Experimental Investigation & Analysis of Mechanical Properties of Carbon and Glass Fibre Composites

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***Abstract*—** Carbon fibre composites and Glass fibre composites are now gaining their usage in aircraft, aerospace and automotive industries because of their inherent properties like high strength to weight ratio, hardness and wear resistance, good creep behaviour, lightweight, design flexibility and low wear rate etc. Carbon fibre reinforced polymer parts were produced in many way such as moulding, vacuum bagging, compression moulding, filament winding. Here we are fabricating the composites using hand lay-up method.

The mechanical properties of carbon fibre and Glass fibre composites were studied by performing tensile and flexural test using UTM Dak 10 ton and hardness test using Brinell hardness test. The mechanical properties such as hardness, tensile strength, tensile modulus, ductility, and peak load of the hybrid composites were determined as per ASTM standards. The mechanical properties were improved as the fibre reinforcement content increased in the matrix material. Objective of our project was finding the mechanical strength of carbon fibre and glass fibre composite and choosing the best composites for aircraft parts.

***Keywords*—** **Brinell hardness test, Carbon fibre composites, Compression moulding, Glass fibre composites, Hand lay-up method.**

Introduction

A composite is a structural material that consists of two or more constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The composite material however, generally possesses characteristic properties, such as stiffness, strength, weight, high-temperature performance, corrosion resistance, hardness and conductivity that are not possible with the individual components by them. Analysis of these properties shows that they depend on (1) the properties of the individual components; (2) the relative amount of components; (3) the size, shape, and distribution of the discontinuous components; (4) the degree of bonding between components; and (5) the orientation of the various components.

I. COMPOSITE MATERIAL

When two or more materials having different properties are combined together, they form another class of material generally designated as composite material. In general, the properties of composite materials are enhanced in many respects, to those of the individual constituents. Reinforcing materials are strong with low densities while the matrix is usually a ductile/tough material. The main constituents of structural composites are the reinforcements and the matrix. The reinforcements, which are stronger and stiffer, are dispersed in a comparatively less strong and stiff matrix material.

The epoxy matrix in carbon fibre/epoxy composites with graphite nanoparticles as filler enhances the mechanical properties. Glass fibre (GF) itself has enough mechanical strength. GF and Carbon/Graphite fibre with epoxy resin gives superior mechanical strength. These developments attract others to use graphite in different form with different fibre materials to modify its mechanical strength and make its use at different locations. In this context, this research work is focused on the preparation of glass fibre reinforced graphite composite and optimization of glass fibre and binder content in relevance to mechanical properties such as flexural and compressive strength.

A. *Reinforcements*

Fibres constitute the main bulk of reinforcements that are used in making structural composites. A fibre is defined as a material that has the minimum 1/d ratio equal to 10:1, where 1 is the length of the fibre and d is its minimum lateral dimension. The lateral dimension d (which is the diameter in the case of a circular fibre) is assumed to be less than 254 nm. The diameter of fibres used in structural composites normally varies from 5nm to 140nm. A filament is a continuous fibre with the l/d ratio equal to infinity. A whisker is a single crystal, but has the form of a fibre.

II. FABRICATION

A. *Hand Lay- Up Method*

The first step is to commix the resin and the hardener. The proportions are customarily given by the supplier and can be found on the containers of the hardener or resin. The portions can be either quantified by weight for by volume but it is paramount to follow these proportions precisely as this is a consummate chemical reaction and all components must react consummately for maximum vigour of the matrix. It is most facile to quantify proportions utilizing the volume method and a screw in pump that inserts into the cans of resin and hardener. These pumps can be purchased along with the containers of resin and hardener.

