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Physico-Mechanical Studies on Graphene based Polymer Matrix Composites

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ABSTRACT
Composite materials are used in a wide range of applications such as automotive, aerospace and renewable energy industries. To meet the specific strength ton weight ratio. Specific stiffness to weight ratio and cost constrains. The increasing public demand for safety and government regulation has stipulated the researchers to work on composite structure which are weight and has an efficient energy absorbing capability. To fully appreciate the role and application of composite materials to a structure, an understanding is required of the component materials themselves and of the ways in which they can be processed. The main idea of the project is to enhancing the mechanical properties of the material by adding glass fiber & Graphene in engineering application. Also to reducing the percentage of collision in energy absorption system for Automotive applications. It also emphasize on Graphene based Polymer Matrix Composites. Aiming of combination of light structures with novel multifunctional materials. which Develop the Mechanical strength of the material. It also study the influence of fiber parameters such as fiber and fiber loading on the mechanical behaviour of the composites.
KEYWORDS: composite materials, composite structure, graphene

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I. INTRODUCTION

Graphene is a one-atom-thick layer of carbon atoms arranged in a hexagonal lattice. It is the building-block of Graphite (which is used, among other things, in pencil tips), but graphene is a remarkable substance on its own - with a multitude of astonishing properties which repeatedly earn it the title “wonder material”. Graphene is the thinnest material known to man at one atom thick, and also incredibly strong - about 200 times stronger than steel. On top of that, graphene is an excellent conductor of heat and electricity and has interesting light absorption abilities. It is truly a material that could change the world, with unlimited potential for integration in almost any industry. Graphene is an extremely diverse material, and can be combined with other elements (including gases and metals) to produce different materials with various superior properties. Researchers all over the world continue to constantly investigate and patent graphene to learn its various properties and possible applications.

1.1 Properties of Graphene

Due to the strength of its 0.142 Nm-long carbon bonds, graphene is the strongest material ever discovered, with an ultimate tensile strength of 130,000,000,000 Pascals (or 130 gigapascals), compared to 400,000,000 for A36 structural steel, or 375,700,000 for Aramid (Kevlar). Not only is graphene extraordinarily strong, it is also very light at 0.77milligrams per square metre (for comparison purposes, 1 square metre of paper is roughly 1000 times heavier). It is often said that a single sheet of graphene (being only 1 atom thick), sufficient in size enough to cover a whole football field, would weigh under 1 single gram.

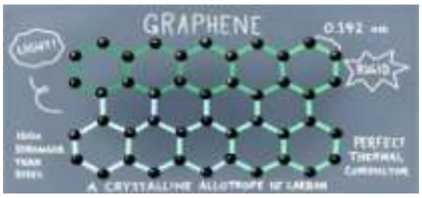

Figure 1 Structure of Graphene

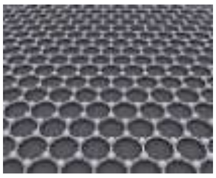

Figure 2 Graphene is an atomic-scale hexagonal lattice made of carbon atoms

II. SPECIMEN FABRICATION

E Glass Fabric - Reinforcement

Fibre glass has a white colour and is available as a dry fibre fabric as shown in fig2.1.In these composite E-Glass Fibre are used as reienforcement because it has good strength.the properties of the E-glass fibre Shown in below

Figure 3 E glass fabric

Properties	Value
Density	2600 kg/m^3
Young's Modulus	85 GPa
Tensile Strength	2050 MPa
Compressive Strength	5000 MPa
Elastic Limit	2875 MPa
Hardness	6000 MPa

Table-1

2.1 Epoxy Resin and Hardener –Matrix

Resin is a generic term used to designate the polymer. The resin, its chemical composition, and physical properties fundamentally affect the processing, fabrication, and ultimate properties of a composite material. Thermosetting resins are the most diverse and widely used of all man-made materials. Epoxy resins are much more expensive than polyester resins because of the high cost of the precursor chemicals most notably epichloro hydrin. However,the increased complexity of the 'epoxy' polymer chain and the potential for a greater degree of control of the cross linking process gives a much improved matrix in terms of strength and ductility. Most epoxies require the resin and hardener to be mixed in equal proportions and for full strength require heating to complete the curing process. This can be advantageous as the resin can be applied directly to the fibres and curing need only take place at the time.

Figure 4 Epoxy Resin and Hardener

2.2 Hardener

Substance or mixture added to plastic compositionto promote or control the curing action by taking partin it. Also, a substance added to control the degree ofhardness of the cured film.

