Improvement in Mechanical Properties by using Two Different Polymer Matrix Composites Reinforced with Carbon Flakes

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Abstract— Polymer Matrix Composite which contains two different resins they are epoxy and polyester resin reinforced with carbon flakes separately by using Innovative Method. High intensity ultrasonicator is used to obtain homogeneous mixture of epoxy resin, hardener with Carbon Flakes and also polyester resin, accelerator and catalyst with Carbon Flakes. The Hot Press Molding technique is used to create composite specimens. Tensile test, flexural test and impact test are performed on different weight ratios i.e., 5wt. %, 10wt.%, 15wt% and 20wt.%, of carbon flakes is reinforced with epoxy and also same weight ratios of carbon flakes reinforced with polyester resin is used to improve the reinforcement effect of composites. Bending strength, tensile strength and impact strength evaluated to represent the behavior of composite structures with flake load. The mechanical properties of composite are measured with help of UTM machine. The tensile test results indicate that the 5wt. % carbon flakes are reinforced with epoxy resin composites possesses the highest tensile strength and the tensile test results indicate that the 10wt. % carbon flakes are reinforced with polyester resin composites possesses the highest tensile strength. As compared to these mixture of carbon flakes are reinforced with polyester resin composites possesses the highest tensile strength.

Key words: Carbon Flakes, Epoxy Resin, Polyester Resin, Theoretical Calculations

I. INTRODUCTION

Composite constituents are naturally occurring ingredients made up of two or more fundamental constituents with considerably dissimilar somatic and organic properties which persist distinct at macroscopic scale inside completed construction. It generally contains two classifications of basic constituents they are matrix and reinforcement. Atleast single portion of each type is required. The matrix material supports and surrounds reinforcement material by maintaining their relative portions. Reinforcement imparts their special somatic and automated possessions to improve matrix properties.

Carbon flakes are filler composites obligate fascinated considerable position as potential structural material. The attractive features of Carbon Flakes are low density and mass, high rigidity, high strength, high fatigue strength, very good corrosion resistance, excellent creep resistance, suitable for integral construction techniques.

Commercially generated composites using Polymer matrix often called as resin solution. There are many different types of polymer materials available which depending upon starting raw ingredients are Epoxy, Polyester, Polyamide, Phenolic, Polypropylene, Vinylester and Polyimide. In reinforcing type materials are fibers, particles and flakes and matrix material are usually continuous.

The addition of Carbon Flakes is used to determine ultimate tensile strength, thermal conductivity of epoxy and polyester resin composites. Different weight percentages of Carbon Flakes are mixed with epoxy and polyester resin used high intensity Ultrasonication. The resulting experimental specimens were obtained by means of Hot Press Casting method.

Composite materials are amongst the earliest and also the latest trend of structural materials. Even though the basic concepts of composite materials were known from ancient times and some materials were used in past engineering applications.

A. Flake Composites

It is one of the types of composite. The flake composites may consist of flat reinforcements of matrices such as Glass, Carbon, Aluminium, Mica, and Silver are commonly used. These types of composites as low cost, light weight, higher strength and it have high flexural modulus.

II. PRESENT WORK AND OBJECTIVES

The objective of present work is mainly concentrated on fabrication of carbon flakes and epoxy resin and also another one carbon flakes and polyester resin composite by directing different tests like tensile, flexural and impact test. The experimental and theoretical evaluation is used to calculate the percentage of difference.

1) Collect of carbon flakes, epoxy resin and polyester resin with its suitable mechanical properties.
2) Fabrication of carbon flakes reinforced with epoxy/ polyester resin based composites with different weight ratios by novel method.
3) Preparing of test specimens with the composite plate as per ASTM standards.
4) Determination of automated properties like tensile test, flexural strength and impact tests.

III. MATERIALS AND METHODOLOGY

A. Materials

The Epoxy-556 resin and the hardener (HY951), unsaturated polyester resin and catalyst of methyl ethyl ketone peroxide, accelerator of cobalt naphthenate, and carbon flake.

B. Methodology

In this process the stipulated amount of epoxy resin reinforced with altered mass percentages of Carbon Flakes as well as stipulated amount of unsaturated polyester resin reinforced with altered mass percentages of Carbon Flakes stood mixed thoroughly by using a magnetic stirrer for maintaining necessary time at imaginable temperature. Then tumbler stood positioned in ultrasonicator at high intensity with respect to time is shown in figure1.

