Characterization of Glass fiber reinforced Hybrid resin (Epoxy and Polybenzamidazole powder)

Prof.Nikhil P.Talwekar M.E. (Heat Power) [1]
Prof.Yogendra L. Jain M.E (CAD/CAM) [2]
Prof.Vaibhav V. Edake M.E. (Design) [3]
[1,2&3] Department of Mechanical Engineering, ISB&M, SOT, Nande,Pune,India.

Abstract - Composite materials are commercially recognized since last three decades due to their excellent mechanical properties. This work is to create an endeavor to boost the mechanical and thermal properties. The objective of the analysis is to see the optimum concentration of constituents to possess best set of properties. In the present work the effect of addition of polybenzamidazole on mechanical and thermal properties of glass fiber reinforced epoxy resin is studied. The woven glass fiber reinforced epoxy resin is fabricated by hand lay-up technique. The polybenzamidazole in powder form was used as filler material. The concentration of filler material within the matrix is varied to possess clear understanding concerning the impact on properties of the composite. The glass fiber 1200 G.S.M and the resin concentration would be varied. Tensile tests and flexural tests were conducted according to the ASTM standards. The result data thus obtained from the tests is useful in assessing the feasibility of glass fiber composite in mechanical applications and for thermal stability.

Keywords — Glass fiber, Polybenzamidizole powder, epoxy.

I. Introduction

Polymer matrix composites are very popular amongst the wide selection of composite materials. The rationale is that it is comparatively cheaper and easy to produce. The mechanical properties of thermosetting polymers like strength, compressive strength and impact properties are found to be low as compared to the standard materials.This disadvantages are often overcame by incorporating a secondary innovate in the polymer. During this method a polymer matrix composite (PMC) is created. [1] A wide range of applications are provided by the polymer matrix composites from civil engineering, sport goods, medical supplies to aerospace industry in making the airplane fuselage. Composite materials are harmful in marine applications wherever the metals fails owing to corrosion. Composite materials even have smart fatigue properties when put next to steels.[2] Producinf processes of metals leads to harmful gases like sulfur dioxide, gas etc. These gases are answerable for acid precipitation that causes a no. of health hazards and environmental problems. Taking the pollution caused due to manufacturing of conventional metallic and alloy materials the composites are the need for tomorrow. The composite materials are used as a substitute for metals in several applications. One among the foremost common example that we see in our day to day life is roofing created from PMC (polymer matrix composites) consisting of fiber or natural fibers that were conventionally created by exploiting iron sheets or concrete. Another example would be the doors. From precedent days the doors are manufactured from forged iron plates or by wood .Considering the unendingly growing civil trade there's large demand for building materials. The composite materials will effectively serve this purpose. There is a wide variety of reinforcement material that is available to use with PMC. The main categories are natural fibers and synthetic fibers. Glass fiber is one of the synthetic fiber type. Glass fibers (GFs) have high strength, high flexural modulus and low expansion rate, they are the most common fiber reinforcements in thermoplastics to reduce the expansion rate and increase the flexural modulus of composites [3-4].The properties of composite material also depends on the manufacturing technique used. The orientation of reinforcement of fibers in matrix also plays a vital role in load carrying capacity of the material. The raw materials used for making E-glass fibres are silica sand, limestone, fluorspar, boric acid, and clay. Silica accounts for more than 50% of the total ingredients. By varying the amounts of raw materials and hence the process parameters, other glass types are produced [7].

Epoxy is a very versatile resin system, allowing for a broad range of properties and processing capabilities. It exhibits low shrinkage as well as excellent adhesion to a variety of substrate materials. Epoxies are the foremost wide used organic compound materials and are utilized in several applications from aerospace to sports equipment.

II. Experimental set-up

A. Selection of the materials

The mechanical properties of the composite material depends on the interaction between the different constituent phases. [7] Glass fibers have good affinity towards epoxy resin. Epoxy resin of grade LY556 is selected as the matrix material.

The filler polybenzamidazole is added to the composite material to introduce properties such as tensile, impact strength and thermal characteristics which cannot be achieved through the reinforcement or matrix phase.

B. Procurement of materials and equipment

Raw materials needed are E-glass fiber woven 650GSM, particulate polybenzamidazole filler and epoxy resin. Equipment needed are brush, sponge roller, measuring jar, tray, polyethylene sheets. Raw material for fabrication of composite is procured from local industrial sources. Glass fiber woven fabric is obtained readily from Sakthi Fibers, Saidapet, Chennai. Epoxy resin of grade LY556, along with the hardner HV 951 IN as a matrix material is obtained from Javanthee Enterprises, Guindy, Chennai. Polybenzamidazole powder of grade GAZOLE 5200P is procured from Garda chemicals Pvt. Ltd. Mumbai. The basic hand layup technique at room temperature is followed. Aradur HV 951 is used as a catalyst hardener to facilitate solidification at room temperature.

C. Preparation of Samples

Samples are to be prepared for performing tensile tests, flexural test to compare results prior and after adding polybenzamidazole. For this purpose the glass fabric is cut into uniform area of 30*30cm2. After manufacturing these prepared samples are cut in specific measurements as laid out in ASTM standards.

