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STUDY OF THE ROLE OF HDPE WASTE AS A MATRIX FOR COMPOSITES REINFORCED BY IVORY FIBER FOR AUTOMOTIVE PRODUCTS

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Abstract

Hybrid composites are composites composed of several matrices and fibers, where the fiber types are vertical fibers and random fibers. The materials used to make hybrid composites are HDPE waste and palm fiber. With variations in fiber and powder volume fractions of 70%: 30% 60%: 40% and 50%: 50%, with different fiber directions, namely vertical and random, specimen making and testing procedures refer to ASTM D 638 for tensile tests and ASTM D256-03 for impact tests. A study has been conducted on the effect of variations in volume fractions in hybrid composites on the mechanical properties of the composite. The tests carried out in this study were tensile tests and impact tests. The results of the tensile test showed the highest value of 16.588 MPa for the variation of the HDPE volume fraction of 70% fiber 30% vertical fiber direction and the lowest value was 8.2762 MPa for the variation of the HDPE volume fraction of 60% fiber 40% with random fiber direction. While for the impact test the highest value was 8.53 joules with the variation of the HDPE volume fraction of 60% fiber 40% vertical fiber direction and the lowest value was 4.53 joules with the variation of the volume fraction of 60% fiber 40% with random fiber direction. It was concluded that if using the unidirectional fiber direction (vertical) to make the specimen, it will have better strength and toughness values.

Keywords: ***Palm fiber, tensile test and impact test, composite, HDPE***

INTRODUCTION

Plastic is a material that is very familiar in human life and has been considered as a basic material for household or domestic needs so that the existence of plastic waste is increasing. Processing plastic waste into fuel oil is one of the developments of science that provides positive benefits to overcome environmental problems. Plastic is also an artificial inorganic material composed of chemicals that are quite dangerous for the environment. Plastic waste is very difficult to decompose naturally, to decompose plastic waste requires approximately 80 years to be completely degraded. (Eddy Kurniawan, 2014). Amidst the advancement of composite technology, natural composites or natural composites (NACO) have emerged as a result of this advancement, due to their recyclable and renewable nature. Polymer composites with natural fibers have many advantages compared to synthetic composites. Due to their excellent mechanical properties, heat and sound insulation properties, corrosion resistance, and good electrical insulators, polymer composites have become highly sought-after materials as substitutes for metals and carbon. In addition, polymer composites are also environmentally friendly. (Sirait, 2010).

Natural fibers as polymer composite fillers are starting to be widely used in the field of material engineering. The reason for using natural fibers as composite material reinforcements is because natural fibers are easy to obtain, inexpensive, have various types and many variations. One of the natural fibers that can be used as composite reinforcement is sisal fiber. This type of fiber is a natural fiber that comes from the leaf petals of the sisal plant after going through a fiber separation process. (Zulmiardi, 2022). Now, the use of composite materials in everyday life is very diverse, for example for the manufacture of household appliances, machine components such as ship guards, cars, and motorbikes made of polymer composite materials. The use of natural polymer composite materials in the automotive industry is currently also experiencing rapid growth and is trying to replace the use of artificial polymer composite materials that are commonly used as reinforcements in composite materials such as E-Glass, Carbon, and Silicone Carbide. The use of polymer composite materials in the production of car components has been proven to be able to balance car functions such as reducing weight and maintaining passenger safety.

(Ezekweb. 2016). Based on the explanation that has been explained, there are main problems that inspired the author to conduct research on "Study of the Role of HDPE Waste as a Matrix for Composites Reinforced with Palm Fiber for Automotive Products".

In addition, the use of natural fibers as raw materials for products has been widely studied in obtaining information on the mechanical properties of products to meet the safety and economic standards of the product. Therefore, research on the potential for developing polymer composite materials with natural fibers in automotive products is very important in order to provide a reference for more measurable material development. In addition, it also aims to create more efficient and environmentally friendly products. The results of this study are not intended to be complete data, because the focus of this study is on the use of natural fiber polymer composites for automotive products in terms of fiber availability and tensile strength of the polymer composite.

Formulation of the problem

The utilization of palm fiber waste is still not optimal or its utilization is still limited, therefore palm fiber can be used as an alternative raw material for making composites, which is expected to be a solution in waste management. From the description above, the formulation of the problem in this study is:

1. What are the impact strength, tensile strength and toughness values of palm fiber composites based on variations in volume fraction?
2. How does the addition of the volume fraction of palm fiber in the composite affect the impact strength and tensile strength?
3. What are the characteristic properties of palm fiber reinforced composites?

