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Effect of Clay Powder Composition on the Tensile Strength and Burn Resistance Properties of Coconut Fiber Composite Materials

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A R T I C L E I N F O

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A B S T R A C T

Composite materials are developing very rapidly. Composite materials widely used in the automotive industry there are required to have burn resistance. In transportation service regulations, suggested that this material must be burnt-resistant to reduce the high risk. There is clay which obtained from grinding red bricks. Size is mesh 200. Variations used are 0:2:88; 3:9:88: 6:6:12; 9:3:88; 12:0:88 (clay, fiber, polyester resin: %). This research aims to determine composite materials' tensile strength and burn resistance. The method used is printing specimens using the hand layup method. The tests carried out were tensile tests, burn tests, and SEM photos. The research results show that at a composition of 0% clay, the tensile strength is 55.65 MPa. The maximum tensile strength at a percentage of 3% clay is 58.67 MPa. The tensile strength decreases at percentages of 6, 9, and 12 clay. Maximum burn resistance at a percentage of 12% clay. The smaller the clay percentage, the higher the burning speed. From the test results, the percentage suitable for use in industry is 3% clay and 9% fiber. This material has tensile strength that meets standards and good burn resistance.

Introduction

Composite materials in the field of materials engineering are developing very rapidly. Its use as a substitute for metal is increasingly widespread, such as for sports equipment, means of transportation (land, sea, air), construction, and the world of space. The advantages of using composite materials include corrosion resistance, the ratio between strength and density is quite

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high (light), cheap, and the manufacturing process is easy. The use of fly ash (coal waste) material as a composite material mixture has been widely studied. The ever-increasing use of coal can cause an extraordinary accumulation of fly ash waste. This can cause serious problems for the environment, such as air pollution, water contamination, and so on.

Geopolymer composite technology is a technology that is still new internationally and is the technology of the future for Indonesia. The development of geopolymer composite technology has penetrated the world of transportation because of its lightness, fire resistance, and strength. Geopolymer materials in Indonesia are still relatively abundant.

Currently, one of the material requirements for transportation equipment is that it has burn resistance so that passenger safety is higher. This has been done at PT INKA Madiun, which has produced train interior panel products from geopolymer composites. Research has been conducted on the use of clay and glass fiber as fire-resistant materials [1]. The research results show that this material is suitable for the automotive industry.

Further research has been carried out regarding the use of natural fibers as composite materials [2]–[4]; The research results show that this material is suitable as a substitute for synthetic fibers. It's just that the strength has decreased slightly; this is because natural fibers have non-uniform sizes. Research on natural fiber pull outs has also been carried out, the results being that the effective fiber length is an average of 4 mm [5].

Composite materials are structural materials consisting of two or more materials combined at a macroscopic level and insoluble in each other. Composites are multi-phase systems composed of matrix materials and reinforcing materials. The matrix material is the continuous phase, and the reinforcement is the dispersed phase. Reinforcing materials can be fibers, particles, or flakes [6]; composites with a polymer matrix are materials that use polymer as a matrix and fiber as a reinforcement. Fibers commonly used in fiber-reinforced polymer composite materials are glass fiber, carbon fiber, and other organic fibers. Typically, the strength and stiffness of the fibers used are much higher than the strength and stiffness of the matrix. The matrix material must have good adhesive properties to the fibers so that it can bind the fibers strongly and transfer the load received by the composite to the fibers. In composite materials, the performance of the matrix, the performance of the fibers, and the nature of the interface between the matrix and the fibers will have a very significant influence on the properties of the composite material. Tensile strength testing is carried out to determine the tensile strength properties of the material. Testing is carried out in accordance with ASTM 638 [7]. The shape and size of the tensile test specimen are shown in Figure 1.

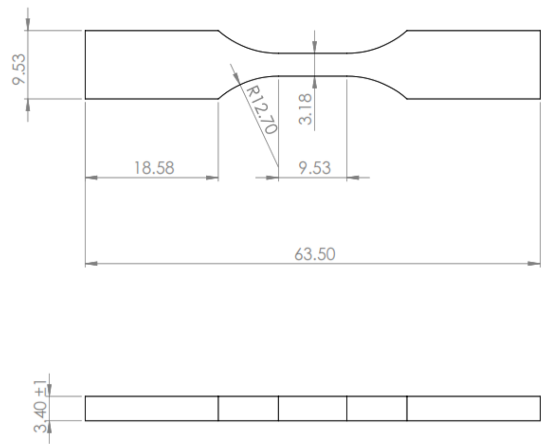

Figure 1. ASTM 638 tensile test specimen

Using natural fibers as reinforcement in composite materials has been widely researched and applied in the automotive industry [8]–[11]. However, there are several areas for improvement, namely that it is resistant to heat and burns. This is challenging for researchers to obtain materials made from natural fibers with burn-resistant properties. In this research, an additional material, namely clay, is added as a mixture. The hope of this research is to obtain material that is burn-resistant. This is in accordance with the material requirements that apply to automotive industry components, which must be strong and burn-resistant in accordance with transportation laws. Burn resistance testing is determined through burn testing according to ASTM 635, as shown in Figure 2.

