ISBN 978-623-7525-37-0

Specimen Test Making of Polypropylene High Impact (PPHI) Polymer Composite Reinforced with Natural Fibres using Hand Lay-Up Methods

Nuha D. Anggraeni[1*], Alfan E. Latief[1], Ramadhan L. Tawadha[1], and Rifki R. Radliya[1]

[1] Department of Mechanical Engineering, Institut Teknologi Nasional (Itenas), Bandung - INDONESIA

* Corresponding author e-mail: nuha@itenas.ac.id

Abstract

Pineapple and hemp are one type of natural fibre that is widely grown in Indonesia and has good mechanical properties. The use of hemp and pineapple fibres as reinforcing and high impact polypropylene (PPHI) materials that are widely used in the automotive industry as a matrix in composites for applications in the automotive field studied. In this research, the process of making bending test specimens using ASTM D 69 standard for PPHI reinforced composites and pineapple fibre uses the hand lay-up method, with meshing below 120 and 10% volume fraction. As a result, in order to make homogeneous specimen, good setting at temperature 250 °C by normalizing cooling and stirring process to enable PPHI and pineapple fibre.

Keywords: pineapple-fibre, specimen, normalizing, homogenous, matrix

1. Introduction

Plastic plays an important role in human life, such as packaging because of its superiority which is lightweight, strong, transparent, not easily broken and the price is affordable by all people and forms of lamination combined with other packaging materials and some are heat-resistant and stable (Nurminah, 2002). However, because plastic cannot be renewed, it is necessary to look for other materials that can be renewed. Materials made from natural fibres can be used to produce renewable and environmentally friendly materials.

Material development using technology that utilizes polymer composite materials with natural fibre reinforcement. The material is an alternative to meet the material needs that can function as a solution to environmental problems and the limitations of natural resources that cannot be renewed. Many researchers have developed composite polymers to use them as testing materials for polymer composites with natural fibre reinforcement (Asim, et. al, 2017; Alzebdeh, et. al, 2019, Hadi, et. al, 2016; Senthilkumar, et.al, 2019).

The composite material can be made using the hand lay-up method, namely by pouring a mixture of Polypropylene High Impact (PPHI) with natural fibre-reinforced (Mardiyati, et. al, 2017). The results of making this composite will be used to get a reference about the mechanical and physical properties of the test specimen components with a volume fraction of 10% so that later it will get the results of various tests.

2. Literature review

2.1. Composite

Composite is a material that is formed from a combination of two or more materials, where the mechanical properties of the forming material differ where one material is as a filler and the other as a reinforcing phase (Gibson, 1994). The continuous composite combination of reinforcement and other material functions as a matrix.

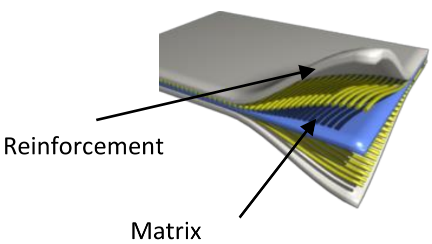

Fig. 1: Composite composition

In general, according to fibre placement, composites classification are:

- Continuous fibre composite (composite reinforced with continuous fibres)
- Woven fibre composite (composite reinforced with woven fibres)
- Chopped fibre composite (composite reinforced with short/random fibres)
- Hybird composite (continuous and random fibre composite)

Structural composite in general:

- Composite laminate
- Composite sandwich
- Particulate composite

2.2. Polypropylene (PP)

Polypropylene is a hydrocarbon polymer included in thermoplastic polymers that can be processed at high temperatures. Polypropylene is derived from propylene monomers obtained from refining petroleum. Propylene molecular structure is CH2 = CH-CH3. Polypropylene is a type of lightweight plastic raw material, density 0.90-0.92 kg/m2, has a high hardness and friability and less stable to heat due to tertiary hydrogen.

Table 1: Plastic Material Specific Gravity

Resin	*Specific Gravity*
PP	0,85 - 0,90
LDPE	0,91 - 0,93
HDPE	0,93 - 0,96
Polystyrene	1,05 - 1,08
ABS	0,99 - 1,10
PVC	1,15 - 1,65
Acetyl Cellulose	1,23 - 1,34
Nylon	1,09 - 1,14
Polycarbonate	1,20
Poly acetate	1,38

2.3. Natural Fibre

Natural fibres derived from nature (not artificial or human engineering). Natural fibre or can be regarded as this natural fibre which is usually obtained from plant fibres (trees) such as bamboo trees, coconut trees, banana trees and other plants that have fibre on their stems or leaves (Rodiawan, et. al, 2016; Sanjay and Yagesha, 2017).

