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Mechanical Characterization of Hybrid Fibre Reinforced Polymer Composite

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Abstract - The study is being done to see the effect of variation in fiber weight percentage on different mechanical property of fiber reinforced epoxy composites. In present work the samples are prepared by using jute fiber, munja fiber, polypropylene fiber and hybrid fiber in the reinforcement phase and epoxy in the matrix phase. Samples are prepared by varying reinforcement fiber weight by 3 percentages and 5 percentages respectively. The mechanical characteristics such as tensile strength, flexural strength and impact strength are evaluated in this study. All the composite samples are manufactured by hand lay up process.

Index Terms - mechanical properties, reinforcement phase, matrix phase, hand lay up process

INTRODUCTION

We all are a part of modern civilization, with the passage of time we are seeing development around us this development is only possible due to new innovations and industrial development. These days all the industries are working for enhancing their capabilities and to produce more and more fluffing demand of developing word. As the consumption of products is rising, industries are having pressure to fulfill this demand by producing products and this leads to increase in the demand of raw material. Lots of tangible products are made with the metals or affected by metals, so due to increasing demand of metal, metal's prices are increasing day by day and industries are looking for alternative of metals. Composite materials are alternative materials for metals due to its significant properties [1]. The use of composite reduces cost and weight of products and increases constructive characteristics. In recent few years the fiber reinforced polymer composites are replacing various metals in the field of engineering and commercial applications [2]. Fiber reinforced polymer matrix composites are made using variety of fibers such as natural fibers like jute, banana, pineapple, kenaf, bamboo, coconut, sun hemp, abaca, munja fibers etc. synthetic fibers like glass, carbon, kevlar, polypropylene etc. and hybrid fibers which are made through the combination of natural and synthetic fibers [3]. In fiber reinforced polymer matrix composite, fibers are usually presenting in discontinuous phase and that are harder and stronger than the matrix constituents [4]. Polymer is used as matrix constituents and it is presents in continuous phase [5].

MATERIALS AND METHODS

I. Reinforcement Material

In this study four types of fibres are used in reinforcement phase for preparing fibre reinforced polymer composite.

Jute Fibres
Munja Fibres
Polypropylene Fibres
Hybrid Fibre

II. Jute Fibres

Jute fibre belongs to the category of blast fibre. It is extracted from plants. It is a low-cost natural fibre available in abundant quantity [6]. India is the largest producer of jute fibres. As a fibrous reinforcement, Jute fibers have very vast potential in polymer matrix composites. Jute fiber is available commercially in two types, first one is white jute (Corchorus capsularis) and second one is tossa jute (Corchorus olitorius) [7]. In this study jute fibres of 15 mm length are being used in reinforcement phase.

Fig.1 Munja fibre of 15 mm length.

III. Munja Fibres

Munja is generally well known by Kana or Sarkanda or Munja. Its botanical name is Saccharum Munja. It shows extremely good capacities that can be used in reinforcement constituents in polymer matrix composite [8]. In this study Munja fibres of 15 mm length are being used in reinforcement phase.

Fig.2 Munja fibre of 15 mm length.

IV. Polypropylene Fibre

Polypropylene also known as Polypropene, is a thermoplastic polymer. It is partially crystalline polymer which is produced by chain growth polymerization from the monomer propylene. Polypropylene fibers are light weight, high strength, and corrosion resistance fibers [9]. In this study polypropylene fibres of 15 mm length are being used in reinforcement phase.

Fig 3. Polypropylene fibre of 15 mm length.

V. Hybrid Fibre

Hybrid fibre is a mixture of two or more distinct verities of fibres. By using hybrid fibre the desire properties of fibre reinforced composite may be improved by balancing deficiency of one fibre by another [10]. In present study two natural fibres jute fibre and munja fibre of 15 mm length with a synthetic fibre, polypropylene fibre of 15 mm length in equal weight percentages.

VI. Matrix Material

Epoxy Resin and Hardener

Epoxy resin is widely used in industries as it is easily available, comparatively less costly and non toxic, having outstanding properties as good adhesion to dissimilar material, chemical resistance, high strength, resistance to moisture and corrosion. It cures at a room temperature. It is a low viscosity thermosetting polymers resin [11]. Atul Limited Lapox Matalam System B epoxy resin and Matalam System B Hardner are used in the ratio of 2:1 in this study.

Fig 4. Epoxy resin and hardener

VII. Composite Preparation Method

In this study hand lay up technique is being used with open mould. It is a simplest method of composite manufacturing. It is a less costly process and requires less equipment, tools and setup. We can apply hand lay up process easily with liquid thermosetting polymers with large variety of fibres like with long fibres or with short fibres [12]. Hand lay up process may be implied for fabricating fibre reinforced polymer composites in variety of sizes it may be small or large in size but this method implies with a limitation that geometry of composite to be produced in simple and flat. [13]

