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Preparation and Testing of Metal and Fiber Reinforced Polymer Laminates

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ABSTRACT:

In recent years there has been an increasing demand from the core industries for the materials possessing high strength to weight ratio. The process of improving the properties of conventional materials has lead to the technique of reinforcing polymers, ceramics and metals with particles, fibres[1] and whiskers. Thus leading to the production of composites. In this project MFRP laminates are prepared and tensile testing is done on it. The results are compared with the metals and FRP laminates. The comparision is made to find out the strength and weight of different materials.

1.INTRODUCTION :

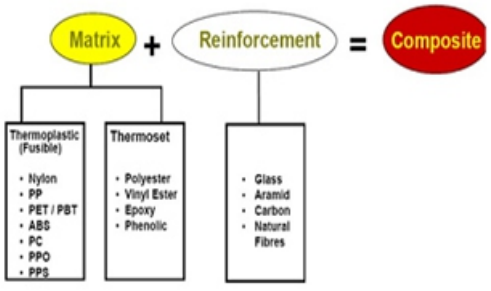
Materials play an important role in designing and manufacturing of any component. This factor has lead to the innovation and development of new materials. As we know the materials are divided into metals, non-metals and composites. The metals and non-metals are used extensively in past and in recent years. But now it is replaced by composites due to their good properties and life compared to them. In the composite materials also there are many different materials which are obtained by changing the composition of the constituents. These composites are brittle and light weight compared to metals. Here we are going to introduce a new material which has both the properties of metals and composites i.e., ductility and brittleness . So, the material is named as MFRP (Metal and Fiber Reinforced Polymer). It is a composite in which metals and fiber are reinforced into a polymer matrix. The applications of the material includes for buildings, bridges and structures such as boat hulls, swimming pool panels, race car bodies, bath tubs and storage tanks.

2. LITERATURE REVIEW:

A composite material[4] is a material made from two or more constituent materials with significantly different physical or chemical composition, that when combined, produces a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

Typical engineered composite materials include:

•Reinforced plastics, such as fiber-reinforced polymer
• Metal composites
•Ceramic composites
•Laminates



Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation imitation granite and cultured marble sinks and countertop. Woody plants, both true wood from trees and plants such as palms and bamboo, yield natural composites that were used prehistorically by mankind and are still used widely in construction and scaffolding.

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Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination.

Engineered composite materials must be formed to shape. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mould cavity or onto the mould surface. The matrix material experiences a melting event, after which the part shape is essentially set. Depending upon the nature of the matrix material, this melting event can occur in various ways such as chemical polymerization or solidification from the melted state. Plywood 3400 BC by the Ancient Mesopotamians gluing wood at different angles gives better properties than natural wood. The first artificial fiber reinforced plastic was bakelite[4], has been used for hundreds of years which was invented in the year 1905 by Dr. Leo Baekeland had originally set out to find a replacement for shellac . He announced his invention

3.PURPOSE OF RESEARCH :

The reinforcement of metals can have many different objectives. The reinforcement of light metals opens up the possibility of application of these materials in areas where weight reduction has first priority. The precondition here is the improvement of the component properties. The development objectives for light metal composite materials are: Increase in yield strength and tensile strength at room temperature and above while maintaining the minimum ductility or rather toughness. Increase in creep resistance at higher temperatures compared to that of conventional alloys. Increase in fatigue Many commercially produced composites use a polymer matrix material often called a resin solution. There are different type of polymers which are available depending upon the starting raw ingredients. There are several broad categories, each with numerous variations. The most common are polyester[2], vinylester, epoxy, phenolic, polyimide, polyamide, polypropylene. at a meeting of the American Chemical Society on February 5, 1909.

One of the most common and familiar composite is fiberglass, in which small glass fiber are embedded within a polymeric material (normally an epoxy or polyester). The glass fiber is relatively strong and stiff (but also brittle), whereas the polymer is ductile (but also weak and flexible). Thus the resulting fiberglass is relatively stiff, strong, flexible, and has ductile strength especially at higher temperatures. It has improved thermal shock resistance and corrosion resistance. Increase in Young's modulus and reduction of thermal elongation.

