"Experimental Investigation & Analysis for Mechanical Properties of Composite Plates"

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ABSTRACT

There are so many applications of composite materials in the past 20 years due to strong demand in material performance set by technological developments, the use of composite materials has increased manifold. Most of these applications of the composite material are situations where the reduction in strength and durability due to fatigue process is very likely. This work has been a great need in the exact fatigue properties of glass and carbon fiber reinforced epoxy composites. In this study, both unidirectional carbon and glass fiber reinforced epoxy composites will be detected for fatigue test by rotating bending machine. In this research work, an investigation was made on the mechanical properties of E-glass fiber reinforced epoxy composites filled by various materials. Composites filled with varying concentrations of fly ash, aluminum oxide (Al_2O_3), magnesium hydroxide ($Mg(OH)_2$) and hematite powder were fabricated by standard method and the mechanical properties such as ultimate tensile strength, impact strength and hardness of the fabricated composites will be studied. The test results show that composites filled by 10% volume $Mg(OH)_2$ exhibited maximum ultimate tensile strength and hardness..

Keyword *Composite, Fatigue test, properties, Strength*.

1. INTRODUCTION

Composite materials produce a combination of properties of two or more materials that cannot be achieved by either fiber or matrix when they are acting alone. A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. Fiber-reinforced composites were successfully used for many decades for all engineering applications Glass fiber-reinforced polymeric (GFRP) composites was most commonly used in the manufacture of composite materials. The matrix comprised organic, polyester, thermo-stable, vinylester, phenolic and epoxy resin .Polyester resins are classified into bisphenolic and ortho or isophtalic. Due to that the use of fillers improved the properties of composites and ulitimately reduced the cost of the preparation and product. Composite materials have wide range of industrial applications and laminated GF reinforced composite materials are used in marine industry and piping industries because of good environmental resistance, better damage tolerance for impact loading, high specific strength and stiffness.

1.1 What Are Composites?

A composite material is defined as a material system which consists of a mixture or a combination of two or more distinctly differing materials which are insoluble in each other and differ in form or chemical composition. Thus composites are combination of two materials in which one of the materials called reinforcing phase is in the form of fiber sheets or particles and are embedded in other materials called the matrix phase. The major constituents of a fiber reinforced composite material are reinforcing fiber, matrix, coupling agents, coatings and fillers. Fibers are the principal load carrying members while the matrix which surrounds it, keeps them in proper location and correct orientation. Matrix acts as the medium by which the load is transferred through the fibers by means of shear stress. Matrix protects the fiber from environmental damages caused by elevated temperature and humidity

1.2 Types of composite materials

Broadly, composite materials can be classified into three groups on the basis of matrix material. They are

i. Metal Matrix Composites (MMC) ii. Ceramic Matrix Composites (CMC) iii. Polymer Matrix Composites (PMC)

1.3 Problem Statement

We know that the influence of thickness on various properties of laminated composites, many structures used in Automobile, Aerospace, Naval and other Transportation vehicle structural parts are subjected to various kinds of loads. These structures are further subjected to bending loads causing changes in the structures. In pre-loading there will be change in original dimensions, designed shape, orientation etc. Further it may cause the failure of the structure. The purpose of this work is to experimentally analyze the progressive failure process of laminated composites subjected to various loads. Operational loading causes stresses in the composites, which vary through the thickness. These operational stresses are the maximum at the outer surfaces and zero in the middle at the neutral axis. The stress in an individual ply depends upon the stiffness of that ply and its distance from the laminate's neutral axis. By including, one or more extra components having relatively better elastic properties in the laminate can help in improving the various properties of the composite.

1.4 Objectives

1. To fabricate new class of a composite material made up of glass fiber and epoxy resin.
2. To evaluation of mechanical properties.
3. To comparison with conventional material.
4. To find out more efficient, strong and durable material for substitution to conventional material

2. MATERIAL SELECTION

Material selection is most important step in the work. Material should be selected on the basis of some important aspects. This includes availability of raw material for manufacturing the component as well as

1. Cost of raw material.
2. Manufacturing process.
3. Strength.
4. Mechanical properties (e.g. density, corrosiveness, weight, specific gravity etc.).
5. Areas of application.

