MECHANICAL BEHAVIOUR OF E-GLASS FIBER REINFORCED WITH EPOXY COMPOSITES

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ABSTRACT

In today's modern age various demands, and various application of advance composite like E-Glass Fibre reinforced polymer and composites, it have been used in a various application like automotive, sports, ships and aerospace work. In this research work, an investigation was made on the mechanical properties of E-glass fiber reinforced epoxy composites filled by various filler materials. the mechanical properties such as ultimate tensile strength, impact strength and hardness of the fabricated composites were studied.

Keywords: *Composites; Fillers; Mechanical; Properties; Strength*

1. INTRODUCTION

Polymers have replaced many of the conventional metals/materials in various applications. This is possible because of the advantages such as ease of processing, productivity, cost reduction, etc. offered by polymers over conventional materials. In most of these applications, the properties of polymers are modified by using fibers to suit the high strength/high modulus requirements. The high performance of continuous fiber (e.g. carbon fiber, glass fiber) reinforced polymer matrix composites is well known and documented [1].

In composite materials there are two constituents one is matrix and other is reinforcement. The constituents which is continuous and present in greater quantity is called matrix. The main functions of the matrix is to holds or bind the fibre together, distribute the load evenly between the fibres, protect the fibre from mechanical and environmental damage and also carry inter-laminar shear. While the other constituent is reinforcement; its primary objective is to enhance the mechanical properties e.g. stiffness, strength etc.

The main elements of polymer matrix composite are resin (matrix), reinforcement (e.g. fibre, particulate, whiskers), and the interface between them. The present work deals with the fibre reinforced polymer. FRP's offers significant advantages, like combination of light weight and high strength to weight ratio and it is way easy to fabricate which is better than many metallic components [2].

The fibrous composites, especially glass fiber–reinforced epoxy composites in which glass fiber is the primary load carrying element, are being increasingly used in military and aerospace applications owing to several desirable properties including high specific strength, high specific stiffness, and controlled anisotropy. The mechanical properties of composites are most important, because they can be influenced by parameters such as type of filler, type of matrix, filler concentration, filler dispersion, alignment of fibers, length of fibers, aspect ratio of fibers, the fiber matrix inter phase properties or adhesion between fiber and resin matrix. Glass fiber reinforcement can be of several types, such as rovings, mats, woven fabric, hybrid fibers, multiaxial fabrics, and the most important and widely used short glass fibers.

2. LITERATURE SURVEY

Recent results published by Yang and Thomason [3] provided further evidence of this fibre structural relaxation phenomenon by investigation of the thermo-mechanical properties of single boron-free E-glass fibres. Using a thermo-mechanical analyser, fibre length changes were monitored, and in situ measurement of the fibres Young's modulus was performed. Aslanova et al. [4] published experimental data on GF of numerous compositions and at many diameters, which were tested using a low frequency torsion pendulum under vacuum and over a range of temperatures. Changes with temperature in both internal friction and shear modulus were reported, and numerous explanations were suggested for various observed effects. Particularly interesting comments on the behaviour of an aluminoboro silicate glass were made: with increasing temperature, its relative shear modulus initially decreased, but at around 300 ˝C, a turning point occurred, and it started to increase again. Gy [5] and Varshneya [6] discussed ion exchange as a method by which glasses may be strengthened, in a similar way to tempering. However, unlike tempering, which is applicable to massive glass with large internal stresses and potentially flaws on the millimetre scale, ion exchange can potentially deliver a strengthening effect to fine glass fibres. When considering the movement of ions through the glass network, one must have an idea of the appearance of the network structure and its chemical makeup. In general terms, by its nature, the structure of E-glass is vitreous and disordered, and the main component is silicon dioxide. However, there are also significant concentrations of compounds whose metallic ions have valences of two or three [7].

3. FABRICATION OF COMPOSITE MATERIAL

For Mechanical Testing: In the present work, short glass fibre is taken as reinforcing agent. The epoxy resin (LY-556), hardener (HY- 917) and Alumina (Al2O3) is used as a filler material, having particle size in the range of 80-100 pm. The short E-glass fibre mixed with epoxy resin and hardener in the ratio of 10:1 by weight with and without use of alumina filler. Then combined mixture is carefully mechanically stirred and poured into different moulds using hand lay-up technique. A mould releasing sheet is used for the easy removal of composites from the mould. The cast is allowed to cure under a load of 20 kg at room temperature 270C for 24 h. By varying weight percentage of E-glass fibre different composite samples are made (EG-1 to EG-4) with no use of filler material. Other composite samples with varying fibre loading and 5% of alumina (EGA-1 to EGA-3) are also prepared. After curing, samples were cut to the desired dimensions for different mechanical test.

For Wear Test Measurement: In case of wear test, the samples are prepared using syringe needle of 2.5 ml volume, of circular cross-section having diameter of 10 mm and 50 mm length. The fibre and filler percentage of the composites, curing temperature and duration remains same as before.

Mechanical Property Testing: Mechanical properties of composites were evaluated by tensile, impact and hardness measurements. Tensile, impact and hardness tests were carried out using Universal testing machine, impact machine and hardness testing machine respectively. Three identical samples were tested for tensile strength, impact strength and hardness.