After the progression was completed formerly all mediators, with hardener / promoter and accelerators were added to previously prepared mixture. The prepared mould of essential proportions remained used for production of samples according to ASTM. The finalized mix stood discharged into mould cavity. After completing the drying process eliminate residual stresses due to heat, formerly test samples are post dried at necessary temperature with respect to time.

Firstly prepared pre-mould for a dimension of 200mm×90mm×4.5mm die was prepared. The pre-mould is prepared for the composite as shown in figure 2.

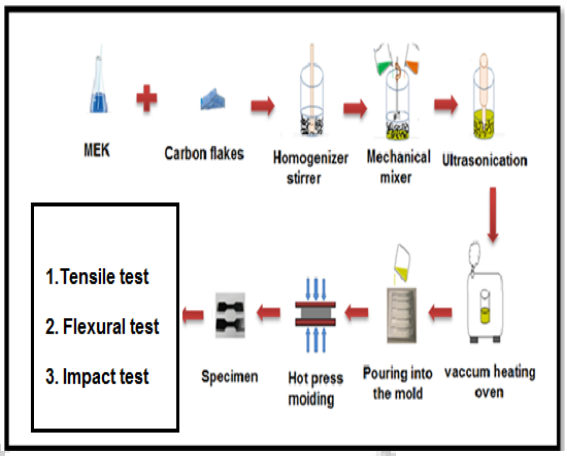

Fig. 1: Schematic showing the manufacturing process of the composite

Fig. 2: Pre-mould

C. Preparation of Composites

Fibre configuration and volume fraction are two important factors that affect the properties of the Composite. In this work, the two different polymer resins like epoxy and polyester are reinforced with four Different weight ratios of carbon flakes they are 5%, 10%, 15% and 20%.

D. Characterization

The prepared composite plates were post cured at 90ºc for 3hr the appropriate ASTM standards were followed while preparing the specimens for test. At least four replicate specimens were tested and the results were presented as a maximum strength of tested specimens. According to ASTM D 3039 and ASTM D 7264 standard for composites, the specimens were prepared for tensile test and flexural test. Impact tests on specimens were performed by using both Charpy methods as per ASTM A 327 for different weight ratios of carbon flakes.

IV. TESTS PERFORMED

Tensile test is performed material as according to ASTM D3039 using test piece of dimension 200×30×4.5mm
Flexural test performed material as according to ASTM D 7264 testing in UTM machine of specimen dimension 200×30×4.5mm.

Impact test using Charpy method the specimen prepared as according to ASTM A327 of dimension 55×10×10 mm

V. RESULTS AND DISCUSSIONS

A. Experimental results

1) Tensile test

The dependence of Tensile Strength on Epoxy resin reinforced with carbon flakes. Weight percentages of Carbon Flakes were in the range of 5% to 10%, the Tensile Strength of composite decreased slightly. The Carbon Flakes weight ratio increased 10% to 15%, the tensile strength decreased sharply. Weight percentage range of Carbon Flakes increased 15% to 20%, the Tensile Strength was decreased rapidly. The Ultimate value was obtained with an addition of Carbon Flakes weight ratio only 5% as shown in figure 4.

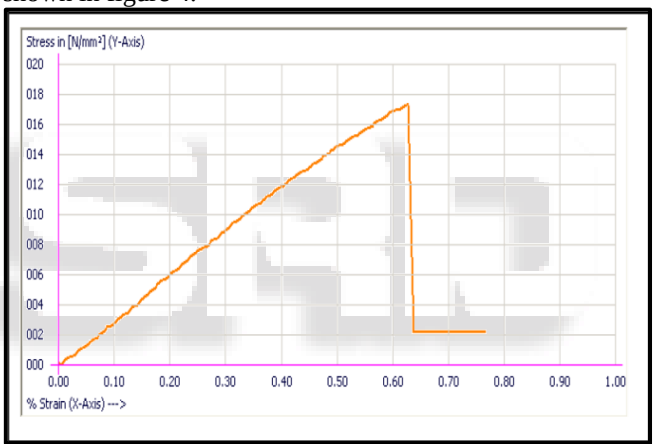

Fig. 3: Stress - Strain for tensile test (carbon flakes 5%+epoxy 95%)

