MECHANICAL CHARACTERISATION OF NATURAL FIBER HYBRID COMPOSITES

Urmilkumar Chaudhari[1], Prof. Kundan Patel[2], Prof. Mayank Madia[3]

[1] *M.E. Advance Manufacturing System, Tatva Institute of Technological Studies, Modasa, Gujarat, India*

[2] *Asst. Prof., Mechanical Engineering, CHARUSAT, Changa, Gujarat, India*

[3] *Asst. Prof., Mechanical Engineering, Tatva Institute of Technological Studies, Modasa, Gujarat, India*

ABSTRACT

Fiber reinforced polymer composites has been used in a variety of application because of their many advantages such as relatively low cost of production, easy to fabricate and superior strength compare to neat polymer resins. Reinforcement in polymer is either synthetic or natural. Synthetic fiber such as glass, carbon etc. has high specific strength but their fields of application are limited due to higher cost of production. Recently there is an increase interest in natural fiber based composites due to their many advantages. In this connection an investigation has been carried out to make better utilization of jute and sisal fiber for making value added products. For the purpose of analysis, to find out hybridization effect by varying weight fraction of Glass/Jute/Sisal fiber in unidirectional, to find out directional effect of unidirectional of hybrid composite with Polyester resin. With help of experimental result the final comparison and optimization carried out.

Keyword :- *Natural fiber, sisal ,jute, hand lay up, sample preparation, tensile strength, Impact strength, Flexural strength, composites*

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1. INTRODUCTION

When two or more materials with different properties are combined together, they form a composite material. Composite material comprise of strong load carrying material (known as reinforcement) imbedded with weaker materials (known as matrix).The primary functions of the matrix are to transfer stresses between the reinforcing fibres/particles and to protect them from mechanical and/or environmental damage whereas the presence of fibres/particles in a composite improves its mechanical properties like tensile strength, flexural strength, impact strength, stiffness etc.

Fibre reinforced polymer composites *also* called fibrous composites consisting of fibres as the reinforcement. Now-a-days, these composites have found applications in various areas such as automotive, marine, aerospace etc. due to their high specific stiffness and strength. Generally, fibres are the most important class of reinforcements in composite materials, as they satisfy the desired conditions and transfer strength to the matrix constituent, influencing and enhancing their desired properties. A fibre is characterized by its length being much greater as compared to its cross-sectional dimensions. The properties of matrix, fibre and its interface have greatly influencing the properties of composite materials.

The main advantages of natural fibres are their availability, biodegradable, renewable, environmental friendly, low cost, low density, high specific properties, good thermal properties and enhanced the energy recovery, low energy consumption, non-abrasive nature and low cost. A great deal of work has been carried out to measure the potential of natural fibre as reinforcement in polymer such as jute, coir, bamboo ,sisal, banana and wood fibres have been reported [11].

2. LITRATURE REVIEW

K.L. Pickering et. al. (2015) studied "*The recent developments in natural fiber composites and their mechanical performance"*. The main factors affecting mechanical performance of NFCs are: fibre selection – including type, harvest time, extraction method, aspect ratio, treatment and fibre content. Strength and stiffness of natural fibres are generally lower than glass fibre, although stiffnesses can be achieved with natural fibres comparable to those achieved with glass fibre. The fraction of cross-sectional area taken up by the lumen has been found to be, for example, 27.2%, 6.8% and 34.0% for sisal, flax and jute respectively.[1]

G.Sundaravadivel , Dr.M.Aruna , S.Anish (2015) investigated "*Evaluation of mechanical Properties of hybrid Sisal fiber Reinforced Composites.*" The experimental investigation on the effect of fiber loading on mechanical behavior of Hybrid sisal/glass fiber reinforced epoxy composites was conducted. Properties such as the Tensile strength, and flexural strength, were evaluated from various experiments and conclusions are: Successful fabrication of hybrid sisal/glass fiber reinforced epoxy composites is possible by simple hand layup technique. Sisal fibres are effective reinforcement of polymers thus creating a range of technological applications beyond its traditional uses such as ropes, furniture, mats etc.[2]

