CHARACTERIZATION OF MECHANICAL PROPERTIES OF HYBRID COMPOSITE

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Abstract: In this project hybrid composite using glass fibre epoxy and multi walled carbon Nano tubes are fabricated. This fabricated laminate is tested for compression and tension and their behavior is studied with variation of percentage of carbon nano particle tubes. Usually composite laminates are fabricated with reinforced plastics. We are further introducing carbon nano particle tubes (CNT's). Which will improve develop the properties than conventional composites.In next few decades the possibilities are that composites will replace steel and other metals because of heavy weight and prone to corrosion. We need to determine the best combination of percentage of CNT's in GFRP

Key word: MWCNT, GFRP, Tensile, bending, compression, SEM.

I INTRODUCTION

MWCNT were used by many researchers to modify different types of resins. Their results conclude improvement in the mechanical properties at different loading percentages of MWCNT. The optimum weight percentage of MWCNT depends upon the use of dispersion technique, and the weight percentages of MWCNT cannot be generalized for the different resins and dispersion techniques. MWCNT are known to have an elastic modulus of up to 1 TPa and tensile strength in the region of 2000 MPa. The interfacial bond strength between resin and MWCNT plays a very important role in transferring the load from lower strength matrix to higher strength nanoparticles and accordingly, improving the mechanical properties of the matrix. One of the important parameter that limits the interface bond is the dispersion of MWCNT in resin owing to the van der Waals attractive interactions .De-agglomeration of the nanofillers in polymer matrix is a problem to be solved in order to prepare homogeneous nanocomposites successfully. In the present work, special attention has been paid to characterize the interfacial bond strength as well as define all the sonication parameters and select the most suitable.

This study is based on the development of different polyester-nanofiller systems that used to enhance the automotive and aerospace composite structures. The polyester resin was modified by ultrasonic dispersion of different weight percentage of MWCNT (0.06%, 0.125%, 0.25%, 0.5%). The experimental results showed that the nanocomposite material with 0.2 wt% nanoparticles has the highest improvements in the tensile and compressive strength compared to the other nanofiller percentages. The enhanced nanophased polyester cannot be used alone for high performance structural applications due to their low mechanical properties. The literature on MWCNT nano-hybrid glass fiber reinforced epoxy composites showed modified the plain woven fabric S2 fiberglass composites either through resin modification or fiber modification. They were characterized the fabricated nano-hybrid composite laminate through tensile tests, double cantilever beam tests and fatigue tests. Their experimental results showed that mode-I fracture toughness was significantly improved with the inclusion of 2.0 wt% aluminananoparticles. However, the hybridization showed insignificant effect on the tensile properties and tension/tension unnotched fatigue life of the hybrid composites.

The performance of fiber reinforced composite materials was always related to the interfacial bond strength that requires special tests, fixtures, and materials for measuring it. The most common methods used for characterizing the interfacial bond strength include, the single fiber pullout/microdrop technique, the embedded single fiber test and the microdebonding/microindentation technique. For bulk composites, there are the short beam shear test, the transverse tensile test, the transverse flexural test and the Iosipescu shear test. In the present work, the interfacial bond strengths were characterized through compact tension fracture toughness tests on the unidirectional laminates with different off-axis angles. Scanning electron microscope (SEM) was used to validate the measurement

Hussain et al. investigated the effect of alumina particle size (1 lm and 25 nm) on the mechanical properties of carbon fiber reinforced epoxy composites. They used the wet ball-milling technique for mixing a 10% volume fraction of alumina nanoparticles with TETRAD-X epoxy resin. They reported that the hybridization of the carbon fiber reinforced epoxy composites by Al_2O_3 micro/ nano-particles showed significant improvements in the mechanical properties. These particles roughening the fiber surface and provide strong bonding at the fiber/matrix interfaces that is caused by thermal residual stresses on the fiber surface. These roughness and strong interfacial adhesion act as mechanical interlocking that leads to improving the flexural and interlaminar shear strengths. The in-plane strain fracture toughness (KIC) was evaluated using the single edge notch method. The results showed that the incorporation of Al2O3 filler leads to improving the fracture toughness of the hybridized composite laminates through improving the toughness of the matrix and crack deviating by the presence of filler particles.