Research and use of natural fibres are growing very rapidly these days because natural fibres have many advantages compared to artificial fibres (engineering), the advantages of natural fibres such as lighter loads, easy to obtain materials, relatively inexpensive prices and most importantly environmentally friendly especially Indonesia has abundant natural wealth (Sari, 2018). In this research, the authors use natural fibres, namely hemp fibre and pineapple fibre.

Table 2: Comparison of natural and synthetic fibres (Surdia, 1995)

Fibre Type	Density (g/cm^3)	Diameter (μm)	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation at Break (%)
Jute	1,3-1,45	20-200	393-773	13-26,5	7-8
Flax	1,5	-	345-1100	27,6	2,7-3,2
Hemp	-	-	690	-	1,6
Hemp (Rami)	1,5	-	400-938	61,4-128	1,2-3,8
Pineapple	1,45	50-200	468-649	9,4-22	3-7
PALF	-	20-80	413-1627	34,5-82,51	1,6
Cotton	1,5-1,6	-	287-800	5,5-12,6	7-8
Coir	1,15	100-450	131-175	4-6	15-40
E-Glass	2,5	-	2000-3500	70	2,5
S-Glass	2,5	-	4570	86	2,8
Aramid	1,4	-	3000-3150	63-67	3,3-3,7
Carbon	1,7	-	4000	230-240	1,4-1,8

3. Methods

3.1. Flow Diagram

This research was conducted based on the flow chart as shown in Fig. 2:

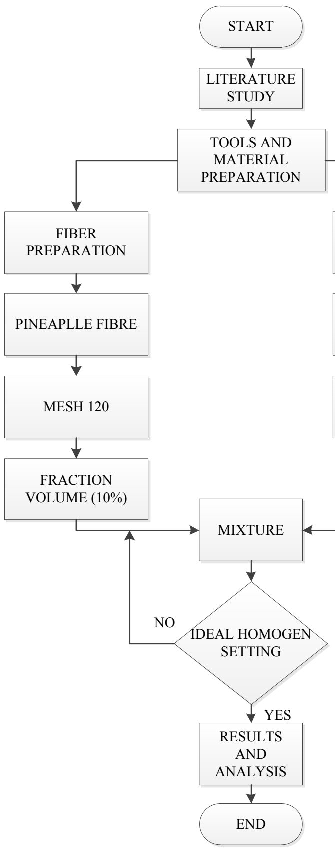

Fig. 2: Research Methods

1. Literature study and field survey are the first steps to find information and references relating to this research study.
2. Materials and tools preparation. Some several tools and materials support the process of specimens test making.
3. After the tools and materials needed are met. The process is continuous to specimens test making.
4. Results and discussion, after the process of making test specimens, will be seen from the physical material of the composite polymer regarding the standard.
5. Conclusions, summarizing the results of research by answering the objectives of this study.

3.2. Materials

Pineapple fibre and hemp fibre in this study were obtained from Sumenep, Indonesia. High impact polypropylene pellets (PPHI) obtained from PT. Chandra Asri Petrochemical Cilegon, Indonesia.

3.3. Preparation of Natural Fibres

The natural fibre is cut along 3 mm, then dried using an oven heater with a temperature of 200 °C and then blended and then shaken with a size below 120 mesh.

3.4. Manufacturing Process of PPHI composites with natural fibre reinforcement

Natural fibres that have been shaken with a mesh under 120 are mixed with PPHI pellets with a fibre volume fraction accounting for 10%. Combine PPHI fibre and pellet put in a mould that meets the test standards processed at a temperature of 250 ℃ after it is cooled for 3 hours.

Natural fibres that have been shaken with a mesh under 120 are mixed with PPHI pellets with a fibre volume fraction accounting for 10%. Combine PPHI fibre and pellet put in a mould that meets the test standards processed at a temperature of 250 °C after it is cooled for 3 hours.

The process of mixing PPHI and pineapple fibre with a volume fraction of 10%, is explained in the table 3:

Table 3: Mixture process

Process	Explanation
	Weighing to determine a 10% volume fraction
	Inserting PPHI part in to the mould
	Melt down PPHI in the furnace

Process	Explanation
	Sowing Natural Fibre and PPHI
	Mix to compact a mixture of Natural Fibre and PPHI
	This process is carried out to restore the form of a mixture of fibre and PPHI that has been mixed
	Pressing/closing the mould using a C clamp and cooling for 25 minutes at room temperature
	Finishing/final process is carried out to eliminate the results that are not needed
	Ready for testing specimen

3.5. Setting process

In this process the material will be seen from three important aspects when related to the level of homogeneity of the specimen using the hand lay-up method when viewed visually that is the mixing process, the stirring process, and the cooling process. These aspects are shown in table 4:

