

Preparing, Studying and Drilling the Composite Materials with different Orientation of Fibers

Vemuri Radha Madhavi¹, Dr. S. Shyam Sunder Rao²

¹(Department of Mechanical Engineering, VNRVJiet/ JNTUH, INDIA)

²(Department of Mechanical Engineering, VNRVJiet/ JNTUH, INDIA)

Abstract: This paper presents the research work done to understand the Tensile and Flexural Strength of epoxy glass fiber laminates with and without orientation. To achieve this, investigation is done on the effects of fiber orientations, resin types and mechanical properties of laminated composites with 0, 30 and 45 degree orientations and calculated surface roughness value after drilling on it.

Keywords: Epoxy resin composites, Fiber orientation, Glass Fiber, Laminated polymer composite, Mechanical properties, Resin.

I. INTRODUCTION

Composites are heterogeneous mixture of two or more components, reinforcing fibers and a compactable matrix. The matrix can be ceramic, polymeric in origin or metallic which gives the shape, surface appearance, environmental tolerance and overall durability for the composites. Where the fibrous reinforcement carries most of the structural load that gives strength and stiffness. Composite materials combines the most desirable properties of its constituents while suppressing their least desirable properties so they provide superior and unique mechanical and physical properties. Some of the key areas where composite materials play a key role are aerospace industry, automobile industry and other engineering applications as they exhibit outstanding strength to weight ratio. An extensive study is going on high performance rigid composites that are made from glass, graphite, Kevlar, boron or silicon carbide fibers in polymeric matrices because of their application in aerospace and space vehicle technology. Composites are broadly classified into ceramic matrix (CMC), metal matrix (MMC) and polymer matrix composites (PMC) based on the matrix material which forms the continuous phase. Among these, polymer matrix composites are much easier to fabricate than others.

PrashanthBanakar and H.K. Shivananda [1] made a research on “Preparation And Characterization of The Carbon Fiber Reinforced Epoxy Resin Composites”, the objective of this research was to gain a better understanding of Mechanical properties of epoxy resin composites reinforced with carbon fiber. Laminates were prepared by hand layup process and cut to obtain ASTM standards which intern used for investigating the effect of fiber orientation. The research deals with testing of tensile and flexural strength on a universal testing machine. This investigation indicates that the mechanical properties are mainly dependent on the fiber orientation.

PrashanthBanakar, et al. [2] studied “Influence of Fiber Orientation and Thickness on Tensile Properties of Laminated Polymer Composites”, the effect of fiber orientation and thickness of laminates is studied to determine property data for material specifications, the method used is hand layup process and made under ASTM standards. This study proved that tensile strength is mainly dependent on orientation and thickness of the composites.

K. Mohamed Kaleemulla et al. [3] made a research on the “Influence of fiber orientation on the In-plane Mechanical Properties of Laminated Hybrid Polymer composites”, and established a relationship between the tensile/compressive strength, fiber content and orientation. The laminated specimens prepared under ASTM standards were fabricated using steel and nylon bi-directional mesh as reinforcements and polyester as the binder. The experiment was done by keeping polyester percentage constant (40%) and changing the volume fractions and fiber orientations and concluded that the specimens with higher percentage of steel sustain greater loads & also the strengths are superior in case of 0/90 degree oriented specimens and established a relationship between the tensile/compressive strength, fiber content and orientation.

Hossein Rahmani et al. [4], made a research on “Mechanical performance of epoxy/carbon fiber laminated composites”, results show that the mechanical properties, in terms of tensile, flexural and impact strengths, were mainly dependent on the fiber orientations followed by the number of laminates. At a similar fiber orientation, the composites made with EM500 epoxy resin showed the highest mechanical properties (such as tensile and flexural and impact strengths) compared to other evaluated composites.

II. EXPERIMENTAL PROCEDURE

First prepare the Epoxy resin composite reinforced with glass fiber at 3 different orientations (0, 30 and 45 degrees) with ASTM standards. Perform tensile test and flexural test using computer controlled UTM. Determining the best orientation of sample prepared that exhibiting more tensile and flexural strength/ withstand to high load, to enable best outcomes on its application. Perform drilling on different orientation of samples to determine the best surface roughness value.

III. MATERIALS AND METHODOLOGY

3.1 Material:



Fig1: Glass Fiber Mat Type

Glass fiber mat type has increasing popularity in different applications. The present investigation carried on epoxy resin bi woven glass fiber mat type, the matrix materials are epoxy resin LY556 and hardener HY951 mixed in appropriate ratio with room temperature curing cycle of 24 hours duration.

