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FABRICATION, MECHANICAL CHARACTERISATION AND ANALYSIS OF CARBON FIBER REINFORCED COMPOSITE USED FOR AIRCRAFTS

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ABSTRACT

The composite materials are replacing the traditional materials, because of its superior properties such as high tensile strength, low thermal expansion, high strength to weight ratio. The developments of new materials are on the anvil and are growing day by day. Fiber composites such as Carbon-Fiber Reinforced Composites (CFRP) became more attractive due to their better properties which are using for Aircraft applications. In this project CFRP is modeled using CATIA and analysis is carried out using ANSYS16.2.In this connection we are fabricating CFRP composite with two different polymer resins epoxy and polyester. After fabricated CFRP composites send for mechanical tests like Tensile, Compressive, Impact and Toughness for experimental study.

keywords: composite materials, Carbon-Fiber Reinforced Composites (CFRP), resins, epoxy, polyester, CATIA, ANSYS, Tensile, Compressive, Impact, Toughness

I. INTRODUCTION

Composite materials are engineering materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. There are two categories of constituent materials: matrix and reinforcement. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. Composites material has been used on aircraft structures since last decades until now. The permanent interest of this specialists increases where there are more application of composites on modern aircraft rather than olden days. A composite material is one which composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. The first time composite used on the aircraft was after the Second World War on the military sites. The use of composites on aircraft structure does reduce the weight in structural design. For advantages, composites offer high strength and stiffness to weight ratio comparing to metal alloys. It also corrosion resistance and act as excellent fatigue properties. In the other hand, for disadvantages, composites are low fracture toughness and moisture absorption.

IJARSE
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A study done by Vaupell and SABIC,[1]companies show that Carbon fiber has a tensile strength of about 38.3 pounds per square inch while aluminum, depending on the type, has a tensile strength roughly between 27 and 33.1 pounds per square inch. From this study we came to know that carbon fiber has more tensile strength than traditional materials like aluminum.In the same these two companies observed that Carbon fibre provides “approximately 50% lower specific gravity than aircraft-grade Aluminum”. From this study we came to know that carbon fiber has good specific gravity.

A News letter written by Energy Weekly News, [2] about the recent use of carbon fibre in the Boeing 787 states that carbon fibre is “less susceptible to fatigue and corrosion” from this we Came to know that carbon fiber has good fatigue and corrosion resistance and have lower maintenance Cost.

An article by the North American post, [3]states that Japanese company that provided the carbon fiber for the Boeing 787 said that “Boeing787 will save 1400 tons of carbon dioxide by reducing 20% of its weight”. From this article we came to know that carbon fiber reduces the emissions of the aircraft.

From the journal published by Daniel J. O’brien, Patrick T. Mather, Scott R. White, [4] which deals about the Viscoelastic Properties of an Epoxy Resin during Cure. From this journal we came to know the importance of curing on properties of composites and the variation curing temperature and duration with resin

From the journal published by Dr.Yadavalli, Basavaraj, Raghavendra H, [5]which deals about the influence of volume fraction on mechanical properties of the composite .They discussed that for a particular volumetric fraction there will be a definite mechanical properties according to it and they fabricated and tested a composites by varying the volumetric fraction.

From the journal published by Lee &Jyongsik, [6]reported that by varying the fiber content the tensile, flexural modulus and other mechanical properties of the carbon fiber composite will get varied and given a Equations used to calculate volumetric fraction and shown that higher the wt% of carbon, stronger the reinforced plastic is nonparallel alignment of carbon fibers reduces strength. Conducted experiment on three main types of synthetic fibers to reinforce plastic. Materials: glass, carbon, aramid fiber. From this we taken the calculations part for maintaining the volumetric fraction.

