STUDY ON THE MECHANICAL PROPERTIES OF GLASS FIBER REINFORCED HOLLOW GLASS MICROSPHERE EPOXY LAMINATED COMPOSITE

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ABSTRACT

This work presents the effects of hollow glass microsphere fillers on the mechanical behavior of glass fiber reinforced epoxy binding matrix composites. Properties like flexural stiffness, tensile strength, and scanning electron microscope, will be studied .The mechanical properties of glass fiber reinforced epoxy-resin/hollow glass-microsphere composites can be suitably tailored by using microspheres with different weight fractions. Because HGM have high specific compressive strength, low density, low moisture absorption and high thermal stability, it is mixed in glass fiber – epoxy mixture to get some useful properties which are highly useful in marine applications. Finite element analysis will be carried out on glass fiber reinforced HGM epoxy composite by ANSYS to measure up deviation between analytical and experimental result.

Keywords: Glass Fiber, Hollow Glass Microsphere (HGM), Epoxy, Tensile Testing, Flexural Testing, Scanning Electron Microscope,FEA-ANSYS

INTRODUCTION

Composite materials containing glass fibers are widely used in applications ranging from aerospace to marine applications. Hollow glass microspheres (HGM) are introduced in the epoxy matrix because of having lesser density as compared to epoxy which results in light weight product.HGM have outer stiff layer and having inert gas in cavity which results in some unique properties. Sarah et al [1] in their work have cited the experimental results of internal damage due to impulse events such impact or shock may not be detected by visual inspection in composite structures. This internal damage can cause catastrophic failure. Young et al [2] have investigated the effects of HGM content descriptions of the fonts, spacing, and related information for producing your proceedings manuscripts effect of the diameters of hollow glass microsphere on the mechanical properties of the HGM – Epoxy composites. The mechanical properties of epoxy-resin/glass-microsphere composites can be suitably tailored by using microspheres with different diameters. Kim et al [4] have shown the fracture and impact behavior HGM –Epoxy composite on the performance of brominated epoxy -matrix composites. The results show that the properties of composites monotonically varied with HGM content. Compared with neat epoxy, the CTE, D_k, D_f, and thermal conductivity of 51.3 vol.% HGM-filled composites decrease by 54.3%, 28.6%, 44%, and 13.3%, respectively, Almeida [3] has analyzed the. Fracture and impact behavior of HGM-Epoxy composites are studied in terms of fracture toughness fractography, flexural properties and impact forces.volume fraction of microsphere are varied up to 0.65. Ariff et al [7] in their work study Compressive Behavior of Syntactic Foam Filled with Epoxy Hollow Spheres Having Different Wall Thickness. Increase in the density and compressive strength of syntactic foams can be achieved by incorporating hollow spheres with different shell wall thickness into the syntactic foam system. The aims of this study are (a) to fabricate glass fiber reinforced laminated composites using HGM-epoxy resin and (b) to compare the mechanical properties of glass fiber reinforced epoxy laminated composites and glass fiber reinforced HGM-epoxy laminated nanocomposites.

EXPERIMENTAL

A. MaterialSystem

The Hollow Glass Microsphere (HGMs) were supplied by SRL Nano Materials. The manufacturer specified dimensions, diameter (l) ~60-100 µm. Bidirectional (BD) glass fiber has been used as reinforcing material in this study.

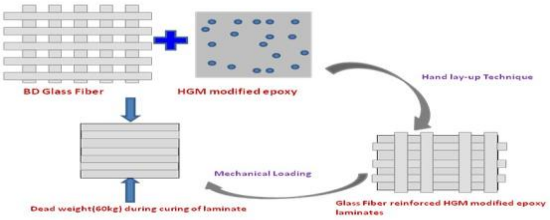
Bidirectional (BD) glass fibers from Pearl Industries, New Delhi., have been used as reinforcing material. The surface density of the fabric was 200 g/m2 and its thickness is 0.15 mm. Average diameter of the fibers is estimated to 20 µm. Epoxy resin Araldite LY556 and the compatible hardener (HY917) used as the matrix were obtained from Ciba Specialty Chemicals.