3.2 Instrumental:



Fig2: Computer controlled



Fig3: Flexural Fixture UTM



Fig4: Tensile Fixture

Loads are applied on laminates under computer controlled UTM. Laminates are subjected to tests by clamping them and the results are monitored at room temperature. The ultimate tensile/flexural load is defined as the load at which the fracture of the specimen occurred.

3.3 PREPARING OF GLASS FIBER REINFORCED EPOXY COMPOSITE:



Fig5: Sample Preparation

The specimen was prepared in shape of rectangles plates by hand layup technique at room temperature and proper care was taken during fabrication of laminates to ensure uniform thickness in the material. The laminates were fabricated by placing the Glass fiber one over the other with a matrix in between the layers. Tools were used to distribute resin uniformly. The laminates were cured in room temperature and constant pressure. The laminated test specimens were prepared by a cutting machine to suit ASTM dimensions.

3.4 TEST CONFIGURATION:



Fig6: Preparing specimen



Fig7: Fractured specimens



Fig8: Drilled specimen

3.5 GRAPHS FOR TENSILE AND FLEXURAL TEST:

3.5.1 Stress vs Strain Curves:

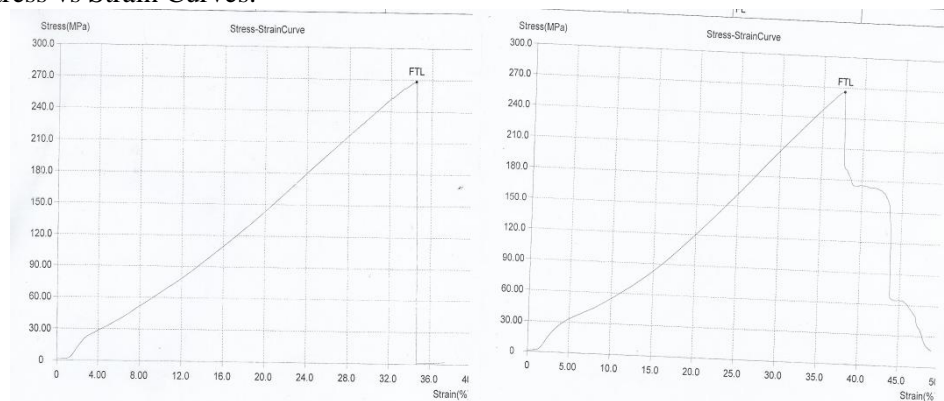


Fig9: Stress Vs Strain 0 (Tensile test)

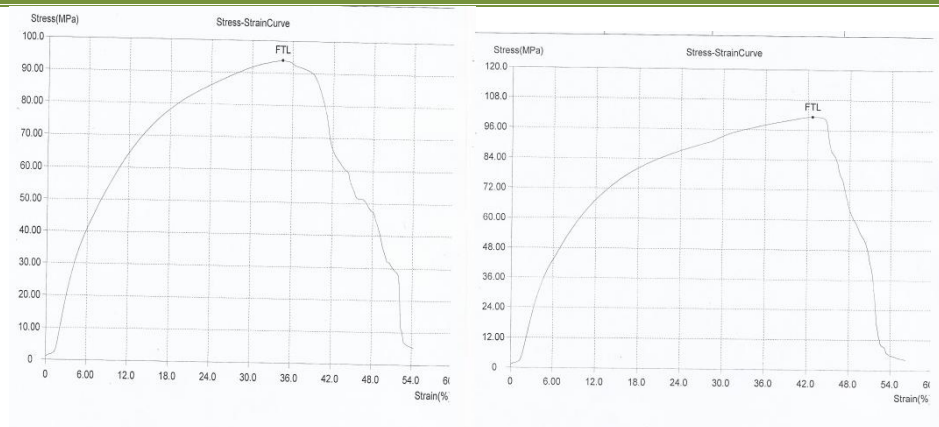


Fig10: Stress Vs Strain 30 (Tensile test)