Omrani et al. investigated the dynamic mechanical properties of epoxy matrix infused by 0, 0.5, 2, and 5 phr levels of alumina nanoparticles using a model DMTA dynamic mechanical analyzer. Their results showed that at low concentration of Al2O3 nanoparticle the damping properties of alumina-nanocomposites are significantly improved. They designated that the enhancement of damping properties was attributed to the lower polymer crosslinking density induced by alumina nanoparticles. It has been reported by Rajoria and Jalili and Khan et al. that the natural frequency is decreased with increasing beam length in free vibrations tests of MWCNT-nanocomposites. Rajoria and Jalili found that the damping ratio is higher for higher frequency for all the samples up to a frequency range of about 200 Hz. In contrast, Khan et al. found that the natural frequency had insignificant effects on damping ratio of both the MECNT-nanocomposites and CFRP laminates. The variation in these results need more research to understand the dynamic behavior of composite materials.

The objective of this work is to enhance the mechanical properties of unidirectional $[0]_4$ glass fiber reinforced composite laminates by ultrasonically dispersing MWCNT in general purpose polyester resin.. This type of polyester resin is extensively used in fiber reinforced laminating systems owing to its lower viscosity, which play a key role in enhancing their modifiability by nanofillers. Tensile, bending and compression. were conducted on the unidirectional . Three point flexural tests were performed on the fabricated materials to estimate the enhancement in the flexural strengths and moduli. Materials properties of modifies resin were calibrated using non destructive testing.

II MATERIALS AND METHODS

A wood mould of 325x300 mm2 was selected for preparation of test samples in compression mould technique. The mould comprises of two half's the lower part of the mould and the upper half of the mould. The main purpose of using top (upper) plate it is to make sure that the weight is equally distributed throughout the laminate and to avoid deformation and uneven surface of laminate. After mould was prepaid the laminate were fabricated a milar film was first placed at the bottom plate as it act as releasing agent. Nano particles were mixed with polyester resin using mechanical stirrer for two hour, later to this modified resin catalyst and accelerator was added. This mixture was applied on to the E glass fiber mat of size 250x250 mm2 which was placed on this film. Again a resin mixer was applied onto the fiber and rolled to remove the excess resin and air bubble trapped in it. These steps were repeated for three more layers of glass fiber, and a laminate of four layers was prepaid. This process continued in preparation of different samples with different weight present of nano particles and one laminate with neat resin. Each laminate was left curing for 24 hr at room temperature. From the laminates prepaid a sample was cut using high speed saw cutting machine as per standards for tensile and bending.

III EXPERIMENTATION:

3.1 Tensile test:

The tensile test was carried on Universal Testing Machine (UTM) with jaws moving at a speed of 1 mm/minute. The cut specimen from the laminate was modified into dumbbell shape using milling machine. The test was carried out till the specimen was broken to get the ultimate strength of each sample. The UTM is provided with digital system which gives load verses deflection graph. If 'F' is the force exerted on the sample and 'A' is the area of cross section of the sample then the stress ( ) experienced by the sample is given as $\sigma=F/A$. The ultimate tensile strength is the stress needed to break the sample or to get the maximum strain.

3.2 Three point bending test:

The flexural properties of the multi scale glass/polyester were measured by conducting three point bending test according to ASTM D790M. The test was conducted in universal testing machine with crosshead speed maintained at 1.2mm/min and a span length of 50mm. For a three point bending, at a given load P, the maximum tensile stress 'σ', the shear stress τ and young's modulus can be represented by for a given span length L will be were b, t are width, thickness of lay-up thickness and m is the slope of the modulus respectively.

