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Flexural and Impact Behaviour of Kevlar/E-Glass Reinforced Epoxy Matrix Composites

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Abstract: Kevlar is a revolutionary material that utilized for making automobile, marine, aerospace, body and vehicle armors for past few decades. It has better mechanical properties like higher strength to mass ratio, resistance to wear, tear, penetrations and high strength, modulus, toughness and thermal stability. Whereas E-glass fiber is well known for its commercial applications and properties like dimensional stability, outstanding electrical resistance, and durability. This proposed work focuses and studies flexural and impact response of Kevlar and E-glass fiber reinforced epoxy matrix hybrid composites made by vacuum assisted resin transfer molding (VARTM).
Keywords: Kevlar, E-Glass, Impact Response, Vacuum Assisted Resin Transfer Molding (VARTM).

I. INTRODUCTION

Polymer matrix composites possess enhanced mechanical properties like tensile and impact strength, strength to weight ratio. Due to its low weight nature fiber reinforced polymer matrix composites are utilized over past few decades as an alternative for traditionally used automotive materials for achieving better fuel efficiency [1]. Vacuum assisted resin transfer molding method is an most preferable process for producing less porous and defects free fiber laminates. Santhosh [2] studied electrical and mechanical properties of Kevlar, basalt reinforced composites of various volume fractions and stated that kevlar/E-Glass reinforced composites shows higher impact and flexural properties than basalt reinforced composites and contains even dispersion of fibers in the resin matrix. Fiore fabricated fiber laminates by vacuum molding and expressed that synthetic fibers are highly water resistance when compared to natural fiber composites and mechanical properties of synthetic fiber laminates are 50% higher than natural fibers [3].
Bandaru et al. Fabricated plain woven two dimensional, orthogonal three dimensional and angle interlock three dimensional kevlar polyurethane laminates and studied its low velocity impact behaviour. They reported that angle interlock 3D kevlar composites shows better energy absorption than other laminates [4]. Fiber volume fraction and stacking sequence are the important parameters to be considered for obtaining better composites with high mechanical properties [5]. Hybrid laminates prepared via vacuum assisted resin transfer molding process in combination with Glass fiber portrays high yield point, and young's modulus [6].
In [7] Asi reported that glass fiber reinforcement in the hybrid composites results in higher tensile and shear strength. Zhu [8] tested kevlar 49 under quasi-static loading with various gauge lengths in high-rate servo-hydraulic testing system and reported that mechanical strength of the composites lowered with increase in gauge lengths. Roman analyzed the tensile properties of unidirectional kevlar reinforced epoxy matrix composites. The catastrophic failure of the kevlar fiber occurred due to high short loading [9]
Kevlar fibers are widely used in defence, aerospace and marine industries due to its specific nature of higher energy absorption and impact load resistance. 80% of the body armor and vehicle armors in the military contains major contribution of Kevlar fiber. The polyamide aromatic structure of the kevlar possess ultimate endurance to the Kevlar configuration [10-14]. Alireza et al [15] analyzed the effect of filler reinforcement into the composites and stated that reinforcement of fillers enhances tensile strength and young's modulus of the composite products.
The proposed work focuses on fabrication of kevlar and E-Glass reinforced epoxy matrix composites by vacuum assisted resin transfer molding with various volume fractions and investigating its impact and flexural behaviour for assimilating optimum hybrid structure.

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II. EXPERIMENTAL PART

A. Materials

Thermoset epoxy matrix (LY 556) supplied by Covai Seenu Ltd, Tamilnadu, was used as an base matrix and W152 LR hardener mixed with resin in the ratio of 67/33. Kevlar and E-Glass fibers are woven fabrics with 230 gm^2 areal density supplied by Hindustan composites, Mumbai, were utilized as an reinforcement. Properties of kevlar and E-Glass fibers are depicted in Table 1.

Table 1 Properties of Reinforcement materials

Property	Kevlar	E-Glass
Tensile strength (MPa)	2900-3450	3100-3800
Elastic Modulus (GPa)	230-800	72.5-75.5
Elongation at Break (%)	0.5-1.5	4.7
Maximum Working temperature (^oC)	650	380

The volume fraction of an resin-fiber configuration is measured by the following relationship

$$Vf = \frac{Wf/\rho f}{Wm/\rho m + Wf1/\rho f1 + Wf2}$$

Where,

f = Fiber, m = Matrix, W = Weight, ρ = density

Table 2 portrays the various volume fraction composition of fiber resin configuration used for this proposed research work.

