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Experimental Study on Silicon Carbide Composite Laminated Plates

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Abstract

In this work an attempt has been made to experimentally investigate the mechanical properties and natural frequencies of the silicon carbide composite laminated plates in simply supported and fixed-fixed boundary condition. The composite plates used are Sic-glass fiber reinforced composites which was the mixture of silicon carbide with glass fiber reinforcement. The mechanical properties tested in this work are tensile strength, flexural strength and hardness of the composite plates. Tensile strength and flexural strength of the composites has been carried out on Universal Testing Machine of capacity of 1000 KN and hardness test on Vickers hardness machine. Free vibration test is also performed on the plates with simply supported and fixed-fixed boundary conditions.

Key words: Sic-glass fiber reinforced epoxy composites, Simply supported and fixed-fixed boundary conditions

I. INTRODUCTION

Composite materials are widely used in fields of automobile and aerospace industries due to their high strength to weight ratio, light weight, high stiffness. The improvement of mechanical properties has made composites a good replacement material for other conventional materials. Glass fiber reinforced composite materials have higher strength and stiffness ratio's unlike metal materials, because the strength can be improved by fiber reorienting in different directions. The cost of production can also be decreased because of its high productivity. Its application can be seen in structures of aero planes, cars and can be used for pipes. K.Devendra et al [1] noticed that composites filled with filler materials exhibited maximum impact strength and tensile properties. S.R.chauhan et al [2] studied the effect of fly ash content on friction and dry sliding wear behavior of Glass fiber reinforced polymer composites by taguchi approach and found that addition of fly ash decreases the coefficient of friction and increased the wear resistance of composites. Prashanth S et al [3] presented a comparative account on various kinds of synthetic fibers and their significance.

K.S.Numayr et al [4] investigated free vibrations of the composite beam using the finite difference method. From the results they observed that shear deformation obtained in clamped boundary condition was greater than the simply supported boundary condition and fundamental frequency was increasing with the small span/depth ratio. P.Ravikanth Raju and J.Suresh kumar [5] studied the Bending analysis of Piezolaminated Composite Plates using HSDT. They analyzed piezolaminated composite plates subjected to electromechanical loading using higher order shear deformation theory. From the results they noticed shear stress across thickness was increasing in composite which is contact with piezo layer and was decreasing in other layers. Oluseun.A.Adediran [6] investigated on the analytical and experimental vibrations of glass fiber reinforced epoxy composite beam. He observed that natural frequencies under simple supported condition were lower than fixed conditions and the fixed-fixed supported beam generated higher stiffness than simply supported composite beam. A.Ramsaroop and K.Kanny [7] compared the fracture toughness of clay Nano composites and glass fiber polypropylene composites. Results showed that with increase in clay content the energy absorption rate was increasing KIC and GIC values were continuously increasing but the rate of increase was reduced at higher clay content. Mariana Etcheverry and Silvia E.Barbosa [8] used polypropylene as matrix in glass fiber reinforced composite. They concluded that strength and toughness increases three times when polypropylene was used as matrix.

Tahir Ahmad, Othman Mamat [9] made observations on the effect of hardener and catalyst ratio on mechanical properties of fiber glass reinforced polymer composites. They observed that 1 cc of hardener and catalyst resulted in better mechanical properties and with increase in thickness of glass fibers tensile strength was increased up to 36MPa and impact energy to 116J.

Izabela Zamorska et al [10] considered the frequency analysis of composite annular membranes. They noticed that with the increase of the ratios of densities of the membrane segment the frequency of the composite annular membrane was decreasing. G.Rajesh Kumar and V.Hariharan [11] performed free vibration analysis of hybrid-composite beams. Natural frequencies for different fiber orientations were investigated. They noticed the natural frequency was maximum for 0^0 fiber orientation and was decreasing with the increase in the fiber angle orientation. The natural frequency for clamped free condition was slightly more than the simply supported boundary condition. Bhadrabasol RevappaRraju et al. [12] analyzed the assessment of cutting g parameters influencing on thrust force and torque during drilling particulate filled glass fiber reinforced epoxy composites. Silicon oxide and alumina were used as particulates. They observed that carbide tool performed better than HSS drill during drilling of particulate filled glass fiber reinforced epoxy composites.