3.3 Compression test

This method determines in-plane compressive properties by applying the compressive force into the specimen at wedge grip interfaces. ASTM D3410 is most appropriate for composites materials reinforced by high-modulus fibers including tape and textile, but other materials may be tested. The test fixture is designed to provide a compressive load to the unsupported center 12 to 25 mm (0.5 to 1 inch) gauge length of the specimen.

IV. Results and Discussion

Figure 4.1 is a plot between load and deflection for all the samples with different weight percentages of MWCNT under flexural loading. The variation in flexural bending strength of carbon nanoparticles can be viewed from the figure 4.2 is due to the increase in cross links of polyester resin which results in high brittleness of the material and due to abrasive nature of the MWCNT, the nanoparticles cuts fibre and it will fail at low load when compare to neat polyester resin. From this figure it can be stated that conventional composite is optimum. As per literature addition of nanoparticles will enhance the properties of polyester and it also increase the bonding property of fibre and matrix. For 0.2wt% sample the bending strength is minimum this is due to the formation of agglomeration of MWCNT with the increase in weigth percentage. This agglomeration is visible in SEM plot in figure 4.6.

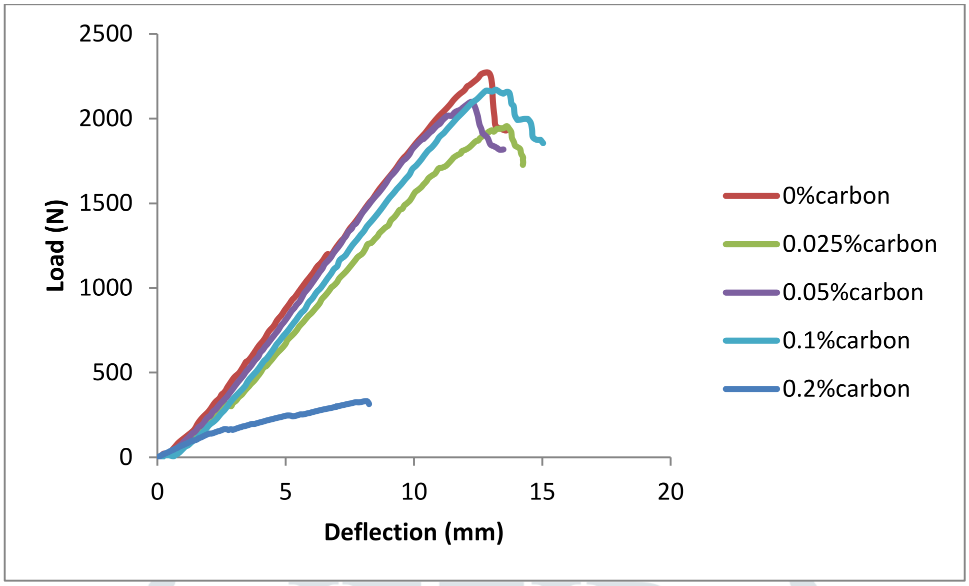

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Fig.4.1: Load vs deflection for MWCNT with different weight percentage in flexural loading

