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Tensile and Low Velocity Impact Behaviour of Carbon/S-Glass Reinforced Hybrid PMC

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Abstract: *S-glass fibres are widely used in defence applications due to its ultimate physical properties including high tensile, compressive strengths, high temperature resistance, and improved impact resistance. This paper discusses thetensile and low velocity impact behaviour of Carbon/S-Glass reinforced polymer matrix hybrid compositelaminatesfabricated via compression moulding process.Compression or open moulding is one of the commercial polymer composite fabrication method which is well known for its low cost and ease of accessibility. As per the ASTM standard, the tensile and impact tests were carried out, in order to evaluate the influencing parameters on the mechanical behaviour of composite laminates. The tensile and impact strengths of the thermoplastic composite laminate responses measured to identify the most influencing parameter and effect of load on the mechanical properties of composites. Using the Scanning Electron Microscope (SEM), a morphological analysis were carried out to observe the bonding between the matrix - reinforcement and damage tolerance of the proposed outcome as well.*
Keywords: *S-Glass,Epoxy,Polymer Composites, Carbon, Compression moulding, SEM analysis.*

I. Introduction

In the history of materials fiber reinforced composite conceives significant advancement where the products developed for the appropriate shape by flexible and basic manufacturing technologies. Polymers generate solute materials that can be gentle to prepare, possess lightweight, and has desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical and automobile applications. These multi-functional materials having remarkable mechanical and physical properties such as corrosion, oxidation and wear so it can be tailored to meet the requirements of particular applications. Epoxy resins are widely used in filament-wound composites and are suitable for molding process. They are reasonably stable to chemical attacks and are excellent adherents having slow shrinkage during curing and no emission of volatile gases. These advantages, however, make the use of epoxies rather expensive. Also, they can withstand a temperature of 140ºC. Fiber reinforced composites offers significant weight saving over existing metals. FRC's can provide structures that are 20-50% lighter than the traditionally used aluminium composites designed to achieve the similar functional requirements. This is due to the lower density of the composites.

The development of composite materials and related design, manufacturing technologies are one of the most important advancement in history of materials. S-glass fibers are widely used in defence application due to its high tensile and compressive strength, high temperature resistance, and improved impact resistance. S-glass/Carbon/Epoxy hybrid composites fabricated via Book press compression molding process to obtain optimum hybrid structure which is preferably suitable for vehicle armours and weapon curtains of defence industry. Bainitic steel and carbon nanotube fibers are currently used in defence applications.

L.j.deka investigated the response of laminated composites subjected to high velocity, multiple-site impacts. The results shows that, specimens subjected to sequential impact exhibited average of 10% greater energy absorption and 18% increase in damage than specimens impacted simultaneously[1]. Santhosh et al, developed Rice husk/Prosopis juliflora reinforced bio composites via compassion moulding and they revealed thathigher weight of fiber reinforcement enhances the tensile strength gradually and the flexural strength of 20 wt.% RH reinforced composites is higher than the all other reinforcement percentages [2].Andy VanderKlok used gas gun testing method to investigate the high velocity impact behaviour of a S2-glass/SC15 epoxy composite. The ballistic limit was found 338m/s and 406 m/s for 6-ply and 10-ply composite panels respectively [3].J.R. Xiao carried out punch-shear test on plain weave S-2 glass/SC-15 epoxy composite laminates with a right circular cylinder punch and he found that the dominant damage mechanisms are observedin the fiber due to its shear and tension [4].

In [5] Maniselvam et al. fabricated carbon fiber reinforced composites and analysed its corrosion and mechanical behaviours. He stated that laminate stacking sequence, fiber - matrix material mixing proportion greatly influences the corrosion behaviour CFRP composites.M.V. Hosur studied about the repair method of s2-glass/vinyl ester laminates subjected to ballistic impact load and he found repair approaches like patching with dry fabric followed by resin infusion, fiber filled resin infiltration, use of stiff lamina patches possess great patching effect and does not affects mechanical and physical properties of laminates [6]. Diptikant Das prepared woven roving E-Glass fiber reinforced epoxy resin composite by hand lay-up method followed by curing at 140^0 C for 6h.Density, porosity and different mechanical properties such as hardness, tensile strength and impact strength were experimentally evaluated. The result represents that E-Glass fiber laminate possess better mechanical and microstructural behaviours [7].In [8] Gopalakrishnan Ramya Devi fabricated fiber metal sandwich (Hand layup process) structure made up of aluminium sheet AA1050, woven E-Glass Fabric reinforced with epoxy polymer and analysed various drilling parameters and reported that influence of stacking sequence on impact parameters of fiber metal configuration. Santiago reported that higher volume fraction of metal layers results in good impact resistance [9].

