COURSE NAME: MME – 102 GROUP NO.: A1

EXPERIMENT NO.: 8 (a), (b), (c)

NAME OF THE EXPERIMENT:

Production and properties of ceramic, polymer and composites – (a) 3- and/or 4-point bend test of materials (ceramics/refractory/glass/tile); (b) Hands-on experience on manufacturing fibre-reinforced polymer composite using hand layup technique; (c) Tensile test of polymer and polymer composites.

DATE OF PERFORMANCE:
24. 11. 2024
DATE OF SUBMISSION:
02. 12. 2024

SUBMITTED TO:
Anika Rahman Riya
Lecturer (Adjunct)
Department of MME, BUET

SUBMITTED BY:
Praggo Pabon
Roll: 2311002
Section: A- 1
Department of MME, BUET

Table of Contents

Introduction

'Fiber reinforced polymer matrix composite' is a type of composite where we use polymer as the matrix and fiber as its reinforcement. Using reinforcement not only makes a new kind of material (composite) but also changes its properties, for example— higher tensile strength, greater hardness, better flexural strength etc. Polypropylene and jute mat in FRP using the hot compression technique was conducted. A mixture of resin and hardener and were used as the matrix, used jute mat as reinforcement in the 'hand layup technique'. After making the FRP, the composite was put under tensile and flexural tests to understand their mechanical properties.

Objective

Properties of polymeric materials are very sensitive to their processing techniques. They are more sensitive, when polymers are reinforced with some fibers. In this experiment, composites of both thermosetting and thermoplastic polymers will be developed by hand-lay-up and hot pressing techniques respectively. The composites developed in the experiment were used for their characterization. In this experiment, tensile and flexural tests were performed

Materials

A. Tray, paint brush, bowel, duster, hand gloves. nose musk. Pipette, syringe, roller, etc.
B. Polyester resin, polypropylene, jute mat, glass mat, initiator, wax, etc.

Procedure

For Thermoset Composite

Hand lay-up techniques are used to fabricate the unique sandwich panels where resin is manually applied to jute mat fiber reinforcement using common paint rollers. Rollers are used to remove air bubbles from the laminate. After cure, assemblies are trimmed to the proper width. To make FRP composite—

1. Cleaned the tray and measured its dimension carefully.
2. Allowed it to dry and waxed the tray thoroughly on both sides and each edge of the tray.
3. Measured the volume of the specimen when no reinforcement was used. The density of resin is 1.04gm/cc.
4. Measure the length, width and thickness of the mat and the fabric supplied.
5. Calculated the weight of the fabric per square meter. The density of Jute is 1.3gm/cc.
6. Calculated the volume percentage and weight percentage of reinforcement in the composite.
7. Took the exact amount of resin and calculated the amount or initiator needed. Usually the initiator amounts 1 % of the weight of resin taken. Blend the initiator thoroughly and apply one layer of resin on the tray and spread it with a brush. Next apply a ply 01 mat/fabric and apply resin and spread well with the roller. Rolling will homogenize the dispersion of resin and also the composite property. Apply the entire process again and make' a final coat' with resin.

For Thermoplastic Composite

1. Familiarized with the hot compression unit and mold.
2. Used a clean mold and applied a mold release agent (Silicon spray).
3. Spread a layer of poly propylene on the mold surface and then place the mat and the top place the polypropylene again. Closed the mould and placed it in the hot compression unit. Applied heat and pressure and held for a half an hour.
4. Took out the mould from the machine, allowed it to cool and took out the composite from the mould. Noted the following points:

I	Dimension of the tray/mould
II	Dimension of the mat/fabric: a. length mm b. width, mm c. thickness, mm
III	Calculated the volume of the mm/fabric
IV	Calculated the volume of the resin
V	Calculated the weight fraction: fraction of the mat/fabric

For Tensile Test

Tensile properties as determined by the test method helps us to know the stress strain behaviour of the composite specimen, their fracture characteristics under load. For tensile test, ASTM D-3039-3039M were followed, where crosshead speed of 2mm/min were used. Calculated yield strength, ultimate tensile strength (UTS) and percentage elongation.