In this paper from the above literature it has been observed that so far the work had been carried out on fabrication of fiber composites, predicting the failure behavior of glass fiber composites, effect of filler materials on glass fiber composites and study of mechanical properties of Glass Fiber Composites. But researchers have not much focused on the free vibration analysis of glass fiber reinforced composite with addition of silicon carbide. So in this paper work on glass fiber reinforced epoxy composites with silicon carbide composites has been carried out. Free Vibration Analysis is performed and the mechanical properties like tensile strength, flexural strength and hardness has been carried out.

II. MATERIALS AND METHODS

In the preparation of composite laminates epoxy LY 556 and hardener HY 951 is taken as matrix constituent and S-glass fibre in mat form is taken as reinforcement which is bidirectional in nature. Silicon carbide (SiC) in the powder form as particulates are mixed with epoxy for the preparation of composite laminates. The composite laminates are made by adopting Hand-layup process technique.

III. EXPERIMENTAL DETAILS

In this study the matrix material Epoxy resin of density 1.18g/cm3 and hardener of density 0.98 g/cm3 is mixed in the ratio of 10:1.silicon carbide, to form SiC- glass fibre composite laminated. The samples are prepared in sizes of 4mm thick 160mm square plate. Two different laminates were prepared which contained epoxy and hardener in the ratio of 100 and 10 parts by weight respectively. The mould is coated with mixed resin before placing s-glass bidirectional fibre as per mould dimensions and mixed epoxy resin with silicon carbide is poured and spread with the help of roller to remove air bubbles and epoxy resin mixed with particulates is poured.

Mould is closed with plastic sheet and load is applied on composite material for 24 hours for curing. Two different laminates composite plates were prepared with different compositions.

III.1. TENSILE TEST

Tensile test determines the ability of a material to withstand loads before elongation. For this the specimens were cut as per ASTM: D 3039 and the tests were conducted on the UTM. The results are displayed in Fig 1 with the help of bar graphs.

III.2 FLEXURAL TEST

The flexural test determines the performance of materials under simple beam loading. It plays a significant role in structural application purpose. To find out the flexural strength of composites, a three point bending test was carried out. For this specimens were cut as per ASTM D 790 and the tests were conducted on UTM. The results are displayed in Fig 2 with the help of bar graphs.

III.3 HARDNESS TEST

Hardness test determines the ability of material to withstand the plastic deformation. The results are displayed in Fig 3 with the help of bar graphs.

III.4 FREE VIBRATION TEST

The composite laminates plates were given excitation by means of small impact hammer. The input signal is captured by a force transducer fixed on the hammer. The resulting vibrations of the plate are measured by accelerometer (DEWE software). The accelerometer was mounted on the free end by using bee wax. The location of the excitation was varied throughout the laminated plate. Both the input and output signals are investigated by means of spectrum analyzer and frequency response functions. Boundary conditions considered were simply supported and fixed and fixed boundary conditions. The output was displayed on the analyzer screen using DEWE software. Natural frequencies for simply supported and fixed-fixed boundary conditions were obtained for the three different composite plates and the comparison was made and shown in Fig 6.

IV.RESULTS AND DISCUSSIONS

The tensile strength of the two different composite plates has been recorded and the comparison of two different composite plates has been shown in Fig 1. From the fig 1 it is observed that the tensile strength of 4%SiC-Glass Fiber Expoxy Composite is greater than the 2%SiC-Glass Fiber Epoxy Composite. 4%SiC-Glass Fiber Epoxy composite showed higher tensile strength as there was a mixture of silicon carbide is more.It forms strong interatomic bonding and better interaction with epoxy and reinforcement which is the reason 4% SiC composite sowed higher tensile strength. Fig 2 shows the comparison of the flexural strength of 2% SiC-Glass Fiber Epoxy Composite, 4%SiC-Glass Fiber Expoxy Composite. It is observed from the Fig 2 that the maximum flexural strength is obtained for 4%SiC-Glass Fiber Expoxy composite plate and the minimum flexural strength is obtained for 2%SiC-Glass Fiber Epoxy composite plate. The hardness of 2%SiC-Glass Fiber Epoxy Composite, 4%SiC-Glass Fiber Expoxy Composite plates is shown in Fig 3.