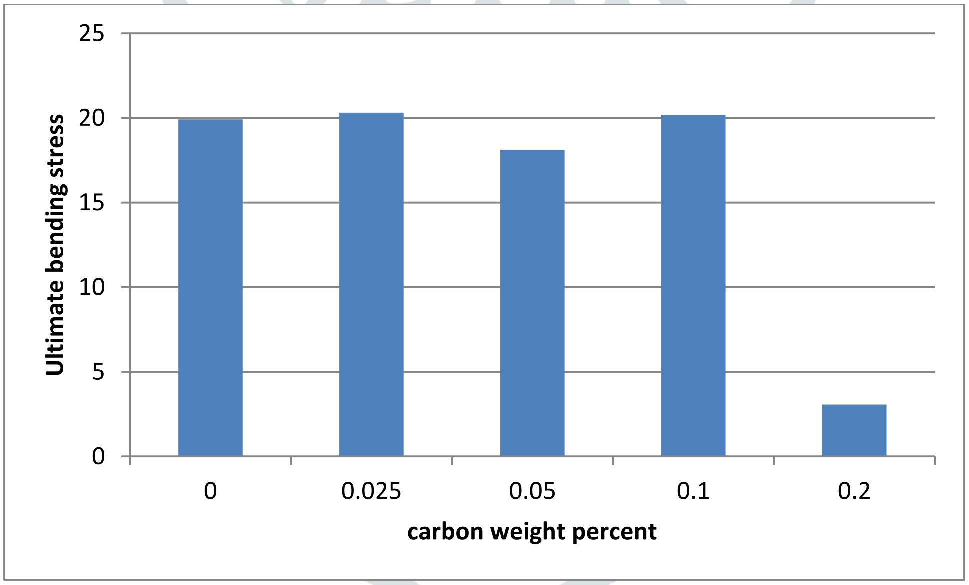

Fig.4.2: ultimate bending stress vs carbon weight percent

Figure 4.3 is a plot between load and deflection for all the samples with different weight percentages of MWCNT under tensile loading. The increase and decrease in tensile strength of carbon nanoparticles is due to the increase in cross links of polyester resin which results in high brittleness of the material. The maximum tensile strength is observed for 0.05 wt% percentage and after this with the increase in MWCNT wt% the tensile strength decreases. This decrease in strength is due to exfoliation of MWCNT in polyester resin. This can be seen in SEM in figure 4.6. With the increase in nano particles the material failure took place with low displacement due to brittle behavior of materials.

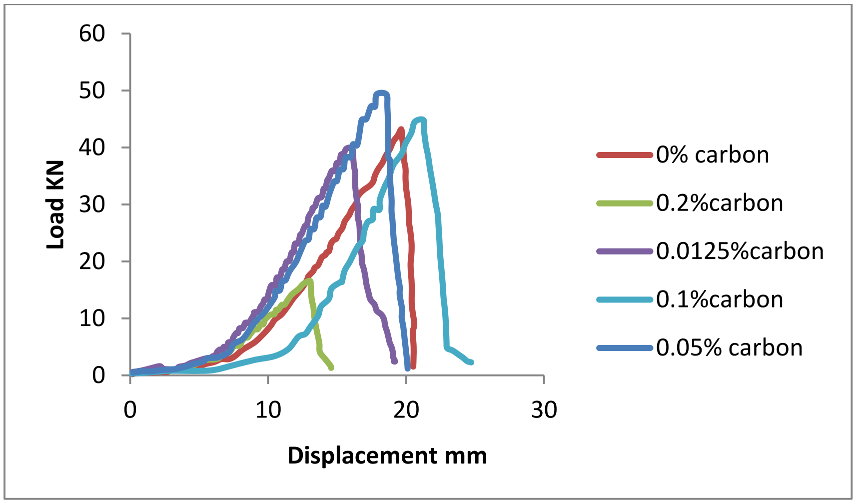

Fig.4.3: Load vs displacement for MWCNT with different weight percentage in Tension test