Table 2 Volume fraction in %

Specimen	Kevlar	E-Glass	Matrix
1	40	30	30
2	30	40	30
3	35	35	30

B. Laminate Preperation

Three fiber laminates containing major contribution of Kevlar and E-Glass fibers with various volume fractions as portrayed on table 2 were fabricated (300mm X 300 mm plate) for the present investigation. All the three laminates arranged in the order of K-G-K-G-K-G-K-G. The required specimen size obtained with water jet machine cutting. The edge smoothened specimens for various mechanical tests are (Impact and Flexural) shown in figure 1 and 2.

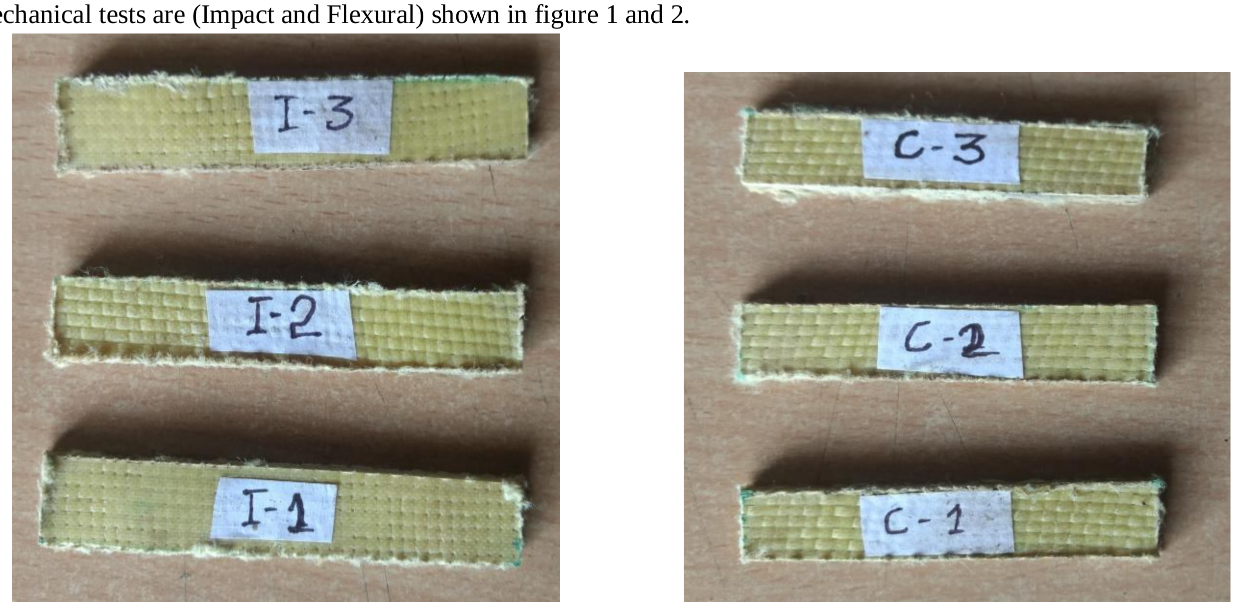

Figure 1 Impact test specimens (Before Test)

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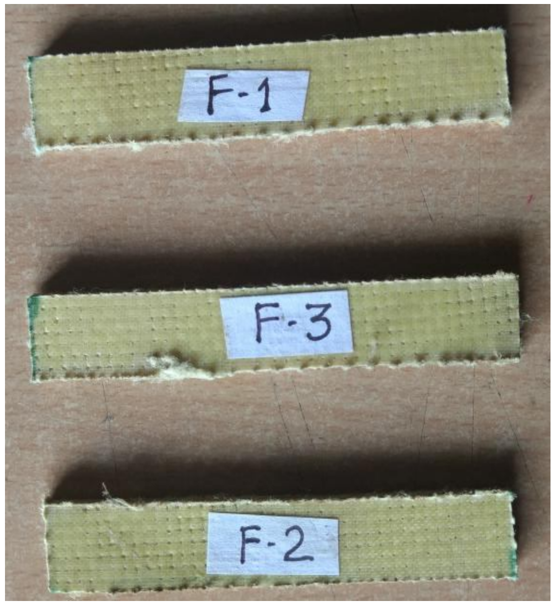


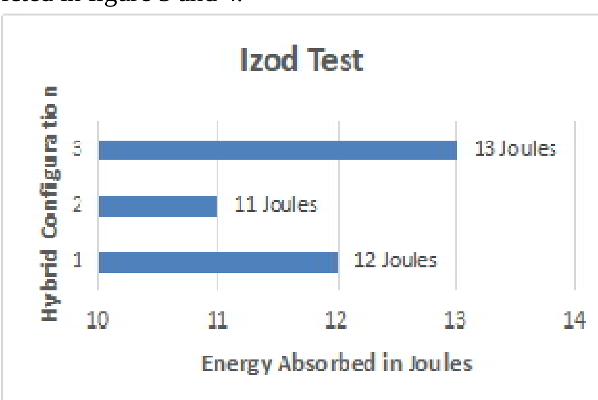
Figure 2 Flexural test specimens (Before Test)

