which has many pores, the matrix distribution cannot penetrate the fibers and bagasse powder and results in the sample part having cavities. The uneven distribution of the matrix is also due to the percentage ratio between the amount of *polypropylene* matrix with fibers and bagasse powder, where the greater the amount of fiber and bagasse powder, the more difficult the matrix is evenly distributed, finally the void will follow the increase in fibers and bagasse powder [30].

The porosity value affects the thermal conductivity ability of a composite. One of the factors affecting the value of thermal conductivity of composite panels is porosity and density. The larger the pores contained in the composite panel, the smaller the value of thermal conductivity. In the pores of composite panels there is a gas which is a material that is bad at conducting heat when compared to liquids or solids. The gas contained in the pores has a gas phase where the distance between the molecules is far apart and moves randomly so that with low conductivity the air trapped in the pores of the composite panel makes the thermal conductivity value on the composite panel also low [31].

In composite panels with variation 5, variation 6, and variation 7 have average porosity values in a row of 3.24880%, 3.09383%, 2.65145% which decreased compared to variation 4, the particle size of bagasse powder and the percentage of bagasse powder which is more than the percentage of bagasse fiber resulted in a decrease in the porosity of the composite panel. The particle size in a small composite panel were not enough to create cavities that cause the decrease of porosity values in the composite panel. This is supported by previous research which states that the smaller the particle size, the smaller the porosity in composite panels, the small particle size causes the pores on the composite panel to become less and less [27][31].

Previous research has said that non-porous material is a material that has a porosity of less than 0.25 or 25% and porous materials usually have a porosity greater than 0.4 or 40% [15][16]. Based on the results of the research obtained, it can be seen that the porosity value on the composite panel still does not meet the criteria as a porous material. It is recommended to uses other natural fiber as reinforcer in composite panel and other natural filler with bigger particle size.

4. Conclusion

Based on the results that has been carried out, it is found that the percentage of fibers and bagasse powder can affect the decreased of thermal conductivity in composite panels which is needed for composite materials with good thermal insulation properties. The thermal characteristics of the composite materials also influence the low thermal conductivity value. Low thermal conductivity value comes from the Polypropylene content which has a low thermal conductivity value, as well as the addition of fiber and bagasse powder which contains silica which is a thermal insulator. The other factor that influences the decrease in the of thermal conductivity value of the composite is porosity. From the research results it was also found that a high porosity value succeeded in affecting the decrease in the thermal conductivity value of the composite board which means that the greater the of porosity value, the smaller of thermal conductivity value.

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