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Making Composite Materials from Unsaturated Polyester and Coconut Fiber Judging from Mechanical Properties

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Abstract. Making combined materials that consist of unsaturated polyester and coconut fiber is the target of this research. The samples were tested by tensile and hardness tests before and after warm-up, and obtained by the result was that the trend value of hardness of unsaturated polyester+coconut fiber experienced proportional degradation with the addition of the composition of coconut fiber. The composition of 3% coconut fiber+97% unsaturated polyester has the highest hardness value, reaching 46,7 kg/mm2, and downhill becomes 43,1 kgf/mm2 moment heated at a temperature of 500C for 1 hour. Analog to the tensile test, 3% coconut fiber + 97% unsaturated polyester composition has the highest ultimate tensile strength and yield point. Adding fiber can boost the elasticity modulus, but the warm-up treatment causes the expansion of coconut fiber. The result is that the value of the tensile and hardness of the polyblend will go downhill.

Keywords: Coconut Fibre, Unsaturated Poliester, Hardness Test, Tensile Test

INTRODUCTION

Recent developments that are adapted to the needs of engineering / industrial plastics and also due to economic considerations demand the engineering of polymer materials to be combined with polymer materials of other types, commonly called polyalloys (*polyblend*). Thermoset polymers are polymer materials with a three-dimensional structure that is hardened due to heating. This material cannot melt back when heated and generally has rigid and brittle properties. The thermoset polymer selected in this study is unsaturated polyester. The selection of unsaturated polyester with several considerations, including the price, is relatively cheap and easy to obtain, widely used for engineering purposes, the construction industry (such as toiletries, floor coatings, truck roofs, car bodies, ship hulls, and plastics from electronic devices) (G.Odion, 1991).

The properties of unsaturated polyester are rigid and brittle; therefore, to improve its structural applications, many ask to increase its strength by adding fillers or combining it with fiber reinforcement, which is expected to reduce production costs. Unsaturated polyester filled with Al2O3 ceramic material produces greater stiffness, yield stress, and tensile strength than unsaturated polyester filled with CaCO3 (N. Revianty, 2002). While poly-alloys of unsaturated polyester–coconut fiber (powder form) with random mixing can increase the yield stress and tensile strength, the material's stiffness decreases until the composition of coconut fiber reaches 25 percent by mass (Prantasi et al., 2003).

Coconut fiber is a natural polymer material. The amount is quite a lot in Indonesia, and so far, its use has yet to be maximized, limited to household equipment such as brooms, doormats, and cleaning brushes (Suhardiyono, 1989). If this coconut fiber is given a little technical touch and combined with other polymer materials, it is expected to produce a new material that is strong and ductile. R. Susilorini (2002) conducted research by adding coconut fibers with a length of 80 mm with an optimum mixture of 25% into concrete; it will increase *the splitting-tensile stress* of concrete by 13.6% higher than concrete without a mixture of coconut fibers.

Experiment

- Materials

Coconut fibers are obtained from old coconuts (taken from the Sidoarjo TBan market)—selection of old coconuts to ensure the fibers obtained are more robust and do not fall off. The fibers are soaked in a large tub of cold water for two months. After two months, separate the fibers from the fibers or other organisms and gently beat them with hammerheads. The fiber obtained is cleaned with clean cold water for a while, then dried in the hot sun. Furthermore, after the fiber is dry, it is ready to be used as an alloy, as shown in Figure 2.1.

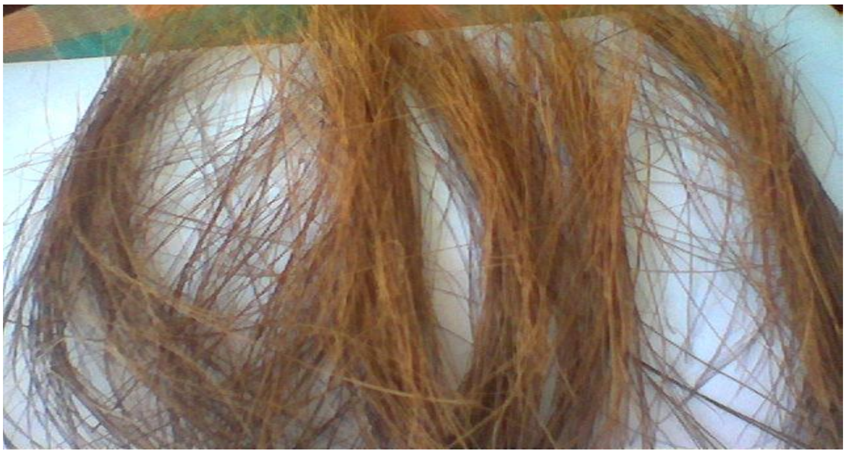


Figure 2.1 Finished dry fiber

The composition of the test material for hardness tests in table I and for tensile tests in table II.