Gonzalez studied tensile behaviour of low ductile aluminium rein-forced FML’s and reported that an increase in the metal composition may results in higher strain to failure [10].Aghamohammad et al., studied surface morphologies of various fractured fiber metal laminates by using profilometry, SEM and optical microscopy, they reported that FPL-Etching and anodizing treatments remarkably improves the flexural properties of FML’s [11].Sandeep P. Patil found that the influence of the amount and dimensions of glass fibers in silica aerogel matrix on the mechanical properties using molecular dynamics simulation method. By adding the glass fibers, the tensile strength, elastic modulus and compressive behavior of silica aerogel were significantly improved due to the resistance offered to bending and axial deformation of the fibers [12].L. Prabhu created composites of glass-jute-tea leaf fiber-reinforced polymers and assessed their mechanical characteristics such as tensile, flexural and impact test. The result showed 10% glass fiber, 20% jute fiber and 10% tea leaf fiber produced the optimum mechanical properties [13].

The recent literatures and background studies clearly indicates that still there is a research scope to analyse the mechanical behaviour of Carbon/S-Glass hybrid matrix composites. This proposed work focuses on

- Fabrication of hybrid Carbon/S-Glass/Epoxy composites.
- Tensile and impact study of hybrid configuration under varying load conditions were studied.
- Fractured surface morphological analysis with different magnification ratios by using Olympus metallurgical microscope.
- Identification of optimum hybrid structure for proposed applications.

II. Materials And Methods

2.1 MATERIALS

In this present work carbon and S-Glass fiber hybrid laminates and epoxy matrix were used for fabricating laminates. Carbon and S-Glass fibers were supplied by Hindustan composites ltd, Maharashtra. Epoxy resin matrix LY 556 (density - 0.9 g/cm3, viscosity - 1.25x104 cP) and hardener W152 LR (density - 1.2 g/cm3, viscosity 1.30x104 cP) were supplied by AYPOLS, Coimbatore, Tamilnadu. The properties of fiber reinforcement as mentioned by supplier were depicted in table 1.

Table 1 Properties of Fiber Reinforcement Materials

Fiber	Specific Gravity	Max Temp. of Application (^oC)	Elongation at Break (%)	Elastic Modulus (GPa)	Tensile Strength (MPa)
Carbon	1.75-1.95	400	0.5-1.5	230-800	2900-3450
S-Glass	2.65-2.8	650	3.1 -6	93-110	3000-4840

2.2 SPECIMEN PREPARATION AND TESTING

Three tensile test specimens were prepared for testing as per ASTM standard to get accurate results. Tensile tests were done repeatedly for all the three specimens in FIE 11/98- 2450 make universal tensile testing machine. Similarly izod impact tests were done in the AIT-300N impact pendulum testing machine (ASTM D256). For each testing three specimens were tested and the results were reported. Figure 2 shows the prepared tensile and izod test specimens. Figure 1, 2 and 3 represents the fabricated carbon/S-Glass/Epoxy laminate, Tensile and impact test samples respectively.

