Enhancement of Mechanical Properties in Carbon Fibre Reinforced Epoxy Composite with and without graphite powder

D. Suresh, A. Sivakumar

Abstract*: *The use of composite material in engineering field is increasing day by day. Composite materials are largely replacing conventional metals nowadays due to their mechanical behaviours. Among all composite materials carbon fibre reinforced composites are of greater interest due to their high strength. There are several new developments made in carbon fibre composites like carbon nanotubes, carbon black etc.. in order to increase the composite strength. In this research, we are going to analyse the strength of the carbon fibre reinforced epoxy composite by using graphite powder as an additive material because of its negligible weight and hardness nature. Generally, composites were prepared by hand layup process. Specifically the tensile, the flexural and the impact properties are taken into the consideration. Three different specimens are prepared and tested for the above strengths. The first specimen is carbon fibre epoxy composite without any addition of graphite powder (filler material). The second one is carbon composite with 5% addition of graphite powder as a filler material and the last specimen is of carbon fibre composite with 10% addition of graphite powder. The above mentioned strengths are calculated for each specimen with the help of a Universal Testing Machine and Impact Tester. Specimen 3 shows greater strengths whereas Specimen 1 shows least strength among all the three specimens. The inclusion of graphite powder in the carbon composite shows increase in the mechanical properties of the resulting specimens.

Keywords* : composite, filler, graphite, *mechanical properties.

I. INTRODUCTION

The main element of a CFRP is a carbon fibre, which functions as a reinforcement. Carbon fibres are produced from a polymer which can be a poly acrylonitrile (PAN), petroleum pitch or rayon through certain chemical and mechanical processes. After the fibres are made, there are several methods of creating CFRPs out of polymers and those fibres, and some of them are: moulding, vacuum bagging, compression moulding, and filament winding. Carbon fibres widest and most common applications include the aerospace engineering, automotive engineering, civil engineering and productions of sports goods.It is a composite material, a type of a fibre-reinforced plastic, and it is used in areas whose products demand high levels of strength-to-weight ratio. This means that carbon fibre is extremely light but at the same time extremely strong, rigid and durable.

II. LITERATURE REVIEW

Bhagwat P.M (2016) [1] illustrates the mechanical behaviour of carbon fibre and hybrid fibres in their study. For conducting the tests like tensile and compressive test for the flat FRP in universal testing machine is unavailable.

Rajesh V (2017) [6] investigated the behaviour of carbon composites under various environmental conditions.

Jidong Dong (2017) [3] studied the interfacial properties of carbon fibre.

Shivakumar S (2012) [8] examined the rate of degradation in polymeric components.

Weiwu Chen and Yoshinari Miyamoto (2014) [9] investigated the effect of graphite powder in the interfacial properties of carbon fibre.

SUMMARY OF LITERATURE REVIEW

- Several forms of carbon constituents can be added to enhance the mechanical properties of carbon fibre is stiff, strong and thermally stable and can withstand wide range of temperature.
- Epoxy shows longer degradation time compared to other matrix combinations. By comparing carbon fibre with various resins like epoxy, vinylester and isoepoxy, it is obtained that carbon-epoxy shows high tensile strength, flexural strength and interlaminar shear strength.
- Interfacial properties between the fibre and matrix plays a prominent role in the properties of CFRP which can be enhanced by carbon black. Carbon black shows significant increase in interlaminar shear strength, IFSS and impact property by 22%, 44% and 22.7% respectively.
- Aged laminates (CF) lacks tensile strength.

Revised Manuscript Received on October 05, 2019.

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- Hard particles with uniform size distribution promote strong bond formation.

III. METHODOLOGY

A mould tool is required to give the unformed resin /fibre combination its shape prior to and during cure. The composite specimens are manufactured by the hand layup method. The various volume fraction of the filler and fibre are to be mixed with resin to prepare the composite by using compression moulding process. The layering pattern are used to prepare the composites with suitable volume fraction of fillers.

Carbon sheet is taken and cut for the dimensions of the die to be used and the die is cleaned well and then 250g of epoxy resin is taken and 15% of hardener is added and then the filler material i.e. graphite powder is added and stirred well. This mixture is poured into the die and spread well. Above to the mixture a layer of carbon sheet is placed and then rolled well by hand lay out method. The above procedure is repeated for the total number of required layers. After setting up the final layer with resin compression moulding process is employed. Then after curing the specimens are taken for testing.