Research purposes

Based on the problem formulation above, the objectives of this study are:

1. Determining the effect of adding the volume fraction of palm fiber to the composite on impact strength and tensile strength.
2. To utilize the waste of aren fiber which was initially useless to make a composite
3. To determine the characteristic properties of fiber reinforced composites
4. Determining the characteristic properties of palm fiber reinforced composites based on mechanical tests

Benefits of research

The benefits of this research are:

1. This research can add to the scientific knowledge base in the industrial and knowledge fields.
2. It can provide benefits, inspiration and references for further research, especially related to composite materials reinforced with natural fibers, where the materials can be easily obtained and can be renewed.
3. Increasing the economic value of palm fiber as a new, quality material.

Research Limitations

There are many things that can be researched and things that can influence the characteristics of palm fiber composites, so the author has research limitations on the following matters:

1. Mechanical tests carried out on composites are tensile testing and impact testing
2. The fiber used is palm fiber.
3. The type of resin used as a composite matrix is HDPE Plastic Seed.
4. The mechanical properties tested in this study were stress, strain, elasticity, toughness and brittleness.

LITERATURE REVIEW

A. Composite

The general nature of composite materials is to have varying bonds with microstructures in the form of matrices and reinforcements. The advantages of this material are strong, stiff, and lightweight, but its 'weakness' is that it is expensive and experiences delamination. Current developments in this millennial century, composite materials have been widely applied to transportation equipment (land, air, sea), machinery, electronics, and buildings. (Tjahjanti, 2018). Composite is one type of material that exists today besides other materials such as metals, polymers and ceramics. Composite material is a multi-phase material, namely a mixed material made of two or more types of materials, with the mixing of which no chemical reaction occurs. The properties of composite materials are a combination of the properties of the constituent materials, namely the matrix and reinforcement or filler, both of which have different properties. The provisions for reinforcing materials must be able to support/improve the properties of the matrix in forming composite materials. (Tjahjanti, 2018).

One of the advantages of composite materials is the ability of the material to be directed so that its strength can be adjusted only in a certain direction that we want, this is called "tailoring properties" and this is one of the special properties of composites, namely light, strong, not affected by corrosion, and able to compete with metals, without losing its characteristics and mechanical strength. In the composite system, 2 types of materials are needed as components, namely reinforcing materials (reinforcement) and binding materials (matrix). Fiber reinforced composites are widely applied to tools that require a combination of two basic properties, namely strong but also light. Composite materials have many advantages, including low specific gravity, higher strength, corrosion resistance and lower assembly costs. The main elements of the composite are fillers in the form of fibers as a framework and other supporting elements, namely the matrix. Fillers and matrices are two elements needed in the formation of composite materials.

B. Reinforcement or Filler or Fiber

Reinforcement is one of the main parts of the composite that plays a role in holding the load received by the composite material so that the high or low strength of the composite is very dependent on the reinforcement used. Fiber is a filler material used in making composites, usually in the form of fibers or powders. Reinforcement materials are usually stiff and tough. Commonly used reinforcement materials are particle types, natural fibers, carbon fibers, glass fibers and ceramics. Based on the form of the reinforcing material, three groups of composites are generally known, namely:

1. Whisker Reinforced Composite in this composite the type of reinforcing material used is the form of whisker or discontinuous fiber (short fibers). Whisker short fibers are made of materials such as metal oxides, carbides, and nitrides. Whiskers that are strong and stiff when added to a ductile matrix will be able to produce a strong, stiff and elastic composite material. Adhesion occurs between the whisker and the binding material (matrix).
2. Continuous Fiber Reinforced Composites In this type of composite, the binding material used is in the form of long fiber filaments. Continuous reinforced composites are in an ideal state following the mixture rules based on the suitability of their fabrication techniques between the estimated mixture rules and their properties.
3. Particles have various effects on KML (Metal Matrix Composites). Depending on the nature of the two components. Ductile particles are added to a brittle matrix so that its toughness increases, and cracks that occur can be eliminated by the presence of these particles. Particles that have a high elastic modulus are added to a ductile matrix to increase stiffness and toughness. As expected, hard particles generally reduce cracks in soft matrices so that their use limitations can be increased. If the hard particles in a matrix are very small and limited in number, the strength reduction is low. In resin matrix composites, strength increases can be done by sintering (if the matrix shape is also particles).

C. Matrix

Generally, matrices are made of soft and ductile materials. The selection of matrix and fiber materials plays an important role in determining the mechanical properties and properties of the composite. The combination of matrix and fiber produces a composite that has higher strength and stiffness (Gibson, 1994). The matrix in the composite structure comes from polymer or metal materials. The main requirement of the matrix used in the composite is that it must be able to transmit the load, so that the fibers can adhere to the matrix and be compatible between the fibers and the matrix. The matrix in the composite composition serves to protect and bind the fibers so that they work well. The matrix also functions as a fiber coating.

