RESEARCH ARTICLE OPEN ACCESS

STUDY AND APPROACH ON HYBRIDPOLYMER COMPOSITE MATERIALS WITH FGM

J.MURALI MOHAN [1], D.SRIKANTH [2], K.PAVAN KUMAR [3]

1(Department Of Mech, Asst. Professor, St Mary's Group Of Institutions, Hyderabad, muralimohan014@gmail.com)

2(Department Of Mech, Asst. Professor, St Mary's Group Of Institutions, Hyderabad, , srikanth.duvvala@gmail.com)

3 (Department Of Mech, Asst.Professor, Vignan Institute Of Technology And Science, Hyderabad, naren2088@gmail.com)

Abstract:

Research work was to investigate experimentally the tensile behavior of Functionally Graded Materials (FGM) made from tubular braided composites and to find out the relationship between the tensile property of the FGM and that of the corresponding non-FGM. Composites were made using tubular braided carbon fiber fabrics and an epoxy resin. The FGM specimens had varying braiding angles and the non FGM specimens had constant braiding angles. The effect of braiding angle on the composite properties was established from the test results for the non-FGM specimens. It was shown that both the tensile strength and modulus decreased as the braiding angle increased. The tensile behavior of the FGM specimens was demonstrated to be related to that of the non-FGM specimens. Moreover, a distribution of the volume fraction of these fibers across the width of the corresponding layers is non-uniform (piece-wise distribution. The goal is to maximize the buckling load subject to the constraint on the total cross-sectional area of the stiffer fibers. Composite materials have been steadily substituting metals and alloys due to their better thermo mechanical properties. The successful application of composite materials for high temperature zones in aerospace applications has resulted in extensive exploration of cost effective ablative materials. High temperature heat shielding to body, be it external or internal, has become essential in the space vehicles. The heat shielding primarily protects the substrate material from external kinetic heating and the internal insulation protects the subsystems and helps to keep coefficient of thermal expansion low.

Keywords **— FGM, Resin.**

INTRODUCTION

Functionally Graded Materials (FGM) refers to one of the most innovative concepts introduced into the composites industry in the last two decadesIt describes a class of material that possesses a continuous or stepwise variation in composition and/or microstructure to give rise to a smooth and spatially controlled change in properties. Previously this group of materials was mainly developed from a combination of metal and ceramic materials, with either a construction or a transport based processIt is only recently that the concept has been applied to the area of fiber reinforced polymer composites. In a study by Jang and Lee a functional gradient of the glass fiber (GF)/carbon fiber (CF) mixed mat was realized fibers. There are few documented researches about continuous fiber reinforced FGM.Continuous fiber reinforced polymer composites play a very important role in the modern composites industry among them, the family of textile composites is well known. Textile composites are generally reinforced with fabrics, typically classified as knitting, braid and weave. These fabrics possess homogeneous geometric patterns. It is difficult to change the homogeneous geometric patterns to produce gradients with the conventional FGM processing method As a result, there is not much FGM development carried out on textile composites. Colombian applied the conventional lamina stacking method to fabricate FGM with woven composites.

Metal matrix composites and metallic alloys: Metal matrix composites (MMC) are composites in which the matrix phase is a ductile metal. The metal matrix provides ductility and thermal stability for the composite at elevated temperatures, while the fiber may increase the strength, the stiffness, enhance the resistance to creep or abrasion, and improve the thermal conductivity. Aluminum and its alloys, copper, titanium, and magnesium are most common metals used in MMCs. Metal matrix composites can be divided into three different categories: related to the type of reinforcement, fiber, or particulate. The most common fabrication processes for MMC are powder metallurgy, spray deposition and squeeze casting As an extension of studying ultrasonic additive manufacturing on NiTi–Al, another work has been done to investigate the bonding between the fiber and matrix in composites fabricated and the shear strength of the fiber-matrix interface. Al 3003-H18 is used as matrix phase and with embedded inside. Composite failure temperatures have been observed by using differential scanning calorimetric. The constitutive models of the NiTi element and Al matrix have investigated average interface shear strength of 7.28 MPa and an effective coefficient of thermal expansion of zero at 135 C. Furthermore, interface failure temperatures can be increased as the embedded fiber length is increased. Mechanical nature is observed after studying of the bonding between the fiber and interface using energy dispersive X-ray spectroscopy, but no evidence to support chemical or metallurgical bonding.

