Characteristic Analysis of Mechanical Properties on Carbon Fiber Reinforced Plastic

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Abstract— Carbon filament reinforced polymer composites are used in a built-up of variety components such as Golf sticks, Tennis rackets, Bicycles frame and wheel disk and also landing Gear doors. To decline these materials becomes important to be familiar with their Mechanical properties namely Tensile, Flexural, Impact and Wear test. Bisphenol resin is a carbon based artificial compound, it is mainly employed in fabricating certain plastics. The present experiment work concentrated on the study of mechanical characteristics of carbon filament reinforce polymer composite, they are fabricate using Hand Layup method and the specimens are developed in the from laminates according to ASTM standard and finally evaluate the mechanical properties such as Tensile, Flexural, Impact and Hardness tests using respective procedure

Key words: Composites, Carbon filament, Bisphenol resin, Mechanical properties

I. INTRODUCTION

Carbon fiber reinforced plastic (CFRP) composite find their applications in a wide range of products such as Aerospace structures, Marine structures, Sports equipments, Electrical panel boards, Medical prosthesis and so on. Composite material is prepared via combination of two or additional materials to provides a distinctive grouping of property. Numerous frequent material is in reality "composites," together with timber, concrete and metals alloys. On the other hand, filament durable composite resources differ from those universal materials in that the ingredient resources of the compound are macroscopically distinguishable and eventually mechanically separable. In additional the ingredient materials work together but remain essentially in their original bulk figure.

The outstanding property of composite is accomplished via positive distinctiveness of the two most important ingredients that is the filament and the resin. In low routine composite the strengthening usually in the form of tiny or chopped particles, provide some stiffening but very little strengthening; the load is mainly conceded by the resin phase. In higher performances composite incessant filament provides advantageous rigidity and potency; while the resin provide shield and hold up for the filament and mainly helping in reallocate the load from broken to adjacent unbroken fiber. The various reasons for the use of composites are due to

- To increase the strength, stiffness and dimensional stability.
- To enhance the electrical properties.
- To decrease the thermal expansion.
- To increase heat deflection temperature.
- To increase tough and impact strength.
- To increase mechanical damping.
- To reduce cost.
- To reduce weight.
- To maintain stiffness at high temperatures while under strain condition in a corrosive environment and reduce the negative impact on the environment.

A. *Need for developing composite materials*

Conventional materials have

- Easily attacked by environments and they experience premature failure
- Generally heavy in weight and they are intricacy to handle
- Lack of material properties
- Less resistance to wear and corrosion

So, all these problems in conventional materials overcome by introducing by advanced materials known as composite materials. Composites materials have lot of benefits over conventional materials.

B. *Categorization of composite material*

largely composite materials can be classified into three groups on the basis of reinforcing material they are:

- Fibrous composite
- Particulate composite
- Laminate composites

1) *Fibrous Composite*

Frequent strand reinforced composites consists of filaments and resin. Filaments are the strengthening and the major foundation of potency whi1e resin glues all the thread collectively in outline and transfer anxiety between the strengthen yarns. The fiber takes a loads along their longitudinal commands.

2) *Particulate Composites*

Particulate employed in strengthening embrace stoneware and Glasses such as minute sandstone particles, metal particles like Aluminium and unstructured materials, together with polymers and carbon black. Particles as well used in raise the modules of the resin and to reduce the ductility of the resin.

3) *Laminated Composite*

Laminar composite were establish in numerous combination as the number of materials. Those can be illustrated as materials include of layer of materials tie together. These may be of numerous layers of two or additional metal materials happening alternately or in a resolute categorize more than one time, and in as several statistics as necessary for a precise principle.

C. *Statement of the problem:*

Ecological as glowing as customer demands in numerous country are impressive superior heaviness on manufacturing of material and finish product. They include considering the ecological blow of their product based on composites and at all the phases of their life sequence, including the recycling and eventual dumping.

Those ecological concerns include freshly create substantial attention during the growth of recyclable composite materials. Therefore, research in the field of using Carbon strands has engrossed a large amount concentration in the material science and commercial discipline. Carbon strand is certainly a renewable reserve that can be grown-up and made within diminutive stage of extent. The main intension of the project will be characterize the mechanical properties of Carbon fiber reinforced with Bisphenol resin, The investigation is focused on fabrication technique by Hand layup technique, followed by specimen preparation, conducting experiments and note down the mechanical data, All the test methods are based on a American society for testing and materials(ASTM).