Table I Hardness test composition of polyester polyalloy materials
unsaturated with coconut fibers

Material	Volume Fraction (%)						
Coconut fibers	0 %	3 %	5 %	10 %	15 %	20 %	30 %
Unsaturated polyester	100 %	97 %	95 %	90 %	85 %	80 %	70 %

Table II Pull-test composition of polyester polysolid materials
unsaturated with coconut fibers

Bahan	Kadar Volume (%)				
Coconut fibers	3%	6%	9%	12%	15%
Unsaturated polyester	97%	94%	91%	88%	85%

- Printing of Polypunity Materials

  Hardness Test

They are making samples (specimens) for hardness testing by JIS B 7724 standards for Rockwell hardness tests, with the form of a block mold with length (p) = 5 cm, width (l) = 2.5 cm, and thickness/height (t) = 2.5 cm. After the mold of the material is ready, on the vertical and horizontal sides are given small holes to insert coconut fibers, which are also arranged horizontally and vertically according to the amount of their composition, and the fibers are pulled tense, not loose. Elsewhere, according to its composition, unsaturated polyester is mixed with a Mekpo catalyst (a relatively small amount), which speeds up the dry and complex process of the material. After that, it is stirred evenly and poured into molds. The drying and hardening process of the test material takes about 24 hours by ordinary drying without having to be dried in the sun. After that, the test material is ready to be removed from the mold and tested for hardness properties.

- Tensile Test

The manufacture of test materials is conformed to ASTM D 638 type IV standard. The size of the test material is shown in table III and the shape of the test material as figure 2.2.

Table III Test material sizes

Notasi	Size (mm)	Tolerance
T = thick test material	3	-
W = width on narrow sections	6	± 0,5
L = length on narrow sections	33	± 0,5
Wo = width of the test material	19	± 6
Lo = the length of the test material	115	-
G = Measurement limit length for test materials	25	± 0,13
R = inner radius	14	± 1
Ro = outer radius	25	± 1
D = distance between tongs	64	± 5

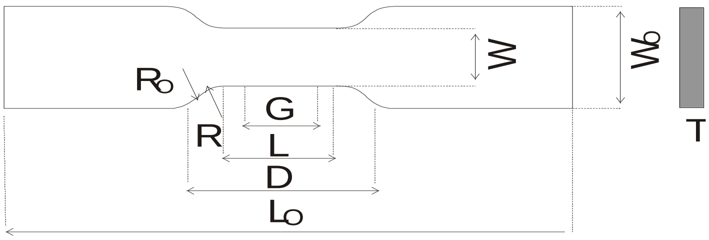


Figure 2.2 Form of test material

Material molds use wax-coated wood so that later on the release of material from the mold becomes easy. The process of making the specimen is the same as in the hardness test, only with a different composition according to the tensile test and the arrangement of the fibers is only arranged horizontally.

DISCUSSION

Hardness Testing

Hardness testing was carried out using the Rockwell – B method, which is HRB 2.5 / 31.2 diameter 2.5 mm load 31.2 kg. The test was performed with 3 points, the results are shown in figure 3.1 for vertical fiber testing and figure 3.2 for horizontal fiber testing.

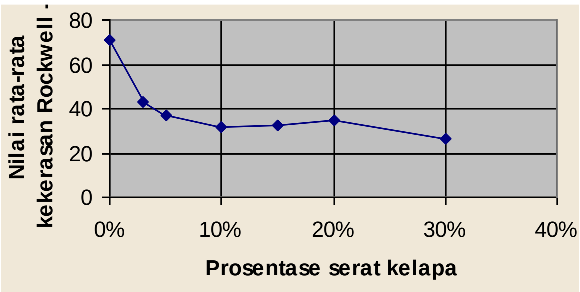


Figure 3.1 Vertical Test Graph

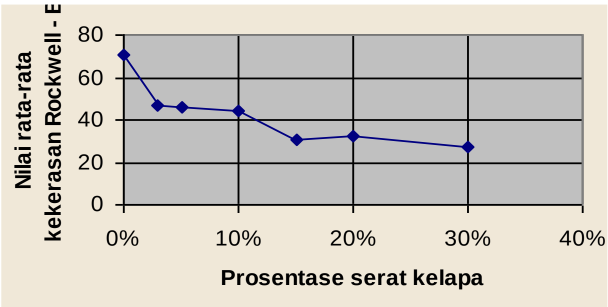


Figure 3.2 Horizontal test graph

When the hardness values for vertically and horizontally arranged fibers are compared with unsaturated polyesters filled with powder-shaped fibers, the results are presented in figure 3.3.