Fig. 1 Fabricated Hybrid Laminate

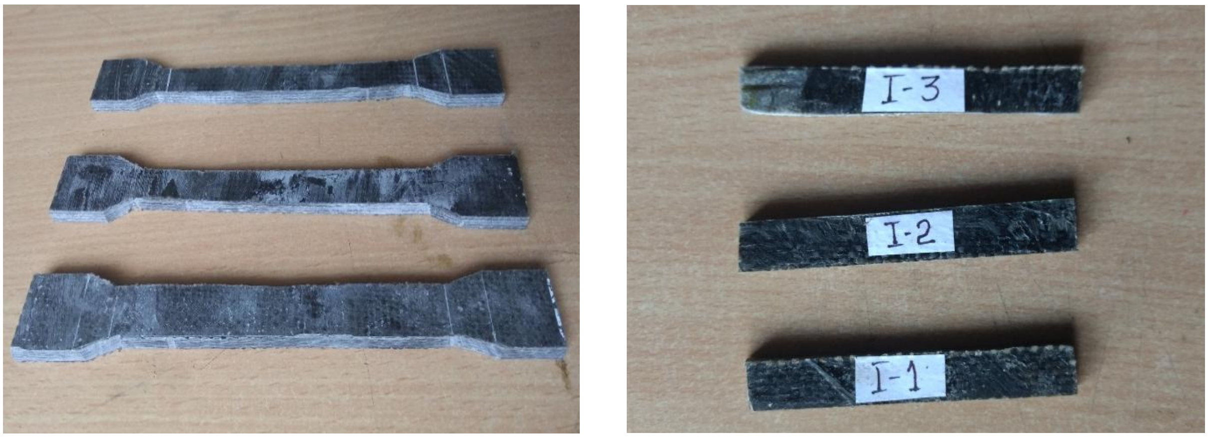
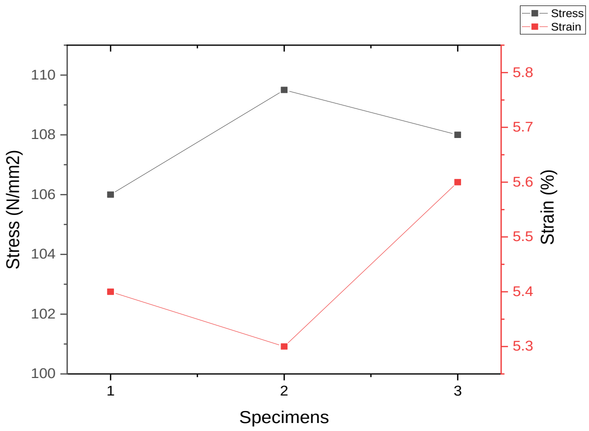


Fig. 2&3 Tensile and impact test samples

III. Results And Discussions

3.1 Tensile and Impact Tests

The results obtained through various experiments like tensile and impact tests were presented for the investigation. Figure 4 represents tensile results of the specimens. Three samples were tested to acquire the average tensile strength of the hybrid specimens.



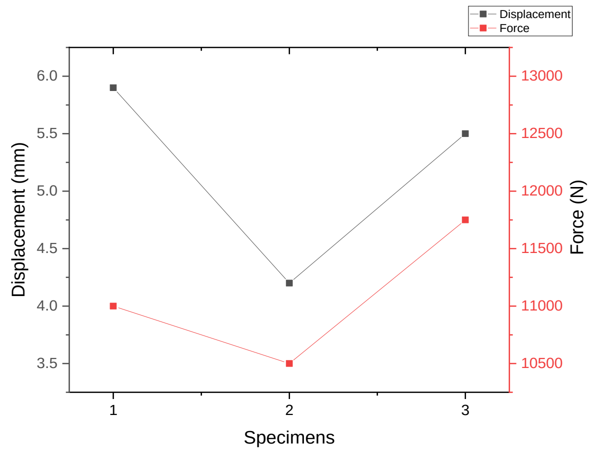


Fig. 4 Tensile Results - Stress-strain curve and Load-displacement curve

Stress strain relationship curves clearly indicates that the gradual increase in strain rate for the corresponding stress levels. It has been identified that specimen 2 possess lower strain values because of the moderate bonding of fiber and matrix in that particular region. Similarly the force – displacement curve indicates that hybrid laminates shows better resistance towards applied force.

Figure 5 represents impact test results of the specimens. The proposed hybrid configuration possess excellent impact and tensile properties than any other fiber reinforced polymer laminates. It is due to the combination of carbon and S-Glass fibers, where S-Glass is well known for its impact resistance and energy absorption and carbon fiber is for better mechanical and thermal properties.