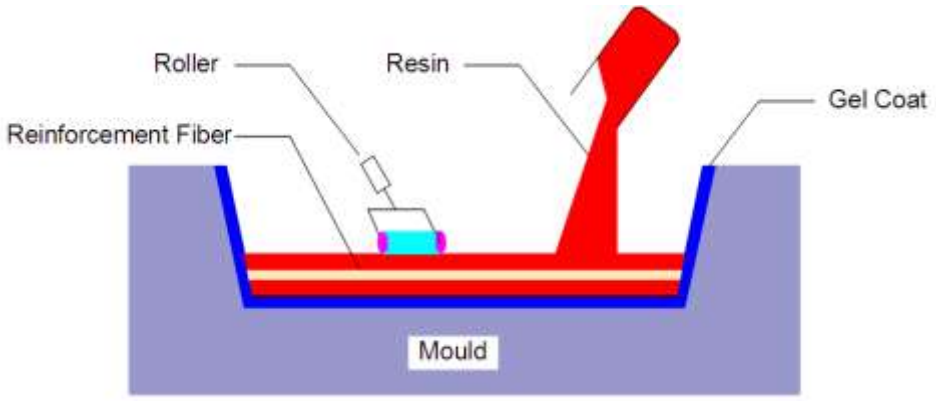

Fig.5 Schematic diagram of hand lay up process

EXPERIMENTATION

Using hand lay up process composite samples for tensile, flexural, impact and hardness test are prepared using three types of fibres such as jute fibre, munja fibre and polypropylene fibre at different weight percentage of fibre content. All the mentioned fibres are used in the reinforce phase and Lapox Matalam System B epoxy resin and Matalam System B Hardner used in the ratio of 2:1 in the matrix phase. Similarly hybrid fibers are also prepared by mixing jute fibre, munja fibre and polypropylene fibre at different weight percentage in reinforcement phase and Lapox Matalam System B epoxy resin and Matalam System B Hardner used in the ratio of 2:1 in the matrix phase.

Table1:List of fibre reinforced polymer composites prepared are as follows.

S. No.	Abbreviation for Composite Samples	Description
1	3JFEPC	Composite prepared with 3% jute fibre as in weight percentage with epoxy
2	3MFEPC	Composite prepared with 3% munja fibre as in weight percentage with epoxy
3	3PFEPC	Composite prepared with 3% polypropylene fibre as in weight percentage with epoxy
4	3HYEPC	Composite prepared with 3% hybrid fibre as in weight percentage in equal ratio with epoxy
5	5JFEPC	Composite prepared with 5% jute fibre as in weight percentage with epoxy
6	5MFEPC	Composite prepared with 5% munja fibre as in weight percentage with epoxy
7	5PFEPC	Composite prepared with 5% polypropylene fibre as in weight percentage with epoxy
8	5HYEPC	Composite prepared with 5% hybrid fibre as in weight percentage in equal ratio with epoxy

Fig 6. Composite samples prepared by hand lay up process

MECHANICAL TESTING

Tensile, flexural, impact and hardness testing methods of test standard ASTM D638, ASTM D790, ASTM D256, and ASTM D2240 respectively are used to identify the mechanical properties of fibre reinforced epoxy composite

I. Tensile test

Tensile testing is a destructive testing procedure. It is performed on Universal Testing Machine (UTM). In this test tensile force is applied gradually on the test specimen clamped in the jaws of UTM until it gets fractured.

This test shows the measure of resistance offered by the material against the axial pull. Universal Testing Machine Model No UTE 40 made by Fuel Instruments and Engineering Pvt. Ltd. with a cross head travels of 10 mm/min is used in this study.

II. Flexural test

Flexural testing is a destructive testing procedure. It is performed on Universal Testing Machine (UTM). This test is performed to find out flexural strength which is a measure of resistance of material against bending. In flexural test, the specimen is placed horizontally on the Universal Testing Machine with the help of two adjacent lower supports and load is applied on the center of the top surface of the test specimen. In present study flexural test is conducted on Universal Testing Machine Model No 40 made by Fuel Instruments and Engineering Pvt. Ltd. In this test the specimen is placed on two lower supports placed 50 mm distance apart and load at the rate of 5 mm/min at the center is applied.

Fig.7 Universal Tensile Testing Machine used for tensile and flexural test

III. Impact test

Impact testing is a destructive testing procedure. It is performed on impact testing machine. The test is performed on the specimen to determine the impact strength of the material. Impact strength is the ability of a material to absorb suddenly applied load or shock load. In present study izod impact test is conducted on Impact Testing Machine made by Krishna Enterprises. During the izod impact test, the test sample is clamped vertically in the fixture and the notch side is kept towards the striking face of swinging pendulum.