For manufacturing of composite materials basically carbon fiber, A-glass fiber, c-glass fiber, D-glass fiber, E-glass fiber, AR-glass fiber, R-glass fiber and S-glass fiber are used as a base material. Along these fibers epoxy resin, polyester, phenolic resins, polyamide resin are used as binder. On behalf of above aspects it has seen that E-glass fiber and epoxy polymer composite will meet our requirement. Also it can be easily available and manufacturing processes required to manufacture the E-glass fiber and epoxy polymer composites are simple as well as easy to understand. Also E-glass fiber and epoxy resin are easily available. For these reasons E-glass fiber and epoxy resin composite is selected for study.

The Researchers now a days developed equipment to make the glass fiber dust in to powder or particle cullet either by calcinations and pulverization or by pyrolysis. This enabled the company to re-use the fiber dust as glass making material. This chapter details the materials used and methodologies adopted during the fabrication, sample preparation, mechanical testing and characterization of the hybrid composites. The raw materials used in the study are:

i) Epoxy resin

ii) Glass Fiber (E-Glass)

iii) Hardener

from above study the E-glass fiber & epoxy resin are selected for manufacturing of composite plate.

2.1 Manufacturing Of Composite Plates

Various techniques (methods) are used for manufacturing of the composite plate from given below.

1. Hand Lay-up process
2. Pre-preg forming
3. Pressure molding
4. Vacuum bagging
5. Filament winding

Out of above methods hand lay - up method are easy to manufacturing of composite plate. It is easy to understand and no complex steps are includes. Also this method of manufacturing doesn't need any special equipment's. For these reasons composite plate manufacturing is done with the help of hand lay -up method.

2.1 Hand Lay-up

Before starting the manufacturing of composite plates we need to prepare the material which is being used for actual manufacturing. It includes,

i. Cutting of E-glass fiber.
ii. Preparation of matrix (epoxy resin).
iii. Fabrication of composite plate.

2.2 Fabrication of composite plates

In this research there are many requirement were needed.
1- Two types of fiber were taken, continuous fiber and discontinuous or random fiber E glass type.
2. Epoxy resin and e-glass composite plate are fabricate. With many keys for fixture the continuous fiber.
3. Epoxy will be taken with hardener to make the matrix by using suitable smooth brush.
4. Many measures and gauges devices are require such balance ,ruler , flask for volume gauge , oil as an isolation for prevent adhere between the resin and the pattern after harder .
5. Sharp cuter to cut specimens for testing in different angles according to load apply.
6. Measurements were taken to specimens according to tests requirements.
7. Hardness, impact, tensile tester devices are used. In the present study the composite laminate specimens are prepared using the hand lay-up technique and the specimen are subjected to the investigation is carried out as per the ASTM standards.
8. The simplest manufacturing technique adopted involved laying down bidirectional type fibers over a polished mould surface previously treated with a releasing agent. After this, a liquid thermosetting resin is worked into the reinforcement by hand with a brush or roller.
9. The process is repeated a number of times equal to the number of layers required for the final composite. Resin and curing agents are pre-mixed and normally designed to cross-link and harden at room temperature.
10. The major advantage of this manufacturing process is its great flexibility, meaning that it suits most common mould sizes and complex shapes.
11. It can be re-used for several runs and the actual cost of the raw materials make this process economically feasible.

Fig -1 Manufactured Composite Plate

3 .EXPERIEMENTAL TESTING`

Mechanical properties are useful to estimate how parts will behave when they are subjected to mechanical loads (forces, moments etc.). In particular, we are interested to know when the part will fail (i.e. break, or otherwise change shape/size to go out-of-specification), under different conditions. These include loading under: tension, compression, torsion, bending, repeated cyclic loading, constant loading over long time, impact, etc. We are interested in their hardness, and how these properties change with temperature. Mechanical properties of composites were evaluated by tensile, impact and hardness measurements. Tensile, impact and hardness tests were carried out using Universal testing machine, impact machine and hardness testing machine respectively. Three identical samples were tested for tensile strength, impact strength and hardness. Let's look at how these properties are defined, and how they are tested.

