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Utilization of Waste Paper as Fiber for Motorcycle Fender Manufacturing Raw Materials

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ABSTRACT

The selection of paper as the main material for making composites in this study is driven by several considerations. HVS paper is produced by factories with the main raw material being wood. Besides, the use of HVS paper as a fiber for composites offers the potential to reduce industrial waste and reduce dependence on conventional raw materials. The purpose of this study was to determine the effect of variations in the volume fraction of HVS pulp fiber on the mechanical properties of the specimen surface and hardness test to determine the use of HVS pulp composites as raw material for making motorcycle fenders. The benefits of this research provide information for the manufacturing industry in developing innovative composite materials, offering sustainable alternatives that are environmentally friendly, increasing the use value of HVS paper processing, which has only been used as waste. From the results of the research conducted, the results obtained with the value: the hardness of the specimen with a volume fraction variation of 70% fiber has the highest average hardness value of 11.5 kg/mm^2, and the variation of the volume fraction of 50% fiber has the lowest average hardness value of 8.6 kg/mm^2, which has a difference of 2.9 kg/mm^2 with a volume fraction variation of 70% fiber. The highest impact price value is obtained at a 70% pulp volume fraction with an average impact price of 0.0402 J/mm^2, while the lowest pulp composite impact price is at the volume fraction of 70% fiber. 50% pulp with an impact price of 0.0263 J/mm^2. The increase in hardness and impact resistance with increasing pulp volume explains that this composite can be an alternative material for application on motorcycle fenders.

Keywords: HVS Paper, Volume Fraction, Composite Materials.

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Introduction

One interesting material to be used as a composite fiber is paper pulp. Paper pulp is a processed product made from paper waste, especially HVS paper that is no longer used. The use of paper as the main material for making composites in this study is driven by several considerations, including the need for materials that have good strength that are very easy to find with a selling price that is certainly very cheap. The choice of this material not only creates an environmentally friendly solution, but also opens up opportunities for exploration of the performance of pulp fiber materials used in the manufacturing industry.

Previous research by Iskandar and friends using paper pulp as a composite fiber with polyester resin as a matrix. Polyester resin is a plastic type polymer with a liquid phase, used as a composite filler matrix. This matrix functions to bind and maintain the position of the fiber to stay in position and distribute the load received by the composite to the fiber evenly [1].

Furthermore, Ahmad Zaky and friends, explained that paper is an integral part of human life and continues to evolve in its current form. As a result, the paper industry is growing rapidly in Indonesia and around the world. The demand for paper around the world is increasing from year to year. Therefore, the paper industry uses recycled paper as a raw material containing cellulose fibers, and the use of papermaking materials uses a combination of long and short fibers to make durable and smooth paper. [2]

This research aims to explore the potential of using paper pulp as a composite fiber using polyester resin in the manufacturing industry. By studying the mechanical properties of these composites through impact tests and hardness tests, it is hoped that optimal parameters can be found to improve the strength and durability of the composites and expand their applications.

The amount of paper production is strongly related to the paper waste generated, be it paper waste from households, offices, institutions and other places. Waste paper, which is considered useless, can still be recycled and processed into new products that have better use value. One example is by utilizing waste paper to be made into pulp and processed again into new goods [4].

With this research, it is hoped that the manufacturing industry can benefit from the use of paper pulp composites with polyester resin as an environmentally friendly and efficient alternative in producing structural components such as motorcycle fenders.

Motorcycle fenders made by manufacturers with various brands used so far using carbon fiber and E-glass fiber with Polypropylene (PP) plastic material have good mechanical properties, but the fender has brittle and clayey mechanical properties if it receives an impact load or when the fender receives an impact load. To reduce the dependence of artificial fiber raw materials used for the manufacture of motorcycle fenders today and see so much HVS paper waste, the idea arose to convert HVS paper raw materials made into pulp to be used as composite fiber. The amount of paper production is strongly related to the paper waste generated, be it paper waste from households, offices, institutions and other places. A lot of paper waste that is considered useless can still be recycled and processed into new products that have better use value. One example is by utilizing paper waste to be made into pulp and processed again into new goods.

