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Mechanical Characterization of Carbon Fibre Reinforced Epoxy Polymer

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Abstract—Carbon fiber reinforced polymer (CFRP) is used in aeronautical industry in the manufacture of different aircraft components. This paper is about studying the mechanical (tensile, flexural, interlaminarshear strength), characterizations of the laminate. A carbon reinforced polymer laminate of G939 material and 913 resin system are selected to study its mechanical characteristics with five different orientations like 0°/90°, 0°/45°, 0°/45°/90°, 0°/0°, 90°/90° .The Laminate is fabricated by vacuum bagging and cured using autoclave at 135°C. Tensile, flexural and ILSS (Inter laminar shear strength) were carried out for the specimens according to the standards.

IndexTerms— CFRP, prepreg, vacuum bagging, autoclave curing.

I. Introduction

Composite materials have the potential to replace conventional materials used in various applications. Because of their anisotropic nature their properties can be enhanced in particular direction by ensuring their orientation in plane. This advantage is the main challenge in developing such material for particular application. Because of anisotropy they have n number of elastic constants and their analysis from strength point of view does not remain as simple as that of conventional material analysis. Composite materials are made up of two or more constituent materials to obtain a new material with the desired properties. Composite materials are being developed and made with two kinds of objectives one is to enhance the material properties and performance efficiency and another to design materials with combinations of desired properties[5]. Carbon fiber is used in industries where high strength and rigidity are required in relation to weight. We know that material density has a direct impact on its weight and carbon fibercomposite has a density 2 times less than aluminum and more than 5 times less than steel [9]. We have used carbon prepreg in which resin system already includes the proper curing agent. Advantage of prepreg is it is less mess and less waste. In this paper we have studied material, thermal and moisture characterization of CFRP laminate. Material characterization includes tensile, flexural and interlaminar shear strength. Interlaminar shear strength is the stress existing between layers of a laminated material [3]. Flexural test is done to know the bending strength of the laminate; it is the maximum stress acting on the outermost fiber of the laminate. Tensile test is done to determine the maximum load that a material can withstand.Different structural components are manufactured by composite materials due to their attractive specific mechanical properties [6]. When compared with metallic materials polymeric composites have high strength to weight ratio, hence CFRP are processed using thermoset polymers, especially epoxy resins. The bonding material that allows fabric to form a composite material is the resin. Resin is a type of matrix which acts as a medium to transfer load. We have used carbon prepreg in which resin is pre-impregnated and it is ready to use in the component. The resin system used is typically epoxy. Interlaminar hear strength is the stress acting between layers of a laminated material, usually it is performed to characterize both fiber and matrix interfacial bonding [2]. Flexural testis done to know the bonding strength of the laminate, it is the maximum stress acting on the outermost fiber of the laminate. And it is an important tool for optimization of process and evaluation of matrices and fiber resin interface [2]. In order to verify specifications, quality assurance of project and also analysis of failure mode, tensile test are carried out.

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II. Experimental Work

Preparation of Material

The prepreg used in this work is HEXPLY G939, material bidirectional (BD) material with 913 epoxy matrix system which is widely used in the fabrication of high strength compositematerials. The cure cycle of 913 epoxy is less.

Fabrication of laminate

To fabricate composite laminate consider material of size 200×200mm which is prepared with different layers of orientation.A flat plate was considered as a base and followed by vacuum bagging procedure the laminate was cured at 135°C using autoclave. After completing the curing cycle,

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laminate was demoulded and trimmed for extra part to required size.Now the laminate is used for further testing process.

Fig 1. Shows the vacuum bag of laminates

III. METHODOLOGY

Material Characterisation of Composites

Five different orientations 0°/90°, 0°/45°, 0°/45°/90°, 0°/0°, 90°/90° were considered to study tensile, flexural and ILSS (Interlaminar shear strength). The orientations and layers of the laminate are listed in the table 1.

Table .1 Features of the layers and its orientations.

