Fabrication and Mechanical Characterization of Glass fibre reinforced Epoxy Hybrid Composites using Fly ash/ Nano clay/ Zinc oxide as filler

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Abstract: In this work the characterization of the mechanical behaviour of glass fibre reinforced epoxy hybrid composites were carried out. With three types of fillers- Nano clay- Zinc oxide-fly ash at different weight ratios and combinations were dispersed with matrix material epoxy by ultra-sonication method. Epoxy glass composites with various fillers were fabricated by hand lay-up technique. Mechanical characterization of Glass fibre reinforced Epoxy Hybrid Composites using Fly ash/Nano clay/Zinc oxide as filler were carried out for tests for tensile, flexural and impact strength properties. Experimental analysis shows Nano clay/fly ash epoxy composites show comparatively higher tensile and impact strength. While Zinc oxide/fly ash epoxy glass composite exhibited better flexural strength. Hybrid filler material dispersed glass fibre reinforced composites can be used for structural application as properties it processes are higher as compared to plain glass fibre reinforced epoxy composites.

1. Introduction

Over the last few decades composite materials have been used widely in engineering field. Due to advantages such as high specific strength, very good corrosion resistant property composite materials becoming important area for researchers and scientists, Composite materials have been used in wide range of applications starting from household applications to advanced applications such as in aircraft and spacecraft. Among the composite materials fiber-reinforced polymer composites are the most widely used one. The addition of fibers to the polymer matrix increases the mechanical strength of the composite material as compared to the neat polymer.

Epoxy is one of the thermosetting polymer resin with excellent properties. Epoxy processes outstanding cost to performance ratio. Some of the properties possesses by epoxy are good adhesion to substrate materials, low viscosity, high strength low creep and low shrinkage during curing. Due to these excellent properties epoxy resin widely used for many applications such as in ship building, aerospace, automobile and structural applications.

In Epoxy/Glass composite it was observed that with higher fiber fraction and the addition of Nano clay particles resulted in improvement of the tensile properties. Also, it was observed the addition of Nano clay to the glass/epoxy composites resulted in increase the flexural strength of the glass/epoxy
composite [1]. Nano composites due to its high specific strength and stiffness properties find applications in automobile, aerospace, marine and structural applications [2].

The addition of Nano clay to Epoxy glass composites reported that it will result in increase of the interfacial shear strength [3]. Also it was observed that addition of Nano filler materials to glass/Epoxy composites is resulted in reduction of the thermal expansion coefficient of the fiber reinforced polymer composite [4]. The interface between the fiber and matrix plays an important role in determining the mechanical strengths of fiber reinforced epoxy composites [5].

When the percentage addition of Nano clay is reached higher than optimal level then it was observed that the mechanical strength of the resultant composites decreases [6]. The percentage addition of Nano clay to be used should be limited to 5 wt.% rate to get better mechanical properties of the fiber reinforced polymer composites [7].

Nanoscale zinc oxide help in reducing wear and promoting ductility and arresting cracks, compartmentalizing damage, and decreasing the consequence of third body debris [8].

2. Experimental Work

2.1 Material Selection. The material selected for the fabrication of Fibre Reinforced Polymer composites were Bi-directional woven E-Glass fabric with 360GSM size due to unique advantages it processes like high strength, low cost, etc. Epoxy LY556 resin chosen as matrix material due to high adhesive and mechanical strength, high electrical insulation and chemical resistance properties. Nano clay, zinc oxide and fly ash were chosen as filler materials to study their effect on mechanical properties of polymer composites.

2.2 Fabrication epoxy glass composite laminates. In present investigation four different combination fillers were added in epoxy matrix and dispersed by using ultra-sonification method. The matrix so prepared by this method was mixed 10 wt.% of HY 951 Hardener at ambient temperature to initiate the cross-linking process, prepared matrix mix used to fabricate hybrid filler dispersed epoxy/glass composite laminates using Hand lay-up technique. The prepared laminates were cured at ambient temperature for 24 hours. Hybrid composites of size of size 250*250*3 mm were prepared. After curing, the specimens for different tests were cut from prepared laminates according ASTM standards. Composition and designation of prepared composites are shown in Table 1.

| Material Designation | Epoxy | Glass fibre | Nano clay | Zinc oxide | Fly ash |
|----------------------|-------|-------------|-----------|------------|--------|
| T1                   | 40    | 60          | 0         | 0          | 0      |
| T2                   | 34    | 60          | 3         | 0          | 3      |
| T3                   | 34    | 60          | 0         | 3          | 3      |
| T4                   | 34    | 60          | 2         | 2          | 2      |

2.3 Mechanical Characterization. Mechanical characterizations were conducted on prepared composites. Tensile and flexural testing were performed on the universal testing machine according ASTM standards, ASTM D638 and ASTM D790 respectively. Impact test was performed on the impact testing machine according to the ASTM D256.
3. RESULT AND DISCUSSION

3.1 Tensile Test Results. By analysing tensile test result of prepared laminates it was observed improvement in tensile strength with addition of filler materials. Fig. 4 indicates tensile strength of laminates T2 and T4 shown better results as compared to laminate with no filler T1. Improvement in tensile strength observed in laminates with addition of fillers due to filler material dispersed in matrix
material will be able to fill the voids inside laminate and help in resisting crack initiation in composites when subjected to external loads.

![Ultimate Tensile Strength in MPa](image1)

**Figure 4** Tensile Test Results

### 3.2 Flexural Test Results

Fig. 5 shows flexural test results it was seen sample T3 with composition 3 wt.% Zinc Oxide and 3% fly ash while in remaining samples no significant improvement in flexural strength as compared to plain epoxy glass composite(T1).

![Flexural Strength in MPa](image2)

**Figure 5** Flexural Test Results

### 3.3 Impact Test

Impact test results for different laminates as shown in Fig. 6. After analysing results for impact test it is seen that laminate with is given the maximum impact strength and laminate without any filler is given least impact strength. From results obtained it can be conclude that dispersion of filler materials helped in absorbing more energy when glass fibre reinforced composite subjected to impact loading.
4. Conclusion

In present research work Epoxy glass composites with filler materials Nano clay, fly ash and Zinc oxide were fabricated with three different hybrid filler combination using hand layup technique and compared it with plain epoxy glass composite. Based upon different mechanical characterization done on all laminates some of important conclusions were made as follows.

- The mechanical properties of polymer composites were greatly influenced by filler dispersion.
- Composite T2 with 3% wt. Nano clay and 3% wt. fly ash as filler exhibited maximum tensile strength, improvement of tensile strength of about 33% observed as compared with glass fiber reinforced epoxy composite with no filler.
- Impact strength of T2 composite is higher as compared with other laminates. And impact strength improvement of 18% observed of T2 composite as compared with composite with no filler.
- While laminate T3 with 3% wt. zinc oxide and 3% wt. fly ash as filler exhibited higher flexural strength as compared with other laminates.
- Based on results obtained it can be conclude that filler material clearly influencing final mechanical properties, and can be used to enhance mechanical properties of polymer composites.

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