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Experimental Determination of Mechanical and Vibration Properties of Epoxy based carbon fiber/SiC composites

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ABSTRACT: *The organic polymer composites filled with inorganic fillers became an important area of research and development in recent years due to their applications in various fields. The aim of the present work was to fabricate and evaluate the mechanical performance of epoxy polymer composites filled with 30% weight percentage of carbon fiber and 2%, 4%, 6%, 8% of Silicon Carbide. The samples were prepared by hand layup technique as this method was easy to fabricate and having low tooling cost and results in the good surface finishand then composites weretested by using UTM and ATALON FFT analyzer. The DEWESOFT software was used to obtain the frequency response functions of the samples. The variations in properties with respect to change in weight of silicon carbide were obtained and represented by graphs. The composite with 30% of carbon fiber and 8% of Sic have shown improved performance in terms of flexural strength, tensile strength, tensile modulus and higher natural frequency indicating high stiffness value.*
Keywords: *Carbon fiber, FFT Analyzer, Flexural Modulus, Silicon Carbide, Tensile Modulus*

I. INTRODUCTION

Composite is a multiphase material of two or more constituent materials with different properties and forms with a great improvement in performance. Ex: straw mud wall, tire cord, steel bar reinforced concrete etc. The phases of component materials in a composite are matrix phase, reinforcement phase and the interface which is the interaction between reinforcement and matrix phase.

Due to their properties like high specific strength, high specific modulus ,good fatigue resistance ,high damage tolerance, and good damping characteristics, polymer matrix composites are occupying major applications in areas like air craft, aerospace, sporting goods, construction industry, anti-corrosion equipment, electrical and electronic industry, agriculture and fisheries and mechanical manufacturing.

In the present work thermoset polymer i. e epoxy resin was taken as matrix material and one of the reinforcementswas carbon fiber, it provides high specific strength and specific modulus and other was Silicon carbide particles which provides high hardness,corrosion resistance and stiffness to the composite. The tensile strength, tensile modulus, bending strength, bending modulus, and natural frequencies of epoxy/carbon fiber / silicon carbide composites were determined experimentally by fixing the weight percentage of carbon fiber and varying weight percentage of silicon carbide.