Ji rí Militký, Abdul Jabbar (2015) studied *"Comparative evaluation of fiber treatments on the creep behavior of jute/green epoxy composites."* In the present work, the effect of novel treatments such as infrared laser, ozone, enzyme and plasma on the creep behavior of woven jute fabric/green epoxy composites was investigated and modeled using Burgers four parameters approach. The Burgers model fitted well the experimental creep data. The creep strain was found to increase with temperature. The treated composites showed less creep deformation than untreated one at all temperatures.[3]

C. C. Angrizani, M. L. Drummond et. al. (2010) studied *"the mechanical properties of pure sisal, pure glass, and hybrid sisal/glass compression-molded composites",* in which various stacking sequences of fibre layers were used at which three different groups of composites were studied 1.Glass/polyester composites. 2. Sisal/polyester composites with untreated sisal, dried sisal and washed sisal 3.Glass/sisal hybrid composites as a result to optimize flexural behaviour, there must be glass fibres mainly on the top and bottom surfaces. Furthermore, depending on the type of loading and stacking sequence, some hybrid composites may show properties very close to those of pure glass.[4]

Girisha. C, Sanjeeva murthy, (2012) studied *"The tensile properties of composites made by reinforcing sisal, coconut spathe and ridge gourd as the new natural fibres into epoxy resin matrix"*. The natural fibres extracted by retting and manual processes were subjected to alkali treatment. The composites fabricated consist of reinforcement in the hybrid combination like sisal- coconut spathe, sisal-ridge gourd and coconut spathe-ridge gourd with the weight fraction of fibres varying from 5% to 30%. To find out the optimum hybridization effect of mechanical properties.[5]

P. Nowshoba, M. Gunasekhar Reddy et. al. (2013) studied *"Fiber reinforced composite was prepared by hand lay-up method using epoxy resin as the matrix and Hardwickia binata fibre as the reinforcement."* Mechanical properties of Hardwickia binata fibre reinforced polymer composites such as tensile and impact properties were investigated as a function of fibre loading and weight fraction. The composite plate was fabricated with different weight fractions of Hardwickia binata fibre (10, 20, and 30 wt. %) and different lengths of the fibre (2, 4, and 6 mm). It can be concluded that alkali treatment of the natural fibres is necessary to get composites with moderate mechanical properties as well as better adhesion between fibres and matrix.[6]

Amit Kumar Tanwer et. al. (2014) studied *"The Mechanical Testing of Uni-directional and Bi-directional Glass Fibre Reinforced Epoxy Based Composites for mechanical properties were evaluated."* Here, Glass fiber is the fiber reinforcement and epoxy polymer resin as a matrix material. Composites were prepared with longitudinal (Unidirectional) and cross (Bidirectional) glass fiber reinforced with epoxy based polymer. Mechanical test i.e. compression and tensile test were performed on UTM and the results are reported. The result showed compressive and tensile strength of unidirectional and bidirectional glass fiber reinforced epoxy polymer composites.[7]

M. Muthuvel , G. Ranganath , K. Janarthanan , K. Srinivasan (2013) investigated " *Characterization Study Of Jute And Glass Fiber Reinforced Hybrid Composite Material".*

They found investigate the hybridization of glass fibers with natural fibers for applications in the aerospace and naval industry. Mechanical properties such as tensile, impact and flexural test of hybrid glass/jute fiber reinforced epoxy composites in the forms of lamina and laminates were determined. The lamina prepared with natural fiber mat showed lower mechanical properties compared to laminas with glass mat. For this reason we proposed to use a hybrid design for the various applications which makes use of glass woven fabrics and jute fiber mats.[8]