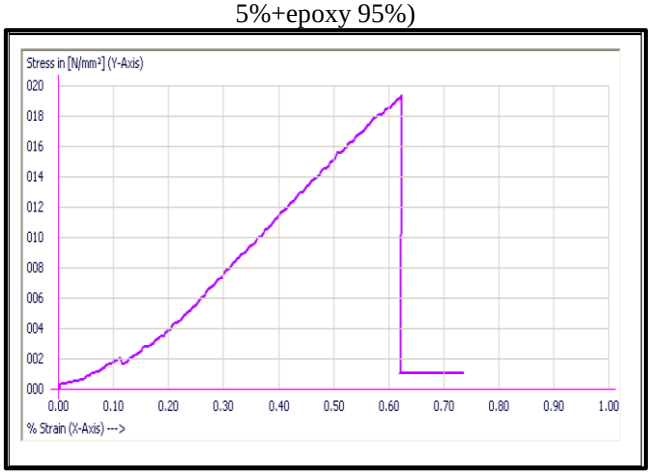

Fig. 4: Stress - Strain for tensile test (carbon flakes 10%+ epoxy 90%)

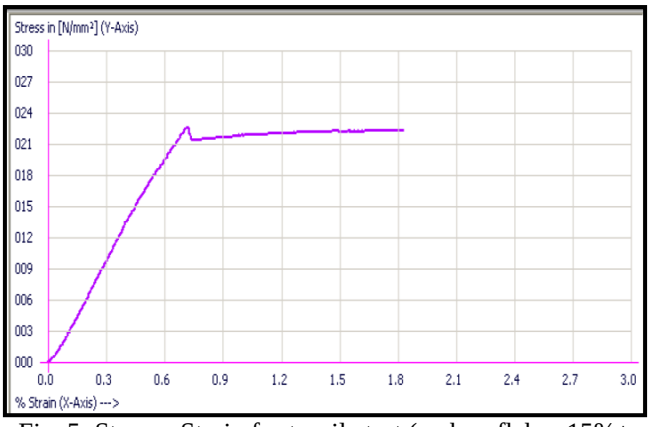

Fig. 5: Stress - Strain for tensile test (carbon flakes 15%+ epoxy 85%)

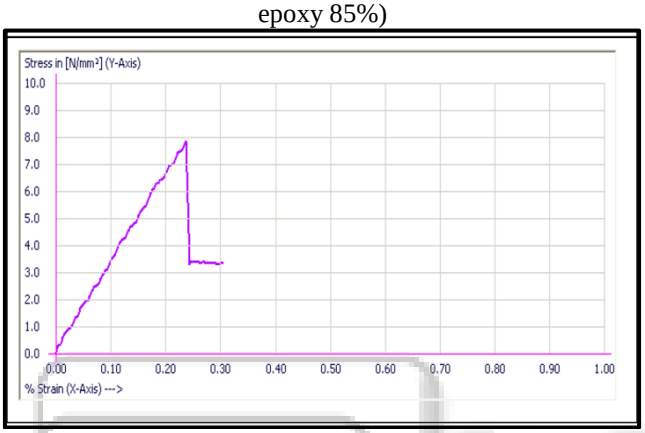

Fig. 6: Stress - Strain for tensile test (carbon flakes 20% +epoxy 80%)

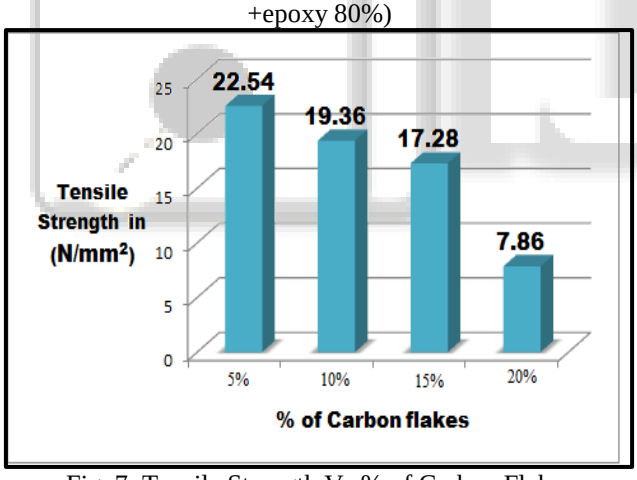

Fig. 7: Tensile Strength Vs % of Carbon Flakes

The above fig. 1 shows graph between tensile strength. Vs weight ratios of carbon flakes with epoxy resin

The dependence of Tensile Strength on polyester resin reinforced with carbon flakes. Weight percentage of Carbon Flakes was in the range of 5% to 10%, the Tensile Strength of composite increased rapidly. Weight ratio of carbon flakes increased 10% to 15%, the Tensile Strength decreased sharply. The weight percentage range of carbon flakes 15% to 20%, the tensile strength was increased slightly. The Ultimate value was obtained with an addition of Carbon Flakes only 10% as shown in figure 6.