The classification of composites based on the type of matrix used is divided into three types, namely:

1. Polymer Matrix Composites (PMCs). Polymer-matrix composites are composites that use polymer materials as the main constituent or dominant composition.
2. Metal Matrix Composites (MMCs)
   Metal matrix composites are composites that use polymeric materials as the main constituent or dominant composition.
3. Ceramic Matrik Composites (CMCs). Ceramic matrix composites are composites that use ceramic materials as the main constituent or dominant composition.

BTQN 157 EX polyester resin is a resin that is often used for the manufacture of composites with fiber reinforcing materials. This type of resin is resistant to water (normal temperature) and weak acids 157 BQTN, The type of polyester used as a composite matrix is an unsaturated type (unsaturated polyester) which is a thermoset that can undergo hardening (curing) from a liquid phase to a solid phase when treated properly [3].

For fiber placement, one must consider fiber geometry, fiber direction, distribution and

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volume fraction in order to produce high-strength composites. For a unidirectional lamina, with continuous fibers with equal fiber spacing, and well bonded by the matrix [1].
To find out the amount of volume fraction here using equation, 1 to equation 4.

$$V_f = \frac{\text{Fiber volume}}{\text{Composite volume}} x100\% \quad (1)$$

$$V_{serat} = \frac{m_f/\rho_f}{m_f/\rho_f + m_m/\rho_m} x100\% \quad (2)$$

$$V_{matrik} = \frac{\text{Matrix volume}}{\text{Composite volume}} x100\% \quad (3)$$

$$V_{matriks} = \frac{m_m/\rho_m}{m_f/\rho_f + m_m/\rho_m} x100\% \quad (4)$$

Hardness testing with the Vickers method aims to determine the hardness of a material against a given loading using a diamond eye indenter called the Vikers hardness testing method as shown in Figure 1.

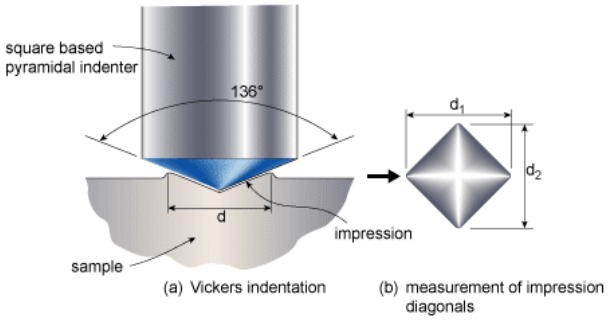

Figure 1. Vickers test

The Vickers hardness number (VHN or VPH), is defined as the load divided by the surface area of the indentation. In practice this area is calculated from microscopic measurements of the diagonal length of the trace. VHN can be determined by equation, 5.

$$VHN = \frac{2\rho\sin\left(\frac{\theta}{2}\right)}{L^2} = \frac{1.854\rho}{L^2} \quad (5)$$

As for knowing the mechanical properties of the impact in this study, Imppact testing was carried out, this impact test aims to measure the resistance of materials to shock loads, namely the absorption of potential energy from the pendulum.

a load that swings from a certain height and hits the test object, so that the test object is deformed. In this impact test, the amount of energy absorbed by the material for fracture is a measure of the impact resistance or toughness of the material.