4. PREPARATION METHOD :

4.1.1 GLASS FIBER :

It is a material made of extremely fine fibers of glass material . It is used as a reinforcement in the polymer. It is a light weight material used to form the reinforced polymer. The fiber pieces are taken according to dimension of 250mmX30mmX0.3mm.

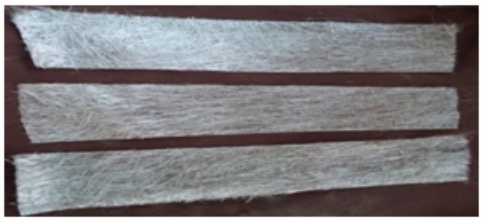

Fig 1. Glass fiber pieces as per dimensions.

4.1.2 METAL:

It is a solid material which is typically hard, shiny, malleable and ductile with good electrical and thermal resistance. A M.S plate of 250mmX30mmX2mm is used for reinforcing into the polymer matrix.

4.1.3 RESIN:

In material science or polymer chemistry resin[2] is a solid or highly viscous substance which are typically convertible into polymers. Such viscous substances may be derived from plant or synthetic origin. They are mixtures of organic compounds. In the preparation of MFRP general purpose resin is used as a matrix and as a bonding agent.

4.2 FABRICATION OF MFRP LAMINATES:

The preparation of MFRP laminates involves the following major activities. A brief illustration of the activities is given below.

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Now the metal sheet and glass fiber is prepared according to the required dimensions. 100gms of general purpose resin is taken, 2ml of catalyst cobalt octate and 2ml of accelerator is added. Then the mixture is stirred till the light pink colour is observed.

Fig 2. Metal piece as per dimensions.

4.2.1 Raw material preparation:

During this the mild steel sheet surface is made rough by using emery paper in order the improve the adhesive bonding between metal layer and fiber reinforced laminate.

4.2.2 Material Deposition:

In this releasing agent is applied on the mould and it is set to dry for 2 minutes. Then the resin mixture is applied on the surface of the mould and the fiber piece is placed on it. Again resin is applied and fiber is placed till we get 4 layers. Now the metal sheet is placed and again 4 layers of resin and fiber are placed on the metal sheet in the form of a laminate.

4.2.3 Curing of laminates:

The laminates along with the mould is left to dry for 6-8 hrs at room temperature. Finally the laminates are removed from the mould .

Fig3.Fiber and metals pieces taken according to dimensions.

Fig 4. MFRP laminates after curing

The above figures shows the preparation of laminates by the combination of fiber, metal and resin by manual layup method.

4.3. TESTING:

The testing includes measuring of weights of FRP,MFRP and Metal laminates of same dimensions and tensile testing[3] is done for finding the strength of the laminates.

4.3.1 WEIGHT COMPARISION:

The weight of frp,MFRP and metal laminates of dimensions 9mm x 30mm x250mm are given below

FRP	MFRP	METAL
110 gms	230 gms	405 gms

4.3.2 TENSILE TESTING:

In order to perform tensile test on a laminate it is made to required dimensions as per ASTM standards. The FRP laminates are tested according to ASTM D638 and metals are tested as per ASTM AE8M[7] as shown in the figure .The laminate is machined as per dimensions shown in the below figure and the area of cross section 12.85mm X 5.6mm is maintained for all specimens.

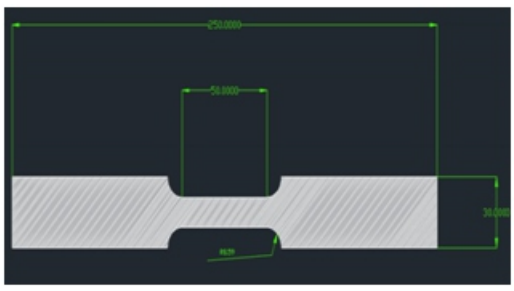

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Fig 5. Laminate as per dimensions according to ASTM standards.