For Flexural Test

Flexural properties are useful for quality control and specification purposes. It depends on depth of specimen, temperature, atmospheric conditions and the difference in rate of stirring during the casting process. Before the flexural test, machines were made ready (polishing, if necessary) to eliminate any unevenness or sharpness of the test samples. Upon startup or following a prolonged period of machine inactivity, the test machines were exercised or warmed up to normal operating temperatures to minimize errors that may result from transient conditions.

Result

FRP Making using thermoplastic:

Jute mat,

Length	= 21 cm
Width	= 14 cm
Thickness	= 0.85 mm
Weight	= 8 gm
Volume	= 210*140*0.85 mm^3 = 24.99 cm^3

Weight of the composite	= 105 gm
Weight of the matrix or resin	= 105gm - 8 gm = 97 gm
Weight fraction of Jute Mat	= Weight of Jute mate / Weight of Composite = 8/105 * 100% = 7.619%
Weight fraction of polymer matrix	= Weight of Jute mate / Weight of Composite = 97/105 * 100% = 92.38%

Tensile Test for Thermoset Matrix Composite:

Specimen,	Width	= 12.35mm
	Thickness	= 1.3mm
	Gauge Length	= 50.2 mm
	Final Length	= 51.35 mm

Flexural Test for Thermotest Matrix Composite:

Specimen,	Width	= 13.4mm
	Thickness	= 1.3mm
	Gauge Length	= N/A

Table: Results from the tensile and the bend test

Properties	3 Point Flexural Test	Tensile Test
Yield Load (kN)	0.0628	1.793
Yield Strength (MPa)	86.57	16.68
Modulus (MPa)	2162 (MOR)	1282 (MOE)
Yield Displacement (mm)	2.608	0.9559
Yield Strain (mm/mm)	4.702	0.0229
Ultimate Tensile Load (kN)	N/A	1.793
Ultimate Tensile Strength (MPa)	N/A	51.08

