Comparative study on Mechanical properties of E-glass / Epoxy laminates filled with Silicon carbide, Activated charcoal and Mica

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Abstract - In this experimental work, a systematic examination was made on the mechanical properties such as tensile, impact, shore D - hardness test on E-Glass fibre reinforced composites consisting of epoxy resin and necessary filler materials composites filled with varying concentration of silicon carbide, activated charcoal and mica. The fabricated materials were made in the form of rectangular plate which was cut into corresponding profiles as per ASTM standards and fabricated it by hand lay-up method, then with the help of testing results mechanical properties were studied. Composites filled with activated charcoal exhibits maximum tensile strength and maximum hardness number. Composites filled with mica exhibits maximum impact strength.

Key Words: Composite material, E-Glass fibre, Fillers, Hand lay-up method.

1. INTRODUCTION

Over the last thirty years composite materials have been used in various engineering fields due to its high strength and weight ratio, and due to these facts, composite materials are becoming popular among researchers, scientists and engineers. The major portion of engineering materials consists of composite materials. It is used in vast applications ranging from day-to-day household articles to automobile field [1]. The composite materials are applied in automotive field which include such as dashboard, roof, floor, front & back bumper, A-pillar [2]. Epoxy resin is the most commonly used matrix for advanced composites due to its desired properties like thermal, mechanical and electrical properties, dimensional stability and chemical resistances etc. Fibres or particles which are attached in matrix of another material are the best example of modern-day composite materials [3]. However, these matrices have some restricted dominant properties which affect the applications than also it is being used. In this Present work, a comparative study was made on E-Glass fibre reinforced composites. The properties of fibre reinforced composites are characterised by its region between fibre and matrix. E - Glass fibre with epoxy resin and required filler materials such as silicon carbide, activated charcoal and mica which gives the better life to the product. The behaviour of glass fibre reinforced composites depends on the material nature and mechanism where it is applied. If these are the limitations compared to other fibres, it includes low thermal and electrical conductivity, perhaps melting temperature condition too so glass fibre is preferred.

2. MATERIAL AND FABRICATION

2.1 MATERIALS

Glass is derived from one of the most abundant natural resources sand. It is the typical glass composites of grade E-glass of calcium Alumino - Borosilica composition. The chemical composition of E-Glass fibre is 55% of SiO_2, 16% of CaO, 15% of Al_2O_3, 10% of B_2O_3 and 4% of MgO. Fibre glass is extremely flexible and can be made into threads. It is fireproof with a density of 2.59 g/cm3 and tensile strength of 34,540 MPa. Activated charcoal, silicon carbide and mica are used as filler materials. Activated Charcoal is a highly porous and brittle material and its properties are characteristics by the carbonization process. It is made from coconut shells and is the purest source. The density of charcoal is in the range of 180 - 220 kg/m^3. Silicon Carbide is chemical compound of carbon and silicon which is produced by electro-chemical reaction of sand and carbon. The percentage weight of silicon carbide is 70% of SiC and 29.94% of C. Mica is a naturally occurring stone which contains the set of minerals where silica in its highest form. This mineral is mostly used in combined compound where it acts as wadding and prevents cracking. LY556 epoxy had been used as matrix material for reinforced composites with hardener HY951.

2.2 FABRICATION OF COMPOSITIES

Hand-layup technique is used for the manufacture of the composite material. First of all, for each laminate nearly 400 g of epoxy-hardener mixture is taken. Hardener is taken in the form of every 10 g of epoxy 1 g of hardener is added. Then the mixture is thoroughly mixed for some time. Arelease gel is sprayed on the board surface with thickness of 0.06 to 0.1 mm. It is done in order to avoid the sticking of epoxy to the surface. Thin plastic sheets are used over the top and bottom portion of the plate to get a better surface finish of the product [4].]. E-Glass fibres are cut as per the ASTM dimensions and placed on the flat board. The mixture of epoxy and hardener with necessary fillers are added and coating is done using brush and one layer is placed. Then Coating is given continuously between four consecutive layers as per the recommend procedure and finally, after the fourth layer mica is placed. Entrapped air is removed manually with help of roller to complete the laminate structure. A steady load is applied over it and allowed it to dry. After curing at room temperature the fabricated material part is taken out and processed further.