2.0 Literature review:

Zheng-Ming Huang1 ,Qiongan Wang(2001) to investigate experimentally the tensile behavior of Functionally Graded Materials (FGM) made from tubular braided composites and to find out the relationship between the tensile property of the FGM and that of the corresponding non-FGM. Composites were made using tubular braided carbon fiber fabrics and an epoxy resin. The FGM specimens had varying braiding angles and the non FGM specimens had constant braiding angles. The effect of braiding angle on the composite properties was established from the test results for the non-FGM specimens. Investigation of the tensile properties of this developed FGM was carried out experimentally, and the relationship between the tensile properties of the FGM and that of the corresponding nonFGM was realized. For the CBA rods, both the elastic tensile modulus and the tensile strength increased as the braiding angle decreased.

Gururajaudupa1 , S. ShrikanthaRao(2014) Material selection is a very critical issue when it comes to aerospace engineering. Materials should have good qualities like light weight, high strength and corrosion resistance with economic viability. Over the period, Aluminum blends of composite are used for variety of applications. Carbon Nanotube reinforced Aluminum composites and Functionally graded composites(FGC) are the new developments in materials engineering.The Advanced Composites Programmed activities have proliferated encompassing number of composite applications and its presence is now being felt across the large geographical canvas of the world as well as diverse user segments. It should be an efficient, successful mechanism in infusing the knowledge component to industrial practices.

Kamran Asemi (2015) Low velocity impact behavior of rectangular plates made of functionally graded materials (FGMs) based on three-dimensional theory of elasticity is studied in this paper. The modified Hertz contact law, which is appropriate for graded materials, is employed. On the basis of the principle of minimum a numerical approach for the low-velocity impact of FGM plates based on the three-dimensional theory of elasticity is extended. By applying the three-dimensional graded elements for analysis of

the plates, discontinuities of the stress distribution that are present in the conventional FE results, are eliminated. The influence of the volume fraction index of the FGM plate, initial velocity of the projectile and projectile mass on the parameters such as time histories of the contact force, velocity of the projectile, lateral deflection and normal stresses are studied.

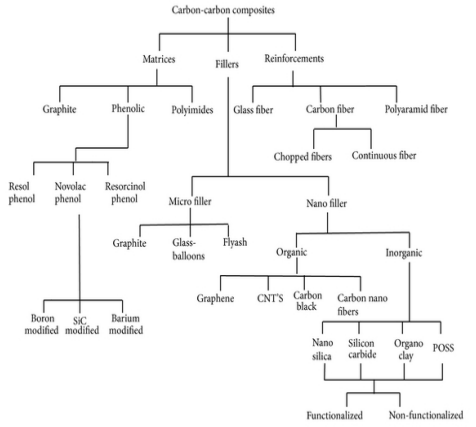
Dr A Thimmana Gouda (2014) This Research Paper constitutes the study of Mechanical Properties of Tensile, Compression and Bending Strength of the 12%, 24% and 36% of Hybrid Fiber (Natural fiber- Sisal, Jute and Hemp) polymer composite material used as Bio-material. Characterization of 12%, 24% & 36% Hybrid Natural fiber polymer composite material with the low density, economical for prosthetic bone with respect to biocompatibility and the mechanical behavior of long human bones, such as Femur Bone.From the Tensile Experimental test results it is found that 12%, 24% and 36% HNFPCM will match the Femur bone tensile property anyhow from this results we suggest 36% HNFPCM is the best material which is having high will match the Femur bone Compression property anyhow from this results we suggest 36% HNFPCM is the best material which is having high Compressive strength, high Density when compare to 12% & 24% HNFPCM.

G Venkatachalam , A Gautham Shankar (2015) The polymer matrix composites attract many industrial applications due to its light weight, less cost and easy for manufacturing. In this paper, an attempt is made to prepare and study of the tensile strength of hybrid (two natural) fibers reinforced hybrid (Natural + Synthetic) polymer matrix composites. The samples were prepared with hybrid reinforcement consists of two different fibers such as jute and Gogra and hybrid polymer consists of polyester and cashew nut shell resins.As the present industry requirement is environment friendly materials, a new composite material with hybrid polymer and hybrid fiber is developed, and its properties are evaluated. It was concluded from the analysis that fiber treatment duration and concentration of alkali solution.