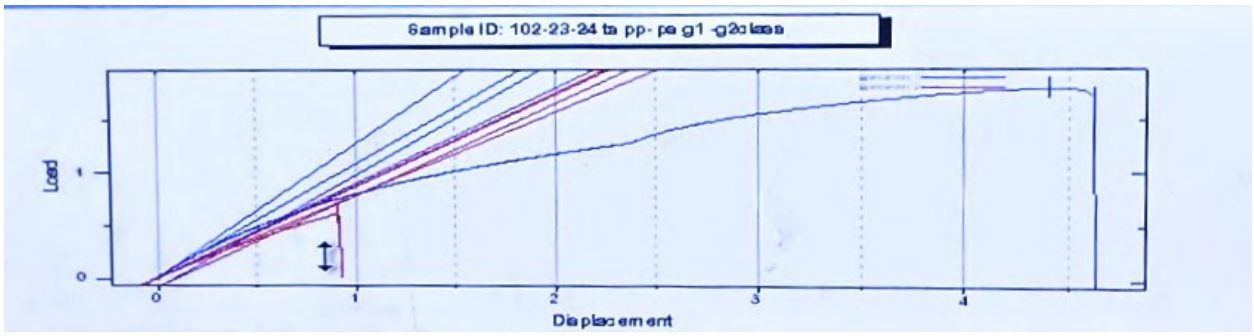


Fig: Load vs Displacement curve in the tensile test of the FRP sample

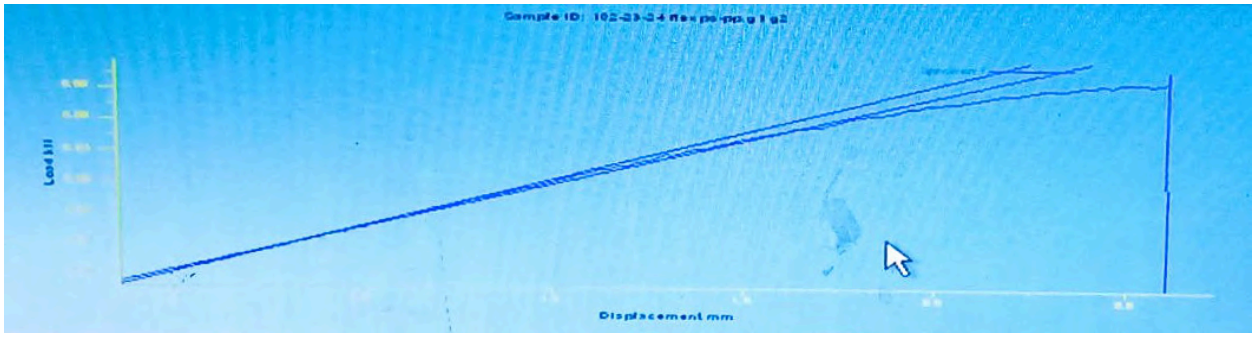
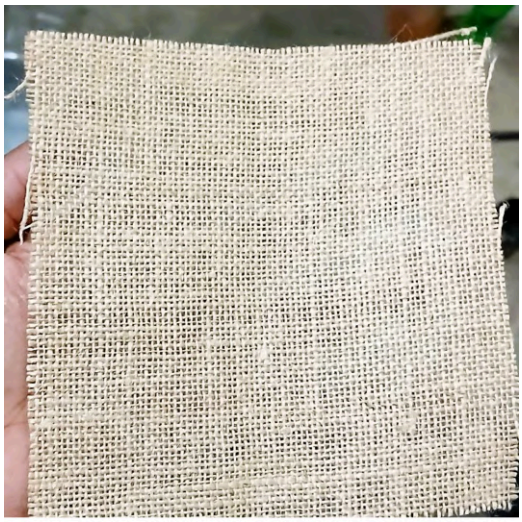


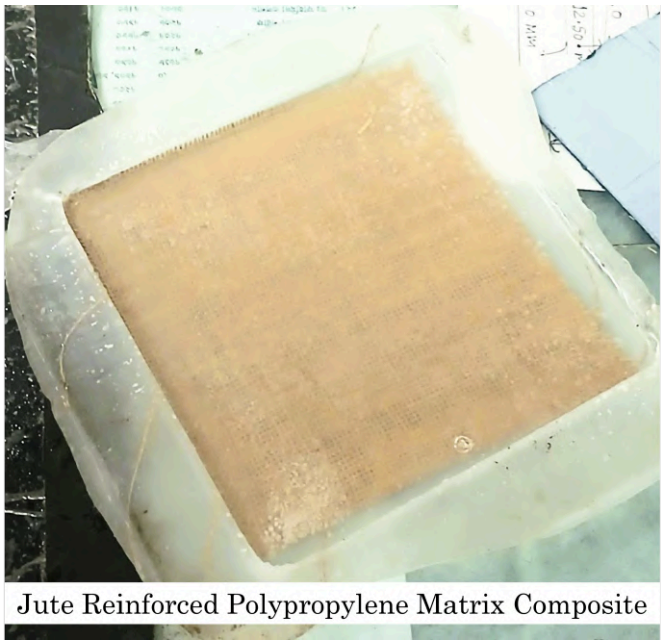
Fig: Load vs Displacement curve in the flexure test of the FRP sample

Discussion

In the process of making FRP, we used two types of polymer matrix in two different methods. In the 'hot compression moulding' method, we used Polypropylene as our polymer matrix. In the 'hand layup method', epoxy was used as the resin. In both of the cases, the reinforcement was jute fiber mat. Thus, the composite was made of I. Epoxy + Jute Mat, II. PP + Jute Mat. In the case of tensile test and bend test, we used our first sample (thermoset matrix composite) and derived some of the important mechanical properties.



Jute Mat as Reinforcement



Jute Reinforced Polypropylene Matrix Composite

What are the differences between thermoplastic and thermoset?

