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Influence of Graphene Addition on Tensile, Flexural, and Hardness Behavior of GFRP Composites

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Abstract

Polymer Matrix Composites represent a new generation of engineering materials in which matrix materials are altered by reinforcing filler materials to enhance strength and other properties. In the present work, the Glass fibre reinforced polymer composites (GFRP) were fabricated by adding different composition of Graphene as Nano filler material using Hand layup technique followed by Vaccum bagging process.

Keywords: glass fibre; filler material ; ultimate tensile strength; flexural strength; microhardness

1. Introduction

Materials are possibly more deep-seated in our everyday life then we realize. Housing, transportation, communication, food production and defense, almost each segment of our daily lives is influenced by one or other way by materials. In history, the development of societies have been reflected by ability to produce or manipulate materials to fill their needs and by the level of their material development. Furthermore, it was discovered that material properties could be altered by adding or combining with other material or by heat treatment to produce superior properties of those basic material [1]. The demand for the materials is increasing in industries to establish the sector with improved properties, reduced cost and improved sustainability. Composites are developed by using constituent materials namely matrix and reinforcement. The role of matrix is to cover and support the reinforcement materials in their relative positions impart specific mechanical and physical properties. Composites gain importance in various fields such as automotive, aerospace, defence, biomedical, electronic equipment and sports[2–7].

In the current scenario, polymers play a major role in many applications due to its some unique properties such as light weight, chemical stability. It can be processed easily and obtained at lower cost gain its importance in many aspects of human life. The properties of the polymers can be altered suitably using fibers, organic/ inorganic particles and nanofillers. These materials have lower density differ from ceramics and metals in terms of strength and stiffness. Polymers can be molded in to complex shapes as it exhibits elastic and ductile behavior[8]. Polymer matrix composites mainly comprises of epoxy resins as the matrix materials gain importance for structural engineers due to its well balance of mechanical and chemical properties[9–12] . Hence in this study, an attempt will be made to study the effect of graphene powder as filler material in larger variations and glass fibre as base material. In this study, we are focusing on mechanical properties and characterization of glass

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fibre reinforced epoxy polymer composites with variation in filler material as graphene powder in larger constituents.

2. Experimental Details

The approach for manufacturing the composite materials in this study was carried out by hand lay-up process followed up by vacuum bagging process to remove the air trapped between the layers of glass fiber and epoxy matri. The reinforcement material i.e. glass fiber was kept constant at 60% and the filler material i.e. Graphene powder was varied from 2% to 4% by reducing the epoxy matrix to the same amount. A plywood board of dimensions 400x400 mm was taken, on the upper surface plastic tape was placed to ensure it acted as releasing agent. In this work, open mould made from plywood was considered as substitute for metal mold or any other kind of mold because it is cheap, easy to handle and light weight. The required quantities of epoxy, hardener, glass fiber and graphene powder were weighed using an electronic weighing machine and taken in a beaker separately. The mixture of epoxy and hardener was mixed properly using a mechanical stirrer for 5 minutes. While for the second filler added composites, the graphene powder was added to the epoxy at 70°C. The mixture was allowed to cool down at room temperature, at a slower cooling rate by providing partial heat to the mixture. Sonication was done for about 20 minutes at 150V, the hardener was added and stirring was done continuously using mechanical stirrer for 5 minutes. Some quantity of prepared mixture of matrix material was poured in the mold, than a layer of glass fiber mat was placed and again the matrix material was poured. This process was repeated until the required thickness is obtained i.e. 2mm. After the required thickness of composite material was achieved, the upper layer was covered with plastic tape to act as releasing agent, over which the excess trapped air was removed by using a roller. Later vaccum bagging process was carried out. Specimens were cut as per ASTM standards using water jet cutting technique. Tensile test was carried out according to ASTM D3039 standard with Mecmesin multi tester machine (Figure 1) using dog bone shaped specimen.