Ultimate Tensile Strength Tensile tests were examined according to ASTM D3039 using a universal testing machine at room temperature. Test specimens having dimension of length 250 mm, width of 25 mm and thickness of 2.5 mm. The specimen was loaded between two manually adjustable grips of a 60 KN computerized universal testing machine (UTM) with an electronic extensometer. Test was repeated thrice and the average value was taken to calculate the tensile strength of the composites.

Details of Universal Testing Machine Universal testing machine is a Micro Control Systems make and model MCS-UTE60 and software used is MCSUTE STDW2KXP. System uses add-on cards for data acquisition with high precision and fast analog to digital converter for pressure/Load cell processing and rotary encoder with 0.1 or 0.01 mm for measuring cross head displacement (RAM stroke). These cards are fitted on to slots provided on PC's motherboard WINDOW9X based software is designed to fulfill nearly all the testing requirements. MCS make electronic extensometer is used with an extremely accurate strain sensor for measuring the strain of the tensile samples.

Impact Strength The Charpy impact strength was carried out on composites in accordance with ASTM E23 using impact testing machine. The dimensions of the specimens were 10 mm × 10 mm × 55 mm size on one side surface of the specimen a V-notch have been made at an angle of 45˚ with root depth of 2 mm. Test was repeated thrice and the average values were taken for calculating the impact strength.

4. Results and Discussion

Results obtained from this experimental work are presented . Mechanical properties of fiber-reinforced epoxy composites are depending on the properties of the constituent materials (type, quantity, fiber distribution and orientation, void content). Beside those properties, the nature of the interfacial bonds and the mechanisms of load transfer at the inter phase also play an important role.

4.1. Ultimate Tensile Strength

The tensile strength of the E-glass fiber reinforced epoxy composites depends upon the strength and modulus of the fibers, strength and chemical stability of the matrix, fiber matrix interaction and fiber length From the obtained results it was observed that composite filled by 10% Volume Mg(OH)2 exhibited maximum ultimate strength of 375.36 MPa when compared with other filled composites but lower than the un filled composite . This may be due to good particle dispersion and strong polymer/filler interface adhesion for effective stress transfer. Composites filled by Al2O3 exhibited better ultimate tensile strength compared with composites filled by fly ash and hematite this is due to that Al2O3 having the ceramic particles these particles distributed uniformly throughout the composites and produces good bonding strength between polymer, filler and fiber. But increase in addition of Mg(OH)2, Al2O3 and fly ash content up to 15% volume to the composites the tensile strengths is found to be less this is due to more filler material in the composites damages matrix continuity, less volume of fiber and more void formation in the composites. Ultimate tensile strength increases with increase in addition of hematite to composites this may be due to improved in inter facial bonding strength between filler, matrix and fiber.

4.2. Impact Strength

Impact strength is defined as the ability of a material to resist the fracture under stress applied at high speed. The impact properties of composite materials are directly related to overall toughness and composite fracture toughness is affected by inter laminar and interfacial strength parameters. it is observed that composite filled by 10% volume fly ash having high impact strength when compared with other filled composites this is due to that good bonding strength between filler, matrix, fiber and flexibility of the interface molecular chain resulting in absorbs and disperses the more energy, and prevents the cracks initiator effectively. But there was reduction in impact resistance as the fly ash content increases which might be because of formation of additional voids and this void increases the crack propagation. Impact strength decreases when increase in addition of Al2O3 and Mg(OH)2 to composites. Typically, a polymer matrix with high loading of fillers has less ability to absorb impact energy this is because the fillers disturb matrix continuity and each fillers is a site of stress concentration, which can act as a micro crack initiator and reduces the adhesion and energy absorption capacity of composites. Test results show that impact strength increases with adding more hematite powder to composites this due to improvement of bonding strength between filler and matrix and rigidity of filler particles absorbs the more energy.

5. CONCLUSIONS

Based upon the test results obtained from the various tests carried out, following conclusions were made: 1) From the obtained results, it was observed that composite filled by 10% volume of Mg(OH)2 exhibited maximum ultimate strength of 375.36 MPa when compared with other filled composites. Composites filled by Al2O3 exhibited better ultimate strength compared with composites filled by fly ash and hematite. Increase in addition of Mg(OH)2, Al2O3 and fly ash to composites leads to decrease in ultimate tensile strength. 2) Experimental results show that composites were filled by 10% volume of fly ash having high impact strength when compared with other filled composites. Composites filled by 10% volume Al2O3 and Mg(OH)2 exhibited good impact strength but increase in addition of Al2O3 and Mg(OH)2 leads to decrease in impact strength. Test results indicated that impact strength increases with adding more hematite powder to composites. 3) The experimental results indicated that composite filled by Mg (OH)2 exhibited maximum hardness number 88.69 BHN when compared with other filled composites. From the results, it is observed that increase in addition of Al2O3 and hematite to composites increases the hardness of the composites. Increase in addition of fly ash to composites leads to decrease in hardness number.

6. REFERENCES

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