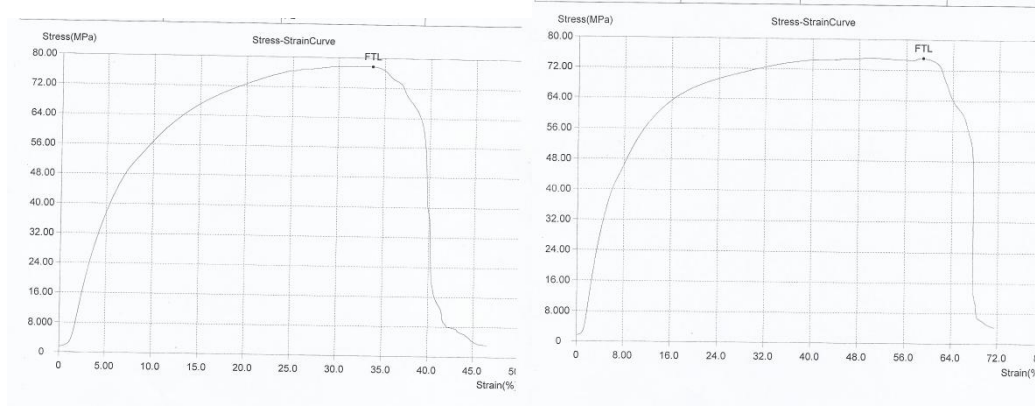


Fig11: Stress Vs Strain 45 (Tensile test)

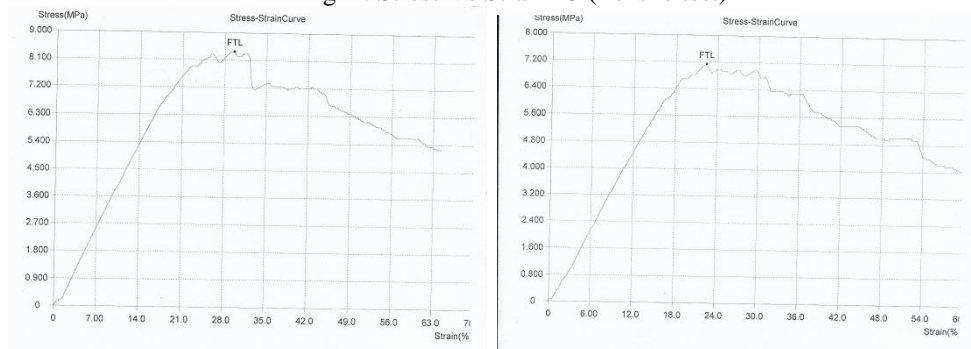


Fig12: Stress Vs Strain 0 (Flexural test)

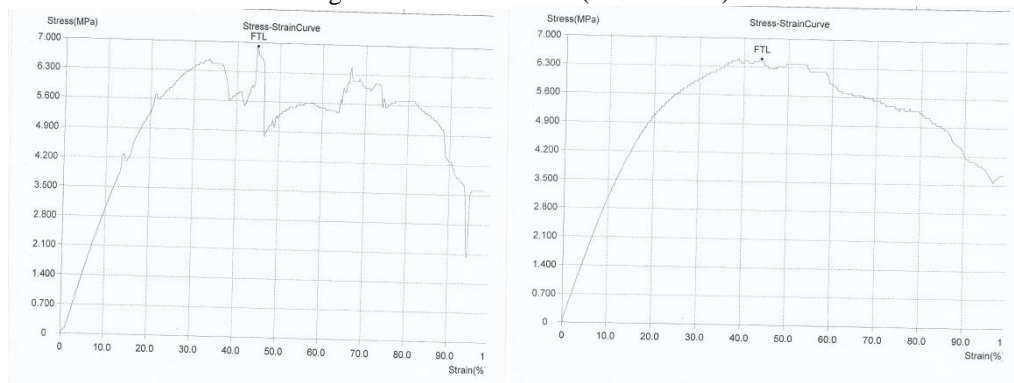


Fig13: Stress Vs Strain 30 (Flexural test)

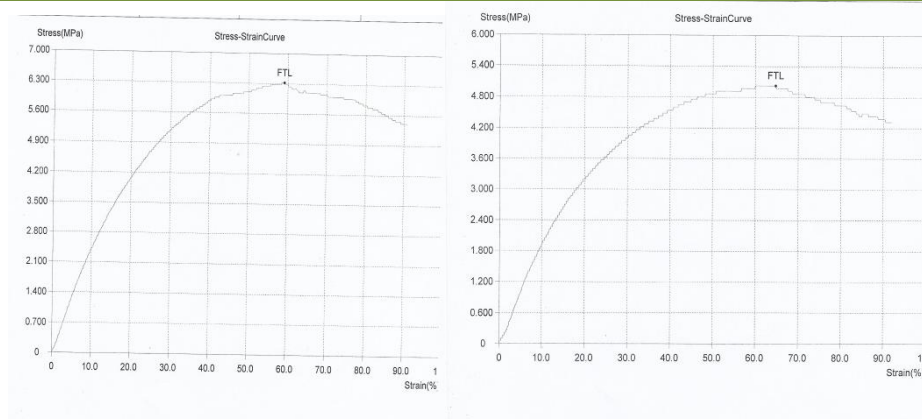


Fig14: Stress Vs Strain 45 (Flexural test)