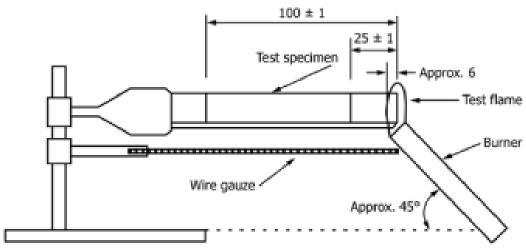

Figure 2. ASTM 635 burn test

Polymer matrices usually used for military applications can be thermoset resins or thermoplastic resins. The most common thermoset resins used in ballistic composites are phenolic, epoxy, vinyl ester, and polyester. Polyester resin is often chosen because of its flame-retardant properties, resistance to fluids and chemicals, high stiffness, and good ballistic efficiency when combined with natural fibers. In this study, clay powder was used as an additional reinforcement. Clay powder is used as a reinforcement with the aim of making the composite material have good fire resistance. This material can be used as a supporting material for the manufacturing industry, especially the automotive industry.

Research Methods

In this research, the materials and tools used include roof tile powder clay produced by processing roof tiles by crushing them into granules, after which they are sifted until a grain size of 200 is obtained, Polyester Resin, and coconut fiber. The length of coconut fiber fiber is 4 mm. Print using the hand layup method. The mold is made of glass with a thickness of 5 mm. The mold is bolted with dimensions of 20 cm x 30 cm (one mold can produce 5 tensile test samples and five burn test samples).

Table 1. composite mixture percentage

No	Clay (%)	Coconut fiber (%)	Polyester resin(%)
1	0	12	88
2	3	9	88
3	6	6	88
4	9	3	88
5	12	0	88

The tools used include:
Crushing machine, used to crush clay into powder.

- Digital balance. This tool is used to weigh materials with an accuracy of 0.001 g and a maximum capacity of 500 g.
- Sieve used to sift Sokka tile powder with 200 mesh
- Stirrer and stirrer: this tool is used to mix materials, namely phenolic, with clay powder
- Other tools are scissors, a cutter, a ruler, a caliper, a hand grinder, and an Astralon.
- The mold is made of glass, which is designed according to size.
- Burn test equipment in accordance with ASTM 635
- Digital clock: to measure the flame time and burning speed of the specimen
- Scanning Electron Microscope (SEM): used to observe the fracture surface morphology and topography of the sample.

Results and Discussion

Composite tensile strength

The tensile test results show that at a percentage of 0% clay: 12% fiber, the tensile strength value has a tensile strength of 55.65 MPa. At a percentage of 3% clay, 9% fiber has the highest tensile strength, namely 58.67 MPa. Meanwhile, the lowest value at a percentage of 12% clay is 0% fiber, with a

tensile strength value of 34.76 MPa, according to Figure 3. At a percentage of 0% clay powder: 12% fiber, the tensile strength is smaller compared to the variation of 3 % clay powder: 9% coconut fiber this is because in the variation of 3% powder in addition to providing tensile strength value also provides fire resistance. This is due to the bond between clay powder, coconut fiber and polyester resin is maximum. While in the variation of 6% clay powder and 6% coconut fiber, there is less than optimal bonding.
This shows that at a percentage of 3% clay and 9% fiber, the matrix is able to hold the reinforcement optimally. The increase in tensile strength is influenced by good bonding between the matrix, fiber, and clay. This shows that the matrix holds to the maximum.
At a fiber percentage above 6%, the ability of the matrix to hold fiber is reduced. This causes the bond between the matrix, clay, and fiber to decrease. As the main function of the matrix is to protect and hold the fiber, so if the fiber composition exceeds its capacity and function it cannot be maximized.

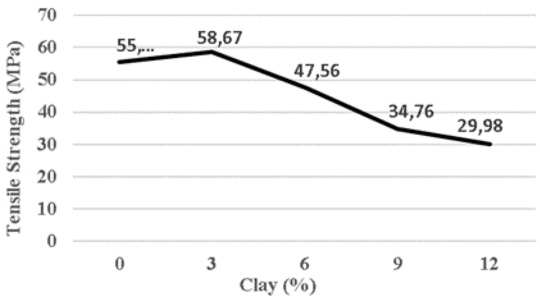

Figure 3. Tensile strength test results

Burn resistance

The burn test results show that as the percentage of clay increases, the burn resistance value also increases, as shown in Table 1. Burn resistance can be seen when the burning speed of the test specimen becomes smaller.

Table 2. Burn time and burn speed

Percentage of clay, fiber and matrix (%)	Ignition time (seconds)	Burn speed (mm/Minute)
0; 12; 88	28,88	12.67
3; 9; 88	31,76	13.45
6; 6; 88	33,65	14,21
9; 3; 88	36,23	14.76
12; 0; 88	40,45	15.56

Ignition time shows that materials that have more clay elements have longer ignition times. This shows that clay material can make composite materials non-flammable.

