Preparation and Characterization of Hybrid Composite Laminated Plates with Variation of Sawdust

P. Ravikanth Raju, Somagani Upendar, P. Chinna Srinivas Rao

***Abstract:** From past two-three decades there has been a gradual shift from monolithic to composite materials in order to meet the increasing demand for lighter, high performance, environment friendly, corrosion and wear resistant materials. Composite materials are majorly used in massive production like boats, automotive and air craft Industry etc. in order to improve hardness and impact strength. The manufacturing of hybrid composite laminates is difficult to handle by traditional methods and gives size restrictions, wetting, poor surface finish, more number of moulding required for manufacturing. The Hand lay-up chosen as the fabrication technique when product needs smooth finish slight variations in thickness and number of moldings required is less. The moulding made from materials like plastics, wood, clay, plaster or plywood depending on the availability. Hand lay-up technique has been adopted to manufacture the hybrid composite laminated plate (sawdust with 1%, 2% and 3% variation) and impact strength and hardness is to be calculated.*

***Key words:** Fiber Glass, Epoxy resin LY-556, Hardener HY-55, Teflon sheets*

I. INTRODUCTION

1.1. Materials Required: The different materials and components required for this manufacturing process of glass epoxy composite are given in Table 1.

Table.1: Required Materials for Manufacturing

SL. No	Materials	Quantity
1.	Fiber Glass	1047.6g
2.	Epoxy resin LY-556	429.04g
3.	Hardener HY-556	100g
4.	Hardener HY-556	21.12g
5.	Teflon sheets (1x 1) m	1
6.	Measuring jar, Stirring rod	2,1
7.	Portable Weighing Machine	1
8	Weights, Scissors	1

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1.2. Glass Fibre

Bundle of glass fiber is material made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products; the resulting composite material, properly known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP), is called "fiberglass" in popular usage. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of fiberglass was only made possible with the invention of finer machine tooling, What is commonly known as "fiberglass" these days, however, was made-up in 1938 by Russell Games Slayter of Owens-Corning as a cloth to be used as insulation. It is marketed under the trade name Fiberglass, which has become a trademark. The properties of saw dust are shown in Table 2.

Table2: Properties of Saw Dust

SL. No	Parameter	Value
1	Density	360 GSM
2	Rockwell hardness	110 M scale
3	Bond strength	>1000 kg
4	Flexural strength	>345 MPa
5	Tensile strength	>310 Mpa
6	Impact strength	>44 Nm/m
7	Compressive strength	>415 MPa
8	Dielectric strength	20 kV/mm
9	Permittivity	4.8
10	Dissipation factor	0.017
11	Young's modulus	3.5x10^6 psi
12	Poisson's ratio	0.136

A somewhat similar, however dearer technology used for applications requiring terribly high strength and low weight is that the use of carbon fiber. fibreglass could be a light-weight, very robust material. Though strength properties are somewhat less than carbon fiber and it's less stiff, the fabric is often way less brittle, and also the raw materials are a lot of less costly. Its bulk strength and weight properties are terribly favorable compared to metals, and it may be simply shaped victimization molding processes. Common uses of fibreglass embody boats, vehicles, baths, hot tubs, water tanks, roofing, pipes, cladding, casts and external door skins. During this method E-glass fiber (54% SiO_2, 15% Al_2O_3, and twelve-tone system CaO) of woven Roving reinforcement kind has been used. the fabric properties of optical fiber is shown in Table 3. The composition of assorted samples is shown in Table 4.

Table: 3 Properties of Glass Fiber

SL. No	Parameter	Value
1	Density	1.175 gm/cc
2	Rockwell hardness	80 M scale
3	Elastic modulus	2415 MPa
4	Flexural strength	>120 MPa
5	Tensile strength	>90 Mpa
6	Impact strength	>20 Nm/m
7	Compressive strength	>173 MPa
8	Dielectric strength	300 V/mil
9	Thermal conductivity	0.188 w/m-^{0}c
10	Dissipation factor	0.017
11	Elongation at break	3-9 %
12	Poisson’s ratio	0.145

EPOXY RESIN:

Epoxy resin is outlined as a molecule containing over one epoxide teams. The epoxide cluster conjointly termed as oxiran group. These resins are thermosetting polymers and are used as adhesives, high performance coatings and plotting and encapsulating materials. These resins have wonderful electrical properties, low shrinkage, adhesion to several metals and resistance to wet, thermal and mechanical shock. Viscosity, epoxide atomic weight and mass are the necessary properties of epoxy resins.