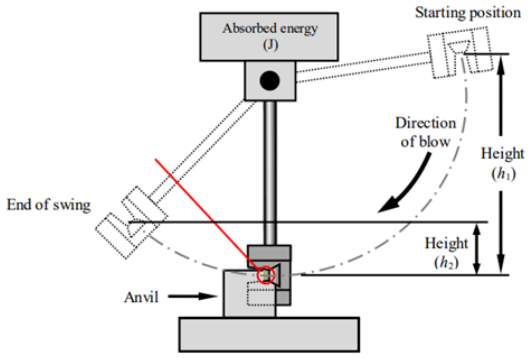

Figure 2. Schematic of Charpy impact testing
The effort made by the pendulum

when striking the specimen or the energy absorbed by the specimen until fracture is obtained using equation 6.

$$m.\ g.\ \lambda\ (\cos\beta - \cos\alpha) \quad (6)$$

from the equation of formula 6 above, the impact price is obtained using equation 7.

$$K = \frac{Absorpted\ Energy\ (j)}{A} \quad (7)$$

Methods

The variables (methods) in this study are varying the mixture between paper pulp for making fenders with a percentage of resin, namely: 50%-50%, 60%-40% and 70%-30%. For the manufacture of paper pulp, the type of paper used as fiber material comes from HVS type paper waste that is no longer used. The process of making paper pulp is by soaking the paper for 30 minutes then drained and crushed using a blender machine for 30 seconds. While the resin used in the manufacture of this composite is a type of polyester resin BQTN type 157 EX and the catalyst used in the manufacture of this composite is Methyl Ethyl Ketone Paroxide (MEKP) catalyst.

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The next stage of making motorcycle fenders using the Hand Lay up method, is the simplest method among other composite material manufacturing methods. The hand lay-up process is the first manual process used in composite manufacturing. The matrix is in direct contact with air, usually proses molding was carried out at room temperature. For the manufacture of the fender, it was done 3 times according to the percentage of resin used in this study.

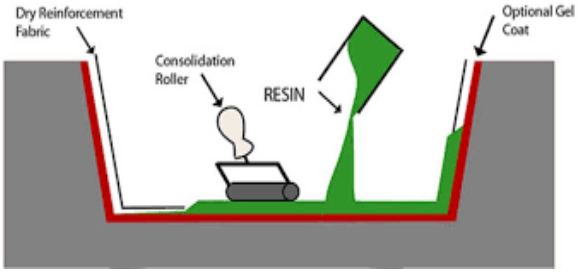

Figure 3. Hand Lay-Up Process

Figure 4. Fenders made with the hand lay up method

To determine the mechanical properties of the fender made using this paper pulp reinforced composite, charpy impact testing and hardness testing with the Vikers Hardnes method were carried out, this test was carried out with a "MATEST" testing machine. The charpy impact testing specimen has dimensions of 64 mm in length, 12.7 mm in width, and 12.7 mm in height and a notch depth of 2.58 mm with an angle of 45°. shown in Figure, 5.

As for the hardness test specimen used, it refers to the ASTM E 10 standard, with a specimen thickness of 7 mm. The test specimen has a length of 60 mm, a width of 40 mm and a thickness of 7 mm. ASTM E 10 hardness test specimen in Figure 6.

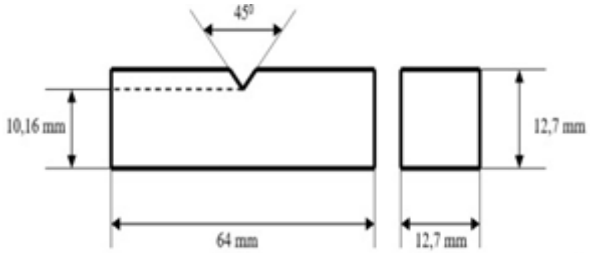

Figure 5. Impact test specimens to ASTM D 5942-96.

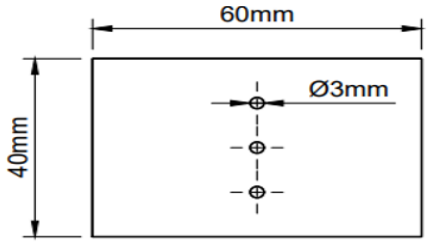

Figure 6. ASTM E10 hardness test specimen.