3.5.2 Load vs Displacement Curves:

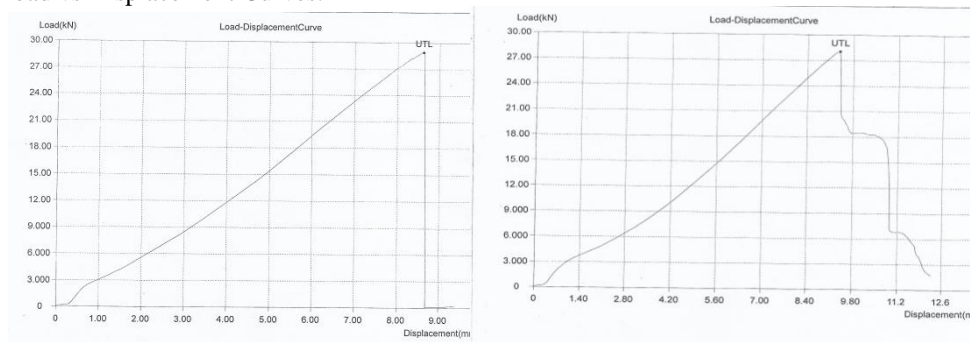


Fig15: Load Vs Displacement 0 (Tensile test)

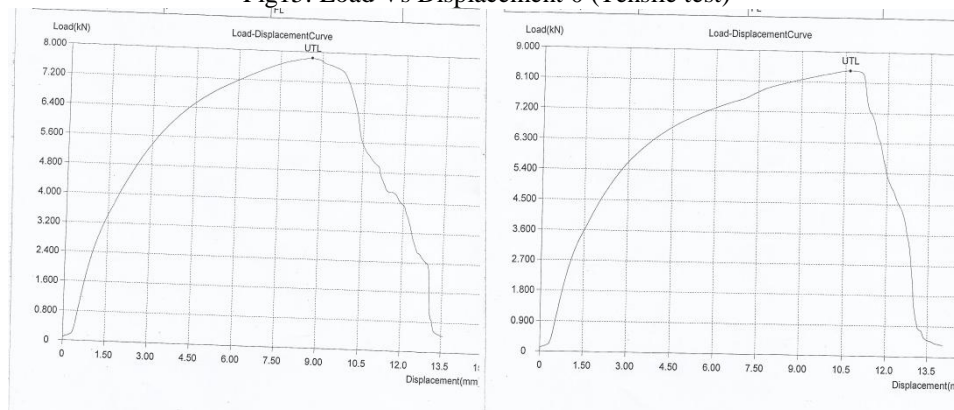


Fig16: Load Vs Displacement 30 (Tensile test)

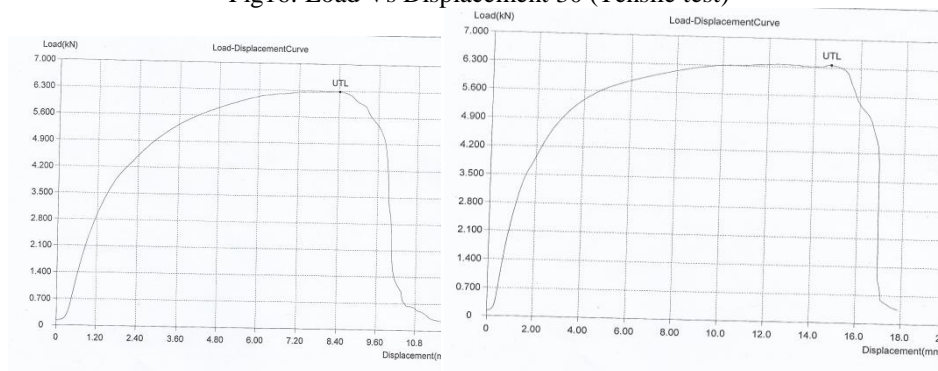


Fig17: Load Vs Displacement 45 (Tensile test)

