Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2016, 3(2): 56-59

Research Article ISSN: 2394 - 658X

Electrical Inserts in Glass Fiber Reinforced Polymer Composite

[1]Baban Parisa Dathwade, [2]Raghu MJ and [3]KR Channakeshava

[1,2]Department of Mechanical Engineering, Bahubali College of Engineeing, Hassan, KA, India
[3]SLV Polytechnic, Hassan, KA, India
baban.pd@gmail.com

ABSTRACT

This paper describes the attempts made in developing a passive smart material by the integration of electrical inserts in the FRP components and studying the electrical & mechanical behavior under different loading conditions. FRPs are fabricated with copper inserts and are tested to study the resistive and capacitive behaviors of prepared specimens. FRP components are also tested for tensile, bending, compression and impact strengths to determine the effect of metal inserts. Prepared smart material is used in the Quadra-copter arms that contain a built-in sensing capabilities as well improved strength to weight ratio.

Key words: FRP, Smart material, Electrical inserts

INTRODUCTION

Fiber-reinforced plastic (FRP) is a composite material made of a polymer matrix reinforced with fibers. The fibers are usually glass, carbon, basalt or aramid. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are used. FRPs always give the feature of high strength to weight ratio. They also possess light, strong and high corrosion resistance properties. FRPs are commonly used in the aerospace, automotive, marine, and construction industries. Smart materials possess the ability to change their physical properties in a specific manner in response to specific stimulus input. Smart materials can be either active or passive. Active smart materials possess the capability to modify their geometric or material properties under the application of electric, thermal or magnetic fields, thereby acquiring an inherent capacity to transducer energy.The smart materials, which are not active, are called passive smart materials fiber optic materials is a good example of passive smart materials. Such materials can act as sensor not as actuators or transducers. This above parameters provided the motivation for the research and development of composite.

Some researchers such as Haertling et al presented various ceramic formulations; their form (bulk, films), fabrication, function (properties), and future are described in relation to their ferroelectric nature and specific areas of application [1]. Goldfine et al demonstrated piezoelectric smart materials using shape memory alloys (SHA) and piezoelectric smart materials can be used for force measurements. Arrays of small inductive coils, placed throughout the shaped field, sense the response from conducting or magnetic unexploded ordnance (UXO) and clutter. To help address the need for a field able detection and clutter suppression capability, high resolution inductive arrays are being developed for UXO imaging [2]. Schlicker et al shows the inductive and capacitive sensor capabilities and arrays are used for imaging of buried objects. These sensor arrays use unique designs incorporating a single drive with multiple sense elements [3]. Kon et al depicts both piezoresistive and piezoelectric materials are commonly used to detect strain caused by s tructural vibrations in macro-scale structures. Piezoresistor geometries are optimized to effectively increase the gage factor of piezoresistive sensors while reducing sensor size. The MEMS strain sensors are capable of high sensitivity measurements, subject to differing constraints [4]. Wang et al, the smart FRP-OFBG composite laminates Fabrication and sensing Properties and the OFBG sensors are embedded successfully for measuring strain & temperature [5].

Fuchs et al., a measurement principle for online moisture determination of wood pellets that is based on capacitive sensing. Conclusion is the test boxes are developed using capacitive sensor for detecting moisture in wood [6]. Florian Schiedeck et al., this work investigates and describes the use of super elastic shape memory alloys (SMAs) for pre-stressing piezoelectric actuators. The piezo electric smart materials can be used for force measurements [7]. Lu et al, sensing and actuating capabilities of SHA polymer composite integrated with hybrid filler. Shape memory polymer composite smart materials are developed for many potential applications [8]. Sharma et al, Non Destructive Testing (NDT) of materials using capacitive sensing technique, concluded that voids in FRP materials can be detected using capacitive sensing [9]. From literature survey it is learnt that potential work has been carried out in developing passive smart materials, but sensing capabilities of these are limited to some critical positions only. It suggests that by selecting proper reinforcements in FRP composites, mechanical strength as well as sensing capabilities of smart FRPs is increased considerably.