Results and Discussions

The test results for specimens totaling 9 and each specimen is tested at three test points so that the hardness test results data are listed in Tables 1, 2 and 3.

Table 1. Data Results of Hardness Value Volume Variation 50%:50%

Sample	Point	Indentation Diagonal (µm) d1	d2	Average indentation diagonal (µm)	Pressure Load (kgf)	Vickers Hardness Number (VHN)	Average
	1	48,9	47,94	48,42		7,9	
1	2	48,76	49,34	49,05	10	7,7	7,9
	3	48,54	47,9	48,22		8	
	1	45,76	45,87	45,82		8,8	
2	2	45,72	42,5	44,11	10	9,5	9,0
	3	46,41	46,13	46,27		8,7	
	1	43,32	43,48	43,40		9,8	
3	2	48,37	48,23	48,30	10	7,9	8,8
	3	45,66	46,3	45,98		8,8	
Total average							8,6

Table 2. Data Results of Hardness Value Volume Variation 60%:40%

Sample	Point	Indentation Diagonal (µm) d1	d2	Average indentation diagonal (µm)	Pressure Load (kgf)	Vickers Hardness Number (VHN)	Average
	1	43,67	43,06	43,37		9,9	
1	2	40,06	40,41	40,24	10	11,5	10,6
	3	41,84	42,19	42,02		10,5	
	1	38,82	44,56	41,69		10,7	
2	2	38,9	40,43	39,67	10	11,8	10,9
	3	43,09	42,4	42,71		10,1	
	1	43,41	42,47	42,94		10,1	
3	2	43,38	42,03	42,71	10	10,2	10,0
	3	43,84	44,24	44,04		9,6	
Total average							10,5

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Table 3. Data Results of Hardness Value Volume Variation 70%:30%

Sample	Point	Indentation Diagonal (µm) d1	d2	Average indentation diagonal (µm)	Pressure Load (kgf)	Vickers Hardness Number (VHN)	Average
	1	37,22	36,99	37,11		13,5	
1	2	37,84	38,41	38,13	10	12,8	13,0
	3	40,34	35,78	38,06		12,8	
	1	42,67	41,94	42,31		10,4	
2	2	41,63	41,05	41,34	10	10,9	10,8
	3	40,8	41,05	40,93		11,1	
	1	42,27	41,35	41,81		10,6	
3	2	41,17	40,94	41,06	10	11	10,7
	3	41,34	42,18	41,76		10,6	
Total average							11,5

The data from the three tables of hardness test results above are then processed to ensure that the value obtained in the test after the data is processed using equation (5), then the value can be explained using a graph as shown in Figure 7 below:

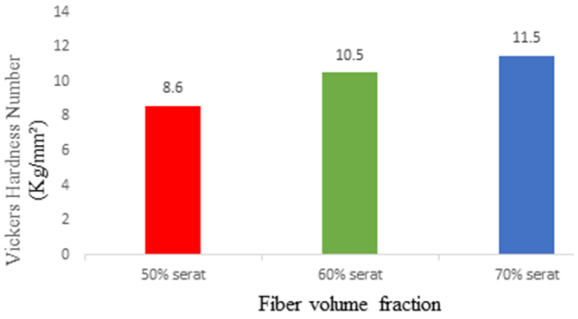

Figure 7. Graph of Hardness Testing Results of Combining Fiber Volumetric Variations

From the contour graph in Figure 7, it explains the hardness value of specimens with variations in volume fractions of 50%, 60% and 70% of the fiber used has a percentage difference in the value of hardness test results. The highest hardness value is 11.5 kg/mm2 using a percentage of 70% fiber, for the value of 50% fiber volume fraction the hardness value obtained is 10.5 kg/mm2 while for the lowest hardness value is found in the 50% fiber volume fraction with a value: 8.6 kg/mm^2. This explains that the greater the volume percentage of paper pulp used as fiber for the composite mixture, the better the hardness value of the composite, and vice versa

To determine the resistance of motorcycle fenders made using pulp-loaded composites to impact, charpy impact testing is carried out which aims to determine the mechanical properties of the fender when experiencing an impact or impact, The number tested was 9 specimens divided into three groups of volume variations, the first 70%:30% variation totaling 3 specimens, the second 60%:40% variation totaling 3 specimens and the third 50%:50% variation totaling 3 specimens.