3.0 Tensile behavior of functionally graded materials specimens:

Tensile strengths of Group 1 FGM rods are plotted against the length fractions of the contained braiding angles Data for CBA rods were introduced into the chart by assuming that either of the angles occupies 100% length fraction. The study of CBA rods has shown that a larger braiding angle would result in a lower strength. Based on this result, it was originally supposed that the strengths of Group 1 FGM rods would be equal to the strength of the specimen group "CBA 17.2°" because the largest braiding angle of all these rods is 17.2°. However, the experiment showed a different result. Although fracture did take place in the section with 17.2° braiding angle in the tests, the tensile strengths of the Group 1 FGM rods were all higher than that of a CBA specimen group with a braiding angle of 17.2°, as shown in Figure 10. Moreover, the strength increased as the length fraction of 5.2° braiding angle increased, but decreased as the length fraction of 17.2° braiding angle increased. These results can be properly characterized the term "dimensiondependent strength enhancement". It is believed that the strength enhancement is caused by tensioninduced microstructure readjustments within an FGM rod. When a tension is imposed, the larger braiding angles of an FGM rod will decrease due to the constraint of the smaller braiding angles. As a result, the strength of the FGM rod will increase. Furthermore, the less the length fractions of the larger braiding angles, or the greater the length fractions of the smaller braiding angles, the more marked is the decrease of the larger braiding angles.

Carbon-carbon composite system and its constituent elements:



The carbon felt has been fabricated by alternatively stacked weft less piles and short-cut-fiber webs by needle-punching technique. This technique minimizes the fiber bend and breakage with the capability to tailor the properties by weaving in appropriate directions. Normally nonwoven carbon composite shows highest tensile strength over woven materials Weave pattern orientation of the carbon fabric affects the heat diffusion rate through the cross section of the composite. and Kiwanis studied the changes in the weave pattern of carbon fibers in different directions and altered specific properties of carbon composite Surface-treatment of the carbon fibers is a current advancement in the fiber technology, in which surface treatment by means of physical or chemical method improves the adhesion between carbon fiber and polymer matrix Production of carbon fiber through fiber spinning is highly expensive process. The usage of mesosphere pitches shows efficient fiber reinforcement with improved cost effectiveness. Chand has described the mesophase pitches, which are of liquid crystalline nature. During graphitization step, mesophase pitches form a graphitic crystalline structure with high modulus carbon fibers with high stiffness.

Preparation of hybrid fiber reinforced polymer matrix composites

The hybrid fiber reinforced polymer composites wereprepared by adopting variousmanufacturing techniques as shown in Table 1 and were discussed below.The rule of mixture is used to prepare the hybrid fiberreinforced polymer composites and the volume fractionof hybrid fiber reinforced composites has been preparedby the following equationsmanually sliced into 1cm-wide strips with a knife. Anextruder was used to get the fiber diameter of approximately 1mm and chips length of 110 mm. A high-speed blender was used to obtain the short bamboofibers. Characterization is carried out using Epoxy resin -LY556 as a matrix material and hardener -HY 951 with 12%, 24% and 36% Natural fibres as the reinforcement material (with fiber weight fraction, randomly continuous long fibre orientation) by using hand layup fabrication technique the specimens are prepared as per ASTM standards for Tensile Tests specimens are prepared by ASTM D-3039, For Compression Tests specimens are prepared by ASTM D-3410 and for Bending Tests specimens are prepared by ASTM D-790.

Mechanical properties of hybrid fiber-reinforced polymer matrix composites:

Investigated the mechanical properties ofrandomly oriented The percentage improvement of tensilestrength after treated with MAPP fibers compositeswas 5.7% compared to untreated fibers composites asshown in Table 2. Similarly the tensile modulus, flexural strength and modulus have been increased to8.3%, 23.5% and 32.3%, respectively. 40investigated the impact properties ofbamboo/GFs-reinforced unsaturated polyester composites with bamboo fiber of 6.2% and GF of 18.8%weight content of 25% total fiber content. The maximum impact strength of 32 kJ/mwas obtained