D. Manufacturing

The manufacturing process is done by conventional hand lay-up technique. Manufacturing of samples is done on polyethylene sheets. The Aradur HY 951 is used as resin with concentration of 10%wt of hardener. Polybenzamidazole in particulate form with 5µm is used in manufacturing. The polybenzamidazole in particulate form is mixed in epoxy resin in beaker. For manufacturing of one specimen 100gms of Epoxy resin was used. 5 layers of glass fabric were used in manufacturing of one specimen. The amount of epoxy used in manufacturing of composite was kept constant as 100gms. While manufacturing the polybenzamidazole powder was mixed with liquid epoxy thoroughly. The mixture is stirred well to have homogeneity in polybenzamidazole distribution as polybenzamidazole powder may get settled down in beaker. The polybenzamidazole concentration used is 0, 5, 10% weight.

Fig. 3 Manufactured specimen of Glass fiber reinforced epoxy composite with 0% of Polybenzamidazole

The sheets of precut Glass fabric is placed on polyethylene sheet and epoxy resin mixture is applied on it evenly using brush. Multiple number of sheets are used in manufacturing with one above another to achieve required thickness.

A uniform pressure of roller should be employed while manufacturing successive layers. As greater pressure may cause the epoxy applied in fabric to come out from sides.

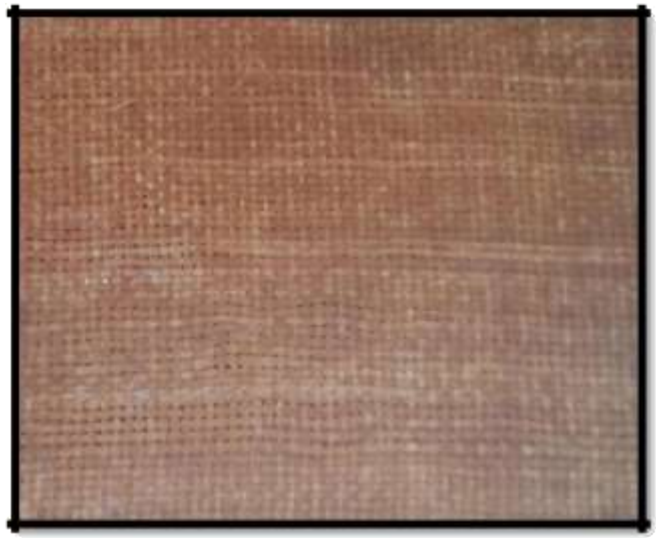

Fig. 4 Manufactured specimen of Glass fiber reinforced Epoxy composite with 5% of Polybenzamidazole

Fig. 5 Manufactured specimen of Glass fiber reinforced Epoxy composite with 10% of Polybenzamidazole

E. Curing

The manufactured samples were first allowed for drying at atmospheric temperature. Later the samples were heated in oven at 120°C for about 1hr. The manufactured samples are allowed to cure at room temperature.

F. Tests

1. **Tensile test**

The ratio of maximum load on an engineering material to the initial cross section is known as ultimate tensile strength. The tensile properties a composite material depend on the adhesion between the constituent phases in the composite material.[1] The samples with different set of concentration in terms of polybenzamidazole % weight were tested on universal testing machine.

Sr. No.	% composition of materials	MPa
1.	0% Polybenzamidazole	150
2.	5% Polybenzamidazole	120
3.	10% Polybenzamidazole	98

2. Flexure test

In flexural test the specimen is simply supported at two ends and the load is applied on the top of the specimen. The specimen is subjected to bending. During the test the top layers are subjected to the compressive stress whereas the bottom layers are subjected to tensile stress. [1] Flexural strength increases with increase in bonding between the phases of composite i.e. fibers and matrix.

Sr. No.	% composition of materials	MPa
1.	0% Polybenzamidazole	193
2.	5% Polybenzamidazole	205
3.	10% Polybenzamidazole	208

3. Impact Test

Not only had this obtained specimen tested under tensile and flexure test but also under Izod/Charpy impact test. Composites are to be tested in impact testing under ASTM D256

Sr. No.	% composition of materials	Joules
1.	0% Polybenzamidazole	4
2.	5% Polybenzamidazole	3.5
3.	10% Polybenzamidazole	3

III. RESULT AND DISCUSSIONS

1.Mechanical properties without filler

The mechanical properties of the composite manufactured without using polybenzamidazole are tested with the same conditions as that of the composites containing the polybenzamidazole. The properties are greatly influenced by the use of the filler. The tests are to be conducted by following the international ASTM standards.

2.Effect of addition of filler on mechanical properties

The mechanical properties of the specimens containing the polybenzamidazole filler are to be tested according to the same ASTM standards used in testing the samples without filler. The test results will give a clear understanding of the effect of addition of the filler.

IV. CONCLUSION

The influence of polybenzamidazole powder on characteristics of glass fiber-epoxy composites is studied. Incorporation of the polybenzamidazole has shown a significant improvement in mechanical properties of the composite material. The damage occurred to fibers in unfilled specimen is overcame in polybenzamidazole filled glass fiber-epoxy composite. The reduction in fiber breakage was due to the increase in density of the polybenzamidazole filled matrix phase.

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