Fig 6. Laminate and metal piece placed in Universal Testing Machine.

5. RESULTS AND DISUCSSIONS:

The a tensile tests are performed on three different material laminates and the load Vs displacement graph is obtained in each case .The ultimate load, elongation and area of cross section according to standards is considered to calculate the ultimate tensile strength and young's modulus of the specimens .

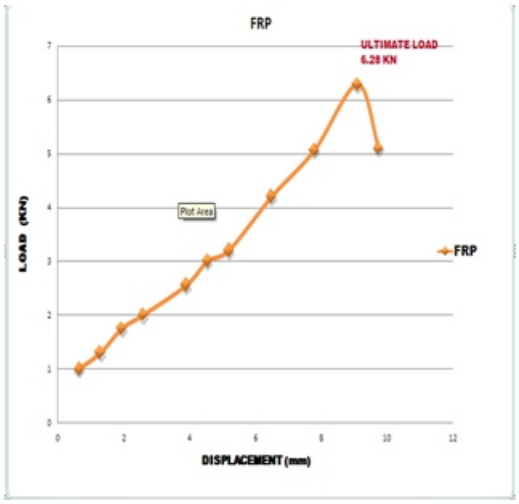

Fig 7. Load Vs Displacement graph of FRP laminate.

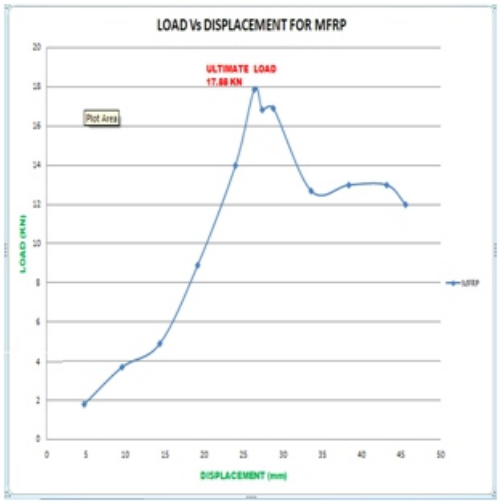

Fig 8. Load Vs Displacement graph of laminate. MFRP

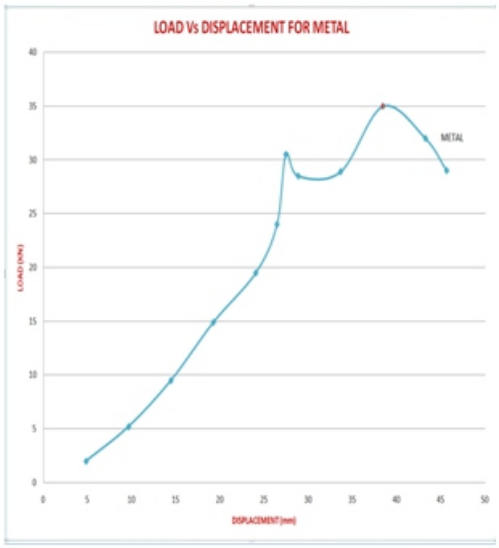

Fig 9. Load Vs Displacement graph of metal laminate.

From the tensile test the ultimate load for particular elongation is found. The ultimate tensile strength and Young's modulus are calculated as follows:

•Ultimate tensile strength = Ultimate load/Area of cross section.

•Young's Modulus E = Ultimate tensile strength / Strain.

•Strain = change in length / Original length.

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MATERIAL / PROPERTIES	FRP	MFRP	METAL
YOUNG'S MODULUS, E (GPa)	8.47	19	24.319
ULTIMATE LOAD(KN)	6.28	17.88	35
ULTIMATE STRENGTH (MPa)	86.3	139.62	486.65

6.CONCLUSION :

From the below table the ultimate tensile strength of MFRP lies in between the metal and FRP for same cross-section .It specifies that MFRP possesses the combined properties of FRP and metal.

MATERIAL	FRP	MFRP	METAL
ULTIMATE TENSILE STRENGTH (MPa)	486.65	139.62	86.3

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