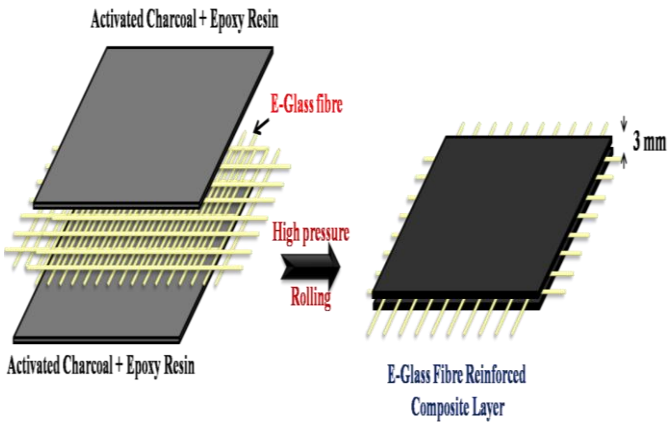

Fig.1 Sample of fabricated material

3. MECHANICAL PROPERTY TESTING

The fabricated material is taken to study for Tensile, Impact and Hardness measurements. Tensile strength was calculated using a universal testing machine. Impact strength is calculated in Impact testing machine and Hardness is calculated in Shore durometer machine. One identical sample was tested for each test and readings were tabulated

4. RESULTS AND DISCUSSION

Experimentally evaluated mechanical properties of E – glass composite laminates are shown in table. The study of fabricated material depends on the properties of the material such as resin content, Fibre volume, ply thickness, direction and orientation. Besides these stuff the nature of interfacial bonds, load applications and its mechanism plays a very important role

4.1 TENSILE STRENGTH

From the obtained values, we can conclude that material C filled with 2% charcoal shows the greatest tensile strength of 85.85 MPa when compared with other fabricated materials, but it seems to be more than the other filled material figure 2 (a). The reason behind that is Activated charcoal particles which posses diameters less than 2 nm (micropores) and also pore with diameters between 2 and 50 nm (mesopores), moreover these grooves and a hole that gives a large surface area for deposit of materials. So this paved way for the materials to adhere properly so the results were good [6]. Material A with filled no additives shows better results when compared with material B, C, D and E with tensile strength of 84 MPa. Material E shows the tensile strength of 80.23 MPa, Because mica is an insulator and has highly tough with elastic power throughout its surface so it produces good addition between filler and fibre. However, whereas the material D the combination of 2% Silicon Carbide and activated Charcoal exhibits 64.83 MPa. This is due to unpredictable reaction that occurs between materials and so the results were less. From this we came to a conclusion that we should not add silicon carbide and activated charcoal. Addition of charcoal increases the strength of the fabricated materials and increases the tensile strength of material.

SAMPLES	GLASS FIBER (VOLUME %)	EPOXY (VOLUME %)	FILLER MATERIALS (VOLUME %)	TENSILE STRENGTH (Mpa)	IMPACT STRENGTH VALUES IN Kgm	SHORE D-HARDNESS
A	60%	40%	Nil	84	0.093	60
B	60%	38%	2% Sic	79.38	0.105	68
C	60%	38%	2% Charcoal	85.85	0.105	72
D	60%	36%	2% Sic & 2% Charcoal	64.83	0.110	66
E	60%	35%	5% Mica	80.23	0.156	55

Table 1 . Symbols used and corresponding volume properties of fabricated composites