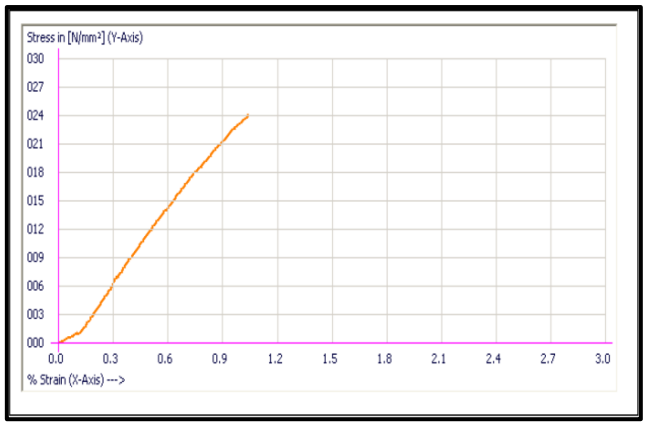

Fig. 8: Stress - Strain for tensile test (carbon flakes 5% + polyester 95%)

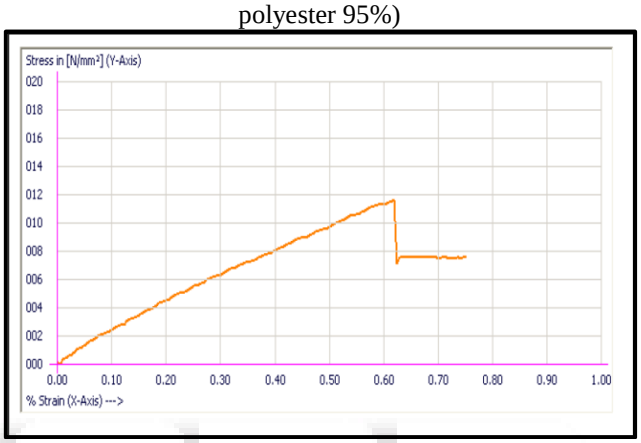

Fig. 9: Stress - Strain for tensile test (carbon flakes 10% + polyester 90%)

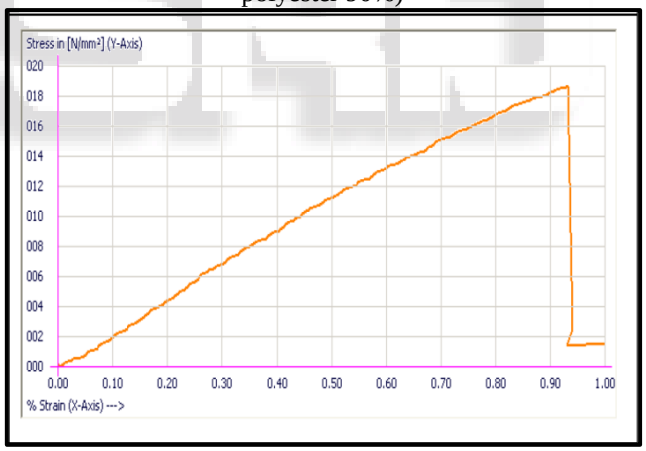

Fig. 10: Stress - Strain for tensile test (carbon flakes 15% + polyester 85%)

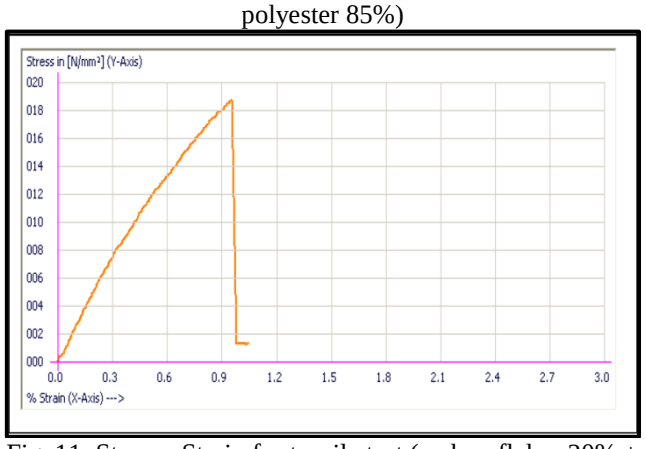

Fig. 11: Stress - Strain for tensile test (carbon flakes 20% + polyester 80%)

