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Development and Analysis of a Composite Protecting Shield with Hybridizing S-Glass and Carbon Fiber

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Abstract:

Composite materials are often utilized in the various sectors of engineeringmainly to intensify the structure, to elevate the productweight reduction and also in theeconomic point of view. Composite material is most suitable in mechanical engineering applications because of the inimitable ratio of high stiffness to less weight density. Composite materials are more precisely applied in the automobile field primarily for the performance enrichment and cost saving capability. The main focus of the present work is to exemplify an experimental study of composite material which is used in the automobile vehiclesas a protecting shield to withstand the mechanical loading. In the automobile sector, many of the researchers are aiming forbringing down the fuel consumption ratio by developing light weight vehicle structure withextemporizing the performance under these conditions. Protective shield behavior is purely depends upon the material characteristics, in this study compositions for the material are selected based on the literature survey.The suitable hybridizationproposition of the fibers for the protective shield is concluded in the study. The mechanical properties such as compression strength, tensile strength, impact strength and hardness are expected to be improved by varying the composition with s-glass fiber and carbon fiber.

Keywords **—Protecting Shield, Composite Material, Automobile, Mechanical Properties.**

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I. INTRODUCTION

Composite materials are man-made materials which are manufactured with an aim of replacing the conventional materials by overcoming their disadvantages. A composite material has two main constituents namely, matrix and reinforcements. The reinforcements or fibers are the main load carrying elements and it provides strength and rigidity to composite whereas, matrix gives the shape to composite, maintains fiber alignment and protects them against the environmental and possible damage. Some of the characteristics of composites are high strength to weight ratio, electrical property, translucency, low thermal conductivity and fire resistant.

Fiber is a natural or man-made substance that is significantly longer than it is wide. Fibers are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibers. Synthetic fibers can often be produced very cheaply and in large amounts compared to natural fibers, but for clothing natural fibers can give some benefits, such as comfort, over their synthetic counterparts. Man-made or chemical fibers are fibers whose chemical composition, structure, and properties are significantly modified during the manufacturing process. Man-made fibers consist of regenerated fibers and synthetic fibers.

Fiberglass, made from specific glass, and optical fiber, made from purified natural quartz, are also man-made fibers that come from natural raw materials, silica fiber, made from sodium silicate (water glass) and basalt fiber made from melted basalt.

Fig.1 Glass Fiber

S-glass is probably one of the more technically important glasses. It has the highest strength, stiffness, and softening point of any commercial reinforcement glass fiber. This glass is used in very demanding products such as FRP lightweight armour. Carbon Fibers are fibers about 5–10 micrometres in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion.

Fig.2 Carbon Fiber

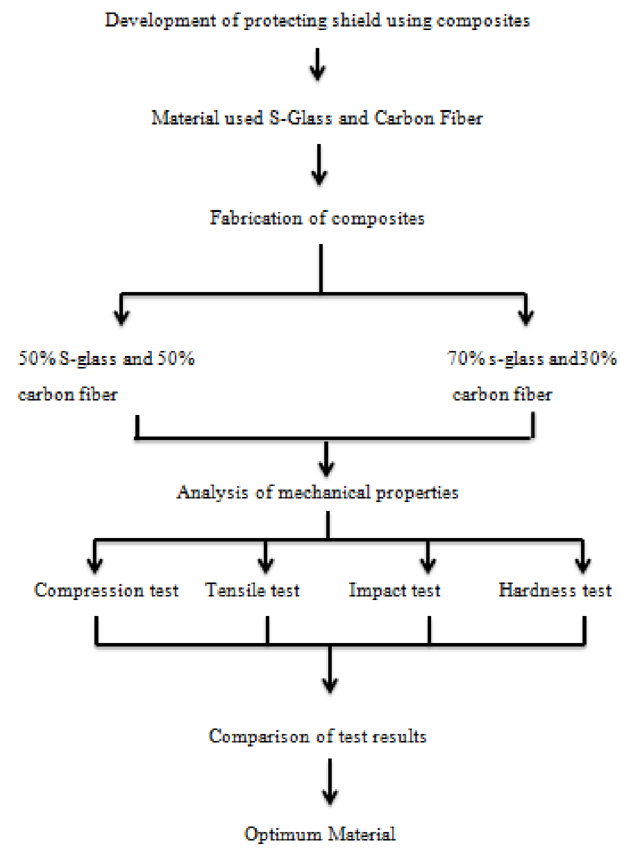
P.Santhanamoorthyet.al., [1] has mentioned that the composite materials reinforced with glass fiber, carbon fiber, etc., play important role due to the excellent properties such as high specific strength, strength to weight ratio, good corrosion resistance in the saline atmosphere. Hybrid composites with glass fiber and carbon fiber will increase the tensile strength and flexural strength of the material. Less amount of carbon fiber will reduce the cost of the material.*Dipak Kumar Jesthiet.al.,* [2] The replacement of metallic components by carbon fiber reinforced polymer (CFRP) composites is inhibited due to expensive carbon fiber. This problem may be addressed through hybridization of carbon and glass fiber to reduce the cost and achieve desirable mechanical properties of the hybrid composites. The percentage of carbon fiber reinforced polymer used, will affect the strength of the material.*Chensong Dong et.al.,* [3] studied on the flexural properties of hybrid composites reinforced by S-2 glass and T700S carbon fibers. Specimens were manufactured following the hand lay-up process in an intra-ply configuration with varying degrees of glass fibers added to the surface of a carbon laminate. A hybrid composite of s-glass and carbon fiber affects the flexural properties and results in dominant failure.*K.Poyyathappan et.al.,* [4] deals with the fabrication of Glass fiber reinforced plastic, Carbon fiber reinforced plastic, Glass-Carbon fiber reinforced plastic, Carbon-Glass fiber reinforced plastic and starting glass & ending carbon reinforced composite laminates that have been organized using hand layup techniques. The inclusion of CFRP composite has significantly enhanced the ultimate tensile strength, ultimate flexural strength and peak load of the composite. *M.Srinivaset.al.,* [5] studied hybrid composites having various ratios of S-glass and high modulus Carbon fibers with various propositions. S-glass-Carbon–epoxy hybrid composite fail with delamination at the interface of the Carbon to S-glass layers. This failure will be more premature if both reinforcements are at equal proportions than when either of the reinforcements is in lower fraction as compared to the other.*Suhad D. Salman* [6] Due to notable characteristics, sustainability concept and environmental issues, hybridisation natural with synthetic fibers to fabricate composites have been rapidly gaining market share in different applications (structural, military, aerospace and automotive vehicles). *H. Fouadet.al.,* [7] studied the three different fiber/ epoxy composite posts. These composites were fabricated using carbon, glass, and Kevlar fibers. The carbon fiber/epoxy composite have fracture toughness close to that of aluminium alloy. The Kevlar fiber composite exhibited higher delamination. However, the stiffness and strength of Kevlar made its composite more sensitive than the other composites to free vibrations generated by a simple force induced by a hammer. *Dongdong Chen et.al.,* [8] investigates the effects of carbon/glass/basalt hybridization and fabric structure on the low velocity impact resistance of fiber reinforced plastic composites. Interply hybrid specimens used in the study were fabricated in a sandwich-like stacking sequence using a vacuum assisted resin infusion moulding technique. Experimental results showed that, hybrid laminates with carbon fiber as the core exhibited superior impact resistance for sandwich-like stacking sequence and the similar impact behaviours appeared for carbon laminates hybrid with either basalt or glass fiber