From the paper byNishath M,[7]which deals about the reduction ofEnergy consumption by using composite material. He explained that though wide range of researches is being laid in the areas of alternate energy sources, proper management of the available energy sources will contribute in controlling this energy crisis, particularly in high populous countries such as India. Ceiling fan being one of the vital electric appliance, consumes considerable electric power in most domestic and Industrial application. Imparting fiber reinforced composite blade in ceiling fans reduces the weight of the blade, thereby considerably reducing the power consumption. In this work the fabrication of composite fan blade made up of glass fiber reinforced polymer is carried out and the performance of this fan is compared with the conventional fans. From this journal, we came to know the effect of weight on cost and speed.

II. FABRICATION, TESTING AND FEA

The specimens for various tests are prepared first by applying the PVA agents and placing the fibers on the bottom plate. Then the binder mixed resin fiber is applied to the fiber. Now another fiber layer is placed on the previous one and is consolidated and the resin is applied again. This layup process is continued until the

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required thickness is attained. At the end, the top plate is placed and is secured tightly using fasteners, now the secured block is cured in the oven after which the plates are removed and the sample is removed. The samples obtained are cut into required shapes for testing.

This standard is for determination of tensile properties for fiber reinforced composite which was prepared by the ISO plastics (Standard: ISO 527-4) of the international organization of standardization and its dimensions is shown in the figure 1. Standard ASTM E23 (Type: IZOD Impact Test) is for determination of impact strength & toughness for fiber reinforced composite. The test specimen is machined to a square section with one notch as shown in figure 4. The specimen for compressive test is prepared according to Standard: IS 13975 of ISO and the dimensions are shown in the figure 7.