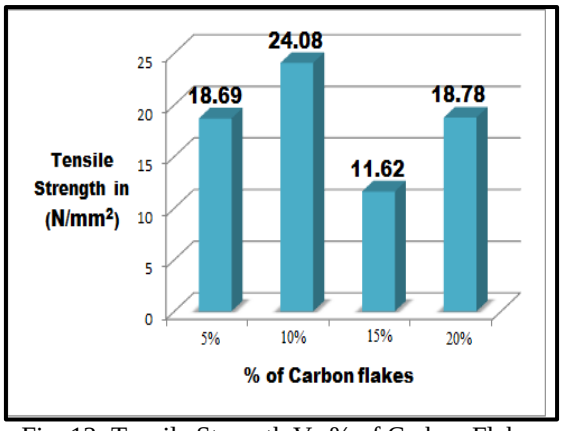

Fig. 12: Tensile Strength Vs % of Carbon Flakes

The above fig. 6 shows graph between tensile strength. Vs weight ratios carbon flakes with polyester resin

B. Flexural Test

The dependence of the flexural strength on epoxy resin reinforced with carbon flakes. Weight percentages of Carbon Flakes were in the range of 5% to 10%, the flexural strength of composite increased rapidly. The carbon flakes weight ratio increased 10% to 15%, 3 point flexural bending strength decreased sharply. Weight percentages of carbon flakes range from 15% to 20%, the change in Flexural Strength was increased slightly. The ultimate value of 3 point flexural bending strength was obtained with a carbon flake weight ratio only 10% as shown in figure 8.

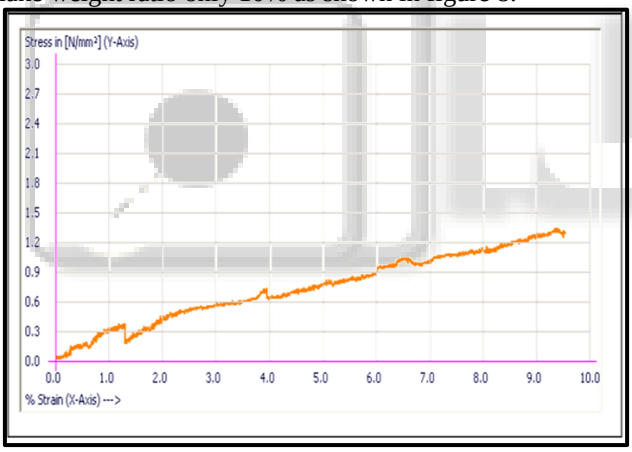

Fig. 13: Stress - Strain for flexural test (carbon flakes 5% + polyester 95%)

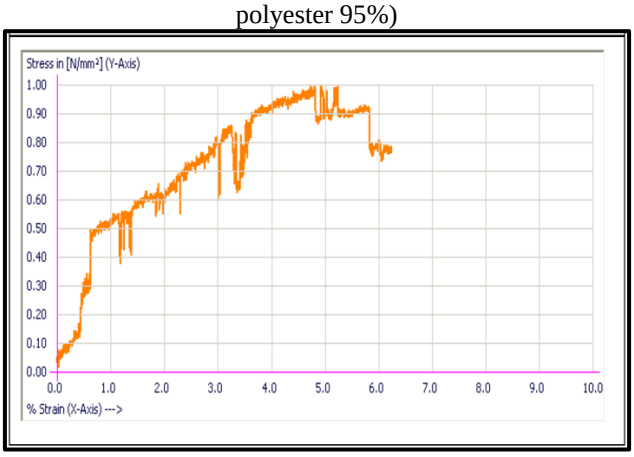

Fig. 14: Stress - Strain for flexural test (carbon flakes 10%+polyester 90%)

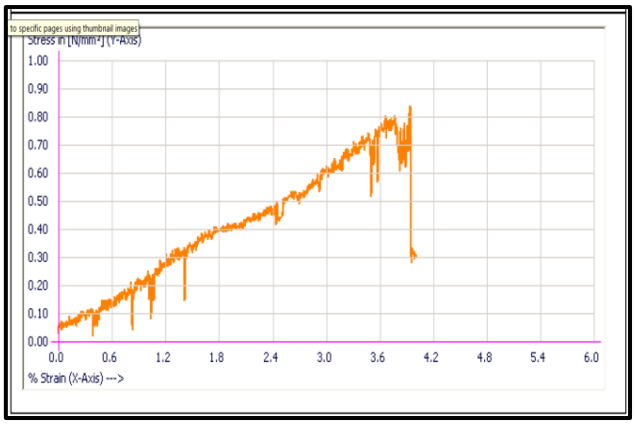

Fig. 15: Stress - Strain for flexural test (carbon flakes 15% + polyester 85%)