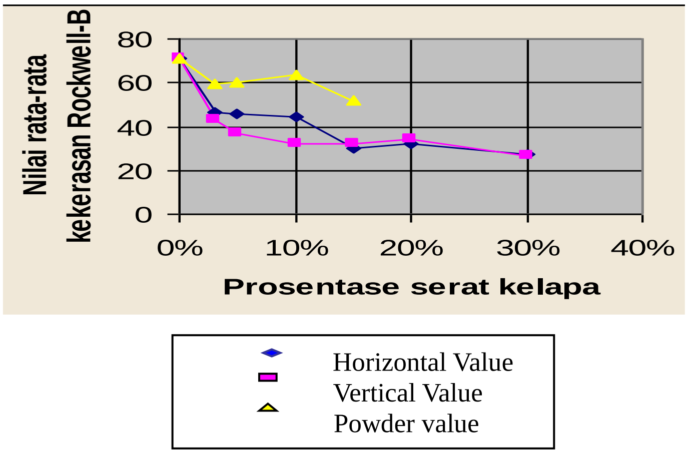


Figure 3.3 Combined hardness test graphs for horizontal and vertical fibers

Testing/Tensile Test

The calculation results for all five sample compositions and unsaturated polyester without fillers for tensile testing are presented in figure 3.4. The results obtained for all five compositions of tensile test samples are presented in table IV.

Table IV. Results for all five sample compositions

No	Data	Composition				
		1 (3%; 97%)	**2 (6%; 94%)**	**3 (9%;91%)**	**4 (12%;88%)**	**5 (15%;85%)**
1	UTS/σ_u (kgf/mm^2)	22,53	22,156	21,69	21,08	21,27
2	Elongation (%)	7,27	6,48	10,42	8,94	11,40
3	Cross-sectional reduction (%)	9,77	9,77	4,944	9,77	4,944
4	Yield stress (kgf/mm^2)(σ_y / Y)	20	19	19,13	19,08	19,77
5	Modulus of elasticity (E)(kgf/mm^2)	6583,33	6480	6703	6510,34	6471

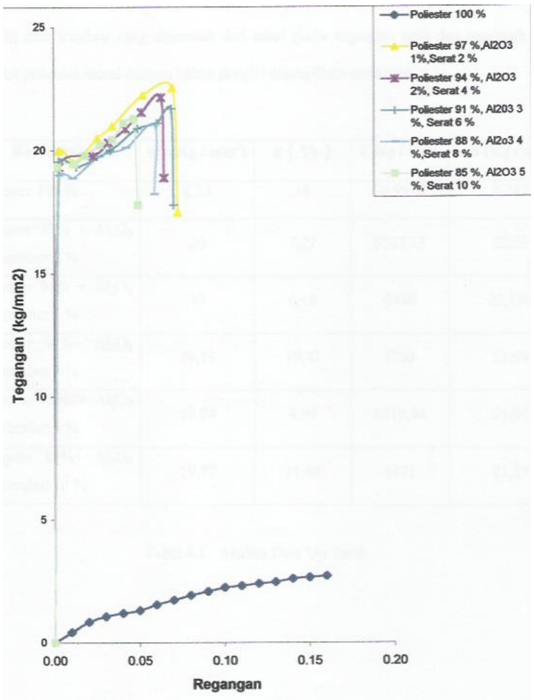
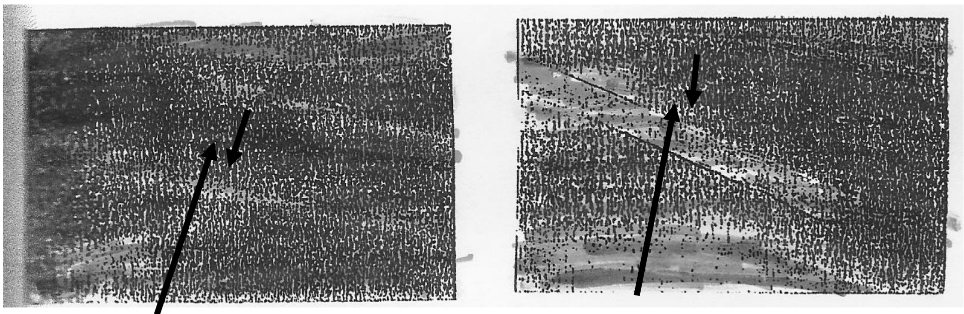