Table 4: Composition of Various Samples

SL. No	Ratio of Glass fiber	Ratio of Epoxy resin	Ratio of Sawdust
1	60%	40%	0%
2	60%	39%	1%
3	60%	38%	2%
4	60%	37%	3%

II. DETERMINATION OF REQUIRED EPOXY RESIN AND GLASS FIBER:

Generally for measuring the required amount of materials for manufacturing composite laminate, we electronic weighing machine which measures exactly in grams. In this work two different ratios of glass fiber to epoxy resin. For determining the exact weight of the material the Density formulae used is:

$$d = \frac{m}{v}$$

d = density
m = mass
v = volume

Density of fiber = 0.97 g/cm^3, Density of matrix = 1.125g/cm^3, Density of sawdust =1.1g/cm^3

Volume of the composite (mould) = 300x300x8 mm = 30x30x0.8 cm = 720 cm^3

Volume of composite = volume of fiber + volume of matrix

Vol. of fiber = 60% of vol. of composite = 60 x (720/100) = 432 cm^3

We know density of fiber = mass of fiber / vol. of fiber

Hence mass of fiber = vol. of fiber x density of fiber = 432 x 0.97 = 419.04g

Similarly Vol. of matrix = 40% of vol. of composite = 40 x (720/100) = 288cm^3

Mass of matrix = vol. of matrix x density of matrix = 288 x 1.125 = 324g

For ratio of 60:39:1 of fiber: resin: sawdust,

Vol. of matrix = 39 x (288/100) = 112.32cm^3

Mass of matrix = 1.175 x 112.32 = 131.97g

Vol. of sawdust = 1 x (288/100) = 2.88cm^3

Mass of sawdust = density of sawdust x vol. of sawdust = 1.1 x 2.88 = 3.168g

Similarly for other 2 ratios i.e. 60:38:2, 60:37:1

Resin and the hardener are added in the ratio of 10:1. After calculating the weights of required material, the glass fiber needs to cut according to the mould dimensions.

Table 5: Estimation of weights

S.No.	% of sawdust	Wt. of fiber in gm	Wt. of resin in gm	Wt. of sawdust in gm
1	0%	419.04	324	0
2	1%	419.04	131.976	3.168
3	2%	419.04	128.592	6.33
4	3%	419.04	116.56	9.504
	Total wt.	1676.16	701.128	19.002

2.1 Preparation of Mould:

For making the test specimen, composite laminates are prepared on a wooden mould of dimensions 30x30 cm^2 as shown in Fig. 1.

Fig: 1 Wooden Mould to Prepare Composite Material

2.2 Cutting of Glass Fibre

Glass fiber should be delve many layers every of dimension 250x250mm in order that it'll precisely work into the mould. Traditional blade will be accustomed cut the fibre and also the weight will be measured by electronic weighing balance. The fibre bundle is shown in Fig. 2.

Fig 2: Cutting of Glass Fiber

III. MANUFACTURING OF COMPOSITE LAMINATES

Initially apply a Teflon sheet to the wooden mold and wax gel is coated on it to avoid the sticking of polymer to the surface. Thin Teflon sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Allow it to dry for few min, once it is dried properly, apply PVA coating which acts as mold release. This PVA coating should be applied only in the area where Teflon is applied, this coating should be applied until it forms a thin film on Teflon.