The matrix is the phase in the composite that has the largest portion or volume fraction. The matrix has the following functions:

1. Protects fibers from mechanical friction.
2. Transfers stress to the fibers evenly.
3. Protects from adverse environments.
4. Holds and maintains the fibers in position.
5. Remains stable after manufacturing process

D. Natural Fibers For Composite Reinforcement

The fibers from these plants can be considered completely renewable and biodegradable. Plant fibers, which have a long history in human civilization, have gained economic value and are now cultivated on a large scale globally (Henry Wardhana et al, 2016). Nature's abundance provides us with many materials that can be called fibrous. Plant fibers are obtained from various parts of plants, such as seeds (cotton, kapok, milkweed), stems (jute, flax, ramie, kenaf, nettle, bamboo), and leaves (sisal, manila, abaca), fruits (coir) and other grass fibers.

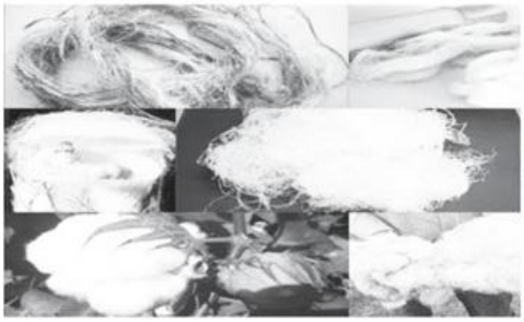

Figure 1. Natural Fiber (Source: Henry Wardhana et al, 2016)

The advantages of using composites include being lightweight, corrosion-resistant, waterproof, attractive performance, and no machining process. The price of component products made from glass fiber reinforced plastic (GFRP) composites can drop by up to 60%, compared to metal products. Various composite industries in Indonesia still use glass fiber as a reinforcement for composite material products, such as PT. INKA. The use of composites in industry can reduce the use of imported metal materials that are more expensive and easily corroded (Henry Wardhana et al, 2016). Various types of natural fibers have been explored to produce composite materials that have sales value and have been produced. Types of natural fibers such as; Sisal, Flex, Hemp, Jute, Rami, Coconut, are starting to be used as reinforcing materials for polymer composites. The matrix functions as a fiber retainer to unite, distribute the load and also functions as a wrapper. The use of polymer matrices is easy, because the operating temperature is low and this polymer matrix can be divided into two, namely, thermoset and thermoplast. Fibers function as reinforcement and cause increased tensile strength and stiffness. The selection criteria for selecting suitable fiber reinforcement are as follows: elongation, heat (stability) adhesion of fibers and matrices, dynamic behavior, long-term behavior, and price and processing costs, (Riedel, U., Nickel, J, 2005).

E. Palm Fiber

Palm fiber also has advantages compared to other natural fibers. Fibers produced from the sugar palm tree have special properties such as: slowing down wood decay, resistant to acid and seawater salt, and preventing subterranean termite attacks (Munandar, 2012). Polymer composites with natural fibers such as palm fiber have advantages when compared to synthetic fibers, palm fiber composites are cheaper in terms of price compared to synthetic fibers.

Figure 2. Palm fiber (Source: Munandar, 2012)

F. HDPE (High-density polyethylene)

HDPE (High Density Polyethylene) HDPE is polyethylene with fewer branch chains compared to PE (Polyethylene). These fewer branch chains make HDPE plastic have stronger, harder, opaque and more resistant to high temperatures. Hydrogen bonds between molecules in this plastic also play a role in determining the melting point of the plastic (Muhammad Ikhwan, 2022). HDPE has a fairly high melting point, therefore HDPE is often used in packaging for milk bottles, tupperware, drinking water gallons, folding chairs, detergent packaging, and milk packaging. HDPE Plastic Seeds can be seen in Figure 3.

Figure 3. HDPE Plastic Seeds (Source: Muhammad Ikhwan, 2022)

G. Tensile Test

Tensile testing is the application of tensile force or stress to a material with the intention of knowing or detecting the strength of a material (Salindeho, 2018). From this test, the mechanical properties of the material can be determined which are very much needed in engineering design. Tensile strength is the maximum stress that can be withstood by the test object material before breaking or being damaged, the maximum load divided by the initial cross-sectional area of the test object. The tensile test is taken based on a specimen that has been damaged with static testing conditions and the results obtained are in the form of tensile strength. Tensile testing is carried out to determine the tensile strength of the composite material. Testing is carried out using a "Universal Testing Machine" testing machine. Tensile test specimens are formed according to the ASTM D 638 standard shown in Figure 5 below:

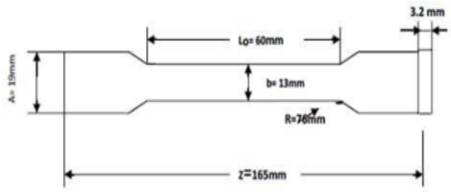

Figure 4. ASTM D 638 specimen

In general, the working principle of tensile testing is to pull a specimen with a pulling tool equipped with a data logger, until the specimen breaks. Data recording is carried out from the time the specimen is pulled until the specimen breaks.