1. Ultimate Tensile Strength
2. Compression Strength
3. Impact Strength
4. Flexural strength
5. Brinell Hardness Test

Fig-2 Tensile Test set-up

Fig-3 Impact test set-up

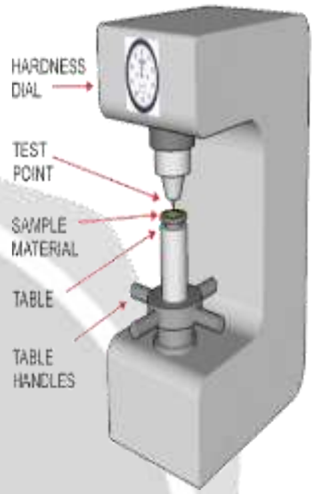

Fig-4 Hardness test set-up

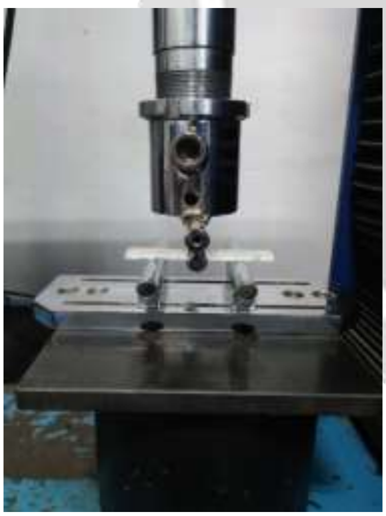

Fig-5 Flexural strength testing set up

Fig-6 Compressive testing set up

4. TESTING RESULT SUMMARY

Table-1 Testing Result Summary

Sr. No	Test Description	Standard	Results		
			No.1	No.2	Means
1	Tensile Strength (MPa)	ASTM D 638-03	300.83	242.86	272.845
2	Compression Strength (MPa)	ASTM D 695-02	148.28	164.94	156.61
3	Izod Impact Strength (J/m)	ASTM D 256-05	2000	1800	1900
4	Flexural Strength (MPa)	ASTM D 790-03	292.69	359.09	325.9
5	Hardness (Shore 'D')	ASTM D 2240-05	86-87	86-87	86-87

Table-2 Mechanical properties of conventional material (steel)

Mechanical property	**Unit (SI)**	**Value**
Tensile strength	Mpa	272.7
Compressive strength	Mpa	148
Flexural strength	Mpa	165
Impact strength	J/mm	10
Hardness	Mpa	1800
Density	Kg/m^3	7800
Elongation	%	2
Fatigue	MPa	275

5. COMPARISON BETWEEN COMPOSITE MATERIAL AND CONVENTIONAL MATERIAL

Composites offer several advantages over steel, steel has intrinsic design limitations, is heavy and costly to transport and is susceptible to corrosion, which leads to high maintenance costs.

1. Composites are lighter than steel
2. Composites are incredibly strong
3. Composites are corrosion resistant
4. Composites are nonconductive
5. Composites allow for parts consolidation
6. Composites are excellent at handling tension

7. Composites can create one-piece designs
8. Composites allow for precise weight distribution

Table-3 Comparison between composite material and conventional material (steel)

Mechanical Properties	Value		Unit (SI)
	Steel	Composite	
Tensile Strength	272.7	272.845	MPa
Compressive Strength	148	156.61	MPa
Flexural Strength	165	325.9	MPa
Impact Strength	10	19	J/mm
Hardness	1800	3000	MPa
Density	7800	2110	Kg/m^3
Elongation	2	3	%
Young's Modulus	200	60.52	GPa
Fatigue Strength	275	300	MPa
Poisson's Ratio	0.3	0.23	

6. CONCLUSION

This chapter is devoted to significant conclusions drawn from experimental observation and FE analysis of polymer laminated composite. Broadly the conclusions drawn are as follows:

Basic conclusions of composites

1) From this study, the behaviour of composite materials and laminates such as isotropic, orthotropic, and anisotropic are studied.
2) Different types of reinforcement fiber such as glass, carbon, graphite etc. and nature of matrix are studied.
3) From the results, it is clear that properties of composite such as tensile and flexural properties are basic need for testing composite materials.

4) It has been observed that, there is a significant improvement in strength of carbon laminates as thicknesses under test. This may be due to good adhesion between carbon fiber and matrix.
5) There is excellent agreement found between flexural stress results estimated by experimental, analytical and FEA methods.

The results of this work, is recommended for designers of composites community for better improvement of strength for FRP composites.

7. REFERENCES

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