Proposed paper aims at integrating mechanical properties of FRP composites with electrical properties of metal inserts. The synergetic integration of these two leads to the passive smart materials having robust structure with in-built sensing capabilities.

MATERIALS AND METHODS

Fiber Material

In FRP material, fiber is used as reinforcement material. In present research work, glass wool is taken as the reinforcement and combined with epoxy matrix. Glass wool is non combustible, non-toxic and resistant to corrosion. It has low weight by volume, low thermal conductivity, stable chemical property and low moisture absorption rate. It is having different thermal and mechanical properties. Glass wool is the best insulating material against noise, cold and heat and excellent fire resistant properties. Barium carbonate, calcium carbonate, magnesium carbonate, arsenic oxide and sodium carbonate these are the raw materials. Nylon and polysulfone are preparation products are used as chemical properties of glass wool. Mixing the raw material and melting them to form glass, forming fibers and finishing the production using these three steps glass wool is manufacturing. Glass wool is used in fixed wing aircraft, helicopters, cavity wall insulation, ceiling tiles and also used insulating piping and soundproofing.

Matrix Material

In fabrication of composite materials the matrix material plays an important role. The different types of matrix materials, polymer matrices are the most commonly used because ease to fabricate the complex parts with less tooling cost and also have excellent room temperature properties. Epoxy, vinyl ester, polyester and phenolics are the most commonly used thermoplastic resins. Among them, epoxy resins have many advantages such as good performance at different temperatures, excellent bonding nature with variety of fibers and superior electrical and mechanical properties. It is also have low shrinkage up on curing and good chemical resistance. Above mentioned thermoplastic polymers in that epoxy (LY 556) having several advantages and it is chosen as excellent matrix material for the present research work. Common name of epoxy is Bisphenol-A-Diglycidyl-Ether.

Electrical Inserts

Electrical inserts are work as a particulate filler material and improves the mechanical properties of FRPs. various types of electrical inserts are used as filler materials in FRP materials. Among them thin sheets of copper, aluminum foil, copper wires, brass strips etc. are commonly used. Copper thin sheets are having good mechanical strengths, light weight, low cost and good physical properties. The FRP materials without copper thin sheets have only mechanical properties. A systematic integration of thin copper sheet in a FRP material not only increases the mechanical properties, but also gives sensing capabilities to the structure.

Specimen Preparation

Various types of FRP fabrication techniques are used for integration of inserts with FRPs. In present work, open mould technique is used. After layup, each mould is cured in room temperature for 24 hours. Moulds are prepared by using PVC material. Cellophane tape is used for covering mould. Specimens are prepared for mechanical testing as per ASTM standard. Fiber volume ratio is maintained in the mould by using precision measuring instruments. Table-1 shows the mixing ratio and the properties of the mix. Table-2 shows the designation of the composite with electrical inserts.

Table-1The Properties of the Mix

a. Mixing ratio

Epoxy LY 556	10 parts by weight
Hardener HY 951	01 parts by weight

b. Properties of the mix		
Viscosity	at 25^0C	1700mPa-s
Gel time	at 25^0C	40-50 minutes

Table-2The Designation of the Composite with Electrical Inserts

Composites	**Compositions**
Bending Specimen	Epoxy (60grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)
Compression Specimen	Epoxy (25grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)
Impact Specimen	Epoxy (40grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)
Tensile Specimen	Epoxy (50grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)

RESULTS AND DISSCUSSION

Characterization of the Composites (Mechanical Strengths)

The bending, compression, impact and tensile tests are performed on prepared specimens. The Fig.-1 & Fig. 2 shows the specimens with electrical inserts before and after testing. As per ASTM standard recommendations, the specimens are tested with fibers and electrical inserts parallel and perpendicular to the loading directions. Table-3 shows the five samples sizes prepared for mechanical testing as per ASTM 638, 256 test standards.