From the test results of the three groups of impact test results that have been carried out, the results can be seen in Table 4.

Table 4. Results of Impact test data process

No.	Fiber volume fraction	Thick (mm)	Width (mm)	Extensive (mm^2)	Starting angle (α)	End angle (β)	E (Joule)	HI (J/mm^2)
1.		12,7	12,7	161,29	160	152	4,4531	0,0276
2.	50%:50%	12,7	12,7	161,29	160	152	4,4531	0,0276
3.		12,7	12,7	161,29	160	153	3,8181	0,0237
			Rata-rata				4,2414	0,0263
4.		12,7	12,7	161,29	160	150	5,7781	0,0358
5.	60%:40%	12,7	12,7	161,29	160	151	5,1038	0,0316
6.		12,7	12,7	161,29	160	151	5,1038	0,0316
			Rata-rata				5,3286	0,0330
7.		12,7	12,7	161,29	160	148	7,1893	0,0446
8.	70%:30%	12,7	12,7	161,29	160	149	6,4680	0,0401
9.		12,7	12,7	161,29	160	150	5,7781	0,0354
Average							6,4785	0,0402

From the calculation data of the impact test results in table 4, the whole is explained in graphical form to see the comparison of the value of the charpy impact test on the nine specimens.

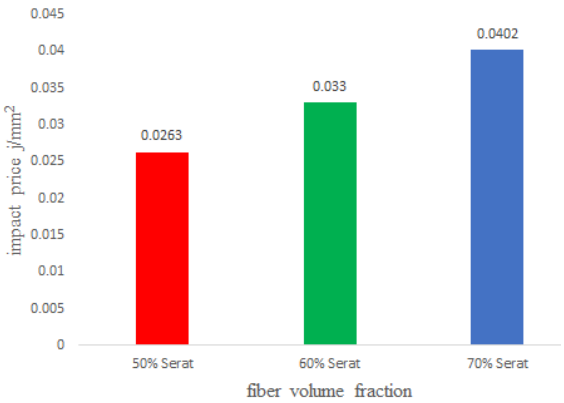

Figure 8. Graph of Impact Test Results

Figure 8. Above explains the contour graph of the impact test values of pulp composites with variations in pulp volume fraction of 70%, 60% and 50% with values of 0.0402 J/mm^2, 0.0330 J/mm^2 and 0.0263 J/mm^2.

The highest impact value is found in the 70% volume fraction with an average impact value

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of 0.0402 J/mm^2, while the lowest impact value of the pulp composite is in the 50% volume fraction with an impact value of 0.0263 J/mm^2. This explains that the 70% volume fraction of paper pulp has better mechanical properties than the 60% and 50% volume fractions, this is also influenced by the amount of pulp mixture used, so that the more the volume fraction of fiber used, the higher the impact price on the composite.

The results of macro photo testing on the surface of pulp fiber reinforced hardness test specimens can be seen in Figs: 9, 10 and 11 based on the variation of the percentage of fiber used. In the photos of the surface of the hardness test specimens carried out, there are differences in the buildup of different resins and paper. The results of macro photos of the surface of the hardness test specimens of each variation can be seen in Figure.

