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Influence of addition of Al_2O_3 and SiC on tensile and flexural characteristics of epoxy/glass fiber hybrid polymer composite

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Abstract

In today's world, hybrid polymer matrix composite is an extremely important component in manufacturing automobiles, aircraft, and sporting goods. This research paper describes the development of epoxy-based hybrid polymer composites (HPC) through a hand-lay technique. Hybrid polymer composite consists of Epoxy resin, E-glass fiber as reinforced materials, and Al2O3/SiC as filler material. The fabrication of a hybrid polymer composite with an equal proportion of Al2O3/SiC during which epoxy resin and hardener are mixed in 10:1 proportion. The tensile and flexural strength were investigated in this study. Experiment findings show that composite with four wt.% of Al2O3/SiC has optimum tensile and flexural behavior. It has an ultimate tensile strength of 170.84MPa and flexural strength of 162.56MPa, which is desirable in applications where epoxy-based composites are typically utilized, such as in tennis and badminton rackets.

Introduction

A fiber-reinforced polymer (FRP) combines high-strength fibers like boron, carbon, glass, aramid, etc., implanted in a polymer resin-like vinyl ester, epoxy, polyester, etc. [1]. There is excellent potential for epoxy base matrix composite to replace traditional metallic materials. The alteration of the polymer matrix is one of the strategies that may be used to produce new classes of hybrid polymer structural materials. This modification can be accomplished by adding various ceramic powders of varying sizes to get the desired levels of mechanical characteristics [2]. The composite material, made up of a polymer matrix and fiber reinforcement, has potential uses in various fields, including aerospace, structural, automotive, and sporting goods engineering.(See Fig. 1).

Salgar Swapnil et al. explored epoxy-based glass fiber composites regarding their tensile properties. They found that developed composite with 50wt% of epoxy and 50wt% of glass fiber have maximum tensile strength [3]. Tensile and flexural strength characteristics of filler-free polyester-based E glass fibre composites were studied by V. Manikandan et al. Their investigation shows that composites with up to 30% fiber exhibit outstanding mechanical characteristics. On the other hand, increased glass fiber reinforcement in composites reduces mechanical properties [4]. The effects of E-glass fibre and SiC on the tensile and flexural properties of an epoxy-based polymer composite were investigated by Amar Patnaik et al. Polymer composite fabricated through hand lay-up technique with fixed wt.% (20) of E-glass fiber and varying wt.% (0, 5, 10, 15, and 20) of SiC. The polymer composite reinforced with 10% SiC showed the highest tensile and flexural strength values [5]. $CaCO_3$ and Al_2O_3-filled epoxy-based glass fiber reinforced composites were studied by K. Sai Sravani et al. It was done by hand lay-up method, and the samples had 45 percent E glass fiber, 0.5 to 10 percent CaCO3 and Al_2O_3. The rest was epoxy, which was mixed in equal proportions. Compared to pure epoxy composites, composites incorporating filler material have inferior tensile and flexural properties [6]. Epoxy-based glass fiber reinforced composites with filler TiO_2/ZnS were tested for tensile strength by P. Deogonda et al. The tensile strength of the polymer composite with ZnS fillers is significantly higher than that of the polymer composite with TiO_2 fillers [7]. The mechanical characteristics of epoxy were examined by McGrath et al. (2008). Changing the particle size, shape, and distribution had minimal influence on the final characteristics. Resin density and filler loading, on the other hand, were the most crucial variables since they had the potential to affect all other qualities [8]. Up to about 20 percent of filler, Siddhartha et al. (2011) found an increase in tensile strength, flexural strength, tensile modulus, flexural modulus, and impact strength. Tensile and flexural strength increased with filler wt.% up to 20 [9]. R. K. Nayak et al. studied the influence of Al_2O_3/SiC on the flexural behavior of epoxy-based glass fiber-reinforced hybrid polymer composites. They found more flexural strength for filler SiO_2 as compared to other fillers. By reducing the size of particles, better flexural behavior was observed [10].

With epoxy matrix alteration, it has been shown that mechanical qualities increase significantly. Mechanical properties of glass fiber/epoxy hybrid composites, including different micro-modifiers, such as Al_2O_3/SiC in equal weight percent, have not been investigated. This research focuses on the effect of changing the weight percentage of micro-fillers in glass-fiber-epoxy hybrid polymer composites on their mechanical properties.

Section snippets

Experimentation

This investigation uses commercially available Al_2O_3 (200 µm) and SiC (1200 µm) to modify the epoxy matrix. Bidirectional E-glass fibers that are woven and readily available have been employed as reinforcement. The matrix material is chosen for the low-temperature curing epoxy resin (LY 556), which is chemically in the "Epoxide" family and has a density of 1026 gm/cc at 25 °C. The equivalent hardener (HY 951) is also used along with matrix material.

E-Glass fiber is chosen as the primary …

Results and discussion

Tensile and Flexural Test were carried out according to ASTM D3039-76 and ASTM D2344-84 standards; tensile and flexural tests were performed. The tensile test specimen is 150mm×20mm×3mm with a 50mm gauge length, while the flexural test specimen is 100mm×20mm with a 3mm average thickness, both in accordance with ASTM standards. The selected specimen parameters allow for meaningful comparison with existing literature and industry standards. This ensures an accurate assessment of …

Conclusions

The following conclusions from the Al_2O_3 and SiC on tensile and flexural characteristics of Epoxy/Glass Fiber Hybrid Polymer Composites.

- The successful fabrication of hybrid polymer composite with varying wt.% (2, 4, 6) of Al2O3 and SiC in equal proportion with a fixed amount of reinforced particle i.e., E-glass fiber, through hand lay-up technique. …
- Tensile strength, flexural strength, and elongation are all improved by adding Al_2O_3 and SiC up to 4wt%; however, further, addition decreases these …

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CRediT authorship contribution statement

Raj Kumar: Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Kedar Narayan Bairwa:** . **D. Raghurami Reddy:** . …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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