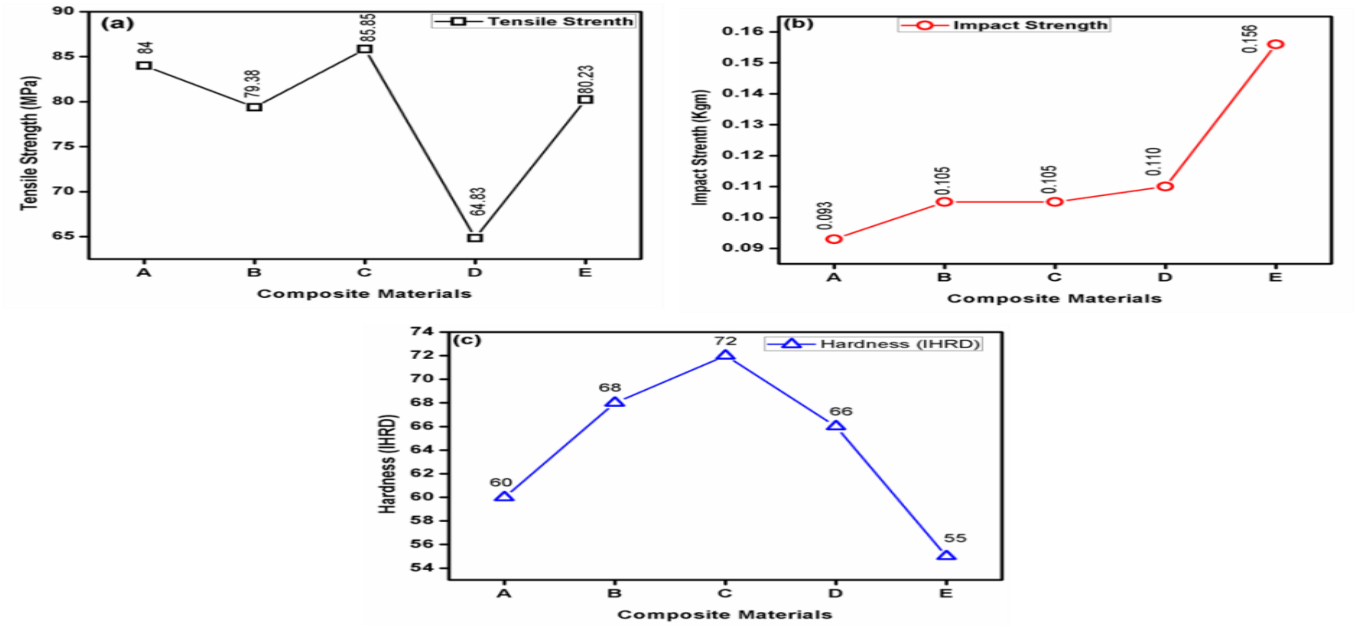

Fig.2 (a) Tensile strength, (b) Impact strength, (c) Hardness strength of composite materials

4.2 CHARPY IMPACT TEST

Impact test is usually used to test the toughness of metals, but can also be used for polymers, ceramics and composites. An impact characteristic of fabricated materials depends upon resisting factor. Impact strength of all the fabricated materials is indicated in the table 1. From figure 2 (b), we concluded that material E with 5% mica has great impact strength of 0.156 Kgm when compared with other fabricated materials this is due to the high level of silica content present in it which provides very good hardness property so these results in better absorption of energy when weight is allowed to strike the material and this prevents the crack formation. Impact strength decreases when no filler materials are added to it. In case of no filler materials it has low matrix continuity between matrix and fibre with low capacity of absorption, which results in micro crack initiation and leads to failure, Then material D with 2% silicon carbide and activated charcoal shows 0.110 Kgm because silicon carbide has high hardness and excellent thermal shock resistance, but activated charcoal reacted with that lead to decrease its impact strength and its value is less than material E. The Test results shows that by adding mica to the material we can get better impact strength. From this we came to a conclusion that we should not add silicon carbide and activated charcoal. By adding mica to the material we can increase the impact strength

4.3 HARDNESS TEST

Hardness may be defined as the resistance of material to plastic deformation. However, the term may also refer to stiffness or resistance. Hardness characteristics of fabricated materials are presented in the table 1. From these results it shows that fabricated materials C filled by 2% charcoal shows the highest hardness number of 72 IRHD when compared with other filled fabricated materials. The reason behind that is due to continuous deposition of activated charcoal powder over the fabricated material. It has a great bonding capacity between fibre and matrix. From figure 1 (c), we came to a solution that increases in addition of silicon carbide to the fabricated materials leads to increase in hardness number and hardness property [3]. This may be due to improved capacity of bonding between the fibre and reinforcement. When increasing the filler material loading in matrix surface which reduces the indentation so values are low. Mica filled material shows low hardness number due to bond strength. By adding charcoal we can get better hardness strength.

5. CONCLUSION

Material C filled with 2% charcoal shows the greatest tensile strength of 85.85 Mpa when compared with other fabricated materials. Addition of charcoal increases the tensile strength of the fabricated materials Material E with 5% mica has great impact strength of 0.156 Kgm when compared with other fabricated materials. By adding mica to the material we can increase the impact strength of the fabricated materials. Materials C filled by 2% charcoal shows the highest hardness number of 72 IRHD when compared with other filled fabricated materials. By adding charcoal we can get better hardness strength. Mostly composites materials are used in the engineering field. In this work, we have highlighted only the major structural application areas such as aircraft, space, automotive, sporting goods, marine and infrastructure. E-Glass fibre reinforced epoxy with filler as activated charcoal is used in racing boats in which weight less is extremely important for competitive advantage and to improve impact resistance and reduce the boat's weight.

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