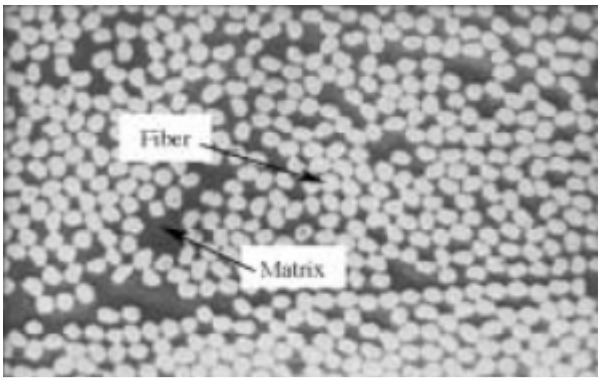


Figure: Micrograph of the cross section of a specimen

Three or more specimens were tested for each group. For FGM rods, two groups were prepared. In the first group, each specimen had the braiding angles changed only once, from 5.2° to 17.2°. In the second group, each specimen's braiding angles was changed twice, from 5.2° to 11.3° and then finally to 17.2°. Although these two groups possessed very simple configurations, it was expected that they would display the mechanical behavior typical of this kind of FGM. The schematic views of configuration of these two groups are shown in Figure 6. By varying the length occupied by each braiding angle, i.e. a or b in the first group, or c, d, or e in the second group, three and four sub-groups were fabricated for the group 1 and the group 2, respectively. For the group 1 for instance, the length occupied by the 5.2° braiding angle was denoted by a and the length occupied by the 17.2° was referred to as b. The a and the b can take each value of 10 mm, 20 mm, and 30 mm with a combination of them equal to the specimen gauge length, i.e. a+b = 40 mm. Similar combinations can be chosen for the c, d, and the e in the second group.

4.0 Functionally Graded Composites:

Functionally graded composite material (FGM) is composed of two different phases in which volume fraction changes gradually along at least one dimension of the solid. Functionally graded Nanocomposite features layer by layer variation in the filler composition and their concentration density profiles in order to realize a designed functionality. Effective design of the various layers in FGM makes minimum heat diffusion through thickness with maximum thermal insulation Functionally graded materials are considered to have smooth spatial variation of microstructure and homogenized material propertiesThis structural variation improves the compressive strength and there is enhancement in the fracture and fatigue strength. Spatial variation of microstructure significantly minimizes the thermal delamination which takes place through the difference in the thermal expansion coefficient of the two materials the distribution of residual thermal stresses is very important in the soundness of FGM composite. the SEM image of the linearly continuous gradient microstructure of carbon-based SiC/C FGM. It signifies that smooth gradient interface in the FGM ensures narrow transition from one material to another and decreases the thermal residual stresses. Developed a composite panel in which the top layer consists of carbon nanotube hybrid carbon phenolic composite and in the bottom layer Zirconium Oxide hybrid C–Ph composite. Presence of the in the composite enhances the flexural and shear strength of the composite, but during charring composite loses its structural integrity due to the improvement in thermal conductivity of the Powder metallurgical approach including plasma spraying method has been widely used in the fabrication of thermal stress relief type of functionally graded materials reported the modeling study of thermal stress in SiC/C functionally graded composite by finite element numerical models and noticed the decrement in thermal stresses with increasing the layer number. The optimum intermediate graded layer and pure SiC layer thickness was 3-4 mm and 0.5–1 mm studied the flexural properties of the carbon Nanofiber/phenolic functionally graded composite by varying the compositional gradient of carbon Nanofiber

and noticed the improvement in flexural properties of FGM.

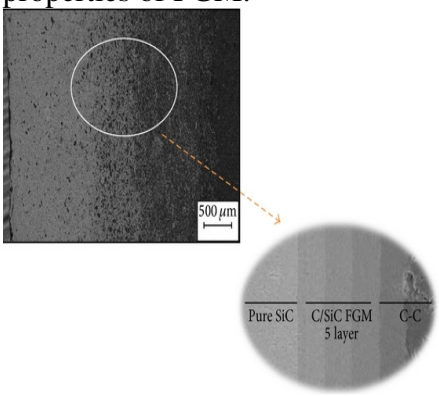


Figure: Micro structure of carbon-based SiC/C FGM and their magnified intermediate transition layers.

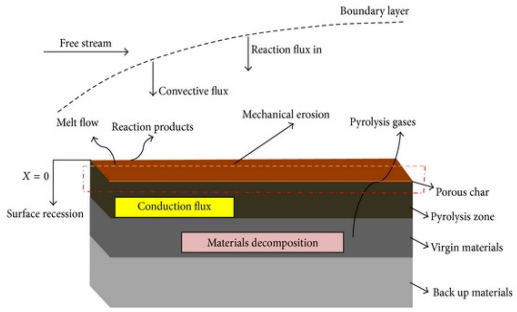


Figure: Pyrolysis mechanism carbon based polymer matrix.

Applications of hybrid polymer composite materials:

The composite solid coneswere developed using the oil palm/coir fiber-reinforcedhybrid composites. the low-cost hybrid bomber-based composites for structural cellular plates were fab-reacted for structural applications the glass/jute fiberreinforced pipe bend was fabricated by.with a cost reduction of 20% and a weight reduction of23% when hemp mat have been used compared to commercial pipe construction The important applications areBuilding and construction industry: panels for partition and false ceiling, partition boards, wall, floor,window and door frames, roof tiles etc.

