

Experimental Comparison of E-Glass Fiber Reinforced Thermosetting and Thermoplastic Composites for Tensile Strength

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Abstract—This current work is concerned with the development of thermos-set and thermo-plastic composites reinforced with e-glass fibers. The influence of fiber content in the composites was studied by tensile test. The thermoset and thermoplastic used in this work are Epoxy and Polypropylene materials. Finally comparing the tensile strength between the Epoxy and Polypropylene composite materials.

Key words: E-Glass Fiber, Thermoplastic Composites

I. INTRODUCTION

Polymers are of two types thermoplastic and thermosetting according to the effect of heat on their properties.

Thermosetting materials, or thermosets, are formed from a chemical reaction, where the resin and hardener or resin and catalyst are mixed and then undergo a non-reversible chemical reaction to form a hard, infusible product. In some thermosets, such as phenolic resins, volatile substances are produced as by-products (condensation reaction). Other thermosetting resins such as polyester and epoxy cure by mechanisms that do not produce any volatile by products and thus are much easier to process (addition reaction). Once cured, thermosets will not become liquid again if heated, although above a certain temperature their mechanical properties will change significantly. This temperature is known as the Glass Transition Temperature (T_g), and varies widely according to the particular resin system used, its degree of cure and whether it was mixed correctly. Above the T_g, the molecular structure of the thermoset changes from that of a rigid crystalline polymer to a more flexible, amorphous polymer. The properties such as resin modulus (stiffness) drop sharply, and as a result the compressive and shear strength of the composite does too. Other properties such as water resistance and colour stability also reduce markedly above the resin's T_g.

Thermoplastics like metals soften with heating and eventually melt, hardening again with cooling. This process of crossing the softening or melting point on the temperature scale can be repeated as often as desired without any appreciable effect on the material properties in either state. Typical thermoplastics include nylon, polypropylene and ABS (Acrylo-nitrile Butadine starring).

II. MATERIALS AND METHODS

A. Materials

Epoxy and Polypropylene are used as a thermosetting and thermoplastic materials. E-glass fiber is a reinforcing material.

1) Epoxy

Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group. Epoxy

resins, also known as polyepoxides are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols.

2) Polypropylene

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labelling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes.

3) E-Glass Fiber

Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time, all glass fiber had been manufactured as staple (that is, clusters of short lengths of fiber).

B. Preparation of Composite Specimen

The specimen prepared as per ASTM D1763 standards, gauge length of 60mm, width 20 mm and thickness 5mm for conduction of tensile test.

1) Polypropylene composite

The polypropylene composite were prepared by compressing at appropriate temperature and pressure by using sandwich making machine as shown in the fig.1. It is a ply-by-ply arrangement of polypropylene and e-glass fibers. The percentage of e-glass fibers in composite is 0%, 2% and 4% in weight.



Fig. 1: Sandwich Making Machine

The setup is called “sandwich making machine” the machine is made up of mild steel and coated with aluminium paint.

An arrangement of Electric heating coil of capacity 750 watts is provided on each plate to heat the top and bottom portion of plate. A Teflon layers is provided on the plates. Which act as a non-stick layer for Polypropylene sheet.

A sandwich specimen is made by placing ply-by-ply layer of polymer and e-glass fiber. The sandwich is then placed on the bottom plate. Which is fixed one and the top plate, which is movable, is brought down against the fixed plate until the required pressure is obtained.

Then the equipment is connected to electric mains, around 200-220° c temperature is allowed to built up. The same temperature and pressure is maintained for a period of 30 minutes.

The equipment is disconnected from the electric mains and let to cool to room temperature. The cooling process adopted is natural air-cooling (different cooling method could be adopted as curing method) once the equipment is cooled, the specimen in the form of sandwich is taken out. Fig.2. shows the tensile test Polypropylene composite specimen prepared according to ASTM standards.



Fig. 2: Polypropylene composite specimen

2) Epoxy composites

The epoxy composite were prepared by mixing the epoxy and catalyst with e-glass fibers by hand lay-up technique. The percentage of e-glass fibers in composite is 0%, 2% and 4% in weight. Fig.3. shows the tensile test Epoxy composite specimen prepared according to ASTM standards. Fig.3. shows the tensile test Epoxy composite specimen prepared according to ASTM standards.



Fig. 3: Epoxy composite specimen

III. EXPERIMENTATION

The test is conducted on Universal Testing Machine (Fine instrument engineering limited, Poona 1979. Model 7181-406, capacity – 40 tons) as per the standards and the readings are tabulated, the UTM is shown in fig.4.

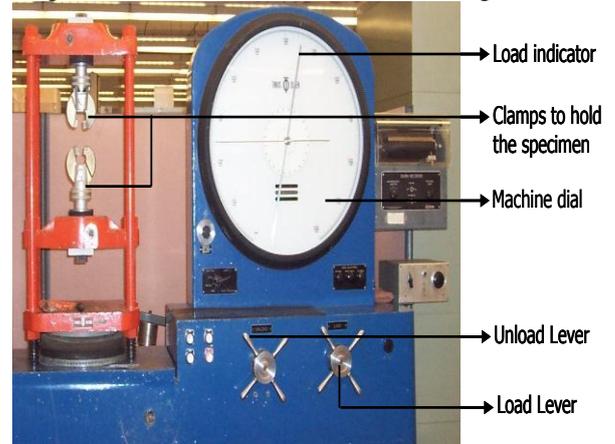


Fig. 4: Universal Testing Machine

IV. RESULT AND DISCUSSION

The Stress and strain of the specimens are determined, from the stress-strain curves for various specimens are discussed below.