2.3 Graphene

Graphene is a one-atom-thick layer of carbon atoms arranged in a hexagonal lattice. It is the building-block of Graphite (which is used, among others things, in pencil tips), but graphene is a remarkable substance on its own - with a multitude of astonishing properties so it is added to Epoxy Resin during Prepare the Composite. it has ultimate tensile Strength 130 GPa.

Figure 5 Graphene

III. FABRICATION TECHNIQUE

3.1COMPRESSION MOLDING

Compression molding is a popular manufacturing technique for composite parts. In particular, the development of high-strength sheet molding compounds drove wide adoption of compression molding process in automotive and appliance applications. In this chapter, we present some advantages and disadvantages of compression molding. We also introduce molding materials for compression molding such as sheet molding compound and bulk molding compound. To obtain high quality products, it is important to optimize mold design and processing conditions. Process modeling, such as flow and cure analysis, is especially useful to predict the knit line formation, part curing, fiber orientation and separation in the final product.

Figure 6 Compression Molding machine

3.2Compositions of composite material

Compositions of composite material for preparation of sample for Testing are shown in table .2

Specimen no	Epoxy Resin :Hardner Ratio	Graphene Weight (%)	E-Glass Fibre
1	10:6	9 %	3 layers
2	10:6	12 %	3 layers

Table-2

The fabrication of the polymer matrix composite was done at room temperature. The required ingredients of resin and hardener were mixed thoroughly in beaker.

3.3 Dough Preparation

The required mixture of resin & hardener were made by mixing them in (10:6) and (10:5) parts in a beaker by stirring the mixture in a beaker by a rod taking into care that no air should be entrapped inside the solution. graphene were mixing with dough ratio is 9 % and 12% of the epoxy composition.

Figure7 Dough and Mould preparation

3.4 Mould preparation

Two mild steel moulds of size 300 X 300 X 10 (mm) were used for casting of polymer matrix composite slabs. The moulds made of mild steel. The mould comprises of two plates one top & other bottom &third square mould cavity inside.

3.5 Castings of samples

The dough prepared was transferred to mould cavity by care that the mould cavity should be thoroughly filled. Leveling was done to uniformly fill the cavity. it is done by hand layup technique.

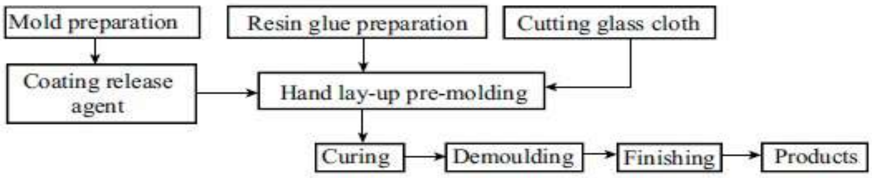

Figure 8 Flow of hand layup Technique

3.6 Curing

Curing was done at room temperature for approx. 24 hrs in Compression mouding machine. After curing the mould was opened slab taken out of the mould and cleaned.

Figure 9 Curing in Compression MoldingMachine **Figure 10 Final Specimen plate**

IV. TESTING OF SAMPLES

4.1 TENSILE TEST

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength or tensile strength at break. Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties.

Figure 11 Tensile Testing Machine

V. RESULTS AND DISCUSSIONS

5.1 TENSILE & ELONGATION TEST REPORT FOR SPECIMEN- 1

The following results have been arrived while doing the experiment. The specimens are separated in to two part as specimen I and specimen II to make and compare the results easily.

Specimen	1 (9 % Graphene)		
Ref. Standard	ASTM D 3039		
Grip Length	165 mm	Guage Length	125 mm
Sample Width	25 mm	Sample Thickness	3 mm

Table-3

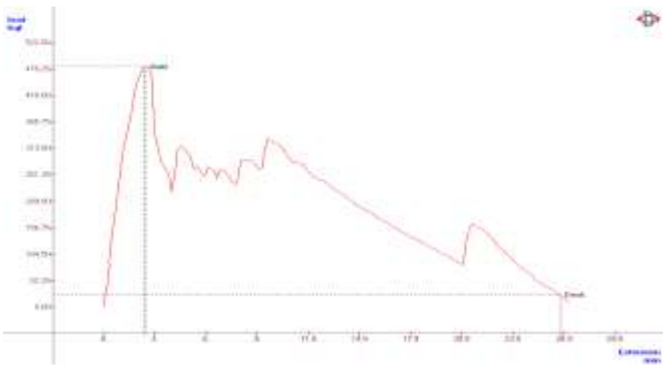

Figure 11 Graph View

Obtained Result

Sr. No.	Results	Value	unit
1	Area	0.75	cm²
2	Yield Force	475.00	Kg
3	Yield Elongation	2.43	mm
4	Break Force	24.0	Kg
5	Break Elongation	26.67	mm
6	Tensile Strength at Yield	633.33	Kg/cm²
7	Tensile Strength at Break	32.00	Kg/cm²
8	% Elongation	16.16	%