Fig. 3: Applying Release Spray

Fig. 4: Applying PVA Coating on Mold

Fig. 5: Mixing Resin and Hardener

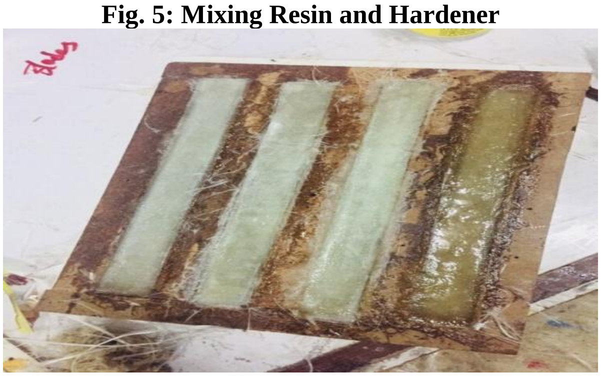

Fig. 6: Settling of Laminate

Allow this whole setup to dry completely. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the mold. The chemical compound is uniformly unfold with the assistance of brush. Resin and hardener are mixed in the ratio of 10:1 i.e. if the resin is taken in 100g then hardener should be taken in 10g. Resin and hardener are mixed just before preparation of the laminates since the mixture hardens after 15-20 minutes and is of no use in such case. Place the reinforcement which is cut earlier in woven mats in layers where resin and hardener are already applied. The process is continual for every layer of chemical compound and mat, until the specified layers are stacked. Now for other compositions, we need to add filler material (here sawdust) in an ascending manner i.e. 1%, 2%, 3% of the resin mixture that is taken. Again repeat the above process and continue until required thickness is obtained. After allowing it to settle for half an hour weights are applied on the mold. In this case a wooden plank of dimensions 30x30cm is placed such that uniform pressure is applied. This is a stage at which the best physical properties of any molding are developed. Once the laminate is settled, allow it to cure for 12-16hrs. Once curing is done, the specimen is taken out of mold and cut to required length as per dimensions (50 x 10 x 8mm). Now the material is tested and results are analyzed.

3.1: Testing of Specimens

Specimen used for testing should be cut into two different shapes for two different tests. For impact test it should be in dimension of 55x10x8mm. For Hardness test it should be in dimension of 55x10x8 mm.

Fig. 7: Specimen For Impact test

Fig. 8: Specimen for Hardness Test

IV. RESULTS AND DISCUSSIONS

4.1. IMPACT TEST: The impact strength for the composite material with different blending compositions of epoxy resin and glass fibers and various orientations are presented in Table 5. The Impact strength was calculated using the equation,

E = wgr(cosB-cosA)-L

Where, E= the energy absorbed by material, w= weight of specimen, r= radius of curvature, B, A= orientation angles and L= length of material

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Table 5: Impact Test Results

S.No.	Fiber (%)	Resin (%)	Sawdust (%)	Impact Strength (joules)
1	60	40	0	9
2	60	39	1	14
3	60	38	2	15
4	60	37	3	11

4.2. HARDNESS TEST: The Hardness test at break for a composite with different blending compositions of epoxy resin and glass fibers are presented in Table 6. The hardness was calculated using the equation, HR = N- (d/s)

Where: N=depth from load point, d,s= Scale factors and HR=hardness strength.

Table 6: Hardness Test Results

S.No.	Fiber (%)	Resin (%)	Sawdust (%)	Avg value of HR in D-scale
1	60	40	0	91.66
2	60	39	1	94.66
3	60	38	2	93.66
4	60	37	3	93.66

V. CONCLUSIONS:

The following conclusions are drawn after the Hybrid composite laminated plates underwent for Hardness and Impact tests:

- The composite material shows higher impact strength with the percentage increase in sawdust upto 1%. The material with low percentage of epoxy and high percentage of sawdust has less impact strength. And the material with high percentage of epoxy and low percentage of sawdust has high impact strength.
- The composite material possesses higher strength in the compositions of 0% and 1% than that of 2% and 3%.
- The composite material possesses higher strength in 0% and 1% of sawdust and constant in 2% and 3% of sawdust.
- The composite material shows lower hardness with percentage increase in glass fibre. The material with low percentage of epoxy and high percentage of sawdust has less hardness. And the material with high percentage of epoxy and low percentage of sawdust has high hardness.

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