IV. FABRICATION

Generally the composite specimens are manufactured by the hand layup method. The various volume fraction of the filler and fibre are to be mixed with resin to prepare the composite by using compression moulding process. The layering pattern are used to prepare the composites with suitable volume fraction of fillers. Graphite powder (Mesh no: 325 ~ 0.44mm) is used as the filler and the fibre used is 3K Carbon -200 Gsm Bidirectional. Epoxy resin is used in the process.

The type of accelerator used is MEKP (Methyl Ethyl Ketone Peroxide) whose Flash point is 70^{o}C and Specific Gravity at 25% is 1.08 kg/m^{3}. Hardener used for epoxy resin is of type 6% (1% to 1.5%). Initially carbon sheet is taken and cut for the dimensions of the die to be used and the die is cleaned well and then 250g of epoxy resin is taken and 15% of Hardener is added and then the filler material i.e. graphite powder is added and stirred well. To the mixture the hardener is added at the final stage of stirring. This mixture is poured into the die and spread well. Above to the mixture a layer of carbon sheet is placed and then rolled well by hand lay out method. The above mentioned procedure is repeated for the total number of required layers and after setting up the final layer with resin compression moulding process is performed. Then the setup is left free for 48 hours to undergo curing process.

THE ADVANTAGES OF COMPRESSION MOULDING

Once the amount of material required has been calculated, it is heated and poured into the mould until there isn't any more space available. Thus, there is little or no waste. This efficiency is particularly important when expensive compounds are involved. Additionally, unlike other moulding systems, such as injection moulding, there are no gates, sprues and runners (passages) through which the material can pass before entering the mould - less material is lost and wasted. Before the resin material undergoes the process of moulding, it is in a soft and solid state. Hence, the manufacturer can easily determine which amount of the material is required, endowing the procedure with ease and accuracy.

V. RESULTS AND DISCUSSIONS

5.1 TENSILE RESULT

Various specimens are tested for tensile strength and each specimen differs in the composition of the Filler material. Figure 6.1 shows the tested specimens of tensile test.

Specimen 1 is made of Carbon Fibre reinforced epoxy composite without any addition of graphite powder as a filler material.

Specimen 2 is made of Carbon Fibre reinforced epoxy composite with 5% of graphite powder (Mesh no: 325 ~ 0.44mm) is added as an additive material.

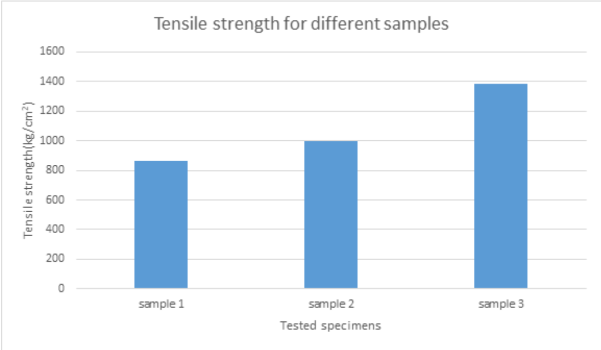
Specimen 3 is of Carbon Fibre reinforced epoxy composite with 10% of graphite powder is added as an additive material.

Sample No.	Area (mm^2)	Tensile Strength (Kg/cm^2)
Specimen 1	39	862.56
Specimen 2	39	999.74
Specimen 3	39	1383.08

Table 5.1.1 Tensile Strength for Specimens

INFERENCE

From the graph, Specimen 1 has low tensile strength compared to other two specimens. Specimen 3 has a maximum tensile strength. This shows that tensile strength of the carbon fibre reinforced epoxy composite increases with the increase in the composition of graphite powder.



