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INVESTIGATION AND CHARACTERIZATION OF GRAPHITE BASED CARBON REINFORCED LAMINATES

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Abstract

The main objective of this work is to investigate the effect of additives on Tensile and flexural behavior of Carbon Fiber fabric at laminate level to explore an alternative skin material for the outer body of aerospace applications and machines. This experimental work investigates the effect of Graphite concentration in epoxy resin on the Tensile and flexural properties of Carbon fiber laminate of 4 mm thickness. The laminate had been prepared by using hand lay-up method and test has been conducted on it. Various Tensile and Flexural properties values obtained from experimentation have been compared for Carbon fiber laminate composites of three different concentrations were fabricated by adding the Graphite powder to resin bath. The effect of Graphite concentration variation (3%, 6% and 9%) weight on the prepared material. Mechanical properties can be studied by universal testing machine (UTM) according to ASTM standards, and the Experimental results were Tabulated and characterized.

Keywords: composites, fiber reinforced composites, mechanical properties, and laminates preparation.

INTRODUCTION

A composite material is made by combining two or more dissimilar materials. They are combined in such a way that the resulting composite material or composite possesses superior properties which are not obtainable with a single constituent material. So, in technical terms, we can define composite as a multiphase material from a combination of materials, differing in composition or form, which remain bonded together, but retain their identities and properties, without going into any chemical reactions. The components do not dissolve or completely merge. They maintain an interface between each other and act in correct to provide improved, specific or synergistic characteristics not obtainable by any of the original components acting singly. Composite materials are generally costlier as compared to conventional materials but still their use is becoming increasingly popular because of their significant properties like lightness, high specific properties, design and processing flexibility, cost effectiveness, functional superiority, durability.

COMPOSITE MATERIAL CLASSIFICATION:

Composite materials may be broadly classified into natural and synthetic composite materials. Synthetic composite materials are generally prepared by taking the ingredients/ constituents separately and physically combining them by different techniques either random or oriented arranged fibers.

Two ingredients may be composed together as (i) layered composition in which layers of ingredient materials are bonded to one another, and (ii) phase composition in which one ingredient is inserted into the other ingredient. The phase that receives the insert in the phase composition is the continuous phase and is called matrix. The purpose of adding the insert is generally to improve the mechanical properties of the matrix. Presently the most common man-made composites are divided into three main groups they are polymer matrix composites (PMC's), metal matrix composites (MMC's), ceramic matrix composites (CMC's), polymer matrix composites (PMC's). Overall, the properties of the composite materials are determined by the properties of the fiber, properties of the resin, ratio of fiber to resin in the composite (Fibre Volume Fraction), geometry and orientation of the fibers in the composite.

MECHANICAL CHARACTERISTICS TESTING:

Tensile Test: Tensile properties, such as tensile strength, tensile modulus, and Poisson's ratio of flat composite laminate, are determined by static tension tests in accordance with ASTM D 638. The tensile specimen is straight-sided and has a constant cross section with beveled tabs adhesively bonded at its ends. A compliant and strain-compatible material is used for the end tabs to reduce stress concentrations in the gripped area and thereby promote tensile failure in the gage section. Balanced [0=90] cross-ply tabs of non woven Carbon -epoxy have shown satisfactory results. Any high-elongation (tough) adhesive system can be used for mounting the end tabs to the test Specimen.

The tensile specimen is held in a testing machine (UTM) by wedge action grips and pulled at a recommended cross-head speed of 5mm/min. Longitudinal and transverse strains arc measured employing electrical resistance strain gages that are bonded in the gage section of the specimen.