Figure 5. Tensile Testing Machine Source: PT. Geotek Saintifik Indonesia

Tensile testing is used to test the strength of composite materials by applying a uniaxial force load. The results obtained from tensile testing are very important for engineering and product design because they produce material strength data. From this tensile testing we can find out some of the mechanical properties of materials that are very much needed in engineering design. The linear equation of the relationship between stress and strain can be seen in the equation below:

1. Voltage formula:

   $\sigma = F/A$ ....(2.1)

2. Strain formula:

   $\varepsilon = \Delta L/Lo \ x100\%$ .... (2.2)

3. Elastic modulus formula:

   $E = \sigma/\varepsilon$ ....(2.3)

   Information :

   σ: Stress (MPa)

   F: Style (N)

   A: Surface Area (mm²)

   ε: Strain (mm)

   ΔL: Length Increase (mm)

   Lo: Initial Length (mm)

   E: Modulus of Elasticity (MPa)

Impact Test

Impact testing is one of the methods used to determine the strength, hardness, and ductility of a material. Therefore, impact testing is widely used in the field of testing the mechanical properties of a material (Wardani, 2017). The toughness of the composite can be determined using the impact test. This test aims to measure the toughness or ability of a material to absorb energy before breaking (toughness). Impact testing is carried out on standard test rod specimens. The material to be tested is initially made into a test rod with a shape according to a certain standard. The middle part of the test rod is the part that receives the tension. The impact test has a test method, namely impact charpy. The principle of the impact charpy test aims to determine the level of resistance or toughness of a material and the test is carried out on the machine according to ASTM D 256 - 03. Can be seen in Figure 6. below:

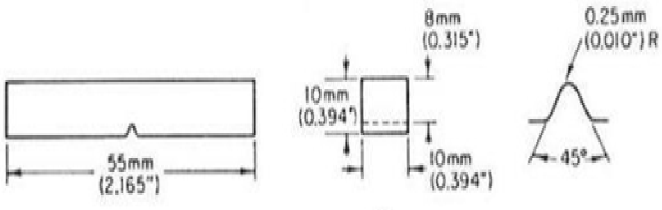

Figure 6. Impact Test Specimen Source: (Sutrisno & Azmal, 2020)

METHOD

The research location was conducted at the Mechanical Engineering Laboratory of HKBP Nommensen University, Medan. This research consists of several stages starting from the preparation of tools and materials, preparation of testing on samples and data collection on testing. Overall, this research was carried out from March to May 2025.

Tools and materials

The following tools and materials were used in this research:

Tool

The tools used in this study are:
1. Print 15 x 17 x 0.2 cm.
2. Digital scales
3. Hot press machine (hydraulic test press)
4. Tensile testing machine
5. Paintbrush
6. Impact testing machine
7. Other tools include gloves, tweezers, ruler, cutter, scissors and stirrer.

Material

The materials used in this study are:
1. Palm fiber
2. wax
3. HDPE plastic pellets

Research Variables

This research was conducted by means of several tests, by creating a composite for testing. The variables used in this study are:

Fixed Variables
1. HDPE Plastic Granules
2. Palm Fiber
3. Print (15 x 17x 0.2) cm
4. Press temperature 160°C
5. Pressing time 10 minutes
6. Press pressure 1 Psi

Independent Variable

The independent variables used in the study were the comparison of the volume fraction of palm fiber and HDPE plastic pellets with variations.

Dependent Variable

The dependent variables used in this study are:
1. Impact Test
2. Tensile Test

Work procedures

The work procedures in this research are divided into several processes, namely:
1. Drying the coir fiber for 3 days
2. HDPE melting using extruder machine
3. Next, the ingredients are arranged into a mold using the sandwich method.
1. (HDPE, palm fiber, HDPE)
4. Then press using a hot press machine at a temperature of 160°C and a pressure of 1 Psi for 10 minutes.
5. After that, remove the mold from the press machine and wait until the mold reaches room temperature.