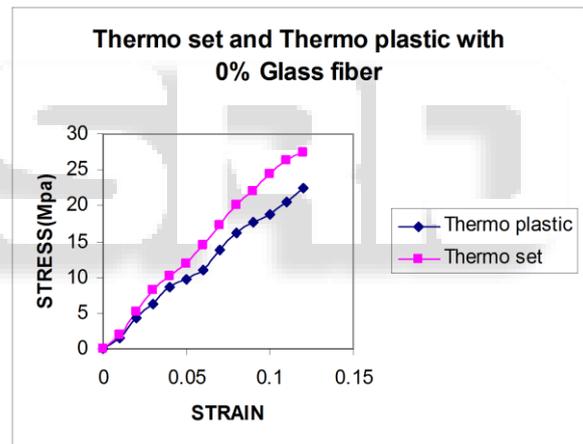


Fig. 5: Stress-Strain curve for 0% glass fiber

Fig.5. shows the stress strain curve for 0% glass fiber. The stress is 22.36 MPa for thermoplastic and 27.46 MPa for thermoset.

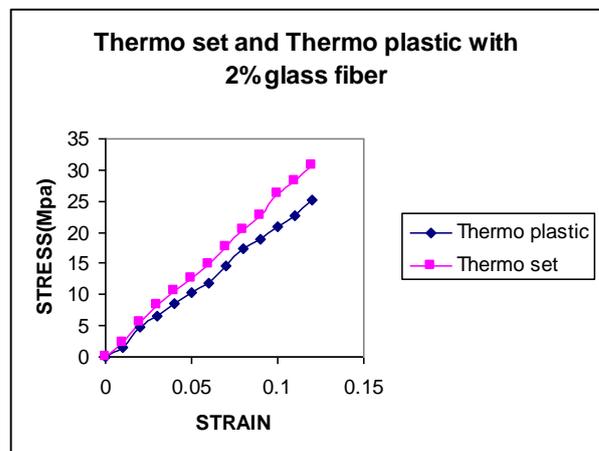


Fig. 6: Stress-Strain curve for 2% glass fiber

Fig.6. shows the stress strain curve for 2% glass fiber. The stress is 25.11 MPa for thermoplastic and 30.60 MPa for thermoset.

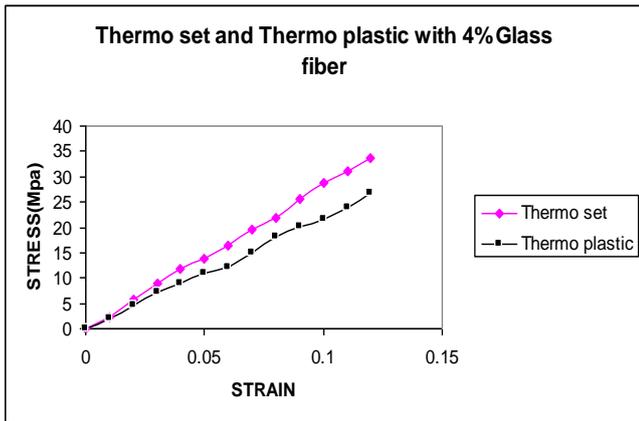


Fig. 7: Stress-Strain curve for 4% glass fiber

Fig.7. shows the stress strain curve for 4% glass fiber. The stress is 26.68 MPa for thermoplastic and 33.74 MPa for thermoset.

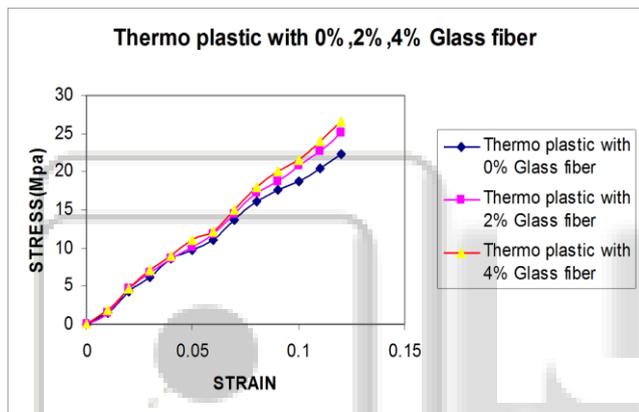


Fig. 8. Tensile strength for 0%, 2% & 4% of glass fiber in thermoplastic material

Fig.8.Shows that the tensile strength of the thermoplastic is increasing with % of glass fiber.

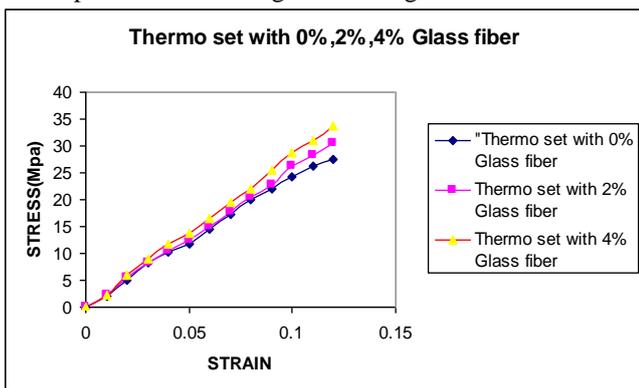


Fig. 9: Tensile strength for 0%, 2% & 4% of glass fiber in thermoset material

Fig.9.Shows the Tensile Strength of the thermoset is increasing with % of glass fiber.

V. CONCLUSIONS

The strength of the specimen are determined. It is found that the tensile strength of the thermoset and thermoplastic is increasing with increase in percentage of E-glass fiber.

The tensile strength of thermoset is more than the thermoplastic material for 0%, 2% and 4% reinforcement of E-glass fiber by weight.

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