ASTM D 638 Standards

- Length- 165mm
- Width- 19mm
- Thickness- 3mm

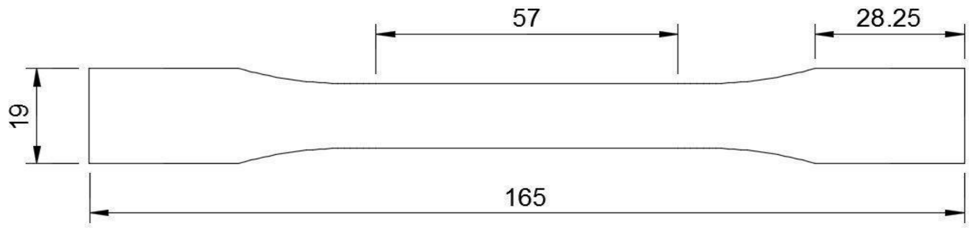


Fig. 01 Tensile Specimen drawing

Flexural Test: Flexural properties, such as Flexural strength, Flexural modulus, and Poisson's ratio of flat composite laminate, are determined by static Flexural tests in accordance with ASTM D 256. The

Flexural specimen is straight-sided and has a constant cross section with beveled tabs adhesively bonded at its ends. A compliant and strain-compatible material is used for the end tabs to reduce stress concentrations in the gripped area and thereby promote Flexural failure in the gage section. Balanced [0=90] cross-ply tabs of non woven Carbon-epoxy have shown satisfactory results. Any high-elongation (tough) adhesive system can be used for mounting the end tabs to the test Specimen.

The Flexural specimen is held in a testing machine (UTM) by wedge action grips and pulled at a recommended cross-head speed of 5mm/min. Longitudinal and transverse strains arc measured employing electrical resistance strain gages that are bonded in the gage section of the specimen.

$$\sigma_f = \frac{3FL}{2WT^2}$$

where F is applied load (N), L is support span (mm), w and t are width and thickness of the specimen (mm), respectively.

ASTM D 790 Standards:

- Length- 127mm
- Width- 12.7mm
- Thickness-4mm

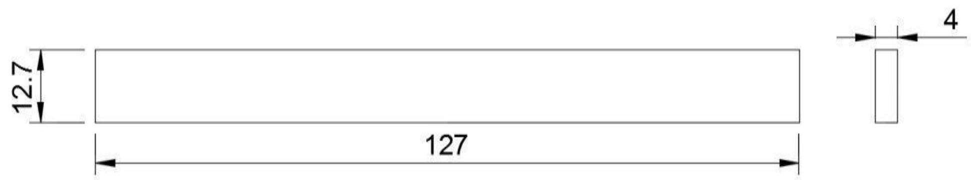


Fig 02 : Flexural Specimen drawing

FABRICATION:

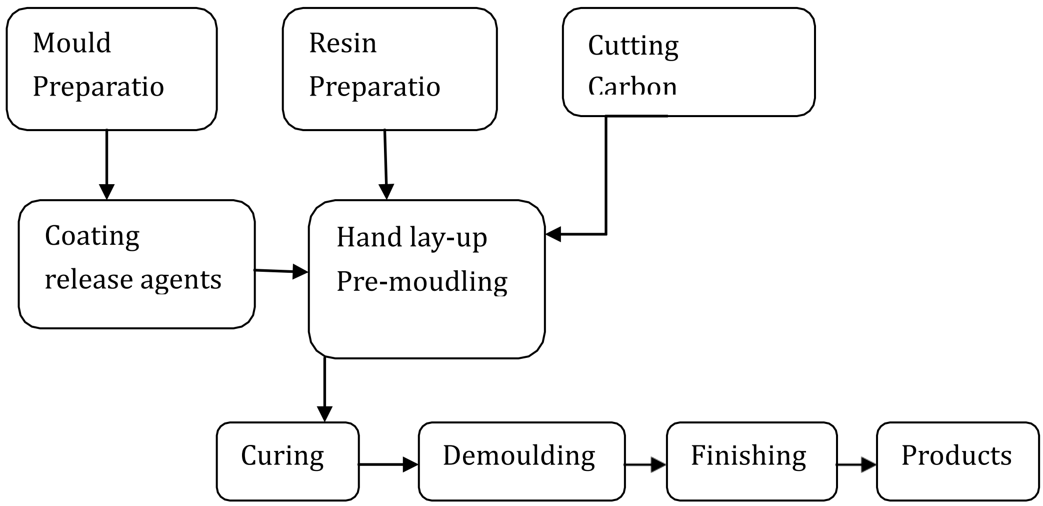


Fig. 03: Technique flow chart of FRP by hand lay-up

Tensile and Flexural test were carried out using Universal Testing Machine for samples of bidirectional oriented Carbon fiber reinforced epoxy resin based polymer composite laminates of different Graphite concentrations and results were discussed.