Na, W., Lee, G., Sung, M., Han, H.N., Yu, W-R. [1] in this work the carbon fibers are arranged in a unidirectional order, by considering the interfacial shear strength to calculate the tensile strength by using the finite element method and then the stress concentration factor of each surrounding fiber was determined. Chen, X. Yin, X. Fan, M. Chen, X. Ma, L. Cheng, L. Zhang [2]in this present investigation carbon fibers are reinforced with Silicon carbide by Vol% to calculate the mechanical properties and electromagnetic shielding properties. Chen Xian, Li Yulong[3] in this paperthe two dimensional carbon fibers are reinforced with silicon carbide, to calculate the dynamic tensile behavior of composite beams. The beams are coatedto improvement in tensile strength but heightened strain rate sensitivity compared with uncoated ones.XiulanHea, YingkuiGuoa, ZeminYua, Yu Zhoub, DechangJia [4] , short carbon fibers are used to reinforce to SiC prepared by the hot pressing method with Sic powder, Polycarbosilane as precursor polymer and $MgO–Al_2O_3–Y_2O_3$ as sintering additives. The phasecomposition, microstructure and mechanical properties of the composites with different polycarbosilane content were investigated. Julia Brunbauer, HannesStadler, Gerald Pinter [5] in this paperthe effect of fiber volume fraction on the fatigue behaviorand damage mechanisms of carbon/epoxy laminates. Epoxy resin and unidirectional carbon/epoxy specimens with two different fiber volume fractions are tested under quasi-static tensile and tension–tension fatigue loads at angles of 0, 45 and 90.Jianbao Hu, Shaoming Dong, Xiangyu Zhang, Haijun Zhou, Bin Wu, Zhen Wang, Ping He, Le Gao[6] in this paperCf/C–Sic composite was fabricated via in situ growth of carbon nanotubes by polymer impregnation and pyrolysis process. The effects of CNTs grown in situ on mechanical properties of the composite, such as flexural strength, fracture toughness, crack propagation behavior and interfacial bonding strength, were evaluated. Hui Mei, Haiqing Li, QianglaiBai, Qing Zhang, Laifei Cheng [7] here in this work appliedthe effect of heat treatment on the strengthening and toughening of a carbon fiber/silicon carbide composite (C/Sic) with a thin pyrolytic carbon (PyC) interphase was investigated.Tensile strength and modulus were measured using tensile tests, and toughness was obtained by calculating the area under the stress–strain curves. Padmavathi, J. Subrahmanyam, K.K. Ray, R. Mohanrao, P. Ghosal, SweetyKumari [8] in this work developed replacement of carbon matrix with SiC is one of the methods to improve the oxidation resistance. A relatively inexpensive process is developed for the fabrication of carbon fiber reinforced Sic composites through solution approach. He Xinbo, Zhang Xinming, Zhang Changrui, Zhou Xingui and Zhou Anchen [9] in this paper investigates the carbon fiber and silicon carbide composite were prepared by precursor conversion –hot pressing sintering with AIN and Y_2O_3 as additives. The effects of sintering temperature and additives on the microstructure and propertiesof the composites were investigated. SupreyaKumfu, PisithSingjai, WandeeThamjareeHaruthaiLongkullabutra and WimNhuapeng [10] in this paper developed the composites materials of silicon carbide nanowire and carbon nanotube (CNTs)/rubber were fabricated. By using the heating technique and infusion chemical vapor deposition method, by the vol% of silicon carbide nanowires and carbon nanotubes were mixed into rubber matrix phase to obtain 0-0-3 composites. Mechanical and physical properties of composite samples such as density, tensile strength and hardness were examined and compared with that of single phase of rubber.Xiaowei Yin, Shanshan He, Litongb Zhang, Shangwu Fan, Laifei Cheng, GuanglaiTian, Tong Li [11] in this workin order to reduce residual silicon in carbon fiber reinforced carbon–silicon carbide binary matrix composite fabricated by liquid silicon infiltration, the aqueous slurry of titanium carbide (TiC) powder was used for introducing Tic into porous carbon/carbon composite (C/C) by slurry infiltration. The composite were taken by vol%, to find out the flexural strength and toughness of the composite. Selzer and K. Friedrich [12] in this paper the effect of moisture on the mechanical properties and the failure behavior of fiber-reinforced polymer composites was investigated. Three materials were investigated, which were all reinforced with continuous carbon fibers. Two thermosetting matrices and one thermoplastic matrix were used. The results showed that the absorbed moisture decreases those properties of both epoxy-based composites which were dominated by the matrix or the interface.

II. FABRICATION AND EXPERIMENTATION

2.1 Composite Preparation

There are different methods used to manufacture the composite material. They are hand layup method, spray-up, vacuum bagging and automated tape process. The present work was done by using the hand layup method to fabricate the composite materials. This method is very easy to fabricate and having low tooling cost and results in the good surface finish. For 30% of weight fraction of carbon fiber, a measured amount of epoxy (GY-257) was taken and mixed with hardener, then the silicon carbide filler with wt percentages of 2%, 4%, 6%, 8% was added into the mixer using tip ultra-sonicator. Carbon fiber was placed on the table and epoxy resin applied over it. After dryingapplied epoxy resin on other side of the fiber as in Fig. 1. A smooth polishing cover was placed on the top of composite plate and by using squeezing out technique air gaps and excess resin was removed. The processed wet composites were dried for 24hrs and cut into samples of size 120mm x 20mm x 3mm as shown in Fig.2.