Shield is mainly used to protect the body and inner parts of an automobile vehicle. The shield must be mechanically stable for vehicle better performance. The protecting shield will perform better if the composition of the carbon fiber is increased in the composites. Here the composite is manufactured using compression moulding technique. In order to predict the performance, the experimental analysis and test is planned to carry out in this work. Still the mechanical properties can be optimized using S-glass and Carbon fiber to find the better proposition for the protecting shield. Mechanical properties can be further improved by hybridizing the composition of both S-glass and Carbon fiber.

II. METHODOLOGY

Carbon fiber (CF) and S-Glass fiber (SG) were used in the fabrication of composite plate. Epoxy resin (LY556) with hardener (HY951) was used as the additive material. The Carbon fiber and S-Glass are mixed in the ratio of 50%CF, 50% SG and 70% SG, 30% CF as Sample 1 and Sample 2 respectively. The composite plates consist of carbon fiber, s-glass fiber and epoxy resin with 10mm thicknesses were manufactured with the respective compositions. At the first stage, composite plates were produced by compression moulding technique. The carbon fiber and S-glass fiber are placed on the compression table. The resin was allowed to flow through the entire fabric network and the material is compressed for 5minutes.After completion of the process the plates were allowed to cure at room temperature followed by post-curing for 2 hours. Test specimens were cut into desired dimensions by wire cut EDM machine according to relevant ASTM standards. The adhesive was applied onto the surface of composite plates.

The experimental study of the composite is done with the following methodology



III. EXPERIMENTAL RESULTS

A. Compression Test

In the compression test, the material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened. Fig. 3 represents the compression Test with 70%

SG & 30% CF, before and after the loading condition. The composite material has differentbehaviour over the applied load and the 50 % SG & 50% CF composite possess high compression load compared to 70% SG & 30% CF composite.

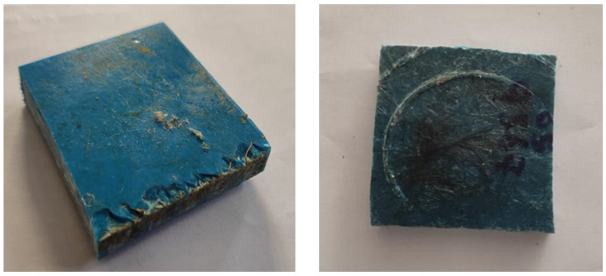


Fig. 3 Compression Test Specimen

The result obtained during the experimental conditions is represented in the Table 1.The result shows that, 9.13 % of improvement in compression strength by using both fibers at the ratio of 50%.