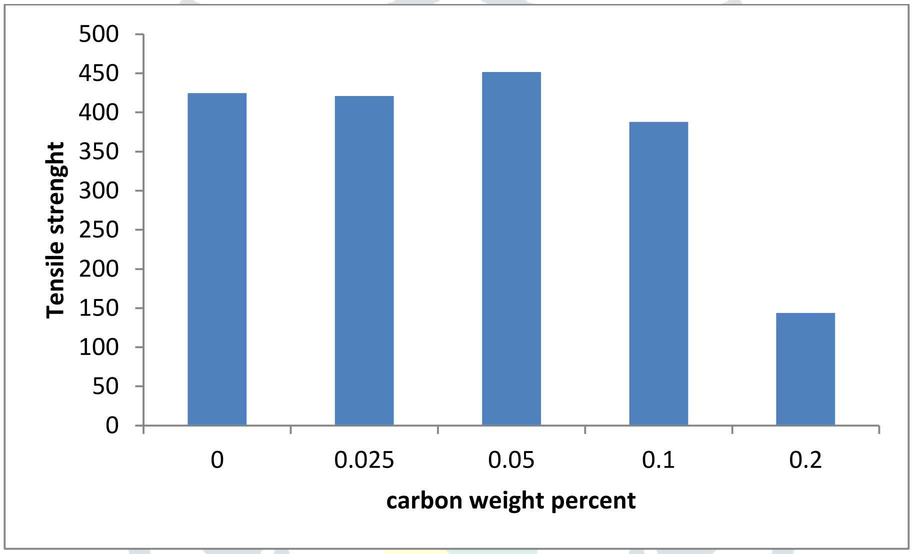

Fig.4.4: Tensile strength vs carbon weight percent

The compression behavior is similar to flexural which is plotted in figure 4.5. In compression loading in minimum strength is for the sample with 0.2wt%. the compressive strength increases with the addition of nano particle due to improvement in material properties of modified resin.