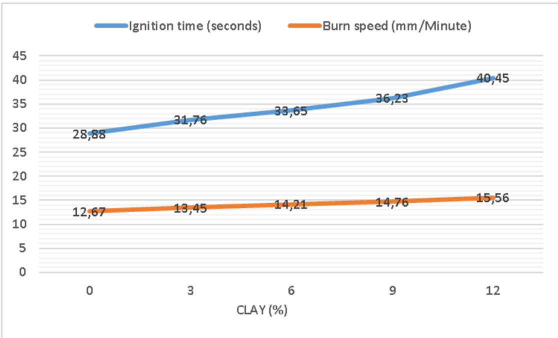

Figure 4. Relationship between ignition time and burn rate

The burning speed will be proportional to the ignition time, where the higher the percentage of clay, the lower the burning speed. This shows that composite materials with clay reinforcement are suitable to be used as industrial manufacturing materials.

Composite Fracture Surface Observation

Figure 5 shows the SEM results of tensile fracture test specimens with variations of 3% clay to 9% coconut fiber fibers, showing the fibers that are uprooted in the matrix. The image shows the loose fibers in the matrix, it looks clean. Things like that show that the bond between the fibers and the matrix is not good.

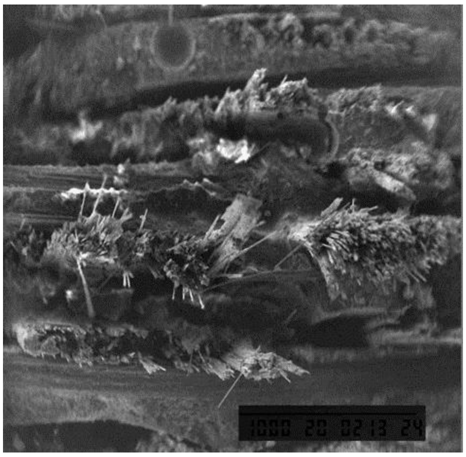

Figure 5. SEM tensile test fracture of composition 3% clay 9% fiber

Figure 6 shows the fibers released from the matrix, with traces of the fibers still attached to the matrix. This shows that the fiber and matrix bonded well. This is because the surface of the fibers is clean and grooved so that the matrix can bind well.

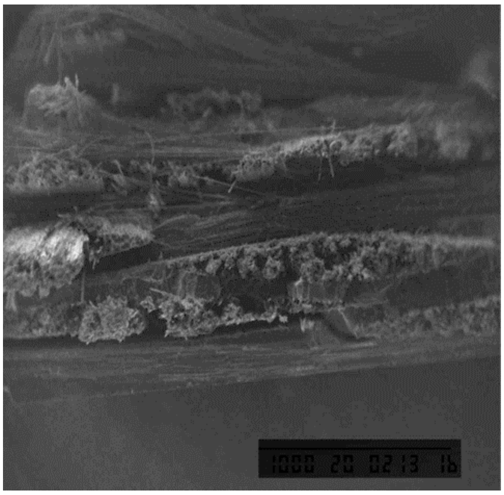

Figure 6. SEM tensile test fracture of composition 3% clay 9% fiber

Figure 7 shows the fiber surface without soaking treatment. The image shows a surface that looks dirty. It is indicated that the fiber surface still contains a lot of lignin or other impurities. If the surface interacts with the matrix, the matrix cannot bind properly. This is because the surface of the fibers and matrix still contains lignin as a separating wall.

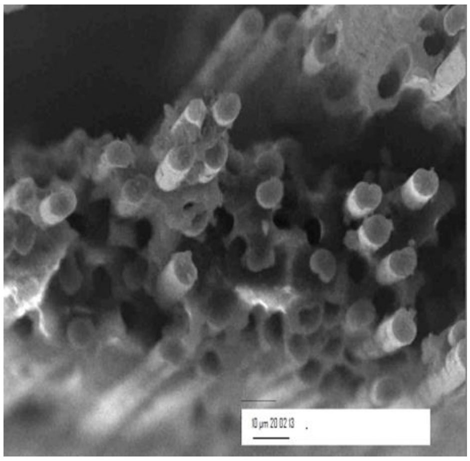

Figure 7. SEM tensile test fracture of composition 3% clay 9% fiber

Figure 7 shows a clean, grooved surface with cavities. The surface of the fibers makes the bond between the fibers and the matrix better. Figure 5.7. shows the fibers released from the polyester matrix; the image shows the fibers are released and look clean. The image shows that the fiber and matrix bonds are not good.

Conclusion:
The research results show that clay powder, as a composite mixture, can increase tensile strength and burn resistance. Clay powder can be used as a composite material for the manufacturing industry. It is easy to obtain and available in abundance. This composite material is durable, so it is suitable for use in the automotive industry.

Suggestion
To improve the quality of good research, it is necessary to carry out in the future, among others:

- The number of samples must be increased because natural fibers vary significantly in dimensions and quality.
- Measurement accuracy needs to be improved, this is because the dimensions of natural fibers are irregular in shape.

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