Table 4: Specimen Homogeinity

Parameter	**Specimen Homogeneity**	
	300 ℃	**℃**
Mixing (Material Density)		
Apart	There is a gap	There is a gap
Not separated	Solid	Solid
Stirring Process (Porosity)		
Without stirring	Major porosity	Major porosity

With stirring	Minor porosity	Minor porosity
Cooling (cracks)		
Normalizing	Minor cracks	No cracks
Quenching	Major cracks	Major cracks

4. Conclusion

Seen from the above table 4, it can be concluded that at a temperature of 250 °C with normalizing cooling and PPHI and pineapple fibre enabling processes by stirring can increase the homogeneity of the bending test specimen. In the final product with the recommended setting found porosity defects caused by trapped gas (hydrogen) and porosity caused by shrinkage between dendrites, the gas can be removed from the specimen by stirring and cooling templates are evenly distributed, or controlled by nucleation diffusion and growth, causing a decrease in hydrogen concentration, increasing the rate of solidification so that the formation and growth of voids can be minimized.

5. References

Alzebdeh, K.I., Nassar, M.M.A, Arunachalam R, 2019, Effect of fabrication parameters on strength of natural fibre polypropylene composites: Statistical assessment, Measurement 146, 195-207. (DOI: https://doi.org/10.1016/j.measurement.2019.06.012)

Asim, M., Jawaid, M., Abdan, K., Ishak, M.R., 2016, Effect of Alkali and Silane Treatments on Mechanical and Fibre-matrix Bond Strength of Kenaf and Pineapple Leaf Fibres, Journal of Bionic Engineering 13, 426-435. (DOI: https://doi.org/10.1016/S1672-6529(16)60315-3)

ASTM D 3039, Standard Test Methods for Tensile Properties of Polymer Matrix Composites Materials

ASTM D 6110, Standard Test for Determining the Charpy Impact Resistance of Notched Specimens of Plastics

ASTM D 790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

Borrachero, B.O., Caballero, S.S., Fenollar, O., Selles, M.A., 2019, Natural-Fibre-Reinforced Polymer Composites for Automotive Parts Manufacturing, Key Engineering Materials 793, 9-16. (DOI: https://doi.org/10.4028/www.scientific.net/KEM.793.9)

Gibson, R.F., 1994, Principles of Composite Materials Mechanics, Mc-Graw-Hill.

Hadi, T.S., Jokosisworo, S., Parlindungan, M., 2016, Penggunaan Serat Daun Nanas Sebagai Alternatif Bahan Komposit Pembuatan Kulit Kapal Ditinjau Dari Kekuatan Tarik, Bending dan Impact, Jurnal Teknik Perkapalan 4, 323-331.

Kozderka, M., Rose, B., Koci, V., Caillaud, E., Bahluoli, N., 2016, High Impact Polypropylene Recycling – Mechanical Resistance and LCA Case Study with Improved Efficiency by Preliminary Sensitivity Analysis, 12th IFIP, 541-553. (DOI: https://doi.org/10.1007/978-3-319-33111-9_49)

Mardiyati, M., Srahputri, N., Steven, S., Suratman, R., 2017, Sifat Tarik Dan Sifat Impak Komposit Polipropilena High Impact Berpenguat Serat Rami Acak Yang Dibuat Dengan Metode Injection Molding, Mesin 26, 39-43. (DOI: http://dx.doi.org/10.561%2FMESIN.2017.26.1.2)

Rodiawan, R., Suhdi, S., Rosa, F., 2017, Analisa Sifat-sifat Serat Alam Sebagai Penguat Komposit Ditinjau dari Kekuatan Mekanik, TURBO 5, 39-43. (DOI: https://doi.org/10.24127/trb.v5i1.117)

Sanjay, M., Yagesha, B., 2017, Studies on Natural/Glass Fibre Reinforced Polymer Hybrid Composites: An Evolution, Materials Today: Proceeding, 2739-2747. (DOI: https://doi.org/10.1016/j.matpr.2017.02.151)

Sari, N.H., 2018, Kekuatan Mekanik Komposit Diperkuat Serat Alam Selulosa, Dinamika Teknik Mesin 8, 51-56. (DOI: https://doi.org/10.29303/dtm.v8i2.139)

Senthilkumar, K., Rajini, N., Saba, N., Jawaid, M., Siengchin, S., 2019, Effect of Alkali Treatmentnon Mechanical and Morphological Properties of Pineapple Leaf Fibre/Polyester Composites, Journal of Polymers and the Environment 27, 1191-1201. (DOI: https://doi.org/10.1016/j.polymertesting.2018.11.011)

Surdia, T., Saito, S., 1995, Pengetahuan Bahan Teknik, PT. Pradnya Paramitha