Thermoplastics and thermoset are two different types of polymers that can be differentiated through many characteristics:

Thermoplastics	Thermosetting
Can be reheated and reshaped multiple times without undergoing chemical changes	Cannot be reheated or remolded without decomposition once those are cured
Weak intermolecular forces between polymer chains	Strong covalent bonds between polymer chains
Have lower melting point	Comparably higher melting point
Usually flexible and recyclable	Neither flexible nor recyclable
Used in medical devices, general accessories, automotive parts, consumer goods	Used in electrical components, automobile parts, construction application and other high-performance cases

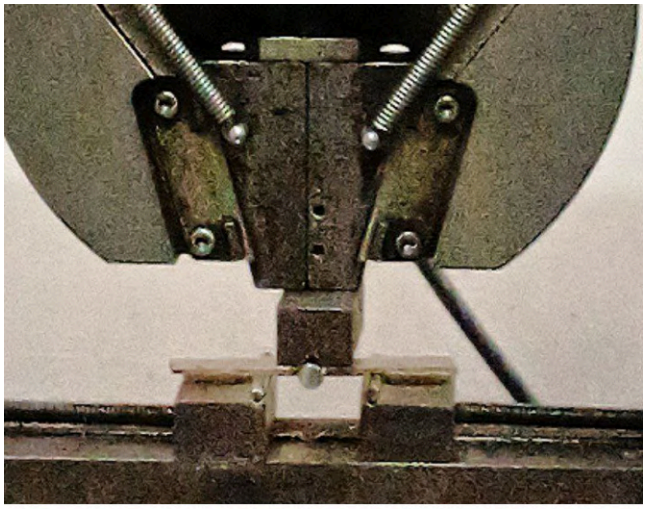
Compare the results of tensile test and 3 point bend test of the composites.

Comparison between Tensile test and 3 point bend test:

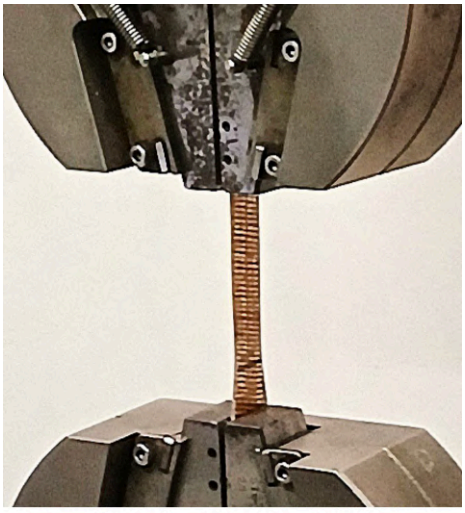
1. MOR > MOE
   In the bend test, the modulus is called the 'modulus of resilience' (MOR) which is much higher (2162 MPa) than the 'modulus of elasticity' (MOE) we found in the tensile test (1282 MPa)

2. $YS_{Flexure} > YS_{Tensile}$
   A material can resist higher loads in a bend test, thus, the yield strength is supposed to be much higher in the bend test, which is 86.57 MPa. On the other hand, this yield strength in the tensile test is 16.68 MPa.

3. $Yield\text{-}Strain_{Flexure} > Yield\text{-}Strain_{Tensile}$
   Yield strain for the flexure test is 4.702, yield strain in the tensile test is 0.0229.



Flexure Test for FRP



Tensile Test for FRP

What is the significance of using hand layup and hot compression molding techniques in composite preparation?

In processing fiber reinforced polymer matrix composite, both hand layup techniques and hot compression moulding techniques are used. We used hot compression molding technique in making jutemate fiber reinforced thermoplastics and used the hand lay up method while working with the thermoset.

Hand layup method:

1. Firstly, this method is of low cost and the technique is simple. Thus, it can be heavily used in small scale operations.
2. To get different shapes and sizes of composites, the hand layup method is very useful. In case of any design changes, this method can be used for making the mould for the composite quickly and easily. Thus, it is highly adaptable.

Hot compression method:

1. As we use high temperature and pressure for a certain amount of time, the bonding between the matrix and reinforcement is formed better.
2. The process is faster and efficient as we use higher temperature and pressure for curing the composite.
3. The hot compression method increases tensile strength, flexural strength and impact resistance as the bonding is better in this technique.

Why do we use a Roller in Hand lay-up technique?

We used a roller in hand lay up technique because—

1. Rolling homogenizes the liquid polymer solution through dispersing it throughout the jute fiber.
2. Using a hand roller in rolling would flare the upper surface of the composite after cooling down.
3. Rolling makes air bubbles in the liquid to get out and makes the composite without air bubble defect.