Behnaz Baghaie, Mikael skrifvars, Lena Berglin (2013) studied *"Manufacture and characterization of thermoplastic composites made from PLA/hemp co-wrapped hybrid yarn prepregs"* PLA/hemp co-wrapped hybrid yarns were produced by wrapping PLA filaments around a core composed of a400 twists/m and 25tex hemp yarn (Cannabis sativa L)and 18tex PLA filaments. The hemp content varied between 10and 45mass%,and the PLA wrapping density around the core was 150 and 250 turns/m. Composites were fabricated by compression moulding of0/90 bidirectional prepregs, and characterized regarding porosity, mechanical strength and thermal properties by dynamic mechanical thermal analysis (DMTA)and differential scanning calorimetry (DSC).[9]

M. R. MANSOR, S. M. SAPUAN et. al. (2013),studied "*Stiffness Prediction of Hybrid Kenaf/Glass Fiber Reinforced Polypropylene Composites using Rule of Mixtures (ROM) and Rule of Hybrid Mixtures (RoHM)*" In this report, rules of mixture (ROM) and rule of hybrid mixtures (RoHM) were utilized to predict the mechanical properties of kenaf/glass fiber reinforced polypropylene short random oriented hybrid composites material. Three hybrid composition were studied with total fiber contents 30 vol%, 40 vol% and 50 vol% and the relative glass fiber contents are varied from 0 to 100 vol%.[10]

3. MATERIALS AND METHODS

The raw materials used in this work are:

1. SISAL FIBER
2. JUTE FIBER
3. GLASS FIBER
4. POLYSTER RESIN
5. CURING AGENT

The hand lay-up is the oldest, (simplest but most widely used) fabrication process for the composite materials. Essentially, it involves manual placement of dry fiber in the mold or mandrel and succeeding application of resin matrix. The wet composite is then rolled using hand rollers to facilitate uniform resin distribution, to ensure better interaction between the reinforcement and the matrix and to achieve the required thickness. The layered structure is then cured. In general, the hand layup fabrication process is divided into four essential steps:

- Mould preparation,
- Gel coating,
- Lay-up and
- Curing.

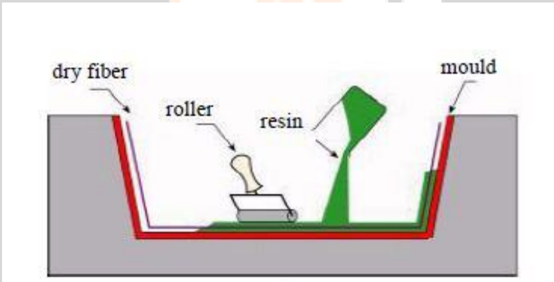

Fig 3.1 Hand lay-up Technique

There are many composite manufacturing techniques available in the industry. The hand lay-up manufacturing process is one of the common techniques to combine resin and fabric component.

- **SAMPLE PREPARATION**

To prepare the composite specimen for testing purpose. Composites sheet was manufactured at Bansari Composites ltd., GIDC, and V.V.Nagar. A composite mould dimension 12x12" with different thickness as required for composite sheet. In this process fibre reinforcement in to a single sided mould where resin is then forced through fibre mats and plastic miler using hand rollers and hand pad. After Hardening of sheet 70-80 kg Load applies on it for 24 hrs. The all sheets are cut by hand cutter on board to achieve desired dimension and to remove extra fibers and polyester.

(a)

(b)

(c)

(d)

(a) Polyester coating (b) Remove air bubble (c) Cutting extracted fiber and resin