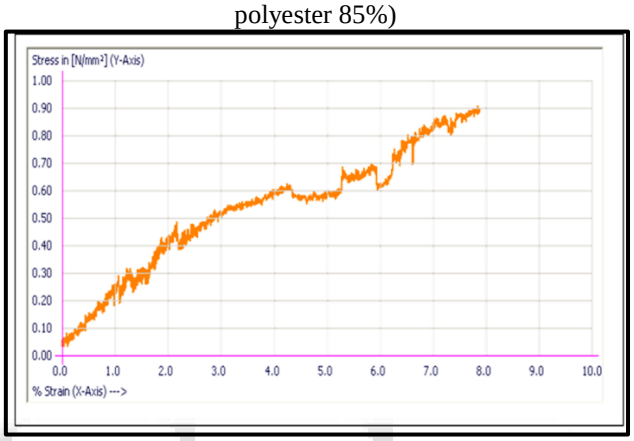

Fig 16: Stress - Strain for flexural test (carbon flakes 20% + polyester 80%)

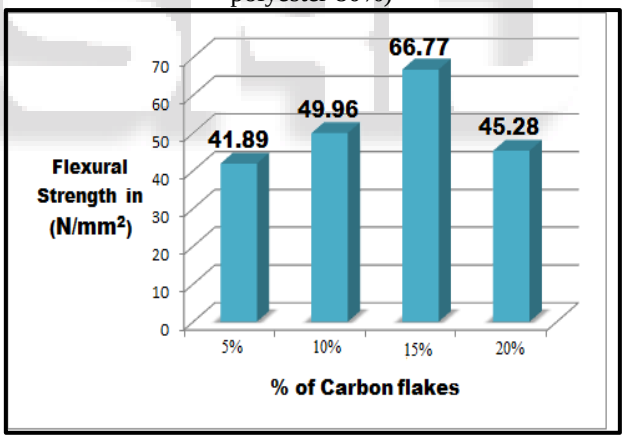

Fig. 17: Flexural Strength Vs % of Carbon Flakes

The above fig. 1 shows graph between flexural strength. Vs weight ratios carbon flakes with epoxy resin

The dependence of the flexural strength on the Epoxy resin reinforced with Carbon. Weight percentages of Carbon Flakes were in the range of 5% to 10%, the flexural strength of composite increased slightly. The carbon flakes weight ratio increased 10% to 15%, the flexural strength increased rapidly. Weight percentage range of Carbon Flakes increased 15% to 20%, flexural strength was decreased sharply. The ultimate value of flexural strength was obtained with an addition of carbon flakes weight ratio only 15% as shown in figure 10.

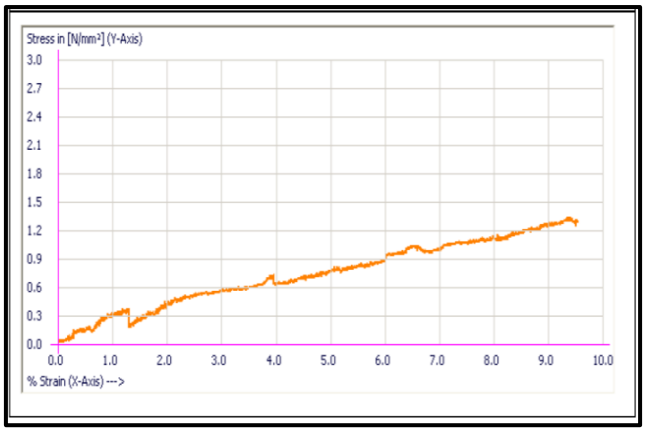

Fig. 18: Stress - Strain for flexural test (carbon flakes 5% + polyester 95%)

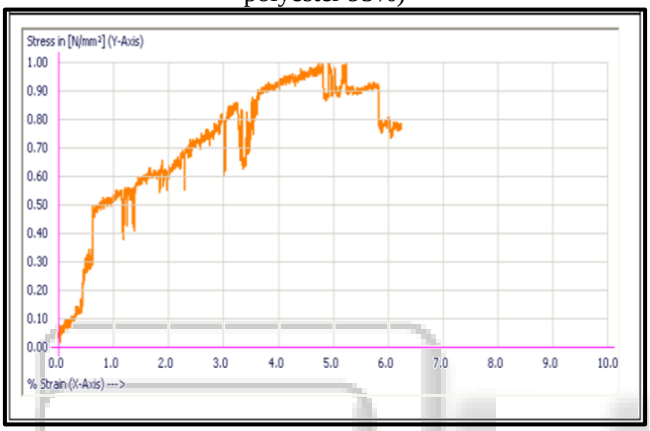

Fig. 19: Stress - Strain for flexural test (carbon flakes 10%+polyester 90%)