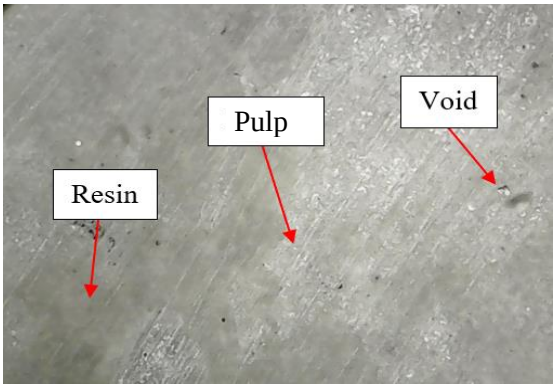

Figure 9. Surface Photos of Specimen Hardness Test Variation 50% : 50%

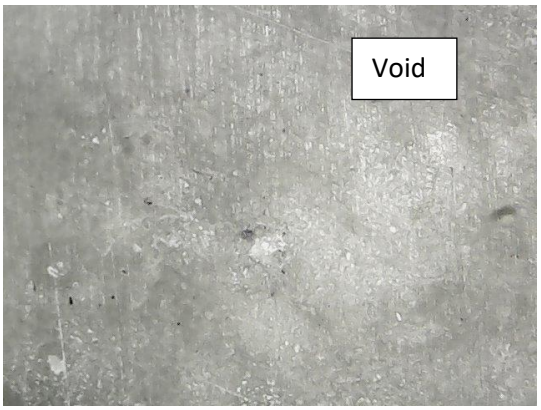

Figure 10. Surface Photos of Specimen Hardness Test Variation 60% : 40%

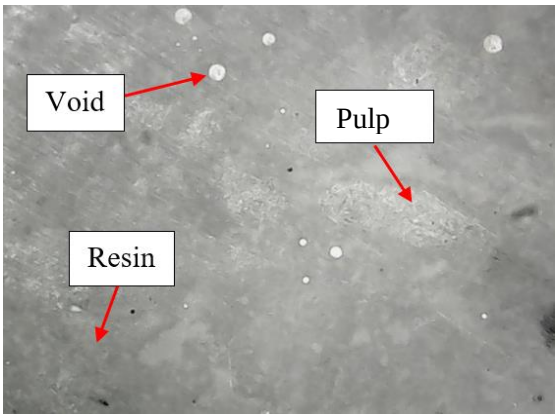

Figure 11. Surface Photos of Specimen Hardness Test Variation 70% : 30%

The observation results from the macro photos above figures 9, 10 and 11 with 50%, 60% and 70% paper variations show that each volume fraction variation has a different number of voids, this happens because the more the volume fraction of paper used, the possibility of the appearance of voids is greater so that a lot of air is trapped in the paper, This is influenced by the uneven stirring process of the matrix and the lack of pressing process during the process of making test specimens. The voids found on the surface of the fender or test specimen are influenced during the process of mixing resin and catalysts that are less evenly distributed so that air bubbles are trapped during the molding process.

When viewed from the form of voids that appear in Figure 9, 10 and Figure 11, it can clearly reduce the strength of a material, but what happens in this study is the opposite in the volumetric fraction with 70% fiber which has more voids than in the volumetric fraction of 50% and 60% fiber has better impact strength and hardness values, this happens due to several factors such as fiber orientation, volumetric fraction, fiber mass and the matrix used.

Conclusions

1. That the variation of pulp fiber volume fraction affects the hardness value, impact value and density of the composite. From the three variations in the volume of pulp fibers used, it can be concluded that with the increase in the number of pulp fibers used, the value of mechanical properties and impact hardness of the composite will be higher.

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2. The use of paper pulp composites as raw materials for the manufacture of motorcycle fenders has promising potential for the world of manufacturing, especially in its mechanical properties.
3. It should be noted that the increase in hardness and impact resistance with increasing pulp volume explains that this composite can be an alternative material for applications on motorcycle fenders.

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Author Contributions
AIR, KS, TYH: Conceptualization, method, writing, analyses, supervision, review, AMS, EU, AA, F: editing review, EU, MHBAH: methodology, analyses, drafting, RPS, HRYS: experiment, data experiment.

Conflict of interest
The authors declare no conflict of interest in this paper.

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