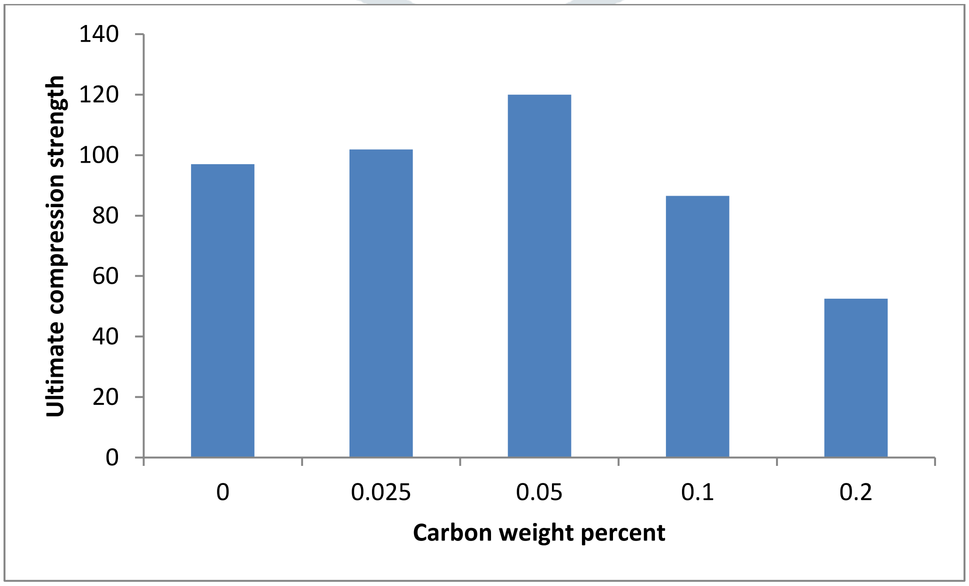

Fig.4.5: ultimate compression strength vs carbon weight percent

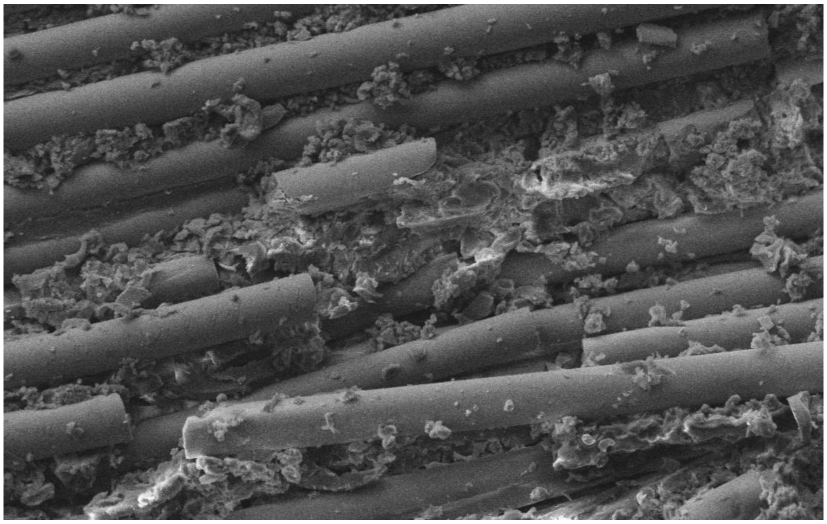

Fig.4.6: SEM photo of fractured surface under bending condition

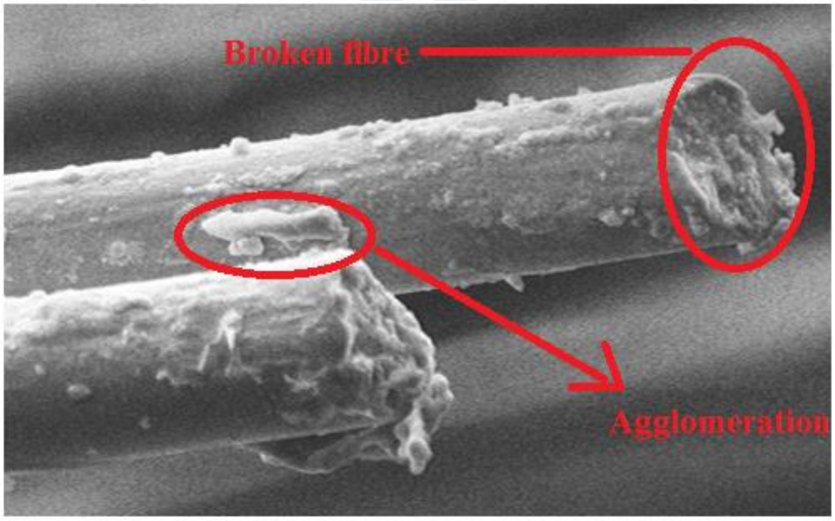

Fig.4.7: SEM photo of fractured surface under tensile condition

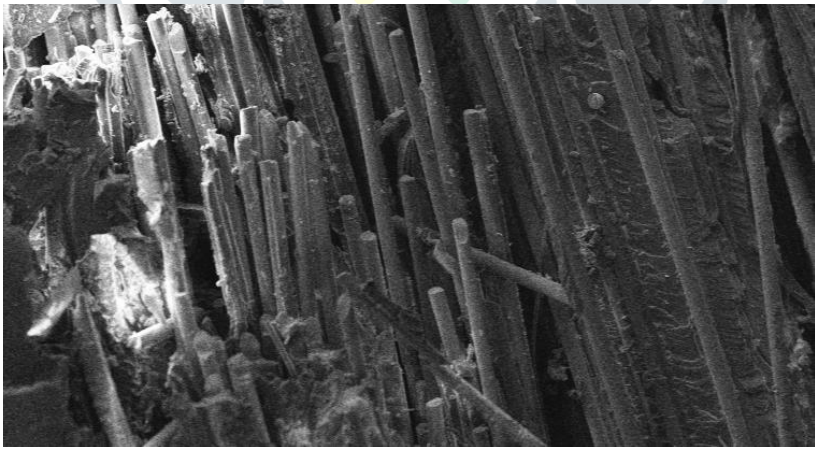

Fig.4.8: SEM photo of fractured surface under compression condition

5.0 CONCLUSION

We can conclude that glass fiber/ MWCNT of multiscale reinforcement composites have a considerable change in mechanical properties that could be used in many potential applications. There is increase in compression strength but it does not work with tensile and three point bending. The maximum compressive strength is achieved is 0.05wt% of carbon nano tubes and minimum is at0.02wt% MWCNT. The reduction in all the samples of tensile ,bending and compression strength is at 0.02wt%.This reduction is due to formation of agglomeration at higher rate percentage and there by MWCNT more than wt% should not be used for application.

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