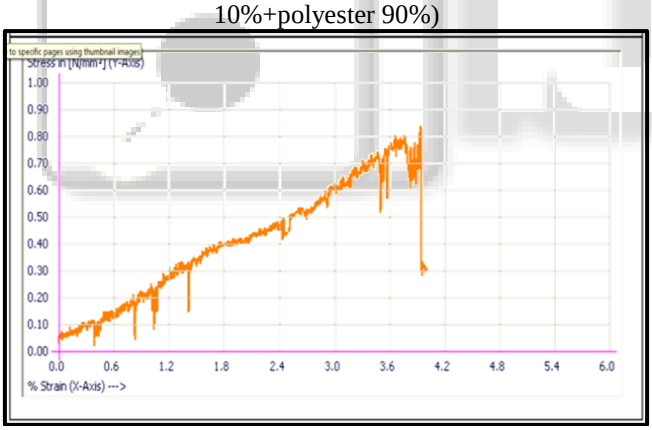

Fig. 20: Stress - Strain for flexural test (carbon flakes 15% + polyester 85%)

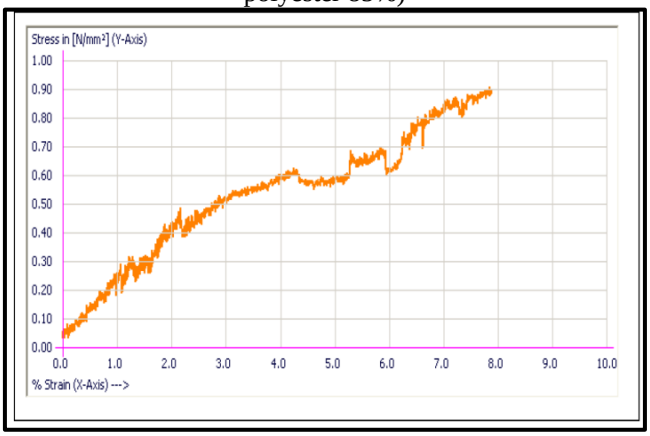

Fig. 21: Stress - Strain for flexural test (carbon flakes 20% + polyester 80%)

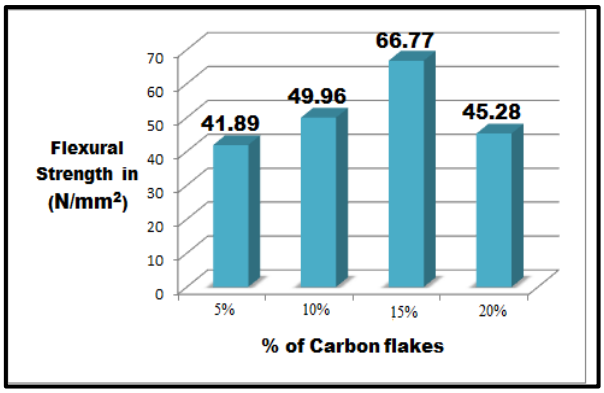

Fig. 22: Flexural Strength Vs % of Carbon Flakes

The above fig. 1 shows graph between flexural strength. Vs weight ratios carbon flakes with polyester resin.

C. Impact Test

Impact strength by Charpy method is carried out in impact testing machine and fig.11 (a) shows graph for Impact Strength Vs % of Carbon Flakes (epoxy)

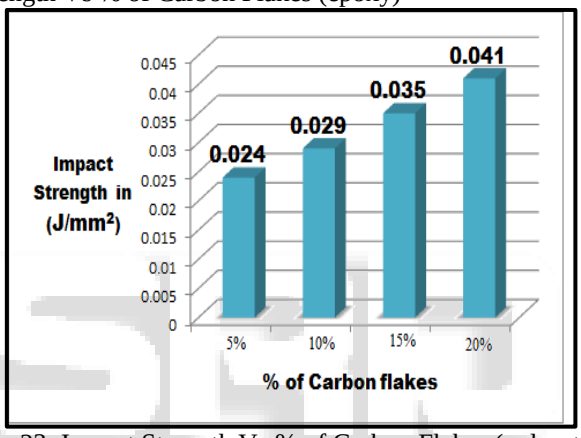

Fig. 23: Impact Strength Vs % of Carbon Flakes (polyester)