Research methods

This research is a pure experimental research and laboratory-based which leads to the study of mechanical properties and morphology of composites made from HDPE plastic and palm fiber. Research that takes data and determines variables and is measured to analyze. The method of making composites using a press machine which is the manufacture of composites with a layer method where the layer contains a matrix and filler

Composite Testing Stage

The stages of composite testing that will be carried out in this study are:

Tensile Test

The composite specimen part that has been printed according to ASTM D-638 type IV is mounted on a tensile tester. After the specimen is pulled, the tensile strength number will be obtained on the monitor of the tester. The tensile test specimen mold uses ASTM D-638 type IV which can be seen in Figure 1 below.

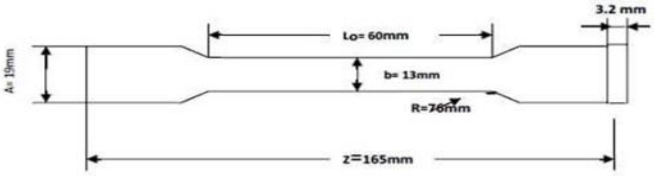

Figure 7 ASTM D-638 Type IV Standard

Impact Test

The basic principle of impact testing is the swing of the load imposed on the test object or specimen. The energy required to break the test object or specimen is calculated directly from the difference in potential energy of the pendulum at the beginning of being dropped and the end after hitting the test object or specimen. To ensure the broken part of the specimen, a notch needs to be made on the specimen. Measurement of the test object or specimen uses the Charpy impact method.

Research Design

The gram (gr) data for making specimens can be seen in Table 1 below.

Table 1 Research Design

No	Fiber Direction	HDPE Waste: Palm Fiber	Testing	
			Tensile Test	Impact Test
1	Vertical	70 : 30		
2		60 : 40		
3		50 : 50		
5	Random	70 : 30		
6		60 : 40		
7		50 : 50		
9	Fiber Free	100 : 0		

Research Flow Chart

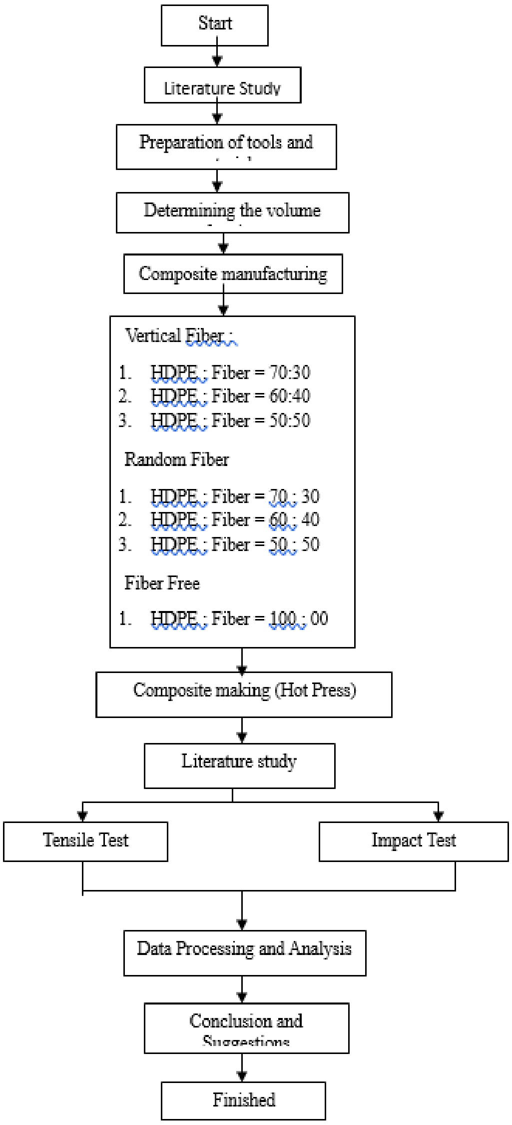

Figure 8. Research Flow Diagram

RESULTS AND DISCUSSION

The mechanical properties of materials reflect the relationship between the load, energy and received by a material with the reaction given or deformation that will occur. The mechanical properties of materials are divided into several properties including strength, stiffness, elasticity, hardness, fatigue, toughness, plasticity and creep-crack. Mechanical properties are one of the properties that state the ability to receive loads, forces or energy. This study conducted several tests including impact testing and tensile strength testing. The composite used was a composite made from High Density Polyethylene (HDPE) waste and palm fiber, the ratio of each vertical fiber (HDPE: fiber, 70: 30, 60: 40 and 50: 50), random fiber (HDPE: fiber, 70: 30, 60: 40 and 50: 50) and without fiber (HDPE: fiber, 100: 0)

Tensile Test

Tensile strength is also one of the important properties to describe the mechanical performance of a material. Based on the tensile strength test, the value of tensile strength, elasticity and toughness of the material will be obtained. The tensile strength test is one of the tests to determine the mechanical properties of composite materials as test materials in this study. By pulling a material, we will know how the material reacts to tensile force and to what extent the material increases in length. One of the most important and dominant mechanical properties in a construction design and manufacturing process is tensile strength.