TABLE I
EXPERIMENTAL RESULTS ON COMPRESSION TEST

Composition (%)	SpecimenDimension (mm)	Compression Load (KN)
50 SG & 50 CF	50 × 50 × 10	550.050
70 SG & 30 CF	50 × 50 × 10	504.294

B. Tensile Test

In the tensile test, the test sample is loaded in tension when it experiences opposing forces acting upon opposite faces both located on the same axis that attempt to pull the specimen apart. These tests are simple to setup and complete and reveal many characteristics of the material that is tested.Fig. 4 represents the before and after loading with the Tensile under the 70% SG & 30% CF.

TABLE II
EXPERIMENTAL RESULTS ON TENSILE TEST

Material Composition (%)	Tensile Stress (N/mm^2)
50 SG & 50 CF	97.52
70 SG & 30 CF	55.39

From the results represented on the Table 2, the 50% SG & 50% CF composite material shows high tensile stress of 97.52 N/mm^2 over the maximum loading conditions. And also the test result shows that, 50 % ratio gives 76 % higher tensile strength comparing with the 70-30% proposition.

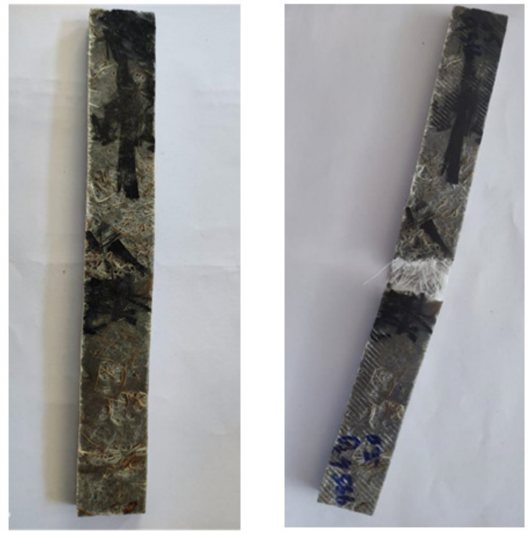


Fig. 4 Tensile Test Specimen

C. Impact Test

An impact test is used to observe the mechanics that a material will exhibit when it experiences a shock loading that causes the specimen to immediately deform, fracture or rupture completely. Impact Test Specimen with the two different compositions after the loading conditions are represents in the Fig. 5. From the result shown in the Table 3, the 70% SG& 30% CF composite material shows high impact test of 0.214 J/mm^2 over the maximum loading conditions mainly due to S-glass fiber percentage. The result shows that, 70 – 30 ratio gives 5.6 % improvement in impact energy compare to 50 – 50 ratio.

Fig.5 Impact Test Specimen

TABLE III
EXPERIMENTAL RESULTS ON IMPACT TEST

Specimen Composition	Initial reading (J) E1	Final reading (J) E2	Izod impact value (J) E1 ~ E2	Izod impact (J/mm²)
50 SG & 50 CF	168	26	142	1.42
70 SG & 30 CF	168	18	150	1.5

D. Hardness Test

Hardness tests are extensively used to characterize a certain material and to identify if it is appropriate for its intended purpose. The major applications of hardness tests are to verify the type of heat treatment to be used on a part and to identify if a material possesses the required properties for its intended use.Fig. 6 shows the Test Specimen with 50% SG& 50% CF before and after the loading conditions. From the results (Table 4), the hardness number of 50 – 50 fiber ratiosis improved 12.88 % than the 70 – 30 propositions of S-Glass &Carbon fiber.

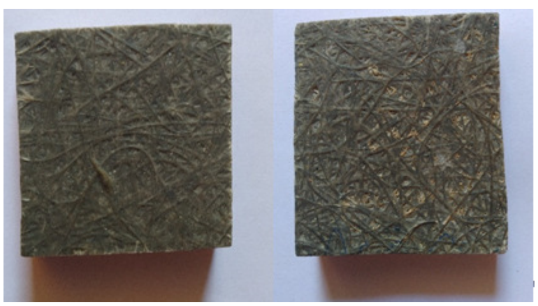


Fig. 6 Hardness Test Specimen

TABLE IV
EXPERIMENTAL RESULTS ON HARDNESS TEST

Specimen Composition (%)	Load (Kg)	Penetrator used (mm)	Rockwell Hardness Number
50 SG & 50 CF	250	1.5875	92
70 SG & 30 CF	250	1.5875	81.5

IV. CONCLUSIONS

This experimental study aims to find a suitable composition fiber which is used as a protecting shield and also to predict the effect of carbon fiber in the composites. The shield is made-up of hybridizing carbon fiber and s-glass fiber and the fibers possess better strength. The comparison over the composition is done by experimentally under mechanical loading. The mechanical property such as tensile strength, compression strength, impact strength and hardness shows that the more composition of the carbon fiber material results in good strength for the shield. Experimental study indicate that, there is 76 %, 9.13 %, - 5.6 % and 12.88 % of improvement in result in the respective tests. The study results in, the composite material with 50 - 50% sample gives the better results than the 70 - 30%. On the other hand, the preparation cost of the sample 1 is more than the other. The sample 2 gives acceptable results in term of both performance and cost factor.

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