Preparation Step 1:Dispersion

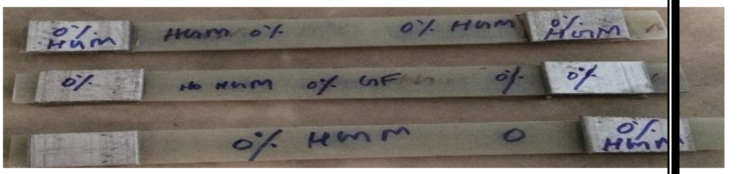
In the first step, the HGMs were added into the epoxy in such a way that the final material was 5.0wt%, 10wt%, 15wt% of HGMs contents by wt% of resin in epoxy. Next, this mixture was mixing by using glass rod for 15 minutes at room temperature and then the mixture is kept in oven for one hour to eliminate any air bubble. After this step, the required amount of hardener was added into the mixture (ratio of 10:1 by weight). It was thoroughly mixed by glass rod for 15 minutes at room temperature to make a homogeneous mixture.

Step 2: Lamination and Curing

Below fig shows the schematic of the preparation of glass fiber reinforced HGM modified epoxy composite. Two different material configurations designated as GFE (Glass fiber reinforced Epoxy Composite) and GFHE (Glass fiber reinforced HGM-Epoxy composite) were considered. Material GFE is made of epoxy resin and glass fiber, whereas, material GFHE is made of HGM-epoxy resin mixture and glass fiber with classical processing. The hand lay-up technique was used for the preparation of laminated composite. The epoxy resin and the curing agent were taken in the ratio of 10:1 by wt% in a beaker and mixed thoroughly until a clear homogeneous viscous liquid was obtained. Twelve layers of fabric were impregnated with epoxy resin and placed in a mold. The laminates were fabricated by using conventional compression molding at a constant dead weight of 60kg. The mold removed from the mold and placed in an oven for 5 hrs at 50°C for post curing. Five specimens of each series were prepared was kept under dead weight (60) for 4 hrs at room temperature to obtain a cured laminate. The cured samplewas



(a)



(b)

Fig 1:(a) Flow chart for fabrication and (b) Prepared specimens as per ASTM standard

RESULTS AND DISCUSSION

- **TensileTest:**

Tensile test is performed on the INSTRON machine by applying gradually increasing load. The specimen is clamped at the extreme ends, one end is kept fix and load is applied from the other end of specimen. Two specimen of each type are prepared to test the tensile properties of our specimen. The tensile elastic modulus of glass fiber-epoxy laminate with HGMs is lower than that of glass fiber epoxy laminate and it decreases continuously as the HGMs contents increases in epoxy matrix. The tensile modulus and stress to failure of the glass fiber-epoxy laminate is varied according to the contents of HGMs presents in epoxy matrix. Maximum tensile bearing load is decreases as the amount of HGMs contents increases in the specimen. Young's modulus, stress to failure and strain to failure are listed in Table-1. It is worth mentioning that the deformation in presence of HGMs is very slow compared to the pure glass fiber-epoxy laminates.

Table 1: Tensile Property of Specimen

Mechanical properties	*O% HGM*	*5% HGM*	*10% HGM*	*15% HGM*
Tensile stress (MPa)	*328.77*	*291.92*	*269.31*	*184.07*
Tensile strain	*3.722*	*3.009*	*2.642*	*3.415*
Max load (N)	*8394*	*7417*	*6147*	*4506*
Modulus (MPa)	*16759*	*15665*	*13217*	*11045*