1) Objectives:

- The reinforced material of two layers Carbon fiber along with Bisphenol resin to evaluate the performance analysis by experimental results such as Tension, Flexural, Impact and Hardness properties.
- To evaluate the performance analysis for three layers Carbon fiber along with Bisphenol resin by experimental results.
- To evaluate the performance analysis for four layers carbon fiber along with Bisphenol resin by experimental results.
- To evaluate the performance analysis for five layers carbon fiber and Bisphenol resin by experimental results.

a) Fabrication of composite materials

The Hand layup technique is the one of the oldest open mould composite processing method. The main processing steps in the Hand lay- up method include:

- Matrix: Bisphenol resin
- Fiber: Carbon filament woven mat
- Hardener: HY951, Promoter, Accelerators and catalyst
- Other accessories used in the preparation of CFRP laminates are:
- Brush, Roller, Mould tool, waste cloth, Scissor and optional gel coat.

Fig.2.1: Required Materials to Prepare Laminates

D. *Fabrication steps*

- The primary step in a Hand lay- up process is cleaning the surface of the mould by the releasing agent or film.
- The thin gel is applied to the outside surface of the mould by using roller.
- Chopping the Carbon fiber woven mat according to the required dimensions.
- The ratio of the carbon fiber to resin hardner mixture is taken as 60:40.
- Based on the weight of Carbon fiber strands and the weight of the resin hardner mixture proportion is calculated.
- Proper care was taken during the preparation of laminates to avoid the voids (Air gap).
- The initial sheet of Carbon fiber is fed and matrix is extend uniform1y above the cloth by means of brush, after this to augment soaking and impregnation, a teethed steel roller is used to roll above the fabrics.
- This process is repeated to all the two, three, four and five layers are placed respectively.
- At last detached on or after the mould to acquire a well completed compound p1ate.

E. *Sample calculation*

1) Carbon –Bisphenol laminate

Dimension of each laminate = 200×200 mm
Thickness of Carbon fiber layer one = 0.016mm
Thickness of layer two laminate = 0.1mm
Thickness of layer three laminate = 0.2mm
Thickness of layer four laminate = 0.25mm
Thickness of layer five laminate = 0.35mm
Ratio of Carbon fiber and resin mixture is 60:40
Weight of Carbon fiber = 150grams
Weight of the resin mixture = 90grams