Laminate No	Orientation	0° layers used	90° layer used	45° layer used	Total no of layers used
1	0°/90°	4	4	-	8
2	0°/45°	4	-	4	8
3	0°/45°/90°	3	2	3	8
4	0°/0°	8	-	-	8
5	90°/90°	-	8	-	8

Tensile test

The tensile tests were performed according to ASTM D638 standard. using a minimum often specimens (250×25×2mm) for each laminate family. By bonding end tabs of carbonfiber/epoxy laminate the specimens were prepared The tests were carried out in an UTM

Fig 2.Tensile test specimens

Fleural test

This test was performed according to ASTM D790 standard. This is a bending test (3 point loading) considering 5 samples (100×10×2mm) for every laminate. The test were carried out in an UTM at exact speed of 2mm/min at room temperature

Fig 3. Flexural test specimens

Inter laminar shear strength

The interlaminar shear tests (ILSS) were performed according to ASTM D2344 standard by considering five samples (short beam: 20×10×2mm) for every laminate. The tests were carried out in an UTM

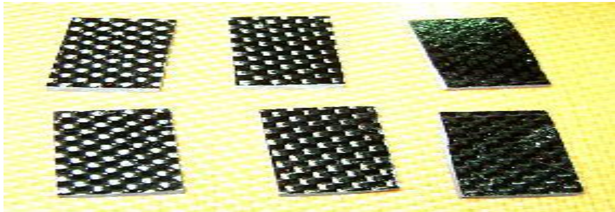


Fig.4.ILSS test specimens

IV. RESULTS AND DISCUSSION

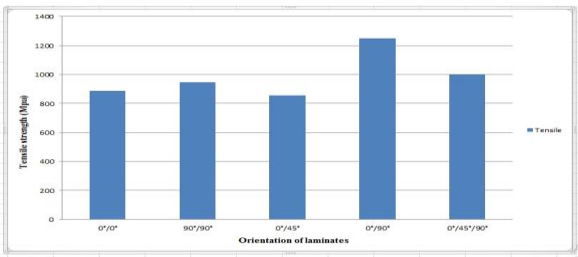
Result of Tensile Test

Table 2 shows the mean outcome of tensile strength. The outcome obtained is according to ASTM D638 is represented ,it is concluded that the 0°/90° orientation shows maximum Strength and comparison of different orientation with tensile strength is represented in the Fig .5

Table 2 Tensile test values of the laminates studied

Sl no	Orientation	Tensile strength (Mpa)
1	0°/0°	887
2	90°/90°	945
3	0°/45°	857
4	0°/90°	1250
5	0°/45°/90°	998

Fig 5. Tensile values at different orientation



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Result of flexural test

Table 3 shows the mean outcome of flexural strength. The outcome obtained is according to ASTM D790 standard. It is concluded that the 0°/90° orientation shows maximum strength and Comparison of different orientation with flexural strength is shown in the Fig.6

Table 3. Flexural values of the laminates studied

Sl no	Orientation	Peak load(N)	Flexural strength(Mpa)
1	0°/0°	374.36	844.313
2	90°/90°	341.04	835.101
3	0°/45°	390.00	671.26
4	0°/90°	284.20	859.33
5	0°/45°/90°	284.2	686.15

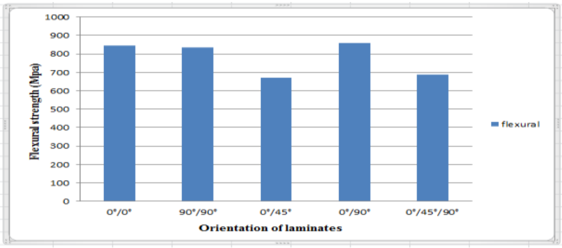

Fig 6.Flexural values at different orientations

Result of ILSS test

Table 4 shows the mean results of ILSS. The outcome obtained is according to ASTM D2344 standard. It is found that the 0°/0° orientation shows maximum strength and comparison of different orientations with ILSS is represented in the Fig.7

Sl no	Orientation	Load (kN)	Peak load (N)	ILSS (Mpa)
1	0°/0°	2.36	2365.62	81.20
2	90°/90°	2.31	2312.53	80.96
3	0°/45°	2.14	2144.73	74.00
4	0°/90°	2.52	2519.27	75.47
5	0°/45°/90°	2.21	2212.28	75.42

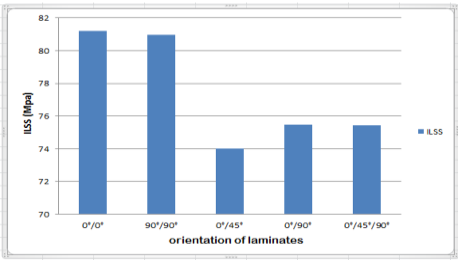

Fig 7.ILSS values at different orientations

V. Conclusion

- Maximum tensile strength is obtained for 0°/90° orientation.
- Maximum inter laminar strength is obtained for 0°/0°orientation.
- Maximum flexural strength is obtained for 0°/90° orientation.
- It is concluded that fiber orientation changes the mechanical properties of the composite material and also strength and stiffness of the composite laminate can be increased by enhancing the fiber properties.

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