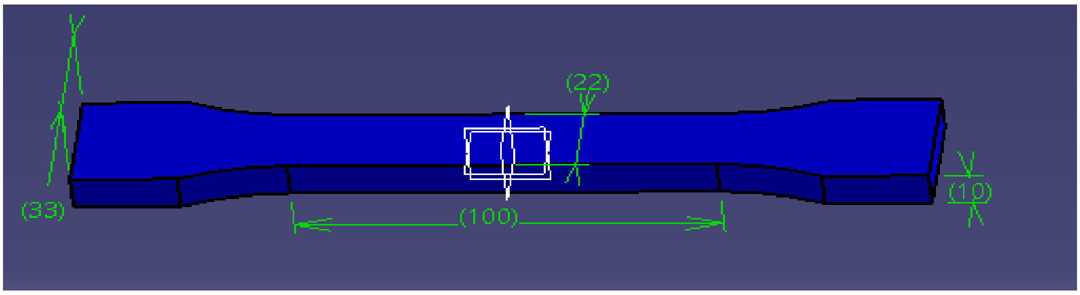

Fig 1: Standard Specimen Size for Tensile Test

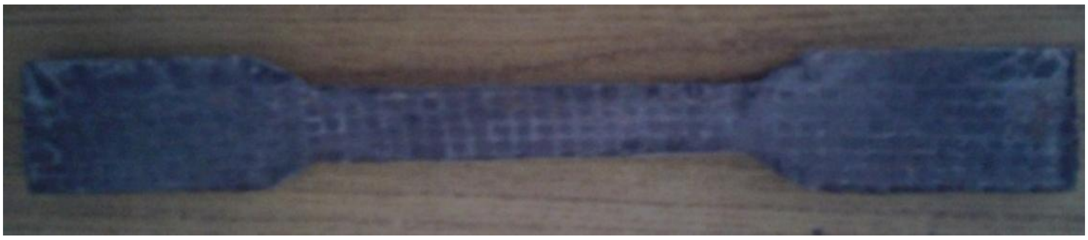

Fig 2: Tensile Specimen of Carbon /Epoxy

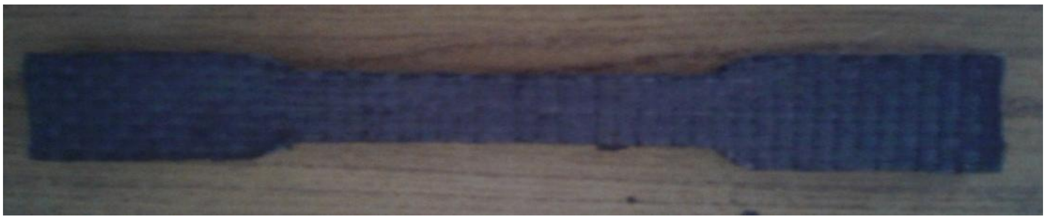

Fig 3: Tensile Specimen of Carbon /polyester

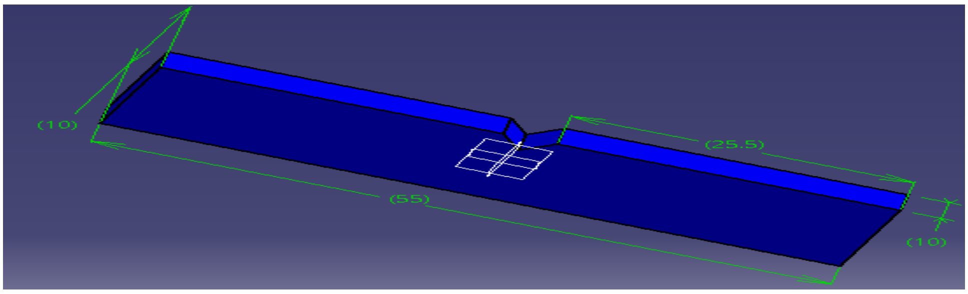

Fig 4: Standard Specimen size for Impact Test

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Fig 5: Impact Specimen of Carbon/Epoxy

Fig6: Impact Specimen of Carbon/Polyester

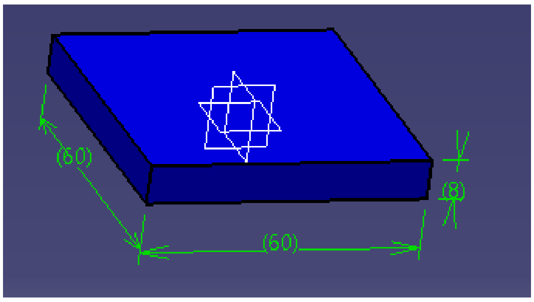

Fig7: standard specimen size for compressive Test

Fig 8: Compressive Specimen of Carbon/Epoxy

Figure 9: Compressive Specimen of Carbon/Polyester

The specimens for testing are first modeled in CATIA as per the ISO standards. These CAD models are then analyzed for various mechanical properties virtually using ANSYS through Finite element analysis. A comparison between the experimental results and FEA results are made on various mechanical properties as shown in the table.

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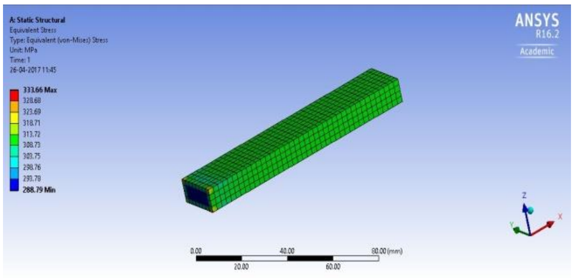

Fig 10: Stress analysis of carbon/epoxy (Tensile)

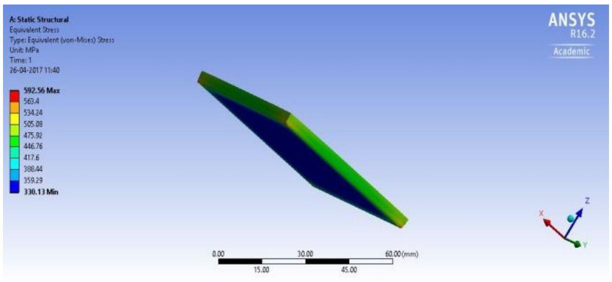

Fig 11:Stress analysis of carbon/epoxy(Compressive)