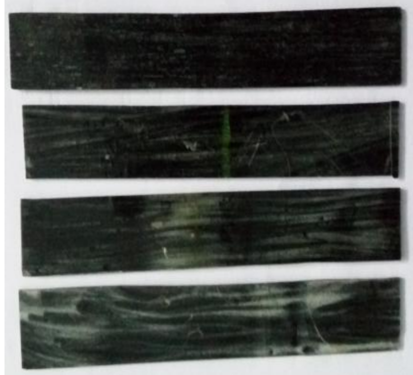



Figure1: Fabrication of Composite Beams**Figure2:**Prepared Composite Beams

2.2 Composite Testing

In this work carbon fiber/sic reinforced epoxy composite material tensile,flexural and vibration properties were determined using Universal Testing Machine (UTM) and Fast Fourier Transformation(FFT) Analyzer.The computerized universal testing machine was designed for testing tensile,elongation, flexural or compression properties etc. The machine was capable of testing variousmaterials like metals, composite fibres, pipes, tubes, concrete blocks etc. The controlpanel in the machine displaces all the information in relation to actual load capacityand elongation. All these information regarding the tests can be stored in memory forfuture reference or printed reports, presentations and certification. The UTM was fittedwith self-aligned fixed quick grip chuck and other movable self-aligned quick grip chuck to hold the specimen**.** In Universal Testing Machine the specimen was placed in the machine between the grips for applying gradual load and extensometer automatically recorded the displacement between its cross heads on which the specimen was mounted. For testing on FFT Analyzer the composite beam was fixed at one end other end made free and an accelerometer was placed at top of the beam. The excitation was given with the help of impact hammer .The responses of the specimens were transmitted to the FFT analyzer for converting the vibrations in time domain to frequency domain. The FRF(frequency response function) spectrum peaks displayed by DEWESOFT software indicated the natural frequencies of the composite beams.The two experimental setups were shown in Fig. 3 to Fig. 6.


Figure 3: Tensile Test by using UTM **Figure 4:**Flexural Test by Using UTM

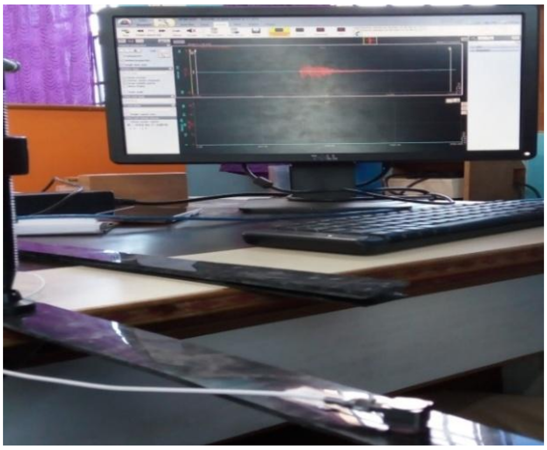



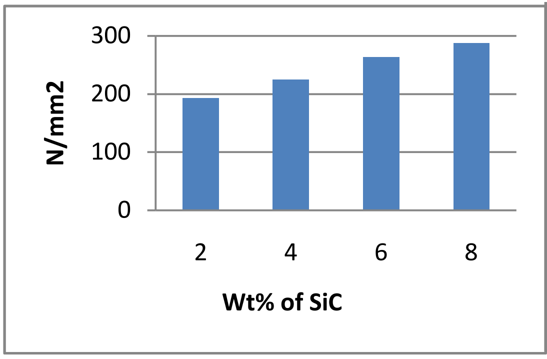
Figure 5: Excitation given by Impact Hammer**Figure 6:**Vibration analysis by FFT analyzer

III. RESULTS

By the addition of carbon fibers and silicon carbide to the epoxy matrix the variation in tensile, flexural and vibration properties were determined. The variation in mechanical properties of the composite withthe variation of weight percentage of the silicon carbide was discussed as follows

3.1 Tensile Properties

From the stress-strain diagrams of composites the ultimate tensile strength, tensile modulus values were determined for different compositions of constituents. The variation of the properties is shown in Fig. 7 and Fig. 8. The tensile strength increased with increasing the wt of the silicon carbide and the maximum strength was obtained for 8% composite and 2 % composite was having the low strength .The composites having 4% and 2 % silicon carbide were having the minimum and maximum tensile modulus respectively.



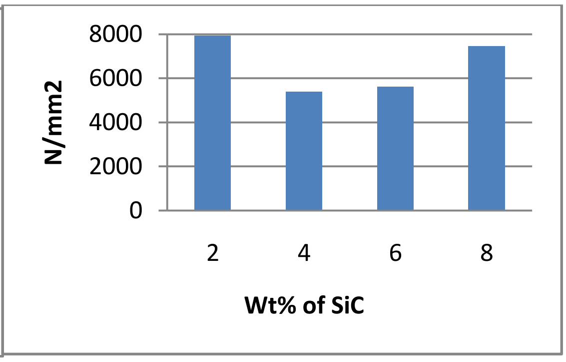


Figure 7: Variation of Tensile Strength **Figure 8:**Variation of the Tensile Modulus

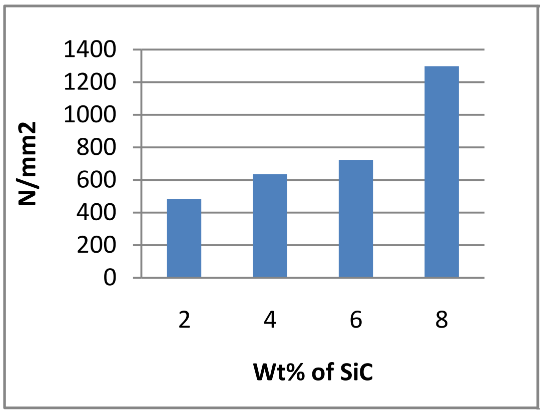
3.2 Flexural properties

Flexural strength was determined from load deflection curve obtained from Universal Testing Machine.