Table-4

5.2 TENSILE & ELONGATION TEST REPORT FOR SPECIMEN 2

Specimen code	2 (9 % Graphene)		
Ref. Standard	ASTM D 3039		
Grip Length	165 mm	Guage Length	125 mm
Sample Width	25 mm	Sample Thickness	3 mm

Table-5

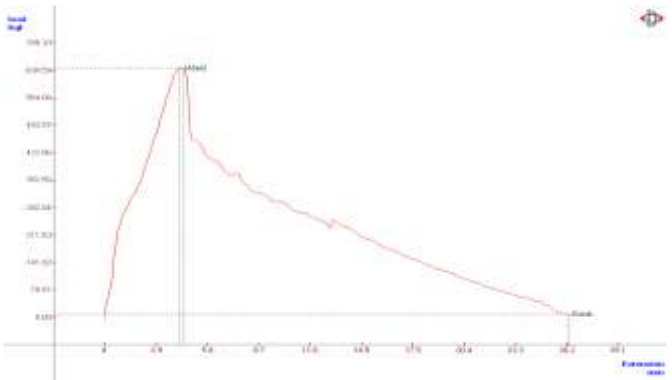

Figure 12 Graph View

Obtained Result

Sr. No.	Results	Value	Unit
1	Area	0.75	cm²
2	Yield Force	641.00	Kg
3	Yield Elongation	4.49	Mm
4	Break Force	8.0	Kg
5	Break Elongation	26.24	Mm
6	Tensile Strength at Yield	854.67	Kg/cm²
7	Tensile Strength at Break	10.67	Kg/cm²
8	% Elongation	15.90	%

Table-6

5.3 TENSILE RESULTS

Specimen	Yield force(kg)	Yield Elongation (mm)	Tensile strength at yield (kg/cm2)	% Elongation
1	475	2.43	633.33	16.16
2	641	4.49	854.67	15.90

Table-7

Specimen 1
3 layer Glass fabric + Weigh % Epoxy Resin + 9% Graphene
Specimen 2
3 layer Glass fabric + Weigh % Epoxy Resin + 12% Graphene

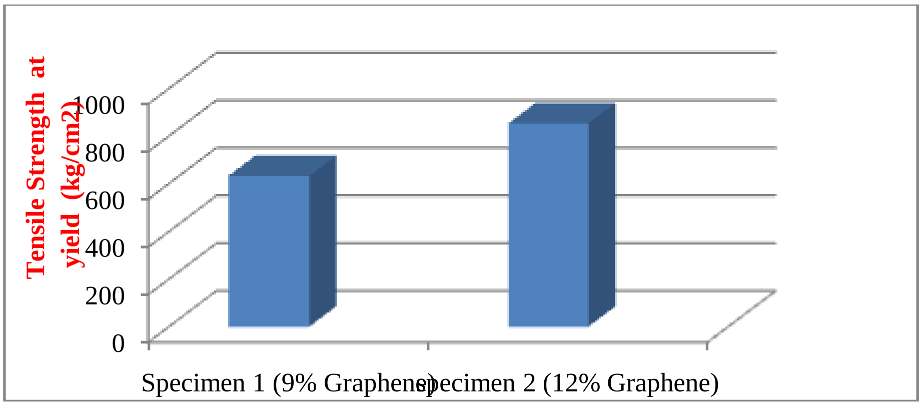

Figure 13 Comparison Chart for Tensile Tests

Figure 14 Specimens before Testing

Figure 15 Specimens after Testing

VI. CONCLUSION

- The Mechanical properties of the composites are Improving, when graphene is add with matrix as Epoxy Resin during the prepare the composite.
- Tensile strength of 9 % Graphene Specimen is 633.33 kg/cm^2 and 12 % Graphene Specimen is 854.67 kg/cm^2 .Here Tensile Strength of the 12 % of Graphene Specimen are improved by adding of 3% Extra graphene to the Composite.
- Tensile strength, Flexural strength of composites are gradually increasing, when increase weight % of graphene is add with matrix as Epoxy Resin During prepare the Composite.
- Mechanical properties are developed by adding the graphene to the composite.

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