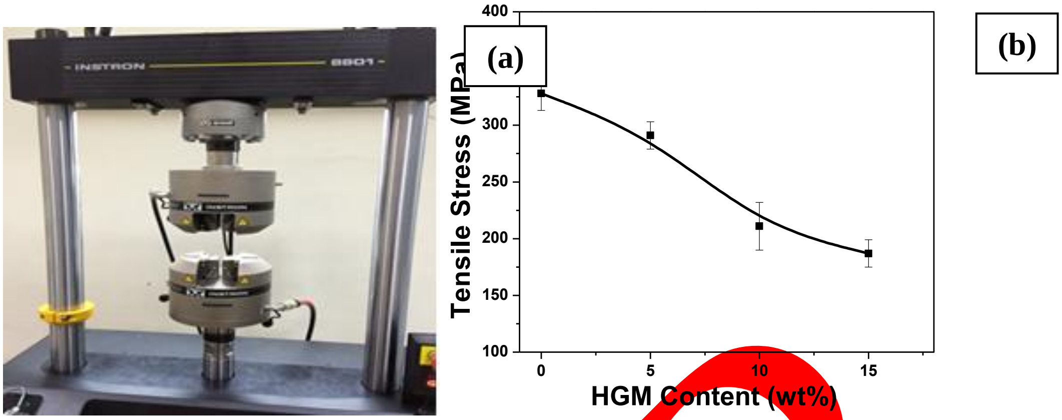


Fig 2 : (a) Tensile test setup (b) tensile strength variation with percentage of HGM content

FLEXURALTEST

Flexural test is carried out by using INSTRON machine, it is a three point bending test in which we calculate flexural stiffness, max deflection and max bending stress.Two specimen of each type are prepared to test the flexural properties of our specimen. The flexural modulus of glass fiber-epoxy laminate with HGMs is greater than that of glass fiber epoxy laminate and it increases continuously as the HGMs contents increases in epoxy matrix.The maximum load and stress to failure of the glass fiber-epoxy laminate is varied according to the contents of HGMs presents in epoxy matrix. Flexural Young's modulus, stress to failure and strain to failure are listed in Table-2. It is important to note that the deflection at the midpoint of specimen in presence of HGMs contents is very less as compared to the pure glass fiber-epoxy laminates.

Table 2: Flexural Property of specimen

Flexural properties	*0% HGM*	*5% HGM*	*10% HGM*	*15% HGM*
Max Flexural Stress(MPa)	*453*	*498*	*541*	*586*
Max deflection(mm)	*25.1*	*22.91*	*21.787*	*20.53*
Maximum load(N)	*120.5*	*132.32*	*143.05*	*156.76*
Modulus(MPa)	*29785*	*39894.5*	*40731.4*	*48251.5*

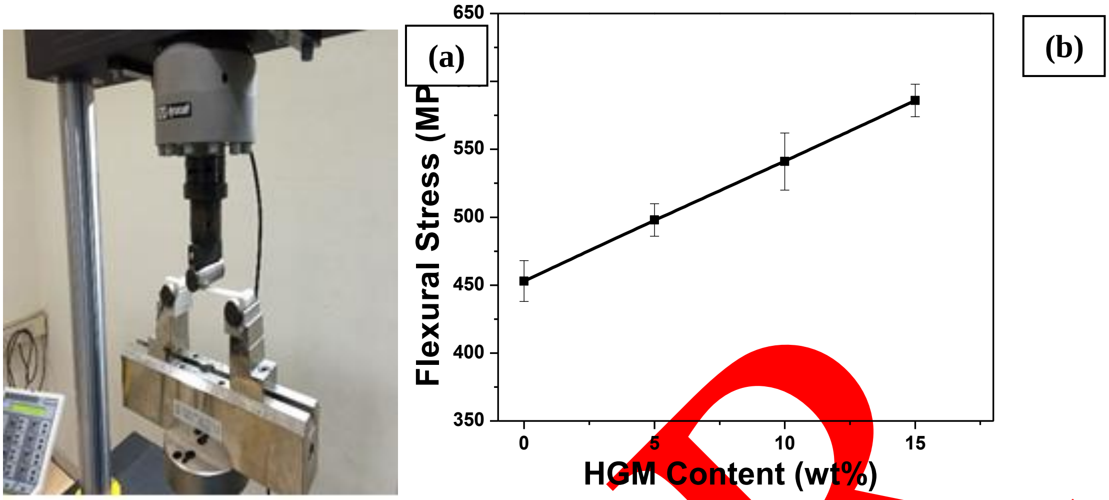


Fig 3 :(a) Flexural test setup (b) flexural strength with the variation of HGM content