C. Characterization

The three point bending flexural test provides the stress - strain relationship of kevlar/E-Glass laminates. As per ASTM 790 standard (80mm x 13mm x 3mm) flexural specimens were prepared and tests were done using Instron 4486 with short head speed 4mm/min. For izod Impact testing ASTM D256 and charpy testing ASTM D6110 standards were followed and AIT-300N impact pendulum is utilized for testing (strike velocity 5.6 m/sec, hammer wt. 18.70 kg, pendulum dia. 1600 mm). The prepared hybrid laminates were tested and results are reported.

III. RESULTS AND DISCUSSIONS

The average impact strength or energy absorption rate of kevlar/E-Glass hybrid laminates with various volume configurations are depicted in figure 3 and 4.



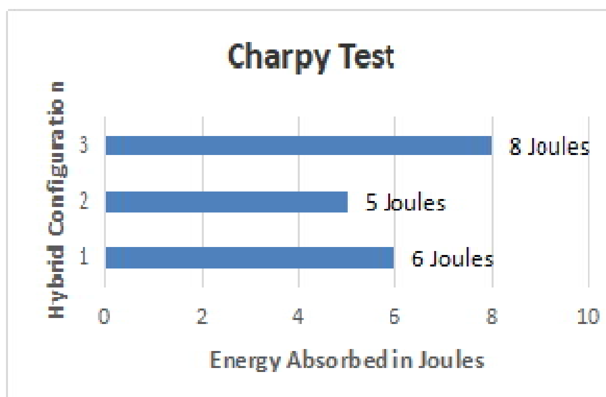


Figure 3 & 4 Izod and Charpy Impact test results

As portrayed in table2 (Volume fraction % configuration) specimen 3 (Kevlar 35%, E-Glass 35%, Resin 30%) shows more (nearly 20%) energy absorption than other two volume configurations. This is because of inter facial bonding between E-Glass and kevlar fibers in equal proportions shows good associative nature. This configuration possess considerable changes in mechanical properties of fiber laminate.

The three point bending flexural test results reveals that specimen 2 (kevlar 30%, E-Glass 40%, Epoxy 30%) exposes greater strength than other two configurations. It is noted that 10% increase of E-Glass fiber composition results in higher flexural and modulus strengths in fiber laminates. The stress - strain and force - displacement curves of higher flexural strength specimen is depicted in Figure 5 and 6.

