THE STUDY ON THE EFFECTS OF MECHANICAL PROPERTIES ON THICKNESS AND ORIENTATION WOVEN E-GLASS/EPOXY LAMINATE COMPOSITE

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Abstract: Composite material is also known as a combination of two or more distinct materials, having a recognizable interface between them. Composites are being utilized as viable alternatives to metallic materials in structures where weight is a major consideration, e.g., aerospace structures, high speed boats and trains. The composite strength is basically due to the ability to absorb more energy to failure. Not necessarily all composite structure can be destroyed and absorb energy. Strength of materials to accommodate the load in a system plays an important role in everyday life. Therefore the research is to identify effects of mechanical properties on thickness and orientation woven E-glass/epoxy laminate composite. Hardness Test and Charpy Impact Test were carried out based on ASTM D2240 and ASTM D-6110, for laminate woven E-glass fiber epoxy composite the thickness is 3mm and 6mm. Based on the Mechanical Testing conducted, it is found that the orientation of 90° for 12 layers and the orientation of 45° for 12 layers are having the highest Hardness and Toughness properties.

Keywords: E-glass, Epoxy, Thickness, Mechanical properties Hardness Test, Charpy Impact Test, Izod Impact Test.

I. INTRODUCTION

Composite materials is also known as composition materials or shortened to composites. The materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components.

Composite laminate is a combination of fiber and resin mixed in proper form. One of the unique properties of composite laminate is that it has high specific strength. In an effort to produce lighter and stronger composite materials such as fiberglass reinforced plastic and is a choice in the design process to replace low carbon steel as the main material. The term of composite also could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term usually refers to a “matrix” material that is reinforced with fibers. For instance, the term “FRP” (for Fiber Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibers, and this particular composite has the lion’s share of today’s commercial market.

The composite strength is basically due to the ability of some structure that can absorb more energy to failure. Not necessarily all composite structure can be destroyed and absorb energy.

Strength materials to accommodate the load in a system plays an important role in everyday life. So, by making testing and learning about the orientation and thickness on the composite material in epoxy broom in layers, this assay can be expected to know the power that can be accommodated by the composite structure and the structural changes. Testing work will be done is testing in terms of hardness and impact.

Composite materials have several advantages compared with conventional materials such as metals. These advantages can generally be viewed from a number of important properties such as mechanical and physical ability (reliability), process ability and cost. In general, the selection of the matrix material and the fiber plays an important role in determining the mechanical properties and the properties of the composite. Dynamic characteristics of components is vital in design, numerous papers been reviewed in properties of strength and strain for static and quasi loading [1]. To get the fuller understanding of the mechanical properties of E-glass/epoxy there has been numerous research been published. ASTM (American Society for Testing Materials) explains procedure for hardness test properties of composite matrix as specified in ASTM D2240 and ASTM D-6110 [2].Databases on glass/epoxy, which mentioned in the references [3][4][5] are reviewed for present paper. The references provide hand full information mechanical properties of E-Glass/Epoxy which serves the objective of present work.

Ties woven an inexpensive method for laminar area, large screen that requires rapid build-up and high-strength reinforcement. It is not suitable for applications that require conformability. Fiber incorporated into the warp and fill yarns that run on zero and 90 degrees, delivering solid power in both directions to complete part of a composite.

Adjusted the threads running in parallel with the load expected, and spare row at 45 degrees to maximize power.Woven E-Glass (woven roving) is often used with chopped strand mat (CSM) to strengthen other materials and make repairs. In this particular case, it isused with polyester or vinyl ester resin alone, as CSM save it from being compatible with epoxy. Using cross-ply carbon/epoxy, was carry out to investigate the effect of strain rate on compressive behavior, with thickness along in-plane for strain rates [6]. Dynamic compressive strength and stiffness were tested on unidirectional and cross-ply carbon epoxy composite lamination, gives comparably higher than static value [7]. Ultrasonic method on quasi-isotropic lamination reveal variation of 30 % in elastic modulus and Poission's ratio for the lamination process [8]. Experimental and numerical values of tension along with compression strength for notch and un-notched quasi-isotropic laminates were carried out with comparing degraded material [9].
Base on the references technical information's, this investigation was carried out onthickness and orientation woven E-Glass/Epoxy laminate composite.