SEM ANALYSIS

The SEM of the fractured surfaces of the glass fiber reinforced HGM-epoxy composite has been done to investigate the HGM-epoxy interaction and the microstructural changes involved on the incorporation of the HGM into the epoxy matrix. From the micrograph of the fractured surface of the glass fiber/epoxy specimen (**Fig 4(a)**), it has been observed that the fracture is brittle in nature. There is smoothness in the fractured surface with very little roughness.

The SEM micrographs of the GF_{CE} composite reveal that HGM have the good contact with the glass fiber and matrix, which shows a good interaction among HGM/epoxy matrix (**Fig 4 (b)**). With introducing HGM content there is a remarkable difference in the surface morphology of the fractured surface. The smoothness of the fractured surface goes on increasing in presence of HGMs suggesting a brittle to ductile transformation in the composite material.

(a) (b)

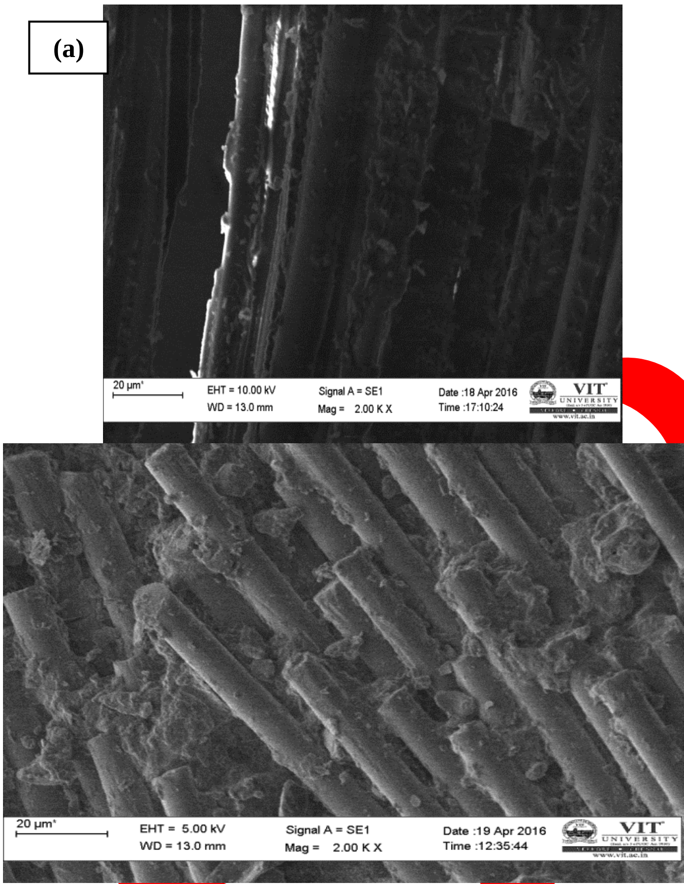


Fig 4. SEM micrographs of fractured samples (a) glass fiber/epoxy and (b) glass fiber/HGM/epoxymaterial

CONCLUSION

The testing of mechanical properties of the glass fiber reinforced HGM-epoxy laminated composite specimen shows that as the quantity of HGM contents in the specimen varies, the mechanical properties like tensile properties, flexural properties also varies. As we increase the HGM contents in the glass fiber reinforced epoxy composite the density of material is reduced to some extent but at the time the mechanical properties like tensile strength is reduced so we have to take care while adding the HGM contents in the specimen. This material may be useful in marine industries because of its better strength to weight ratio, good corrosion resistance, less thermal conductivity and less water absorption etc.

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