(d) Finished Sheet

Fig.3.2 Fabrication of NFC Sheet

4. METHODOLOGY

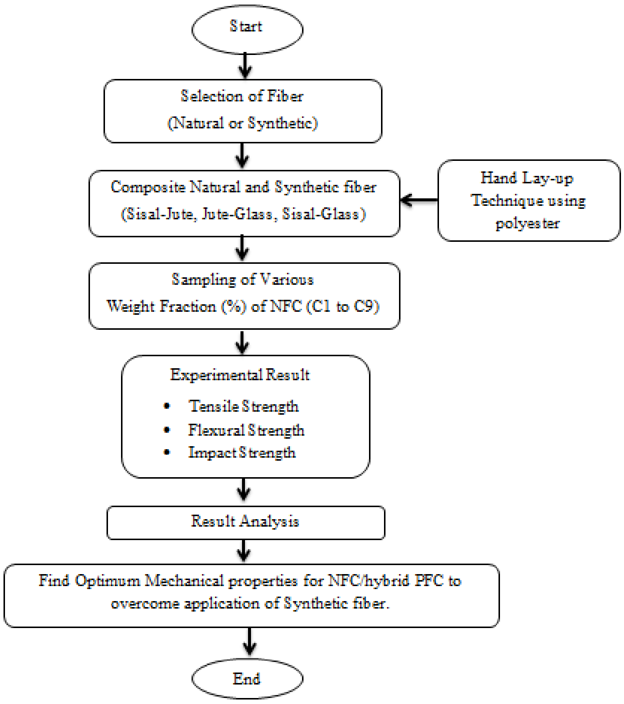

Fig.4.1 Flowchart of Methodology

5. RESULT AND DESCUSSION

5.1 Experimental Result for Tensile Testing for different parameter.

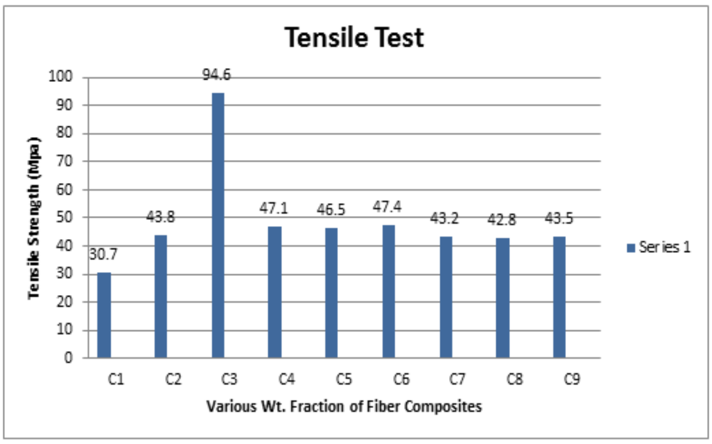

Figure 5.1 shows result obtained from average value of five specimen of tensile testing of unidirectional weight fraction. Experimental result from the table 5.1 shows the comparatively Maximum tensile strength of (G30%) is 94.6 MPa and the minimum tensile strength of (S30%) is 30.7 MPa.

Table 5.1 Tensile strength of various wt. fr. of NFC

Composite	Weight fraction	Width (mm) (± 0.5)	Thickness (mm) (± 0.3)	Max. Tensile Strength (MPa)
C1	S 30%	15	5	30.7
C2	J 30%,	15	5	43.8
C3	G 30%	15	5	94.6
C4	S20% G10%	15	5	47.1
C5	S15% G15%	15	5	46.5
C6	S10% G20%	15	5	47.4
C7	J20% G10%	15	5	43.2
C8	J15% G15%	15	5	42.8
C9	J10% G20%	15	5	43.5