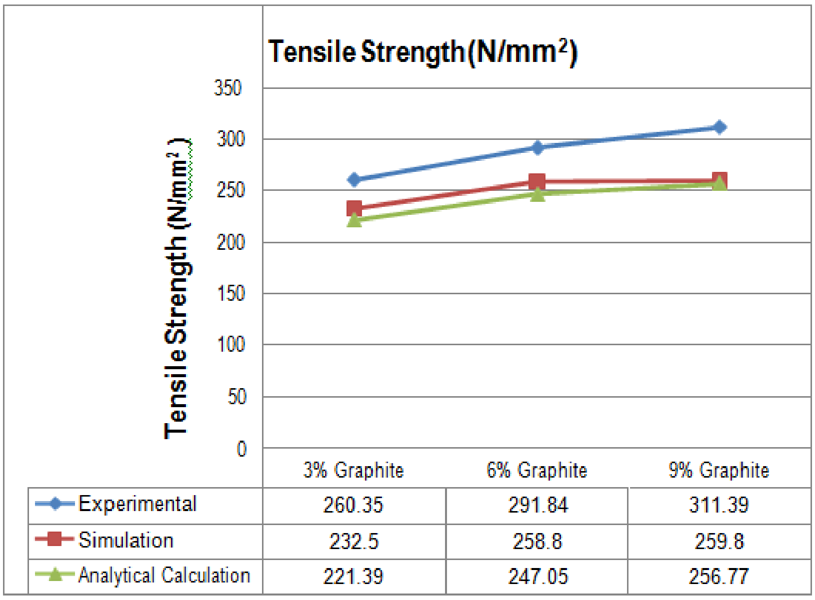
Fig. 04: Final Tensile Specimens from laminates.

RESUTS AND DISCUSSIONS:

The tensile & Flexural specimens from the laminates are subjected to uni-axial load using 20KN capacity Universal Testing machine with the surrounding room temperature of 320C. The load was applied till fracture with a grip displacement rate was maintained at 5 mm/min. Test was done 3 times for each Graphite concentration and the tensile& Impact properties of composite laminates with varying Graphite concentration are calculated and tabulated respectively.

Tensile Test (Carbon+ Graphite)									
	3% Graphite Specimen			6% Graphite Specimen			9% Graphite Specimen		
	n 1	n 2	n 3	n 1	n 2	n 3	n 1	n 2	n 3
Yield Force (N)	11248.23	10173.63	9916.85	9425.37	11136.10	9494.82	10302.49	8921.62	11843.71
Yield Elongation (mm)	11.48	10.32	10.63	11.85	13.56	12.46	13.87	11.84	14.62
Break Force (N)	11512.7	11062.7	10964.7	12150.4	12080.0	12846.7	13352.4	11852.1	12787.9
Break Elongation (mm)	11.81	11.10	11.47	14.55	14.52	16.29	16.75	14.72	15.82
Tensile Strength@ Yield (N/mm^2)	254.37	230.07	224.26	214.12	252.98	215.69	240.26	208.06	276.21
Tensile Strength @ Break (N/mm^2)	260.35	250.17	247.94	276.02	274.42	291.84	311.39	276.40	298.22
Max. Force (N)	11542.43	11087.43	10963.83	12150.44	12121.02	12846.71	13307.62	11852.08	12787.87
Modulus of Elasticity (N/mm^2)	1505.65	1659.13	1457.79	1251.16	1331.06	1296.85	1236.78	1217.27	1227.70