Table 1. Tensile Test Results on Composites

Faction Volume (%)	Position Fiber	Voltage Tensile (MPa)	Stretch (%)	Modulus Elasticity (MPa)
HDPE : Fiber 70 : 30	Vertical	16,588	0.02292	723.73
HDPE : Fiber 60 : 40		13,917	0.01262	1,102.77
HDPE : Fiber 50 : 50		11,947	0.014623	817,000
HDPE : Fiber 70 : 30	Random	11,853	0.022598	524,515
HDPE : Fiber 60 : 40		8,2762	0.012626	655,488
HDPE : Fiber 50 : 50		11.63	0.01329	875,094
HDPE : Fiber 100 : 0	Fiber Free	11,481	0.05217	220,069

Impact Strength Test

Impact testing is one of the important properties to describe the mechanical performance of a composite material. The principle of this test is the absorption of potential energy from a pendulum load that swings from a certain height and hits the test object so that the test object deforms or breaks. By using impact testing, the magnitude of strength, hardness and ductility experienced by a material will be obtained. The method used in this test is the Charpy method. This method is used to study the fracture pattern of composite specimens so that it is known that the specimen has a brittle fracture or ductile fracture or a combination of both. Granular fracture or cleavage fracture is a shiny and granular brittle fracture surface while ductile fracture appears more opaque and fibrous or is also called a fibrous fracture or shear fracture. The results obtained from the impact test in the research that has been carried out on composite materials mixed with High Density Polyethylene (HDPE) waste and palm fiber can be seen in the table below.

Table 2. Impact Test Results on Composites

FactionVolume (%)	Fiber Position	Degree		Power Fracture (joule)	Price Tenacity (joules/mm2)
		a	ß		
HDPE : Fiber 70 : 30	Vertical	160	150	6.86	0.07
HDPE : Fiber 60 : 40		160	148	8.53	0.09
HDPE : Fiber 50 : 50		160	149	7.68	0.08
HDPE : Fiber 70 : 30	Random	160	152	5.28	0.05
HDPE : Fiber 60 : 40		160	153	4.53	0.05

HDPE : Fiber 50 : 50		160	150	6.86	0.07
HDPE : Fiber 100 : 0	Fiber Free	160	151	6.06	0.06

DISCUSSION

Tensile Test Results

The data listed in Table 1. can be visualized in the form of a bar chart. This is done so that the comparison of differences in tensile strength, strain, and elastic modulus parameters from the tensile test results of the 7 research samples tested can be easily observed.

Tensile Strength

Table 1 shows that the tensile strength values obtained range from 8.27 MPa to 16.58 MPa. The bar chart for the comparison of tensile strength can be seen in Figure 9.1.
Shows the lowest tensile strength value in samples with random fiber direction with HDPE: fiber composition, 60: 40 of 8.2762 MPa, while the highest tensile strength value is in samples with vertical fiber direction with HDPE: fiber composition, 70: 30 of 16.588 MPa. Table 1 shows that the tensile strength value is influenced by the fiber, especially in the direction of the sample with vertical fiber direction has a higher tensile strength value than samples with random fiber direction and without fiber, because the arrangement in the same direction the tensile strength will be maximized because the fiber is longer (Agus Sabarudin 2019).

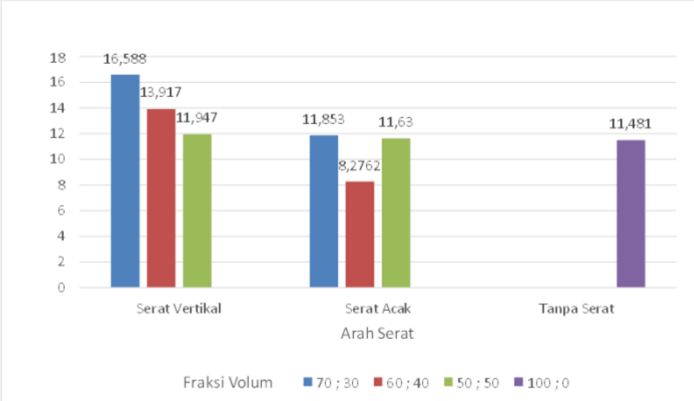

Figure 9.1 Comparison Bar Diagram of Tensile Strength from Tensile Test Results

Stretch

Table 1. shows that the strain/elongation values obtained range from 0.01262% to 0.05217%. The bar chart for the strain/elongation comparison can be seen in Figure 9.2.