B. *Fabrication Of Composite Laminates:*

. To fabricate three types of laminates we are using the following material composition,

TABLE I
COMPOSITES LAMINATES

Composite	**Material used**	**Amount**
Composite laminate 1	E- glass fiber chopped strand mat	400g
	LY556 Araldite	250g
	HY951 Aradur	25g
Composite laminate 2	E- glass fiber bidirectional Oven fabric	350g
	Polyester epoxy resin	250g
	Cobalt accelerator	10g
	MEKP catalyst	5g
Composite laminate 3	Carbon fiber sheet unidirectional	350g
	LY556 Araldite	250g
	HY951 Aradur	25g

All the three laminates consist of 12 layers of its respective reinforcement fibre sheets. To obtain the test specimen we fabricated three laminates with 1m length, 1m width and 4mm thickness and cut it into required dimensions. From the laminates test specimens are prepared according to ASTM standards. For the flexural test specimens the dimension 80, 25, and 3 mm, length, width and thickness respectively were fabricated without any edge damage according to ASTM D790. For tensile test, specimens with dimensions 20mm length, 25mm width and 3mm thickness were fabricated according to ASTM D3039.

C. *Testing the Composites.*

1) *Tensile Test*: The tensile test is done by cutting the composite specimen as per ASTM D3039 standard (sample dimension is 250 ×25 × 3 mm). A universal testing machine (UTM) is used for testing with a maximum load rating of 100 KN. Composite specimens with different Composite laminates are tested, which are shown in Figure 6. In each case, three samples are tested and the average is determined and noted. The specimen is held in the grip and load is applied and the breaking load is observed. The load is applied until the specimen breaks and break load, tensile strengths are noted. Tensile stresses are recorded and load vs elongation graphs are generated.

Fig 1 Tensile Test

2) *Flexural Test:* The flexural specimens obtained from the CF inclusion glass fiber reinforced specimens and another set glass fiber reinforced specimens are subjected to the Point load was applied using a DAK 10-ton universal testing machine (UTM). Five specimens were tested. The spans were 60 mm and the support length is 10 mm each side. The feed rate was 5 mm/min maintained throughout the testing. The test specimens were loaded with a three point bending test as per ASTM D790 (sample dimension is 80 × 25 × 3 mm). The load was gradually applied in the middle of the coupon.

Fig 2 Flexural Test

3) *The Brinell Hardness Test:* The Brinell hardness test method consists of indenting the test material with a tungsten carbide ball of either 1, 2.5, 5 or 10 mm diameter by applying a test force of between 1 and 3000 kgf. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured. The Brinell harness number is calculated by dividing the load applied by the surface area of the indentation.

The diameter of the impression is the average of two readings at right angles and the use of a Brinell hardness number table can simplify the determination of the Brinell hardness. A well-structured Brinell hardness number reveals the test conditions, for example "75 HBW 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10 mm diameter tungsten carbide ball with a 500 kgf test force for a period of 30 seconds. When testing extremely hard metals the tungsten carbide ball indenter may not be suitable as the Brinell scale is limited to materials with hardness values of approximately 650 HBW. For such materials the Rockwell and Vickers tests are more suitable.

Compared to the other hardness test methods, the Brinell ball makes the deepest and widest indentation, so the test averages the hardness over a wider amount of material, which will more accurately account for multiple grain structures and any irregularities in the uniformity of the material. This method is the best for achieving the bulk or macro-hardness of a material, particularly those materials with heterogeneous structures show in figure 3.

Fig 3 Brinell Hardness Test

D. Result And Analysis

Analysis for Tensile And Flexural Test

TABLE 2
FLEXURAL STRENGTH

Sl.no	Plate	Flexural Strength N/mm^2		
		Specimen 1	Specimen 2	Specimen 3
1	Composite Plate 1	89.5	87.5	54.5
2	Composite Plate 2	285	235	280
3	Composite Plate 3	375	390	355

Average Flexural strength :
For,
Composite plate 1 100.3 N/mm^2
Composite plate 2 276 N/mm^2
Composite plate 3 390 N/mm^2

TABLE 3
TENSILE STRENGTH

Sl.no	Plate	Tensile strength Kg/cm^2		
		Specimen 1	Specimen 2	Specimen 3
1	Composite Plate 1	913	1624	890
2	Composite Plate 2	1719	1810	1822
3	Composite Plate 3	1651	1650	2145

Average Tensile strength :
Composite plate 1 1142.3 kg/cm^2
Composite plate 2 1783.66 kg/cm^2
Composite plate 3 1815.33 kg/cm^2

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