II. METHODOLOGY

Processes and methods that will be carried out can be seen in the following figure 1 shows a flow chart of the methodology in more detail.

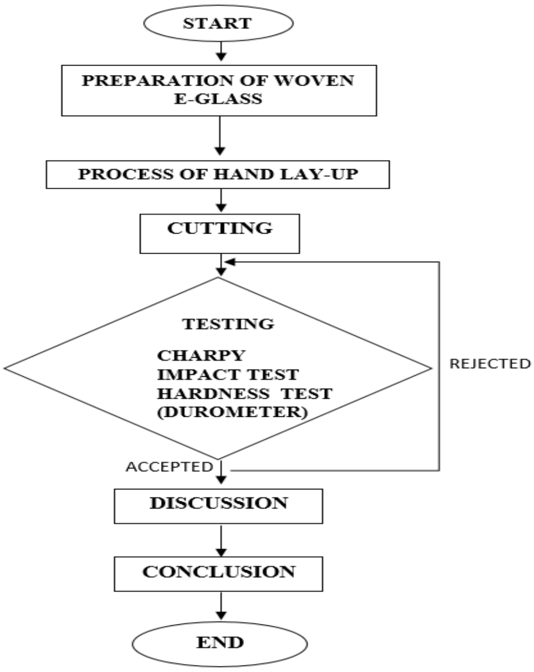


Fig 1: Flow process and method

2.1 Woven E-Glass Preparation

The raw materials for producing the sample is woven glass fiber fabric type and with epoxy resin. Glass fiber yarn types (woven roving) is suitable for use with methods roving hand (hand lay-up). Similarly, the resin suitable for woven fabric (woven roving) is a type of epoxy resin.Mixed woven glass fiber (woven roving) and epoxy resin should be adhered to in the process of producing the sample. The ratio of the mixture is 50% epoxy resin and glass fibers were mixed with a catalyst. The catalyst is used in order to actively engage with epoxy resin to accelerate the hardening process. Locks of glass fiber fabric (woven roving) shall be deducted measured beforehand according to the desired size. Then cut using scissors according to the desired size. Cutting according to the size desired angle will accelerate the process of preparing materials for marking only the beginning only needs to be done as depicts in table1. Damage to the fabric weaving (woven roving) deducted inevitable and reduce wastage. In addition, the woven fabric (woven roving) that has been cut will facilitate the process laminate while producing a multi-layered samples.

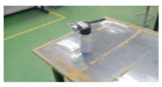
Table 1: Woven E-glass Cutting Process

No	Picture	Function
1		Woven E-glass prepared for cut
2		Measurements taken using a ruler and marker pen with a size of "120mm x 120mm".
3		Material were cut according dimension.

2.2 Hand Lay-Up Mold Preparation

Hand Lay-Up is a simple method for composite production where a mold used for hand lay-up with flat sheet with curves and edges. Before lay-up, the mold is prepared with a release agent to insure that the part will not at here to the mold as depicts in table 2.Reinforcement fibresbeen cut and laid in the mold.

Table 2: Hand Lay-up Process for 6 layers and 12 layers

No	Picture	Function
1		Clean the table so that's no dust or dirt.
2		Cover the table with plastic PVC.
3		Apply mold release on the table was ready wrapped.
4		Measures of epoxy and hardness 70% of the weight of fibre
5		Mix the epoxy and hardness with use stick.

6		Apply epoxy in the table.
7		Start the hand lay-up process with caution and faster and also make sure not have bubble of air.
8		Perform hand lay-up process according layer required
9		Perform hand lay-up process to finish and wait until dry or cure

2.3 Specimen Preparation

Table 3 shows the preparation process of the specimen for future test, with control of 1270 mm x 160 mm in dimension and angle of 45 degree and 90 degree.