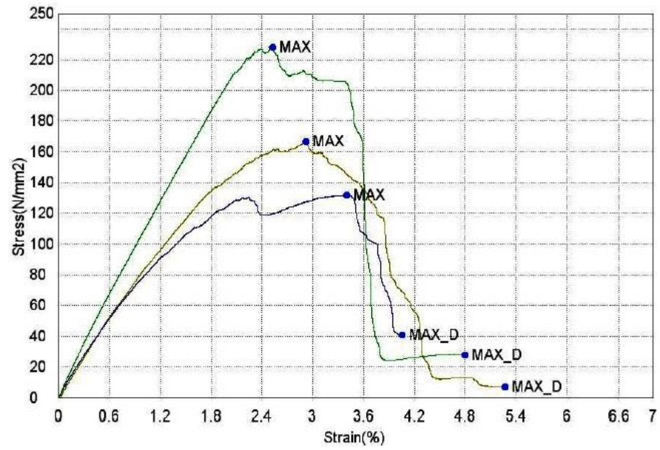


Figure 5 Stress - Strain Relationship

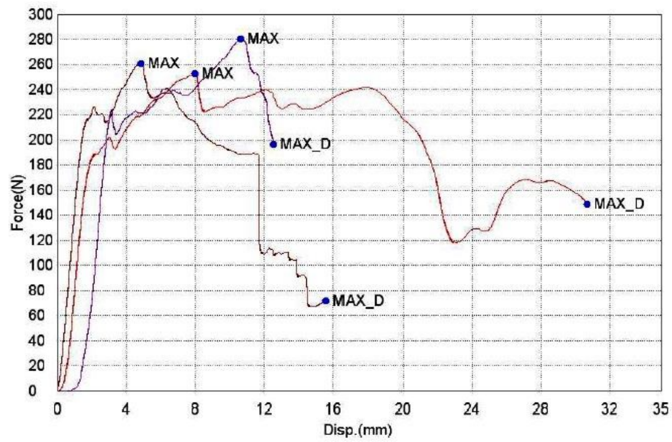


Figure 6 Force - Displacement Relationship

IV. CONCLUSION

Kevlar and E-Glass reinforced epoxy LY 556 composites were fabricated by VARTM process and mechanical characterizations were done for obtaining optimized hybrid configuration. Results indicates that equal proportion of E-Glass/Kevlar reinforced sample shows higher energy absorption, resistance towards catastrophic failure and 10% higher reinforcement of E-Glass results in good flexural strength. The targeted output preferably suitable for automobile front cross member, bonnets and fenders.

V. ACKNOWLEDGEMENT

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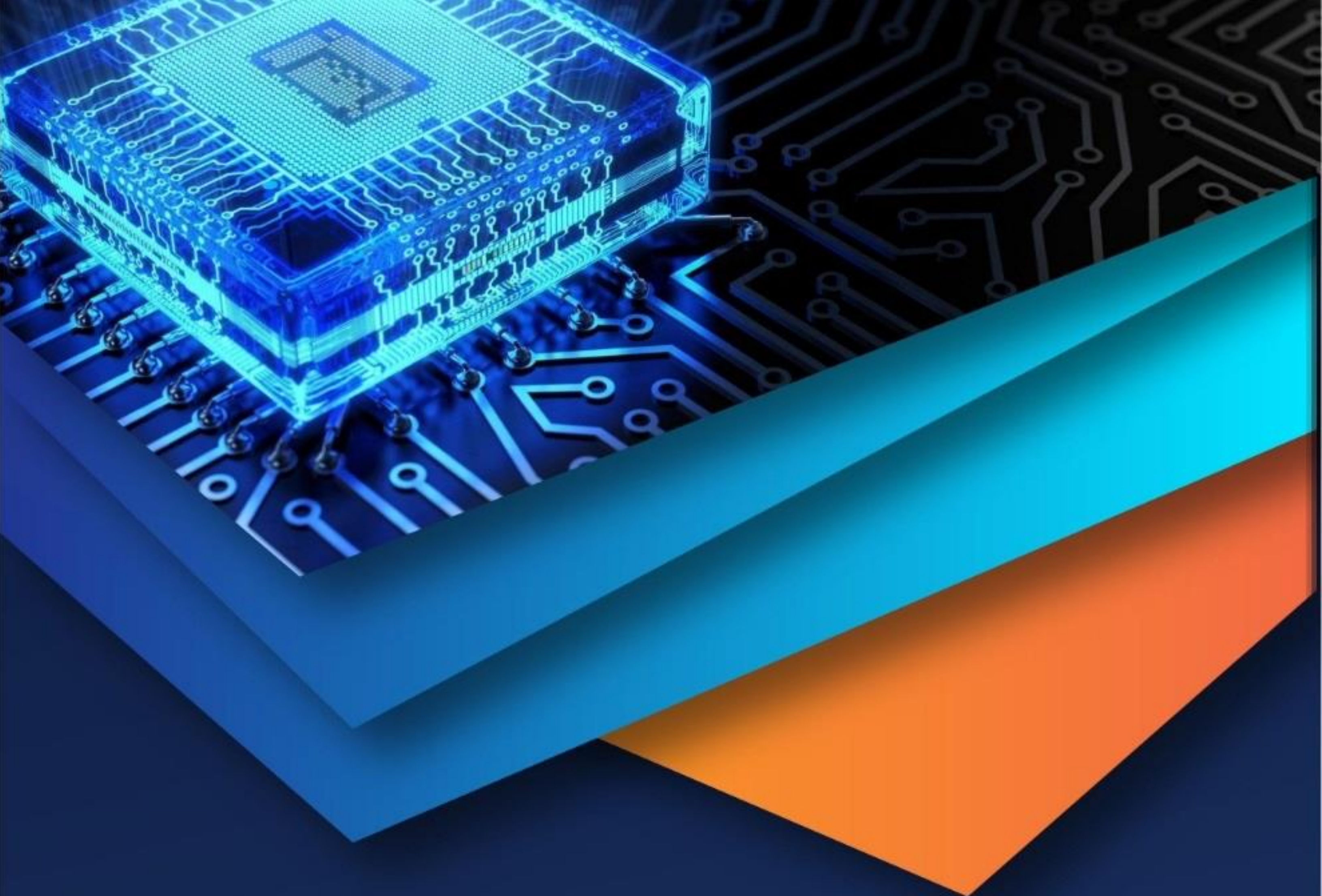

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