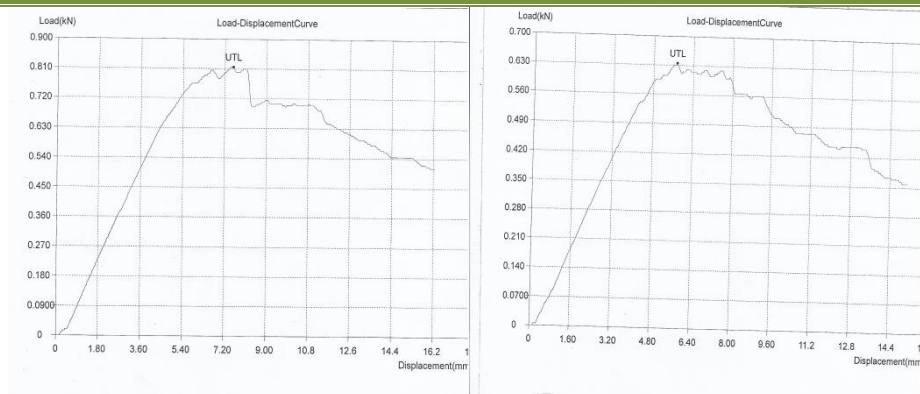


Fig18: Load Vs Displacement 0 (Flexural test)

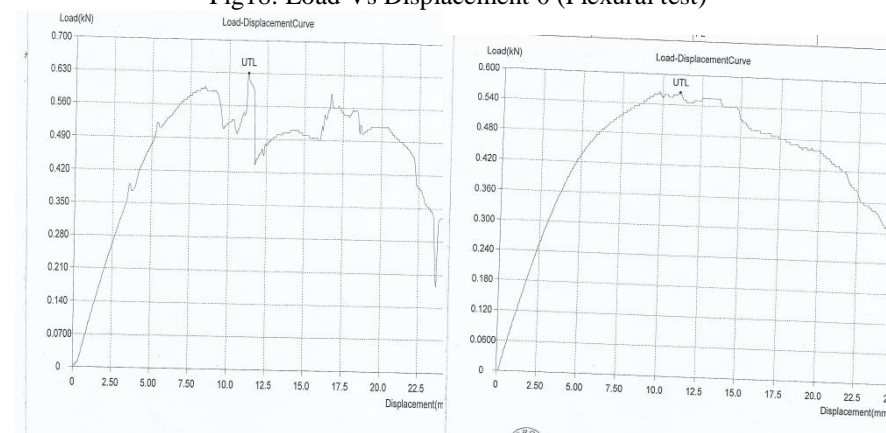


Fig19: Load Vs Displacement 30 (Flexural test)

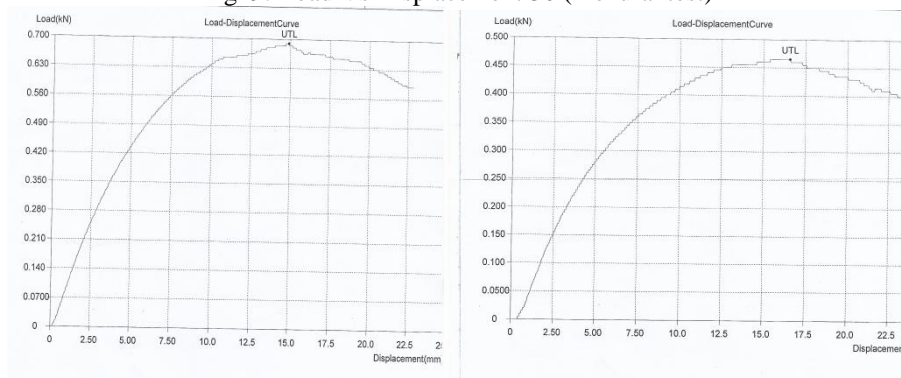


Fig20: Load Vs Displacement 45 (Flexural test)