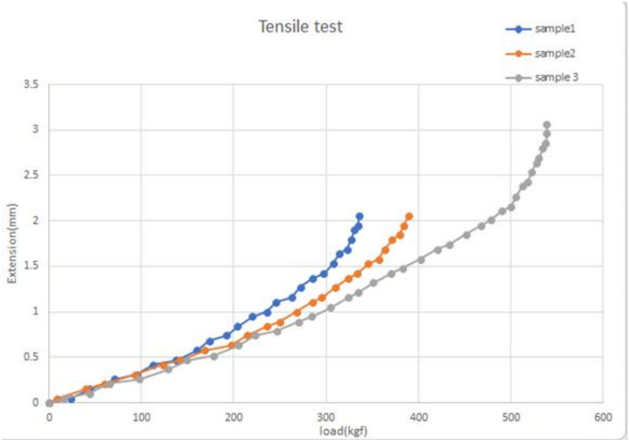
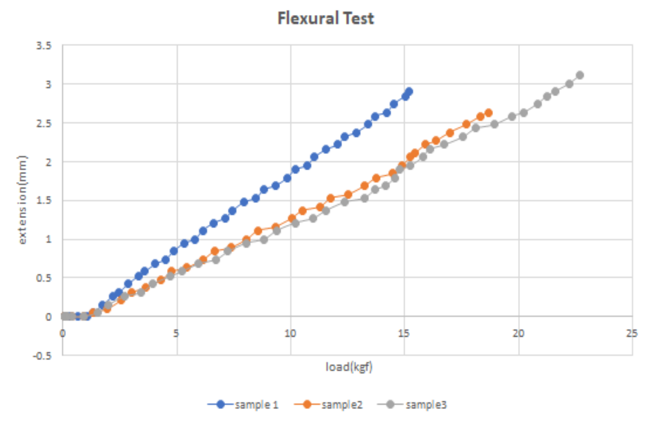


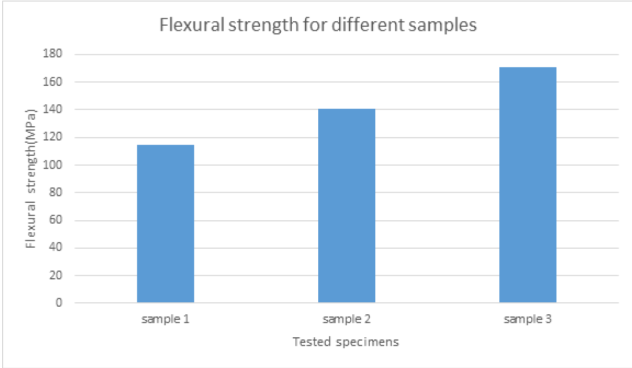
Figure 5.1 Specimen after tensile test.

5.2 FLEXURAL TEST

INFERENCE

From the graph and bar chart, Specimen 1 has low flexural strength compared to other two specimens. Specimen 3 has a maximum flexural strength. This shows that flexural strength of the carbon fibre reinforced epoxy composite increases with the increase in the composition of graphite powder.





5.3 IMPACT TEST

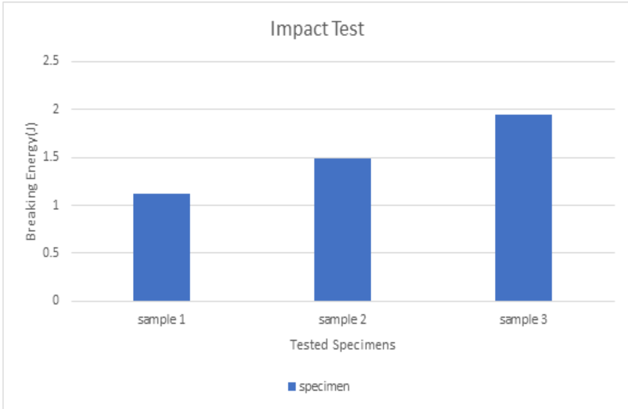


Figure 5.3 Specimens after Impact test.

Table 5.3.1 Impact Test Result

Sample No.	Energy required to break the specimen (J)
Specimen 1	1.124
Specimen 2	1.485
Specimen 3	1.943

Retrieval Number: L25081081219/2019©BEIESP
DOI:10.35940/ijitee.L2508.1081219

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

INFERENCE

From the bar chart, Specimen 1 has low breaking energy compared to other two specimens. Specimen 3 has a maximum breaking energy. This shows that breaking energy of the carbon fibre reinforced epoxy composite increases with the increase in the composition of graphite powder.

VI. CONCLUSION

The inclusion of graphite powder in the carbon fibre composite increases the mechanical properties of the resulting specimen. Thus it could be concluded that the carbon fibre reinforced epoxy composites with the inclusion of graphite powder as a filler material shows increased properties compared to the untreated one. But the proportion of addition of the filler materials and resin in the fibre has a direct effect on the interfacial properties. The results of tensile, flexural and impact test obtained from experiments of various specimens shows that the graphite powder inclusion in the carbon fibre composite increases the tensile, flexural and impact strength by 15.9%, 23.18% and 32.11% respectively.

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