Impact strength by Charpy method is carried out in impact testing machine and fig.11 (b) shows graph for Impact Strength Vs % of Carbon Flakes (polyester)

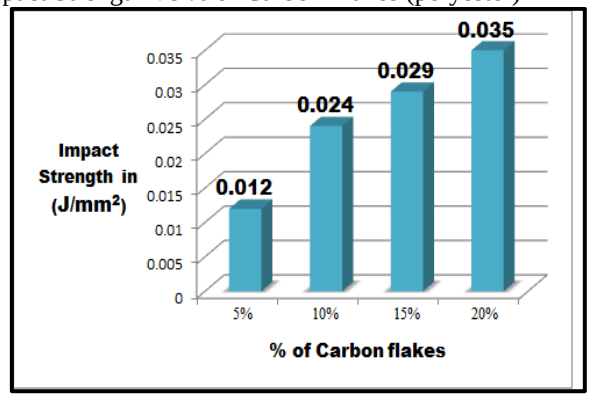

Fig. 24: Impact Strength Vs % of Carbon Flakes (polyester)

D. Theoretical Calculations

1) For Tensile Test Results

$$\sigma = F/A$$

The results are calculated using above ultimate tensile stress formula and theoretically calculated values are for 5%, 10%, 15%, and 20% of carbon flakes are 22.54N/mm^2, 19.36N/mm^2, 17.28N/mm^2 and 7.85N/mm^2 respectively for carbon flakes reinforced with epoxy resin.

The results are calculated using above ultimate tensile stress formula and theoretically calculated values are

for 5%, 10%, 15%, and 20% of carbon flakes are 18.69N/mm^2, 24.08N/mm^2, 11.62N/mm^2 and 18.78N/mm^2 respectively for carbon flakes reinforced with polyester resin.

2) For Flexural Test Results

We know that bending moment equation,

$$\sigma = 3PL / 2bh^2$$

Where,

σ – Flexural strength in N/mm^2
P – Peak load in N
L – Length of specimen in mm
b – Width of specimen in mm
h – Height of specimen in mm

The theoretical results are calculated by substituting values to above equation we will get for different weight ratios of 5%, 10%, 15%, and 20% of carbon flakes are reinforced with epoxy resin are 30.74MPa, 68.15MPa, 38.52MPa, and 59.26MPa respectively.

The theoretical results are calculated by substituting values to above equation we will get for different weight ratios of 5%, 10%, 15%, and 20% of carbon flakes are reinforced with polyester resin are 41.85MPa, 50MPa, 66.67MPa, and 45.19MPa respectively.

3) For Impact Test results

V - Notch impact strength = Absorb energy /Effective Cross section area

The theoretical results of impact strength are calculated by substituting values to above equation we get for different weight ratios of 5%, 10%, 15%, and 20% of carbon flakes are reinforced with epoxy resin are 0.024J/mm^2, 0.029J/mm^2, 0.035J/mm^2 and 0.041J/mm^2 respectively.

The theoretical results of impact strength are calculated by substituting values to above equation we get for different weight ratios of 5%, 10%, 15%, and 20% of carbon flakes are reinforced with polyester resin are 0.012J/mm^2, 0.024J/mm^2, 0.029J/mm^2 and 0.035J/mm^2 respectively.

VI. Conclusion

1) The fabrication of Polymer Matrix Composite which contains two different resins namely epoxy and polyester resins reinforced with carbon flakes was carried out for different weight percentages. When the Percentage of carbon flakes was increased Tensile strength of composite decreased slowly as a result material converted into brittle form.
2) Tensile test of the composite specimen with only 5% of Carbon flakes reinforced with 95% of epoxy resin gives 22.54N/mm^2 of ultimate tensile strength. On other hand Tensile test of composite specimen with only 10% of Carbon flakes reinforced with 90% of polyester resin gives 24.08N/mm^2 ultimate tensile strength respectively.
3) The 3 point bending test on the composite specimen with 10% of Carbon Flake reinforced with 90% of epoxy resin gives 68.33 Mpa of ultimate flexural strength. On other hand 3 point bending test on the composite specimen with only 15% of carbon flakes reinforced with 85% of polyester resin gives 66.77 Mpa of ultimate flexural strength respectively.
4) From these results it is concluded that mechanical properties of carbon flakes reinforced with polyester resin gives highest tensile and bending strength compared to epoxy resin.

VII. Scope of Future Work

This work can continue for conducting different tests to the same laminate.

This work can also continue for carry out finite element analysis to the same laminate.

The filler weight ratios of the laminate can vary to check the better performance comparing to this results.

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