3.5.3 Comparison charts:

Tensile test

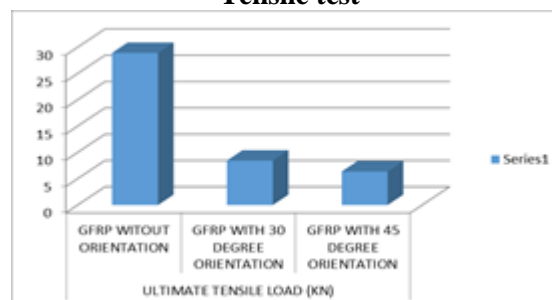


Chart 1:Ultimate tensile load

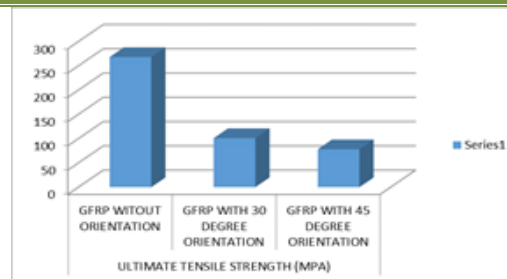


Chart 2:Ultimate tensile strength

Flexural test

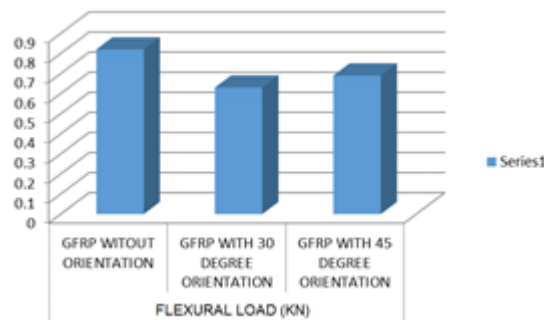


Chart 3:Flexural load

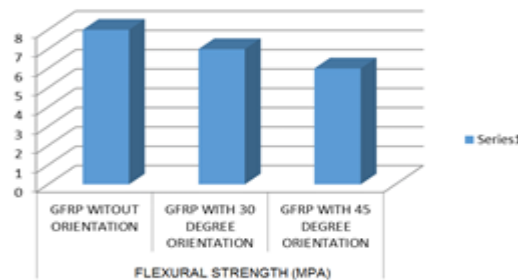


Chart 4:Flexural strength

3.5.4 Tensile properties:

- 3.5.4.1 The ultimate tensile strength is superior in case of $\pm 0^\circ$ orientation.
- 3.5.4.2 More force is required for fracture of glass fiber reinforced polymer composite in case of $\pm 0^\circ$ orientation.
- 3.5.4.3 Maximum load is observed in case of $\pm 0^\circ$ orientation.

3.5.5 Flexural properties:

- 3.5.5.1 The flexural strength is superior in case of $\pm 0^\circ$ orientation.
- 3.5.5.2 Maximum load is observed in case of $\pm 0^\circ$ orientation.

3.5.6 Measurement of surface roughness after drilling:

The specimens are also drilled and surface roughness is calculated using roughness tester and a graph is directly generated. For $\pm 0^\circ$, $\pm 30^\circ$, $\pm 45^\circ$ orientations the surface roughness values are 3.552, 4.786, 4.525 μm respectively.

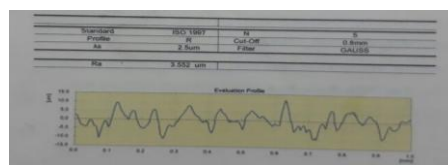


Fig 21:Average Surface Roughness value of 0° specimen: 3.552 μm

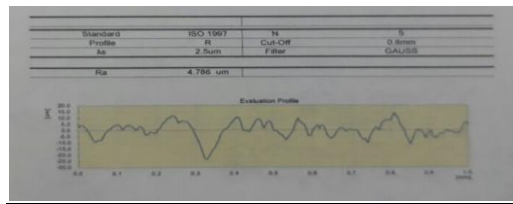


Fig 22: Average Surface Roughness value of 30^0 specimen: 4.786 μm

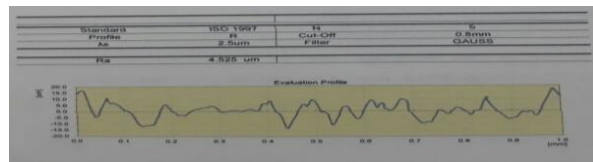


Fig 23: Average Surface Roughness value of 45^0 specimen: 4.525 μm

IV. CONCLUSION

The experimental investigations used for the analysis of tensile and flexural behavior of glass fiber reinforced polymer laminates leads to the following conclusions. In case of $\pm 0^0$ orientation the external tensile load is equally distributed on all the fibers and transmitted along the axis of the fibers. Even in case of ± 0 , ± 30 and ± 45 degree orientations the displacement in case of laminates with 0 degree fiber orientation is large compared to laminates with 30 degree and 45 degree orientations, this is due to off axis loading and significant fiber pull out before fracture.

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