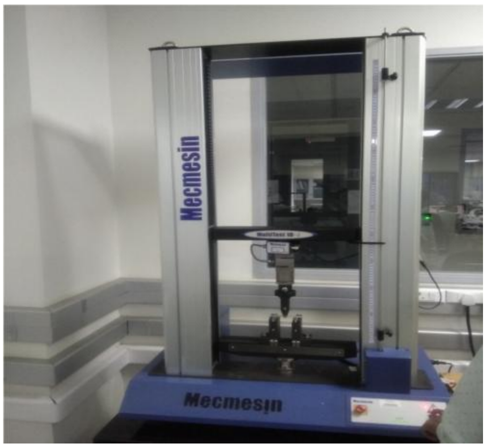

Figure 1. Mecmesin Multi tester.

3. Results and Discussions

3.1. Tensile Test

Figure 2 depicts the maximum tensile load v/s maximum displacement for all the combinations of composites. It was observed that the load carrying capacity was increased for increase in Graphene content in the composites. Initially the tensile load obtained for plain composite without graphene powder was 7587.66 N and it increased to 8004 N for the composite with 4 wt. % of Graphene content. The tensile strength of composites depends on interfacial bonding strength between matrix and reinforcement to a larger extent and also on the inherent properties of composite ingredients. It was

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observed that there is 1.46% tensile load and 7.63% of elongation improvement for composites with 2% filler material, while the composite with 4% filler material showed 5.50% tensile load and 9% elongation improvement. The role of glass fibres in the composite limits the failure and the increase in the filler material content exhibits the upward trend in tensile properties. Figure 3 shows the marginal increase in the ultimate tensile strength as a result of increased interfacial bonding between the glass fiber and epoxy matrix due to the addition of Graphene as filler material.

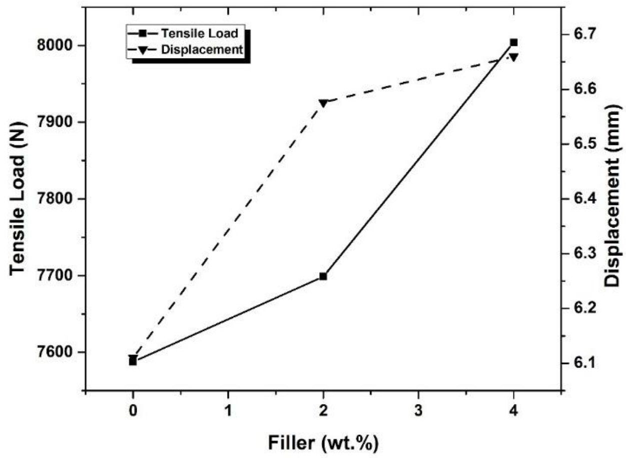

Figure 2. Tensile load vs. Displacement for different composition of filler.

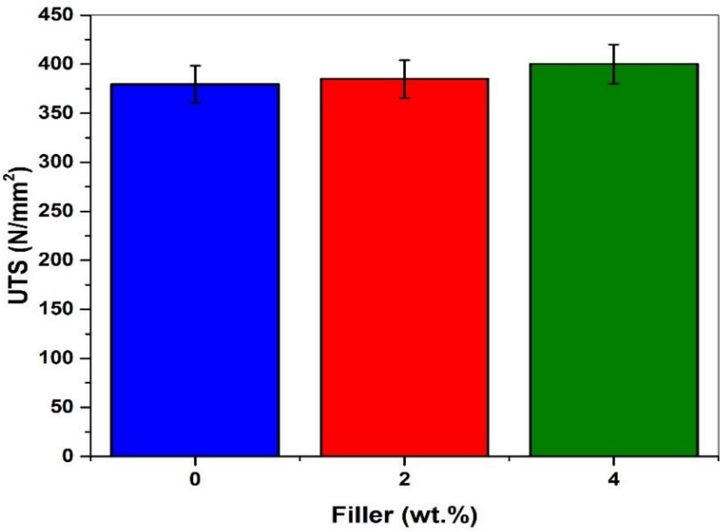

Figure 3. Ultimate tensile strength of filler added composites.

4. Conclusions

The effects of graphene powder reinforcement with different variations in percentage of filler materials have been examined for enhancing the mechanical properties of GFRP composites and their characteristics were studied using a SEM. The GFRP composites were fabricated using Hand lay-up method with and without filler material and specimens for the testing were made as per ASTM standards. From the experimental values it can be observed that the tensile strength and flexural strength of the composite were improved with addition of Graphene powder.

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