F. *Methodology of fabricating the composite material*

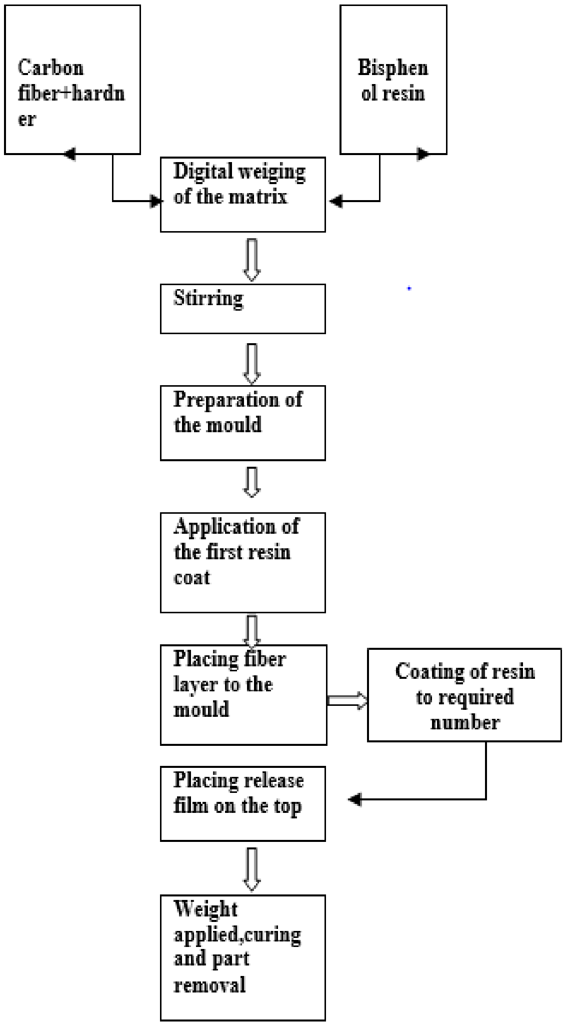

Fig.2.4: Methodology of fabrication of composite

G. Carbon Fiber

Carbon fiber comprises about five to ten micrometers in diameter and composed of Carbon atoms. Carbon fiber is one of a peculiarity to be complete in the midst of strand is the dissimilarity flanked by Carbon and Graphite filament, even though the stipulations are recurrently used interchangeably. Carbon and Graphite filament is pedestal on hexagonal structure network. If the graphene layers are stacked with three dimensional instructions, the material is described as Graphite. Frequently comprehensive occasion and hotness dispensation is necessary to form this array, creation Graphite strand more costly

II. FUNDAMENTALS OF MECHANICAL TESTING

A. Mechanical tests

1) Tests Carried Out

- Tensile test
- Flexural test
- Impact test
- Hardness test

2) Tensile Test

- The term tensile test generally refers to the test in which the specimen is subjected to gradually increasing axial load until failure occurs. In a tension test, The test specimen elongates in a direction parallel to the applied load and load is supplied to gripping ends of the specimen, the usual properties that are directly measured from tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can be determined;
- Youngs modulus (Modulus of Elasticity)
- Poisson ratio
- Yield strength etc..,

Fig:2.5Tensile specimen before testing

Figure 2.6: Tensile specimen after testing

3) Flexural test

- The flexure test routine prescribes manner of material conditioned to simple beam loaded condition. It is also referred as transverse beam examination with few materials extent. Flexure test creates the tensile stress in the curved side of the specimen and compression stress in the dipped side. This generates a region of shear stress along the midline portion. On the way to ensure that the primary failure comes from tensile or compression stress thus the shear stress should be minimized. This is achieved by scheming the length to deepness quotient.

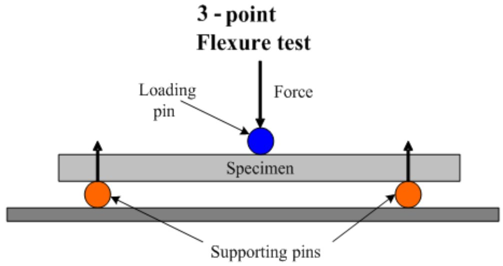

Fig. 3.3: JJ Lloyd computerized universal testing machine

4) Impact test

Fig.3.4: Charpy Impact test

5) Rockwell hardness test

Fig. 3.5: Rockwell hardness test

More commonly utilize rigidity test is Rockwell rigidity test ASTM D785. It is general recognition owing to their velocity and self-determination controls the personal error, capability to differentiate the little hardness difference in hard-bitten Steel, and the minute dimension of the groove (serration), so that ended heat-treated ingredients can be experienced devoid of spoil.

III. RESULTS AND CONCLUSIONS

A. Tensile Strngth Results

Sl No.	Specimen Label	Width (mm)	Thickness(mm)	Maximum Load (N)	Maximum Flexure Stress (N/mm^2)	Flexure Modulus (N/mm^2)
1	LAYER 1	13.07	1.25	128.42	214.73	8034.06
2	LAYER 1	12.7	1.2	130.20	245.40	8196.41
3	LAYER 1	13.06	1.08	131.04	222.96	8001.28
4	LAYER 2	12.77	1.28	156.38	224.12	12932.30
5	LAYER 2	13.04	1.24	158.12	226.67	12730.36
6	LAYER 2	12.82	1.2	156.38	254.12	12685.92
7	LAYER 3	12.82	1.76	224.43	237.36	13731.65
8	LAYER 3	12.79	1.65	195.14	221.93	14394.22
9	LAYER 3	12.9	1.7	199.66	248.50	14330.33
10	LAYER 4	13.06	2.96	342.21	228.71	11301.40
11	LAYER 4	13.00	2.91	351.21	238.42	11055.21
12	LAYER 4	12.76	3.11	362.66	242.16	10618.44

Table 4.1 Tensile Strength as per ASTM D638 Standard

The above table shows the variation of tensile strength of different laminates of different thickness along with their extension. Thus corrersponding maximum Tensile stress at corresponding load reffered as maximum load can also be documented. Then corresponding tensile strain at yield of material interms of percentage can be noted it leads to the responsible Modulus of elasyticity.