The relation: $F.M = mL^3/4bt^3$.................(1)

It is used to find flexural modulus of the composites

Where F.M = Flexural modulus, m= Slope of the load deflection curve, L= Span Length, b= Width of the beam, t=Thickness of the beam. The observed properties of composite, flexural strength is increases with increasing the wt percentage of silicon carbide as shown in Fig. 9. Whereas the flexural modulus properties are decreased with increase in wt percentage of silicon carbide as shown in Fig. 10.



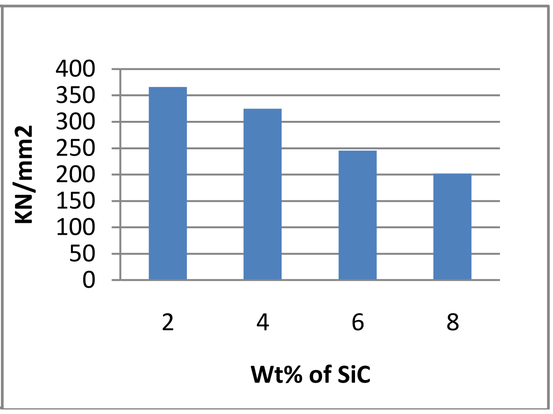


Figure 9: Variation of Flexural Strength**Figure 10:**Variation of the Flexural Modulus

3.3 Vibration Properties

The first three fundamental frequencies are given by the FFT analyzer. With increase in weight of the SiC the natural frequency of the composites also increases asshown in Fig.11 indicating the better stiffness of the composite by the addition of SiC

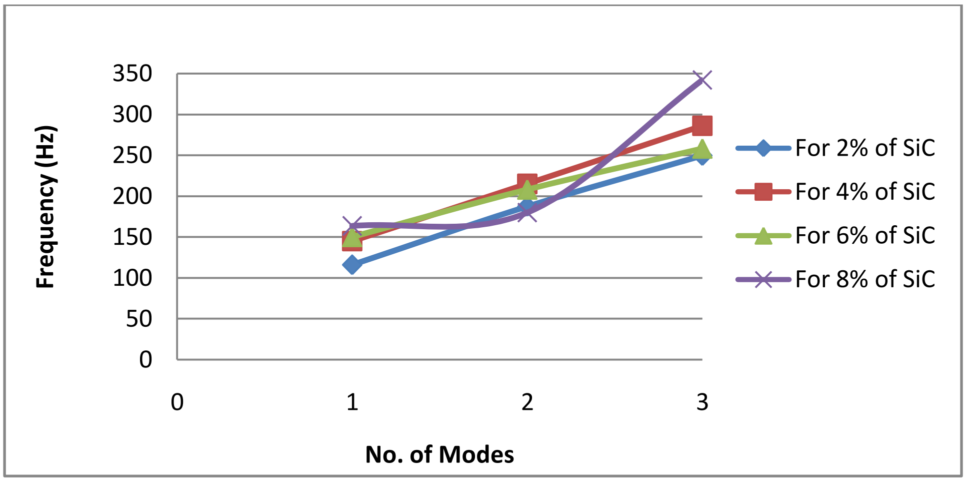


Figure 11: Variation of the Natural Frequencies for Different Weight Percentages of SiC

IV. CONCLUSIONS

The present work experimentally evaluated the mechanical and vibration properties of fabricated epoxy polymer reinforced with carbon fiber and silicon carbide. The weight percentage of carbon fiber was fixed and the silicon carbide was varied. The composite with 30% carbon fiber and 8% of SiC have shown the better tensile properties and the flexural strength. The composite with 30% carbon fiber and 2% of Sic exhibited better flexural modulus. The natural frequencies of first three modes of the composites were determined and variation of the frequencies with weight fraction of SiC was also studied indicating better stiffness of composite having 8% of SiC In future this work can be extended by simulation using modeling and analysis softwares.

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