5.2 Experimental Result for Flexural Testing for different parameter.

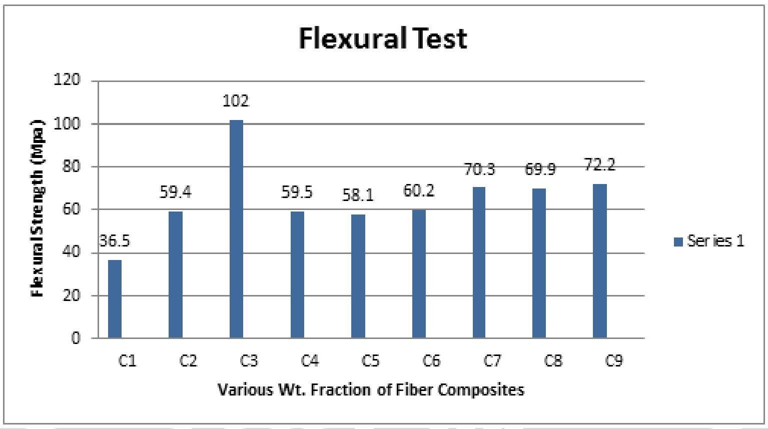

Figure 5.2 shows result obtained from average value of five specimen of flexural testing of unidirectional weight fraction. Experimental result from the table 5.2 shows the comparatively Maximum flexural strength of (G30%) is 102 MPa and the minimum flexural strength of (S30%) is 36.5 MPa.

Table 5.2 Flexural strength of various wt. fr. of NFC

Composite	Weight fraction	Width (mm) (± 0.5)	Thickness (mm) (± 0.3)	Max. Flexural Strength (MPa)
C1	S 30%	12.7	4	36.5
C2	J 30%,	12.7	4	59.4
C3	G 30%	12.7	4	102
C4	S20% G10%	12.7	4	59.5
C5	S15% G15%	12.7	4	58.1
C6	S10% G20%	12.7	4	60.2
C7	J20% G10%	12.7	4	70.3
C8	J15% G15%	12.7	4	69.9
C9	J10% G20%	12.7	4	72.2

5.3 Experimental Result for Impact Testing for different parameter.

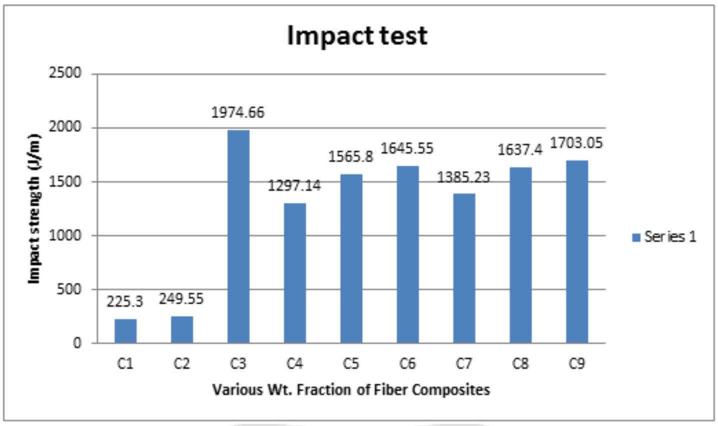

Figure 5.3 shows result obtained from average value of five specimen of impact testing of unidirectional weight fraction. Experimental result from the table 5.3 shows the comparatively Maximum flexural strength of (G30%) is 1974 J/m and the minimum impact strength of (S30%) is 225 J/m.

Table 5.3 Impact strength of various wt. fr. of NFC

Composite	Weight fraction	Width (mm) (± 0.5)	Thickness (mm) (± 0.3)	Max. Flexural Strength (MPa)
C1	S 30%	12.7	4	225.30
C2	J 30%,	12.7	4	249.55
C3	G 30%	12.7	4	1974.66
C4	S20% G10%	12.7	4	1297.14
C5	S15% G15%	12.7	4	1565.80
C6	S10% G20%	12.7	4	1645.55
C7	J20% G10%	12.7	4	1385.23
C8	J15% G15%	12.7	4	1697.40
C9	J10% G20%	12.7	4	1703.05

6. CONCLUSION

- After Experimental process of Tensile test And Flexural test, The Experiment of Impact Test is carried out and find out the optimum value of mechanical properties with different weight fraction.
- Varying Weight fraction of Natural fiber and Synthetic fiber, Tensile, Flexural and Impact tests will carried out for mechanical characterization.
- Here we examine that in variation of weight fraction of 5% of natural fiber there is small variation in Tensile, Impact and Flexural strength.
- Here we replace the glass fiber by natural fiber like Sisal and Jute. Jute fiber is more preferable than sisal fiber.

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