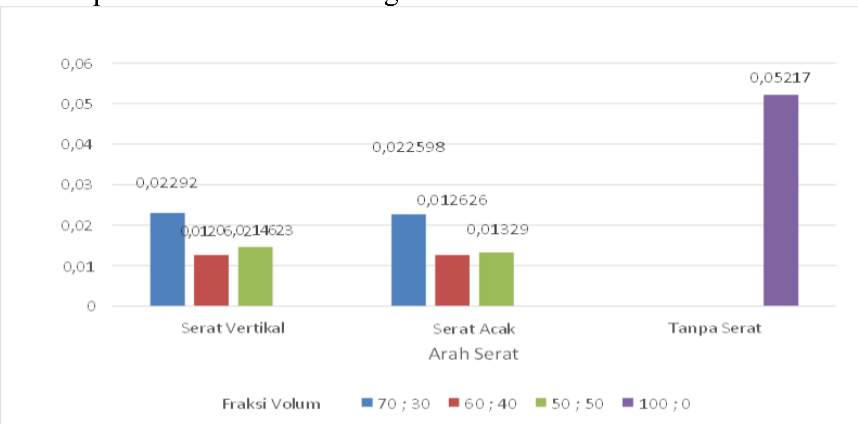

Figure 9.2 Strain Comparison Bar Diagram from Tensile Test results.

Shows the lowest value of strain in samples with random fiber direction with HDPE composition: fiber, 60: 40 of 0.01262% and vertical fiber direction with HDPE composition: fiber, 60: 40 of 0.01262%, while the highest tensile strength value is in samples without fiber with HDPE composition: fiber, 100: 0 of 0.05217%. Fiber greatly affects the strain value with increasing fiber will cause stiffness in the composite. The increase in tensile strength with increasing fiber volume fraction is because fiber is an element that functions as a load-bearing element so that the more fiber content in the composite will potentially provide more support to the composite to withstand the load. The increasing tensile strength is supported by the good bond between the fiber and the matrix. When loading takes place, the load is evenly distributed over the entire surface of the fiber so that each fiber bears the same load. The higher the fiber volume fraction, the more the tensile stress and tensile strain of the composite material increase. This is in accordance with previous research conducted by (Wicaksono et al., 2021).

Elastic Modulus.

Table 1 shows that the elastic modulus values obtained range from 220.069 MPa to 1,102.77 MPa. The bar chart for the comparison of elastic modulus can be seen in Figure 9.3.

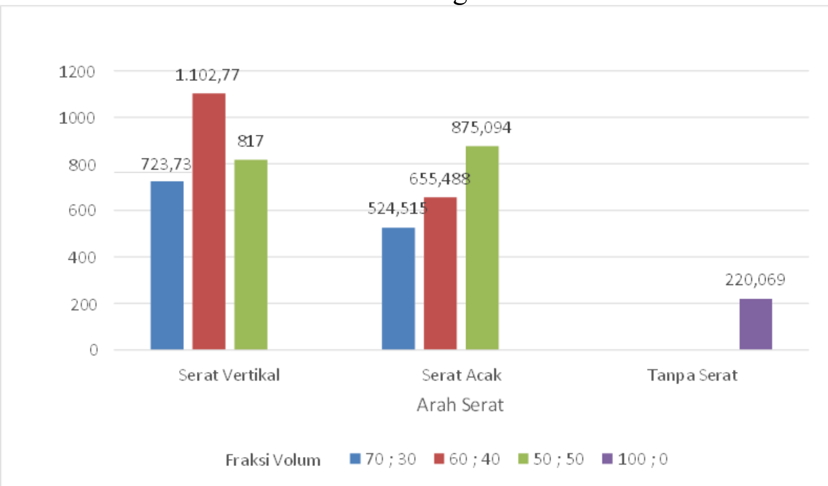

Figure 9.3 Bar Diagram of Comparison of Elastic Modulus from Tensile Test Results

Shows the lowest value of elastic modulus in samples without fiber with HDPE composition: fiber, 100: 0 of 220.069 MPa, while the highest tensile strength value is in samples with vertical fiber direction with HDPE composition: fiber, 60: 40 of 1,102.77 MPa. Basically, the elastic modulus is directly proportional to the tensile strength, but inversely proportional to the strain. The higher the elastic modulus value, the higher the tensile strength and the lower the strain value. Conversely, the lower the elastic modulus, the lower the tensile strength and the higher the strain value. Materials with high elastic modulus values are stiff and easily broken, while materials with low elastic modulus values are flexible and not easily broken. However, conditions can change because the elastic modulus is affected by the extrusion process and volume fraction.