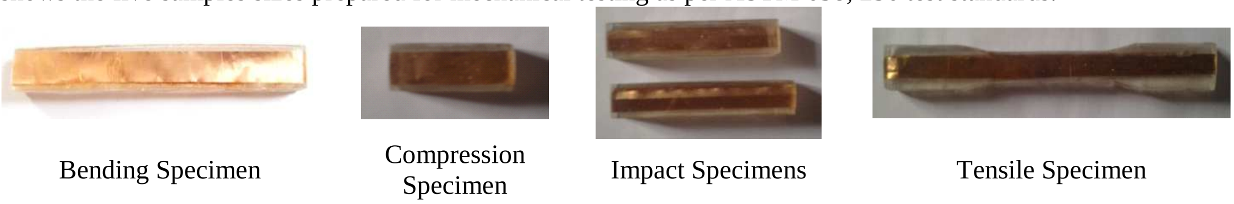


Fig. 1The flat specimens with electrical inserts before testing

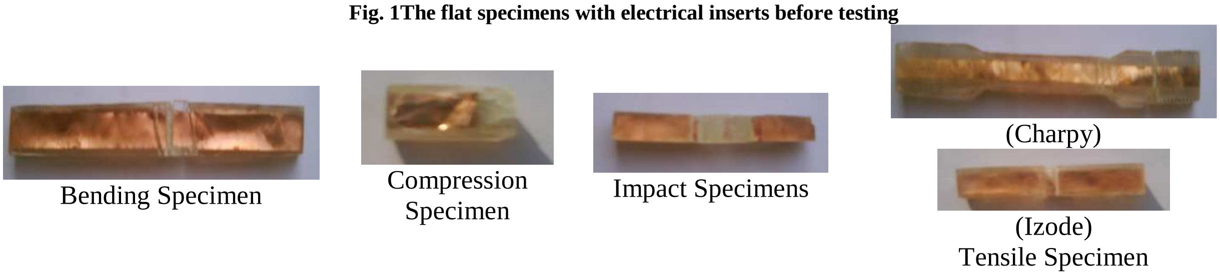


Fig. 2The flat specimens with electrical inserts after testing

The mechanical strengths of the composites for glass fiber reinforced epoxy with electrical inserts are shown in Table-4. The results are promising as they yielded better results compared to the specimens prepared without electrical inserts. Mechanical properties are comparable with the Mild steel.

Table-3The Specimen Dimensions as per ASTM Standards

Composites	Dimensions as per ASTM standards
Bending Specimen	165mm X 19mm X 10mm (ASTM 638)
Compression Specimen	25mm X 14mm X 14mm (ASTM 638)
Impact Specimen	
Izode	60mm X 10mm X 10 mm (ASTM 256)
Charpy	60mm X 10mm X 10 mm (ASTM 256)
Tensile Specimen	{[165mm X 19mm] – [(55mm X 13mm) + R17]} X 10mm (ASTM 638)

Table-4 The Mechanical Strengths of the Composites for Glass Fiber Reinforced Epoxy with Electrical Inserts

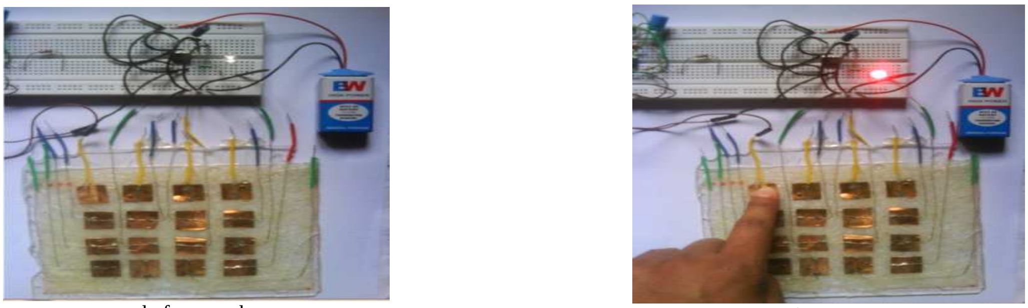
Name of Tests	Compositions	Mechanical Strengths
Bending Specimen	Epoxy (60grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)	120 Kg/ mm^2
Compression Specimen	Epoxy (25grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)	1375 Kg/ mm^2
Impact Specimen	Epoxy (40grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)	
Izode		0.025 J/ mm^2
Charpy		0.028J/ mm^2
Tensile Specimen	Epoxy (50grm) +Glass Fiber (25wt %) +Copper Thin Sheet (25%)	370 Kg/ mm^2