Fig.8 Impact testing machine

Table 2 : Mechanical testing results

S. No.	Composite Name	Tensile Strength in MPa	Flexural Strength in MPa	Impact Strength in J/cm^2
1	3JFEPC	38.48	43.52	64
2	3MFEPC	33.66	39.21	58
3	3PFEPC	24.27	30.12	46
4	3HYEPC	30.31	36.71	50
5	5JFEPC	42.91	48.21	76
6	5MFEPC	37.93	43.32	64
7	5PFEPC	27.33	32.15	52
8	5HYEPC	34.88	41.18	56

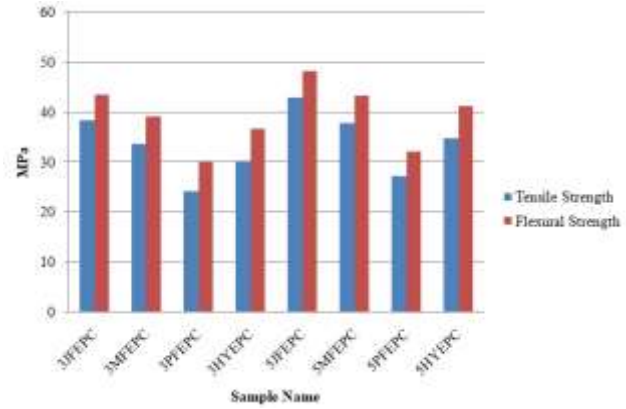

Fig.9 Comparison of tensile and flexural strength of different composite samples.

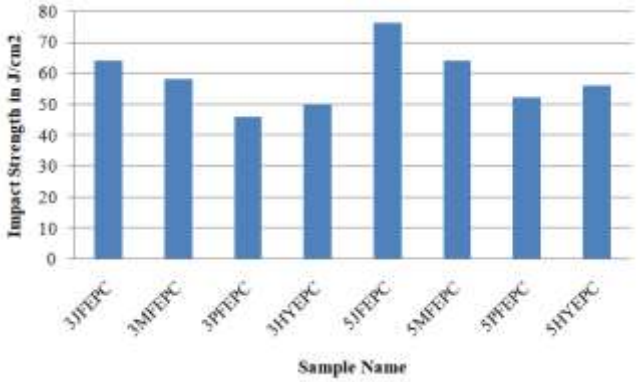

Fig.10 Comparison of impact strength of different composite samples.

In the tensile test 3JFEPC sample showed a tensile strength of 38.48 MPa and 5JFEPC sample showed a tensile strength of 42.91 MPa. In the flexural test 3JFEPC sample showed a flexural strength of 43.52 MPa and 5JFEPC sample showed a flexural strength of 42.91 MPa. In impact test 3JFEPC sample showed an impact strength of 64 J/cm^2 and 5JFEPC sample showed an impact strength of 76 J/cm^2. In case of jute fibre reinforced epoxy composite the tensile strength, flexural strength and impact strength increases with the increase in weight percentage of reinforcement.

In tensile test 3MFEPC sample showed a tensile strength of 33.66 MPa and 5MFEPC sample showed a tensile strength of 37.93 MPa. In the flexural test 3MFEPC sample shows flexural strength of 39.21 MPa and 5MFEPC sample shows flexural strength of 43.32 MPa. In impact test 3MFEPC sample shows impact strength of 58 J/cm^2 and 5MFEPC sample shows impact strength of 64 J/cm^2. In case of Munja fibre reinforced epoxy composite tensile strength, flexural strength and impact strength increases with the increase in the weight percentages of reinforcement.

In the tensile test 3PFEPC sample showed a tensile strength of 24.27 MPa and 5PFEPC sample showed a tensile strength of 27.33 MPa. In the flexural test 3PFEPC sample showed a flexural strength of 30.12 MPa and 5PFEPC sample showed a flexural strength of 32.15 MPa. In impact test 3PFEPC sample showed an impact strength of 46 J/cm^2 and 5PFEPC sample showed an impact strength of 52 J/cm^2. In case of Munja fibre reinforced epoxy composite tensile strength, flexural strength and impact strength increases with the increase in the weight percentage of reinforcement.

In tensile test 3HYEPC sample showed a tensile strength of 30.31 MPa and 5HYEPC sample showed a tensile strength of 36.71 MPa. In flexural test 3HYEPC sample showed a flexural strength of 30.12 MPa and 5HYEPC sample showed a flexural strength of 41.18 MPa. In impact test 5HYEPC sample showed an impact strength of 50 J/cm^2 and 5HYEPC sample showed an impact strength of 56 J/cm^2. In case of hybrid fibre reinforced epoxy composite tensile strength, flexural strength and impact strength increases with the increase in the weight percentage of reinforcement.

CONCLUSION

The results of tensile, flexural and impact test showed that the tensile, flexural and impact strength increases when we increase the weight percentage of reinforcement fibres in the composite. The jute fibre reinforced epoxy composite showed the higher values of tensile, flexural and impact strength as compared with the other composite samples. There are no remarkable benefits found of hybridisation of jute, Munja and polypropylene fibres in the case of hybrid fibre reinforced epoxy composite, even jute fibre composite showed a higher value of impact, tensile and flexural strength as compared to the hybrid fibre reinforced epoxy composite.

FUTURE SCOPE

It is seen from present study if we increase the weight percentage of reinforcement fibre in composite it improves mechanical properties so there is a scope of study of mechanical characteristics by varying weight percentage of reinforcement constituent. In the present study short fibres of 15mm length are being used in the reinforcement phase so there is also a scope to vary the fibre length and analysis of mechanical properties. In present work comparative study of tensile, flexural and impact strength are made. There is also a scope to study other mechanical characteristics like hardness, density, compression strength and thermal properties.

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