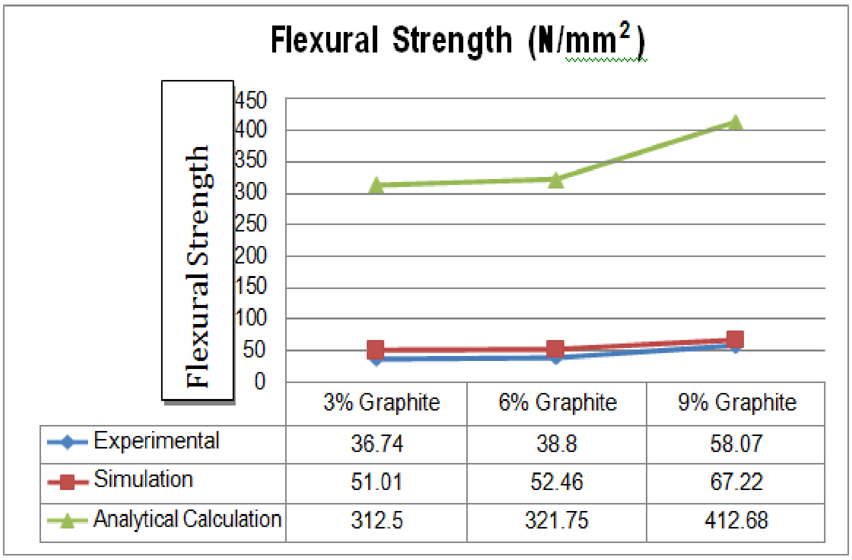
Table 01: Tensile Test results (Carbon + Graphite)



Graph 4: Comparison of Experimental, simulation and Mathematical relations (Tensile Test)

Flexural Test (Carbon+ Graphite)									
	3% Graphite Specimen			**6% Graphite Specimen**			**9% Graphite Specimen**		
	n 1	**n 2**	**n 3**	**n 1**	**n 2**	**n 3**	**n 1**	**n 2**	**n 3**
Yield Force (N)	311.71	304.02	324.51	333.4	299.94	339.40	373.08	343.59	440.31
Yield Deflection (mm)	3.10	2.93	2.95	2.87	2.76	3.7	3.41	3.42	4.34
Max. Force (N)	312.3	313.0	333.4	333.4	304.0	343.2	382.5	353.0	440.2
Max. Deflection (mm)	15.2	11.1	15.6	3.4	3.1	4.6	6.6	6.6	6.1
Flexural Strength @ Yield (N/mm^2)	35.29	34.42	36.74	37.75	34.29	38.80	49.20	45.31	58.07
Flexural Strength @ Max (Mpa)	171.59	171.98	183.20	183.20	167.84	189.500	226.81	209.36	261.02
Flexural Strain	0.119	0.086	0.12	0.026	0.024	0.035	0.051	0.05	0.04
Flexural Modulus of Elasticity (N/mm^2)	6584.33	4716.20	6682.45	8928.50	7653.62	7560.58	9695.84	8472.46	11336.74

Table 02: Flexural Test results (Carbon + Graphite)



Graph 02: Comparison of Experimental, simulation and Mathematical relations (Flexural Test)

CONCLUSION:

Based on the experimental results the effect of additives on Tensile and flexural properties ans behavior of Carbon Fiber at laminates were studied and presented here. And tried to explore an alternative skin material for the outer body of aerospace applications and machines.

The different Graphite concentration processes different properties, and following conclusions are drawn from the above results

- The Tensile Strength of Carbon with 9% Graphite has increased by 19.63% and Carbon with 6% Graphite has increased by 12.11% than Carbon 3% Graphite.
- The Flexural Strength of Carbon with 9% Graphite has increased by 59.25% and Carbon with 6% Graphite has increased by 5.7% and then Carbon 3% Graphite.

With this work Carbon with 9% Graphite is recommended for Tensile and Flexural application. Hence the present study not only discloses that different proportions of Graphite, it also promotes the performance of composites. But those unique tailored properties are improved by changing the proportions of the Graphite filler on the matrix. This indicates that the mechanical properties are mainly dependent on the fiber Filler (Graphite) and orientation of polymer composites.

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