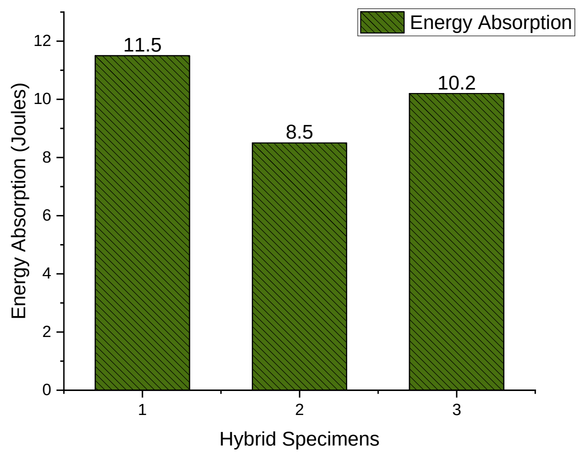


Fig. 5 Impact results graph

3.2 Scanning Electron Microscopic Analysis

The SEM images of fractured specimen surfaces were shown in figure 6. It represents that the bonding between metal and fiber laminates are rigid enough to form uniform stress concentrations in FML.Microstructure SEM analysis reveals that delamination’s and pull outs present in the fractured samples. Mostly minor de bonding and fiber pull outs occurred between fiber and matrix. The damage tolerance of fiber gets improved with the matrixconcentration. Equivalently the energy dissipation and absorption behaviour of carbon/S-Glass fibers protects the core fiber plate from the fracture.

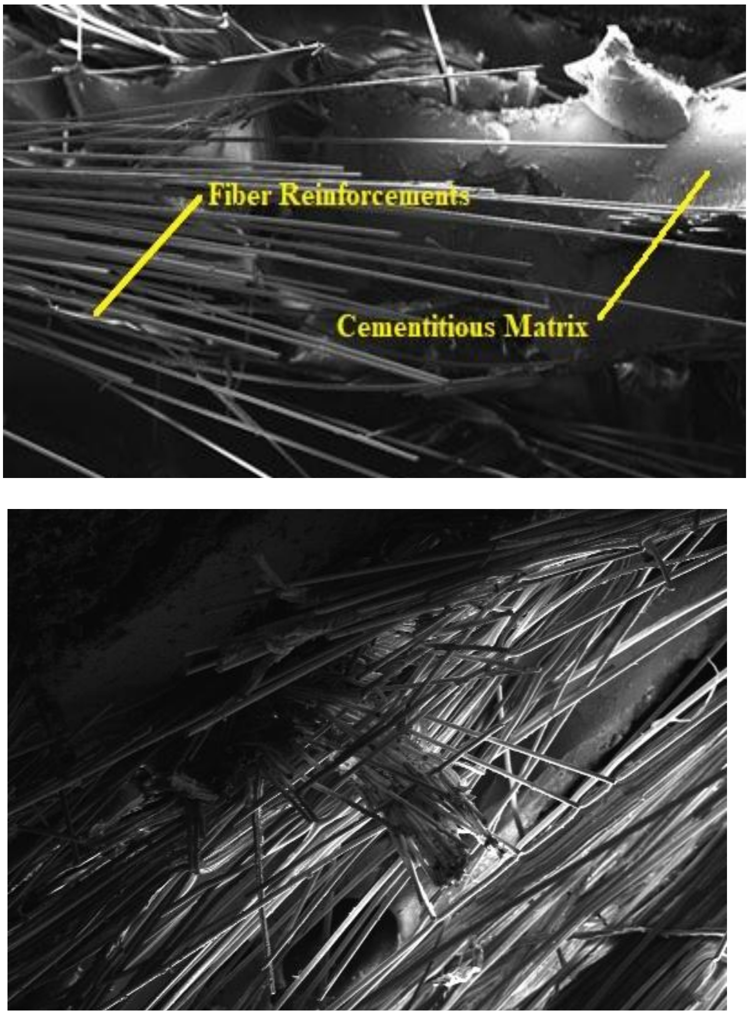


Fig. 6SEM Images of Fractured Surfaces

IV. Conclusion

In this proposed research Carbon/S-Glass/Epoxy reinforced hybrid laminates were prepared by compression moulding to study its mechanical properties. From the experimental results the following outcomes has been obtained.

- Hybrid configuration shows great tensile modulus and strength with the increasing stress conditions than conventional fiber reinforced polymer matrix laminates.
- Tensile and impact properties are intensively great in the hybrid laminate due to the hybrid reinforcement of Carbon and S-Glass fibers.
- SEM microstructure analysis clearly indicates the delamination, de bonding, cracks and pit formations of the fractured samples.
- The fabricated hybrid sandwich structure is preferably suitable for high strength commercial automobile applications.

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