B. Flextural Test Results

Sl No.	Specimen Label	Width (mm)	Thickness(mm)	Maximum Load (N)	Maximum Flexure Stress (N/mm^2)	Flexure Modulus (N/mm^2)
1	LAYER 1	13.07	1.25	128.42	214.73	8034.06
2	LAYER 1	12.7	1.2	130.20	245.40	8196.41
3	LAYER 1	13.06	1.08	131.04	222.96	8001.28
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12	LAYER 4	12.76	3.11	362.66	242.16	10618.44

Table 5.2 Flextural Strength as per ASTM D790 Standard

The above table shows the variation of Flextural strength of different laminates of different thickness along with their thickness. Thus corrersponding maximum Flextural stress at corresponding load reffered as maximum load can also be documented. Then leads to the responsible Flex Modulus.

C. Rockwell hardness test

LAMINATES	RHN
LAYER 1	**95**
LAYER 2	**96**
LAYER 3	**97**
LAYER 4	**98**

Table 4.2 Hardness number

RHN = rockwell hardness number

D. Impact test

LAMINATES	ENERGY (J)	DEGREE (ang)
LAYER 1	**1.505**	**105**
LAYER 2	**2.75**	**114**
LAYER 3	**3.50**	**124**
LAYER 4	**4.005**	**132**

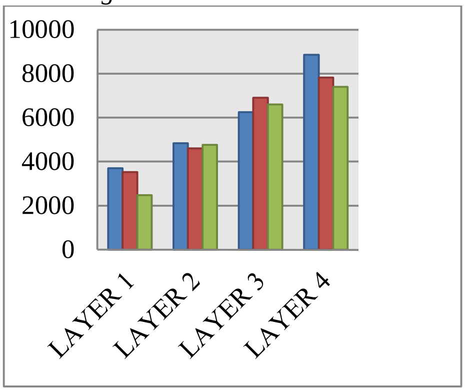
Table 4.3 Impact Test data

E. Graphs maximum loads

X axis = Layer

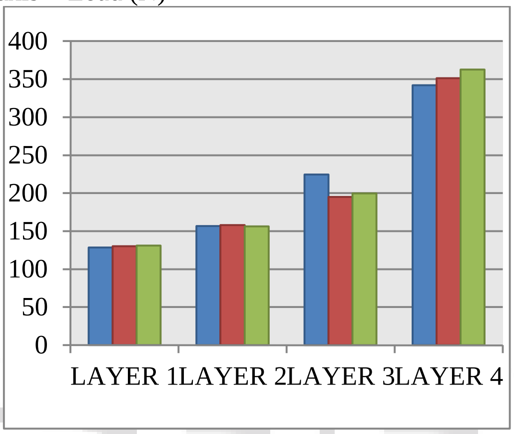
Y axis = Load (N)

1) Tensile Strenngth Loads



2) Flextural Strength Loads

- X axis = Layer
- Y axis = Load (N)



IV. CONCLUSIONS

Subsequent to carrying out the experimentations, the different mechanical properties of the composites materials are estimates and are represent in the form of graphs. Carbon fiber reinforced with Bisphenol resin composites has been successful fabricated by simple hand lay-up technique. And the Mechanical tests results documented then the following conclusion can be drawn

A. Tensile Strength

- As the width of the laminates increases it leads to increasing Modulus (Layer 1 & 4)
- As the thickness of the laminates increases it leads to decreasing Modulus (Layer 1 & 4)

B. Flextural Strength

- As the width of the laminates increases it leads to increasing Modulus (Layer 1 & 4)
- As the thickness of the laminates increases it leads to decreasing Modulus (Layer 1 & 4)

C. Hardness test

As the thickness of the laminates increases it leads to increasing hardness number

D. Impact test

As the thickness of the laminates increases it leads to increasing energy level to failure and angle of rotations.

E. Scope for future work:

This work leads an extensive extent for future investigators to search a lot of additional aspects of composite. This effort is able to be auxiliary comprehensive to revise other feature of such composite in the vein of dynamic mechanical analysis, end product of other types of factors, cryogenic effect, loading pattern etc.

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