Table 3: Process of Cutting and preparing the Specimen

No	Picture	Function
1		Specimen have been finish Hand lay-up process.
2		Make measurements on the surface of the specimen with dimension 1270mm x 160mm.
3		Cutting the specimen using the Horizontal Band Saw
4		Label with the different angle for easy work when test it.

2.4 Charpy Impact Test Carried out

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition.

Table 4: Charpy Test Process

No	Picture	Function
1		The specimen have been cut is 45° and 90° of angle. The dimensions is 12.7mm x 127mm, and the thickness 3mm, angle in the middle 45 degree.
2		Place the work pieces horizontally and the angle "V" of the front
3		Make sure the tool is located in the state reading test angle of 0 degrees and the energy absorption 0 joule.
4		Pull the trigger and let it move. Weight of the test material is 4.4kg.
5		The results of the Charpy test

III. RESULTS AND DISCUSSION

Observation and result obtain in this study was conductor bycarrying out preparation materials characterization, orientation, thickness,Charpy impact test, Hardness impact test, physical properties testing, analyzing the result of the test and its effect on the mechanical properties of the material.

3.1. Data Collection

Calculate the absorbed energy:

$$E = W * R * g\,(\text{Cos B} - \text{Cos C})$$

Where;

C = hammer lift up angle (degree) = 120°

B = wing up angle after hitting the sample (degree)

g = gravity = 9.81 m/ s²

W = weight of hammer = 4.4 kg/ 8.8 kg

R = length of pendulum shaft

Table 5 shows the readings from experimental test and compared with the values obtained from calculation depicts in Table 6.

Table 5: Data collection from Charpy Impact Test on woven E-glass fiber epoxy composite.

Sample	90°,12pcs		90°,6pcs		45°,12pcs		45°,6pcs	
	Angle (°)	Energy, J	Angle (°)	Energy, J	Angle (°)	Energy, J	Angle (°)	Energy, J
1	10	28.65	92	9.06	1	29.03	78	14.6
2	4	28.83	96	7.10	1	29.03	75	14.2
3	5	28.83	96	7.10	3	29.09	75	14.2
4	2	29.06	91	9.03	31	26.70	76	14.3
5	0	29.0	93	9.10	37	25.70	77	14.3
Average	**4.2**	**28.87**	**93.6**	**8.28**	**14.6**	**27.91**	**76.2**	**14.32**

Table 6 : Data collection from Charpy Impact Test on woven E-glass fiber epoxy composite by calculation method.

Sample	90°,12pcs		90°,6pcs		45°,12pcs		45°,6pcs	
	Angle (°)	Energy, J	Angle (°)	Energy, J	Angle (°)	Energy, J	Angle (°)	Energy, J
1	10	29.50	92	9.23	1	29.75	78	14.0
2	4	29.73	96	7.85	1	29.75	75	15.07
3	5	29.70	96	7.85	3	29.76	75	15.07
4	2	29.77	91	9.58	31	26.95	76	14.73
5	0	29.78	93	8.89	37	25.78	77	1.40
Average	4.2	29.70	93.6	8.68	14.6	28.40	76.2	14.65

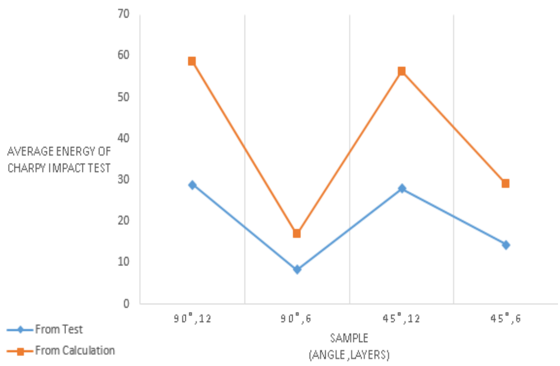


Fig 2: Average Energy, J For Charpy Impact Test.