Figure 3.4 Tensile test calculation result

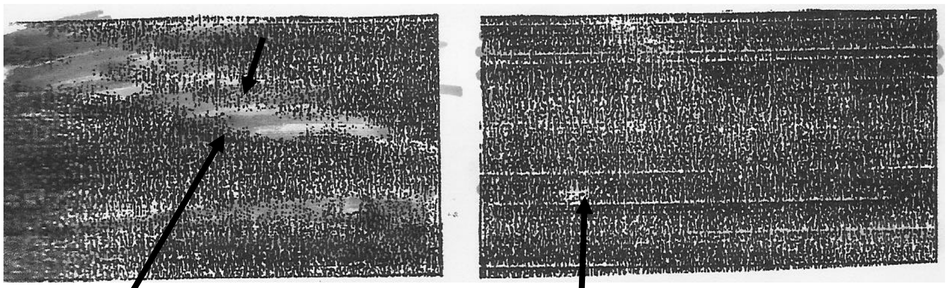
Microstructures Test

The microstructure observed with an optical microscope is a sample with a composition of 3% fiber+97% unsaturated polyester arranged horizontally. This is because optimal results for both hardness tests and tensile tensile tests are obtained for such samples. While horizontal arrangement was chosen because it was equated with tensile tests which were also arranged horizontally. The full picture shows figure 3.5, which is a microstructure image for hardness tests and tensile tests before and after heating.



fiber before heating fiber after heating

Microstructure in hardness test



fiber after heating fiber before heating

Microstructure in tensile tests

Figure 3.5 Microstructure for a sample with a composition
of 3% fiber + 97% horizontally laid out unsaturated polyester

Hardness Test Results

Hardness tests for samples with both vertical and horizontal fiber arrangements show that the hardness value decreases with increasing the percentage of coconut fiber. This means that samples with a composition of 3% fiber + 97% unsaturated polyester have the highest hardness value. This happens because the fibers filling in unsaturated polyester make the sample brittle, reducing the hardness. Unsaturated polyester grains do not become compact when fiber is added to them.

Although, in general, the addition of fibers for both horizontal and vertical arrangements will reduce the hardness value of the material, it can be seen that the horizontal arrangement of fibers is higher than the vertical arrangement. There is a significant difference, respectively, for horizontal and vertical, with a composition of 3% fiber + 97% unsaturated polyester, which has a hardness value of 46.7 kg / mm2 and 43.1 kg / mm2; this difference is not due to the arrangement of horizontal or vertical fibers but only because of the technical manufacture of the sample. This means that the hardness value of the sample will be high when the press on the Rockwell tool hits the unsaturated polyester. In contrast, the value decreases slightly when it hits the fibers immersed in the unsaturated polyester.

It is heating the sample composition of 3% fiber + 97% unsaturated polyester with horizontal fiber arrangement for 1 hour at a temperature of 500C, lowering the hardness value of the material from 46.7 kgf/mm2 to 45.5 kgf/mm2. This is because the fiber that undergoes heating will expand, and the cross-sectional surface enlarges, thus pressing unsaturated polyester grains, causing the material to increase brittle, as a result of which the hardness of the material decreases.

Tensile Test Results

The tensile test results also showed that materials with a composition of 3% fiber and 97% unsaturated polyester had a maximum tensile strength value (u/UTS=Ultimate *Tensile Strength*) and a higher yield strength/yield stress (sy/Y) than samples with other compositions. The modulus of elasticity (E) and *elongation* is not among the highest compared to other sample compositions. Overall, the results concluded that adding horizontally laid out fibers will strengthen the material's tensile strength for both its maximum tensile strength and yield strength.

The fiber will hold and support the unsaturated polyester when both are subjected to attraction. The tensile load received by unsaturated polyester is partly channeled to the fiber so that unsaturated polyester does not support the entire tensile load. It was proven that unsaturated polyester was the first to fracture in tensile testing, while the fiber had not experienced any signs of breaking. This means that the fractures experienced by unsaturated polyester alloys and fibers do not cause concomitant fractures. As for the modulus of elasticity, adding fibers increases the material's rigidity, but the material becomes brittle, so its ductility also decreases.

The results of microstructure observations using optical microscopes are similar to hardness testing. Polyalloy materials heated for 1 hour at a temperature of 500C will expand the fiber. This condition causes the tensile strength of the poly alloy material to decrease, getting stiffer and brittle so that its ductility decreases.

CONCLUSION

From the results of this study can be concluded as follows:

1. Hardness value of polyalloy material polyester unsaturated+coconut fiber, subjected to the decrease is proportional to the addition of the composition of coconut fiber. Composition polyintegration 3% coconut fiber+97% polyester unsaturated has value the highest hardness reaches a hardness of 46.7 kgf/mm2 and decreases to 43.1 kgf/mm2 when heated at 500C for 1 hour.
2. The tensile test also shows polyalloy materials with composition 3% coconut fiber and 97% polyester unsaturated have pull strength value maximum (σ_u/UTS=Ultimate Tensile Strength) and strength yield/yield voltage (σ_y/Y) is highest. As for the modulus its elasticity indicates that the addition of fibers increases stiffness material, however, the material becomes brittle so that its ductility also decreases.
3. Heating on polyester polyintegrated material unsaturated+coconut fiber causes expansion of coconut fibers. This condition results in a value hardness and tensile test of polyalloy materials decreased.

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