2%SiC-Glass Fiber Epoxy Composite has lowest hardness number when compared with4%SiC-Glass FiberExpoxy composite plate. Fig 6 show the comparison of the natural frequencies of the composite plates under simply supported boundary conditions and fixed-fixed boundary condtion.It is observed that the natural frequencies of composite plates obtained under fixed-fixed boundary condition was greater than the frequencies of composite plates obtained under simply supported boundary condition. The

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natural frequencies obtained in fixed-fixed boundary condition were almost double the natural frequencies in simply supported boundary conditions.

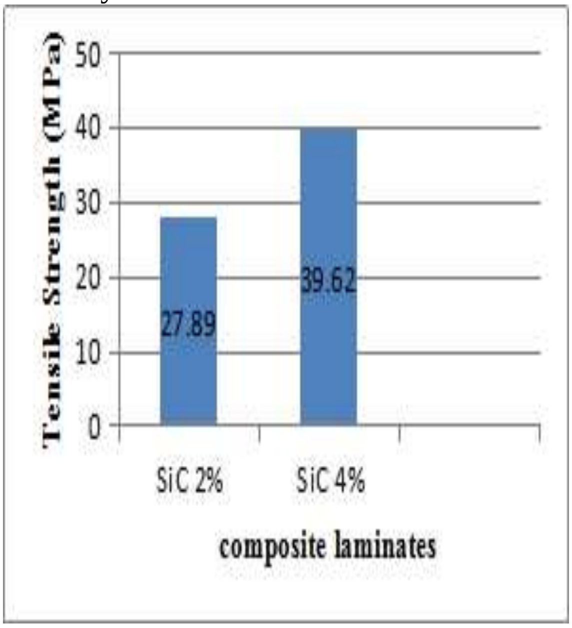

Fig 1: Tensile Strength of Composite Plates

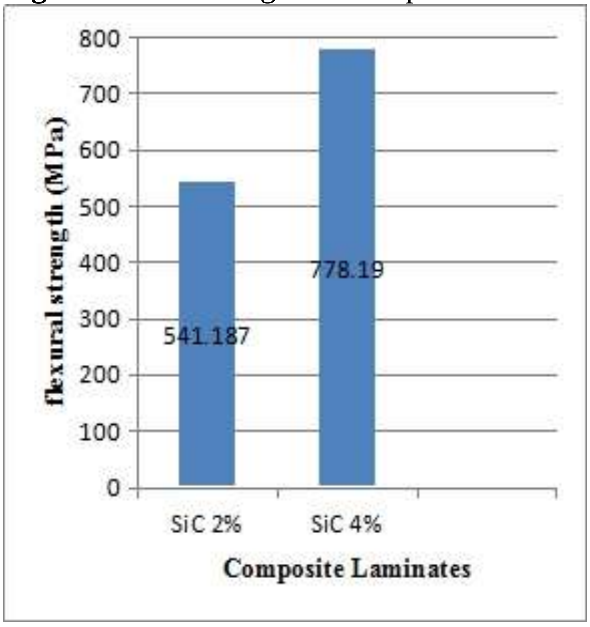

Fig 2: Flexural Strength of Composite Plate

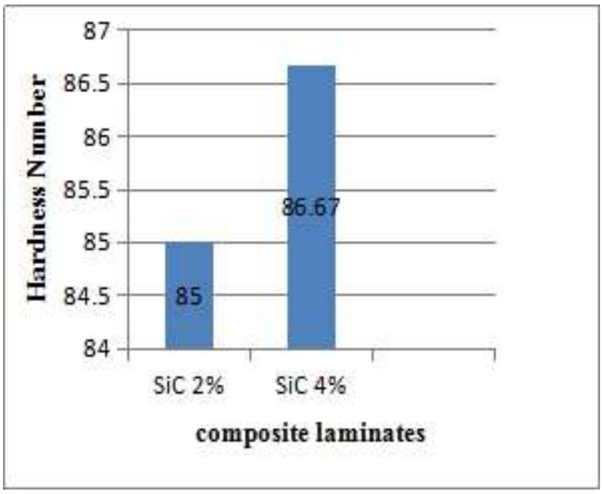

Fig 3: Hardness of Composite Plates

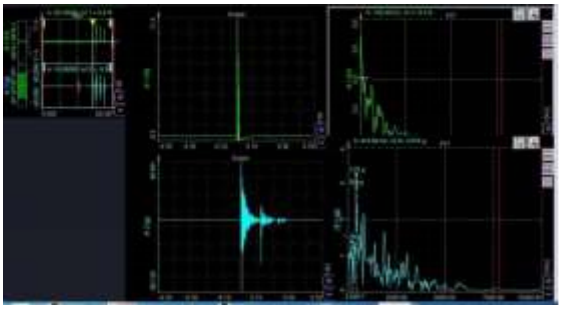

Fig 4: SiC-glass fiber reinforced composite plate under simply supported boundary condition

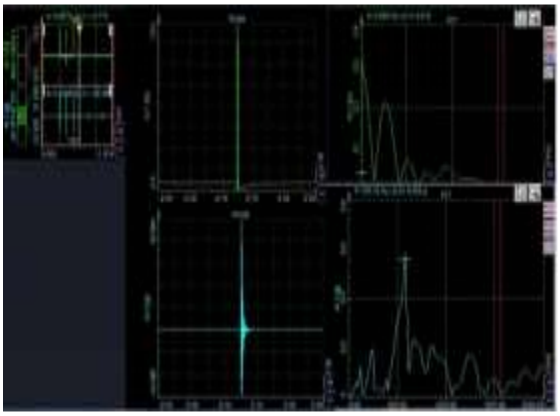

Fig 5: SiC-glass fiber reinforced composite plate under fixed-fixed boundary condition