This is because coconut fiber has a higher strength compared to polyester resin. So it will improve the mechanical properties of the composite formed. This is in accordance with research conducted by (I. Astika et al., 2013) which made about the mechanical properties of polyester composites with coconut fiber reinforcement, that the increase in tensile strength is due to the increasing number of fibers, the reinforcement in the composite will be greater so that it will be able to receive a greater tensile load. The description above shows that the more fibers will increase the value of mechanical properties.

Impact Test Results

Composites can be identified using impact tests, namely by measuring the toughness or ability of a composite material to absorb energy before breaking (toughness). Visualization of the comparison of fracture strength values from the impact test results on 7 samples is presented in Figure 9.4, while the comparison of toughness values from the impact test results is presented in Figure 9.5.

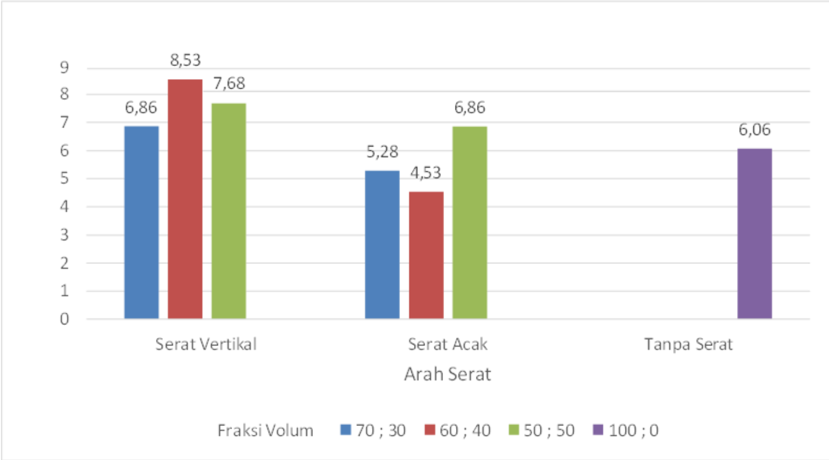

Figure 9.4 Comparison Bar Chart of Impact Energy from Impact Test Results

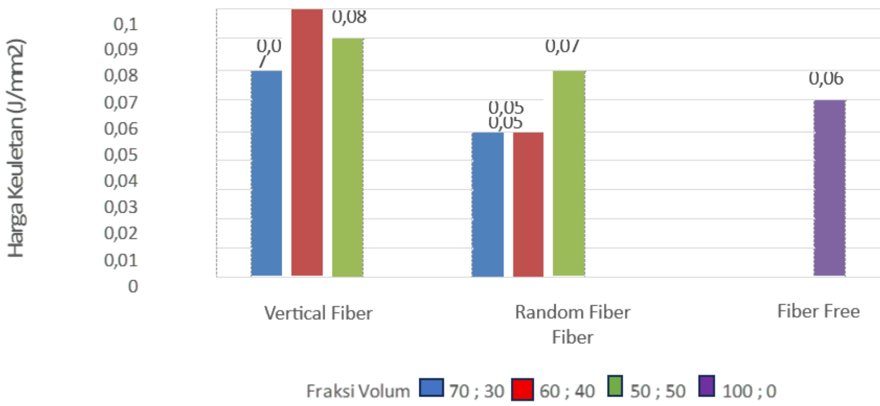

Figure 9.5 Bar Chart Comparison of Impact Prices from Impact Test Results

Figure 9.4 and Figure 9.5 show that the highest fracture strength value of 8.53 J with an impact value of 0.09 J/mm2 is owned by a sample with a vertical fiber direction and a composition of HDPE: fiber, 60: 40. Basically, the greater the volume of filler used in making the composite, the smaller the volume of the matrix used in making the composite. This has an impact on the impact strength of the composite which will decrease due to the presence of air gaps. However, this can be overcome by adding filler volume to the composite to cover the lack of matrix volume on condition that the bond between the filler and the matrix must also be good, so that it will produce good impact strength as well.

CONCLUSION

Based on the analysis and calculation of data obtained from the test results that have been carried out, the conclusions that can be drawn from this research are as follows:

1. After conducting a tensile test on the composite mixture of HDPE waste with palm fiber, the tensile stress value was obtained as 8.2762 - 16.588 MPa, strain 0.012626 - 0.05217% and elasticity value 220.069 - 1,102.77 MPa.
2. After conducting an impact test on the composite mixture of HDPE waste with palm fiber, the fracture strength value was obtained as 4.53 - 8.53 Joules and the toughness value was 0.05 - 0.09.
3. After the tensile test and impact test, the composite of palm fiber and HDPE with vertical fiber direction has better quality compared to the composite using random fiber direction and without fiber. This is due to the direction of the fiber being in the same direction.

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