Study of Sensing Capability

Prepared specimens are tested to verify the sensing capability of the material. The inserts in the specimens are arranged in a suitable pattern to achieve mechanical strength as well as sensing capabilities. Fig.-3 shows one of the arrangements to check the touch sensing capabilities of the materials. In this inserts are embedded in the FRP material in the matrix form. FRP material is connected with the electronics circuit that will process and display the sensed information. Electronic circuit contains microcontroller, which will check the sensory circuit in every scanning cycle and display the output according to the touch input.

Application

FRP materials integrated with metal inserts are used for developing Quadra-copter arms. In Quadra-copter development, weight reduction and the electrical wiring is a key requirement. The copper reinforced FRP arms are developed for the Quadra-copter. These arms have 20% more strength to weight ratio than the traditional plastic arms. The copper inserts are used to monitor the arm deflection during quadra-copter's flight. The embedded copper inserts inside the FRP will also make path for electrical connections. Fig. 4a & 4b shows the Quadra-copter with plastic arms and developed Quadra-copter arms.



before touch after touch

Fig.3 The specimen with electrical insert working as capacitive touch sensor

actual Quadra-copter arm Developed Quadra -copter arm

Fig. 4The actual quadra-copter arm and smart material quadra-copter arm

CONCLUSION

Copper metal strips are successfully reinforced inside the FRP composite by using hand layup technique. Mechanical test results shows that the copper inserts increase the material strength. The Quadra-copter arms are effectively fabricated using copper reinforced FRP material. This resulted in weight reduction, ease of wiring and deflection sensing capabilities of the arm.

Acknowledgement
This work was created in the context of the 'Sensing Capabilities of Fiber Reinforced Polymer Composite Integrated with Electrical Inserts'. We would like to thank Professor T Rangswamy, Dr. Govardhangoud and my friends for their kind help.

REFERENCES

[1] Gene H Haertling, Ferroelectric Ceramics: History and Technology, *Journal of American Ceramic Society*, **1999**, 82 (4), 797-818.
[2] Neil Goldfine, High-Resolution Inductive Sensor Arrays for UXO Detection, Identification, and Clutter Suppression, *SPIE Aero Sense*, **2003**, 5089, 01-12.
[3] D Schlicker, Inductive and Capacitive Array Imaging of Buried Objects, *16th World Conference on Nondestructive Testing Montreal*, Canada, **2004**.
[4] Stanley Kon, Kenn Oldham and Roberto Horowitz, Piezoresistive and Piezoelectric MEMS Strain Sensors for Vibration Detection, *Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems*, SPIE, **2007,** 6529.
[5] Yanlei Wang, Zhi Zhou and Jinping Oab, Study on Fabrication of Smart FRP-OFBG Composite Laminates and their Sensing Properties, *Proc. of SPIE*, **2007**, 6595, 65952W-1.
[6] Anton Fuchs, Michael J Moser and Hubert Zangl, Using Capacitive Sensing to Determine the Moisture Content of Wood Pellets – Investigations and Application, *International Journal on Smart Sensing and Intelligent Systems*, **2009**, 2(2), 293-308.
[7] Florian Schiedeck, Sebastian Mojrzisch and JörgWallaschek, Pre-Stressing Piezoelectric Actuators by using Super Elastic Shape Memory Alloys, *Journal of the Korean Physical Society*, **2010**, 57 (4), 889-891.
[8] Haibao Lu, Kai Yu, Yanju Liu and Jinsong Leng, Sensing and Actuating Capabilities of a Shape Memory Polymer Composite Integrated with Hybrid Filler, *IOP Publishing Smart Materials and Structures, Smart Material Structure*, **2010**,19, 065014 (7pages).
[9] Devinder Sharma, Swetha Goyal, Rajesh Khanna, Abhijith Mukharji, Non Destructive Testing (NDT) of Materials using Capacitive Sensing Technique, *MIT International Journal of Electronics and Communication Engineering*, **2011**, 1(2), 73-77.