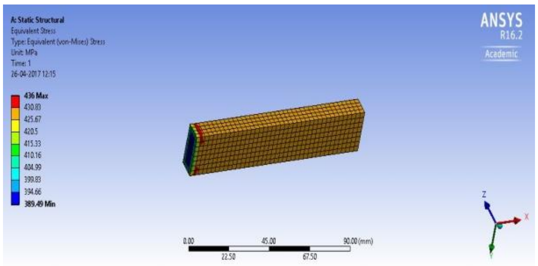

Fig 12:Stress analysis of carbon/polyester(Tensile)

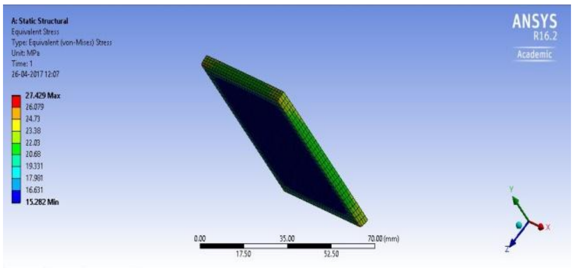

Fig 13:Stress analysis of carbon/polyester(Compressive)

Table 1 Comparison of FEM Analysis and Experimental Results

Properties	Analysis (Carbon/epoxy)	Experimental (Carbon/epoxy)	Analysis (Carbon/polyester)	Experimental (Carbon/polyester)
Tensile Stress (MPa)	333.36	374.094	436	390.12
Compressive Stress (MPa)	592.56	450.22	27.429	380.13

III. RESULTS AND DISCUSSION

The graph (figure 14) compares the impact strength of the carbon composites of epoxy and polyester. The test is conducted on the Izod impact testing machine. For these two samples was taken for each composite. By observing below graph composites reinforced with epoxy have high impact strength than composites with polyester.The graph (figure 15)compares the toughness of the carbon composites of epoxy and polyester. For each composites two samples was taken to conduct test .From graph it is observed that the composite reinforced with epoxy had more toughness compare to polyester. The graph (figure 16)compares the tensile strength of the carbon composites of epoxy and polyester. From graph it is observed that composites reinforced with carbon epoxy have high tensile strength than composites of polyester.The graph (figure 17)compares the density of different carbon composites of epoxy and polyester. From graph it is observed that the carbon fibre reinforced with epoxy has low density compared to composite of polyester.The graph (figure 18)compares the compressive strength of carbon composites of epoxy and polyester .From graph it is observed that the carbon epoxy has high compressive strength compared to composite of polyester.

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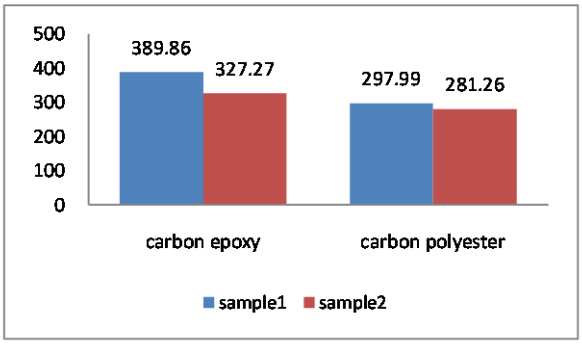


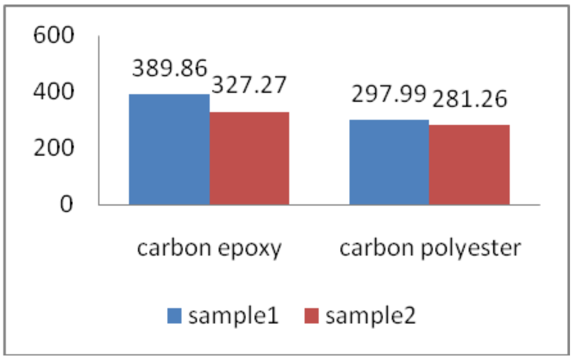
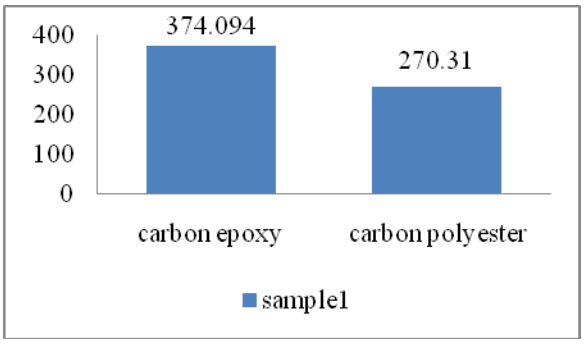