Figure 2, depictsresults Charpy impact test shows the average toughness value that was obtained for the charpy impact test on the specimen. For the 90° angle and 12 layers, the average reading that was obtained was 28.87J. Then, for 90° angle and 6 layers, the average toughness was around 8.28J, later for the 45° angle and 12 layers, the average of the value of toughness obtained was 27.91J and lastly for the 45° angle and 6 layers, the average reading that was obtained 14.32J. Otherwise, from the calculation methods to get the average energy, the data were obtained for the 90° angle and 12 layers was 29.70J, for the 90° angle and 6 layers the result obtained was 8.68J, while for the 45° angle and 12 layers was 28.40J and for the 45° angle and 6 layers the result obtained was 14.65J.This absorbed energy is a measure of given materials notch toughness and acts as a tool to study dependent ductile- brittle transition. In this testing, the best part that obtained the maximum force was 90° angle and 12 layers also 45° angle and 12 layers is 28.87J and 27.91J. This part has the best impact rather than the 90° angle and 6 layers also 45° angle and 6 layers where the average difference between the two parts is around 8.28J and 14.32J.

3.3. Hardness Test

Hardness is not an intrinsic property of a material. The values ascribed are due to a complex combination of deformation and elastic behavior. Hardness is an empirical test and therefore hardness is not a material property. This is because there are several different hardness tests that will each determine a different hardness value for the same piece of material.

According to the result obtained, the best part of on woven E-glass fiber epoxy composite with the best hardness impact test 12 layers. According to the testing conducted, this part had the best average reading on hardness impact with 85.5. This part has the best harder type rather than the 6 layers.

Table 7: Data collection from Hardness Test (durometer) on woven E-glass fiber epoxy composite

Layers of sample	No Samples								
	1	2	3	4	5	6	7	8	9
6 layers	85	87	85	83	86	83	86	85	84
12 layers	86	85	87	86	86	85	84	86	85

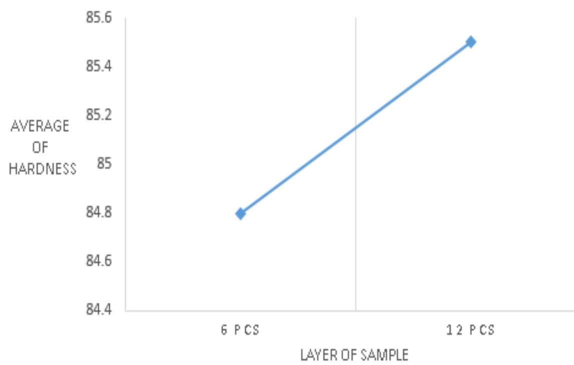


Fig 3: Average from Hardness Test (durometer) on woven E-glass fiber epoxy composite.

Based on the table 7 and figure 3, shows the average for the surface on woven E-glass fibre epoxy composite. It shows that for the 12 layers, the highest average obtained was 85.5 and followed by 6 layers the reading was 84.8

CONCLUSION

The objective of this research is to identify the optimum composition in producing best thickness and orientation woven E-glass fiber epoxy composite and also find the best mechanical properties woven E-glass fiber epoxy composite. The Mechanical Testing on Hardness and Charpy Impact Test were carried out based on ASTM D6110-02 and ASTM D2240 (Type D). It is found that the average value of 6 layers Hardness is 84.8 joule, the average value of 12 layers Hardness is 85.5. Then, the average value for Charpy Impact test the 90° angle and 12 layers that was obtained was 28.87J. Then, for 90° angle and 6 layers, the average toughness was around 8.28J, later for the 45° angle and 12 layers, the average of the value of toughness obtained was 27.91J and lastly for the 45° angle and 6 layers, the average reading that was obtained 14.32J.

Based on the result of the testing conducted, it is conclude that , the part woven E-glass fiber epoxy composite90° angle and 12 layers also 45° angle and 12 layers is the highest Hardness and Toughness properties. The two part of that is found to have the best mechanical properties.

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