Failure Mechanism Analysis:

To understand the failure mechanism, the fracture surfaces of both the CBA rods and the FGM rods were examined using a Scanning Electron Microscope (SEM). No significant difference was found between the fracture surfaces of FGM rods and those of CBA rods.A functionally graded material (FGM) was developed using tubular braided carbon fiber fabric reinforced epoxy composites. Investigation of the tensile properties of this developed FGM was carried out experimentally, and the relationship between the tensile properties of the FGM (FGM rods, with varying braiding angles) and that of the corresponding Non-FGM (CBA rods, with constant braiding angle) was realized. A typical SEM photograph was both the fracture and the pullout of fibers were observed on the surface. The failure mechanism can be characterized as extensive rupture of fibers, followed by pullout of some of them. Moreover, the stress-strain curves of FGM rods and CBA rods have also demonstrated a similar feature Therefore, it can be concluded that there is no significant difference between the failure mechanism of the FGM rods and that of the CBA rods.

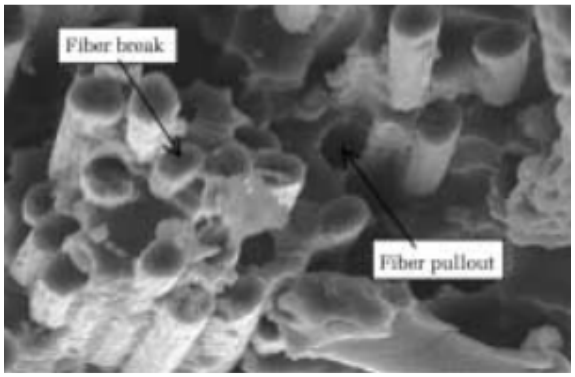


Figure:a typical SEM micrograph of the fracture surface.

Conclusions:

The mechanical, dynamics, tribological, thermal andwater absorption properties of natural fibers and GFreinforced hybrid polymer composites have been dis-cussed. The important applications of these compositesare highlighted.. The randomly, longitudinally and woven mat hybridfiber reinforced polymer composites were preparedby using various manufacturing techniques withvarious fiber volume fraction or weight fractionand fiber length. Also, the composites were preparedwith various chemically treated fibers. Among thosemanufacturing the simple hand lay-up method followed by compression moulding process was used toprepare the composites. Mechanical properties like tensile, flexuraland impact of the hybrid composites were examinedfor various fiber content and fiber length withtreated and untreated fiber. The fibers volume fraction or weight fraction and fiber length wereoptimized. It is also observed that some of the fibers were broken instead of a pullout. Hence the bonding between the silk fibers and the matrix was found to be good.

References:

[1] Zheng-Ming Huang1 , Qiongan Wang(2001) Tensile Behaviour of Functionally Graded Braided Carbon Fibre/ Epoxy Composite Material Vol. 10, No. 4, 2002

[2] Gururaja udupa1,S. ShrikanthaRao(2014) A review of Carbon Nanotube Reinforced Aluminum Composite and Functionally Graded composites as a Future material for Aerospace International OPEN ACCESS Journal Of Modern Engineering Research (IJMER) ISSN: 2249–6645, Issue:7.

[3] Dr A Thimmana Gouda (2014)Characterization and Investigation of Mechanical Properties of Hybrid Natural Fiber Polymer Composite Materials Used As Orthopaedic Implants for Femur Bone Prosthesis IOSR Journal of Mechanical and Civil Engineering ISSN: 2320-334X, Volume 11, Issue 4.

[4] G Venkatachalam , A Gautham Shankar(2015) Evaluation of tensile strength of hybrid fiber (jute/gongura) reinforced hybrid polymer matrix composites" Global Conference on Polymer and Composite Materials.pp:12-49.

[5] D. Amalraju and ShaikDawood (2012) Paper Entitled "Mechanical Strength Evaluation Analysis of Stainless Steel and Titanium Locking Plate for Femur Bone Fracture" IRACST – Engineering Science And Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Volume: 2,

[6] K R Dinesh, Jagadish S P and A Thimmanagouda paper entitled "Characterization and Analysis of Wear Study on Sisal Fibre Reinforcement Epoxy Composite Materials Used As Orthopaedic Implant" international journal of advances in engineering & technology, Jan. 2014. IJAET ISSN: 22311963 vol. 6, issue 6, pp. 2745-2757