Fig 14: comparison of Izod impact strength in KJ/m^2

Fig 15: Comparison of Toughness in MJ/M^3



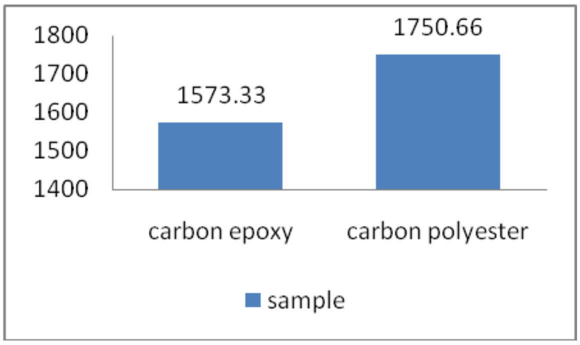
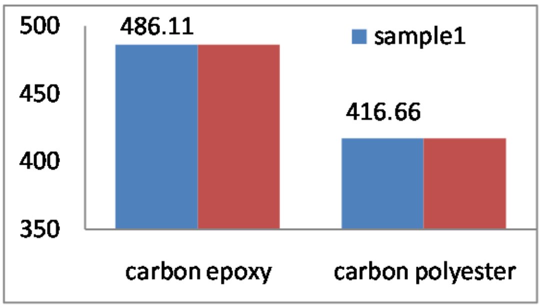


Fig 16: Comparison of Tensile Strength in MPa

Fig 17: Comparison of Density in Kg/M^3



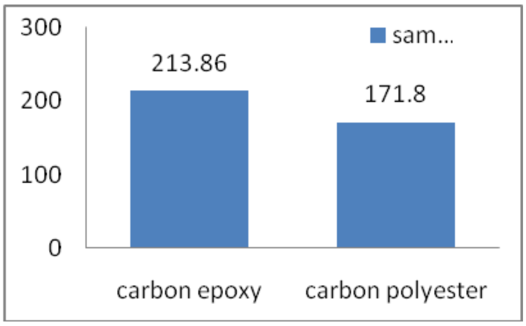


Fig 18: Comparison of Compressive Strength in MPa

Fig 19: Comparison of Specific Strength in KJ/Kg

The graph (figure 19)compares the specific strength of carbon composites of epoxy and polyester. The specific strength is the strength to weight ratio. From the graph, carbon fibre reinforced with epoxy has high specific strength and carbon fibre reinforced with polyester has low specific strength.

Table 2

PROPERTIES		
IMPACT STRENGTH (KJ/M2)	222	133.33
TOUGHNESS (MJ/M3)	389.86	297.99
TENSILE STRENGTH (MPA)	374.094	270.31
COMPRESSIVE STRENGTH (MPA)	486.11	416.66
DENSITY (KG/M3)	1573.33	1750.66
SPECIFIC STRENGTH (KJ/KG)	213.68	171.8

IJARSE
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IV. CONCLUSION

The experimental study shows a high Tensile strength, high Compressive strength, high Impact strength and low Density by Carbon Fibre Reinforced with Epoxy compared to Carbon Fibre Reinforced with Polyester and are best replacement for traditional materials in Aircrafts. From the detailed study and analysis process it is observed that CFRP composites are suitable for Aircraft applications. This can be improved in near future by varying the layup process and by adopting the natural fibres for making composites used for various Marineapplications and also the modern manufacturing technologies can be used like 3D printing.

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