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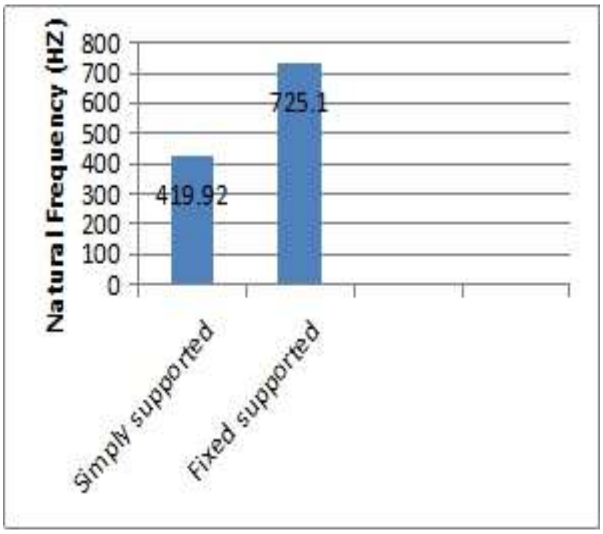

Fig 6: Comparison of Natural Frequencies of Composite Plates in Two Different Boundary Conditions.

V.CONCLUSIONS

Two different composite laminated plates were fabricated using Hand Lay-up technique. Tensile strength, flexural strength and the hardness of the two composite laminated plates were found out. The natural frequencies of two different composite laminated plates were studied in simply supported and fixed-fixed boundary conditions. From the study it is found that 4%SiC-Glass Fiber Expoxy composite laminated plate has the highest tensile strength, flexural strength and hardness number than the 2%SiC-Glass Fiber Expoxy composite plates. SiC-Glass Fiber Expoxy composite plate showed higher natural frequency and natural frequencies in fixed-fixed boundary condition was almost double the simply supported boundary conditions. It may be recommended that 4%SiC-Glass Fiber Expoxy composite laminates plates can be used in ship hulls due to high natural frequencies and in the pipe lines.

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