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TESTING OF MECHANICAL PROPERTIES OF FIBER REINFORCED POLYPROPYLENE COMPOSITE MATERIALS

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Abstract:—Today the overall inquire is being persuaded on the investigations of utilizing regular fibers as reinforcement in polypropylene composites. The direction of government and simplicity of accessibility of regular fiber made the examines to strive for fiber strengthened polypropylene. With ease, simplicity of manufacturing and high mechanical and tribological properties, characteristic strands speaks to a decent option to the greater part of the regular composites. With the assistance of composites substantial assortment of materials can be made. By suitable utilization of these normal strands physical and mechanical properties of the traditional polypropylene materials will be upgraded. The employments of common fiber strengthened plastic (NFRP) composites in engineering applications, for example, Automotive, airplane and produce of spaceships and ocean vehicles ventures have been expanded extensively as of late because of their huge points of interest over different materials.

In the present study jute and luffa aegypticafiber is reinforced in polypropylene at different weight ratios and the mechanical properties will be evaluated

Keywords— luffa aegypticafiber, reinforced, tibological, polypropylene

INTRODUCTION

"Composite" signifies at least two particular materials physically limited together". Hence, a material having two progressively particular constituent materials or stages might be viewed as a composite material. Fiber-reinforced composite materials comprise of fiber of high quality and modulus installed in or clung to a matrix with unmistakable interfaces (limit) between them. In this shape, both fiber and grid hold their physical and concoction identities, yet they deliver a blend of properties that can't be accomplished with both of the constituents acting alone. In general, the load carrying unit is fiber where nearby matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperatures and humidity etc.

1. DEFINITION OF COMPOSITES:

A composite material is defined as a material system which consists of a mixture or a combination of two or more distinctly differing materials which are insoluble in each other and differ in form or chemical composition. Thus composites are combination of two materials in which one of the materials called reinforcing phase is in the form of fiber sheets or particles and are embedded in other materials called the matrix phase. Composites are made by combining two or more natural or artificial materials to exploit their useful properties and minimize their flaws

1.1 TYPES OF COMPOSITES

A) Classification by matrix

i.Metal Matrix Composites (MMCs):

ii.Ceramic Matrix Composites (CMCs):

iii.Polymer Matrix Composites (PMCs):

B) Classification by reinforcing materials

i.Particulate Composites

ii.Fibrous composite

Luffa Aegyptiaca as a natural fiber There are many potential natural resources, which India has in large quantity. Most of it comes from the agriculture and forest.

Fig-1.1(a)

Fig-1.1(b)

Fig-1.1(c)

Fig. 1.1 The Luffa aegyptiaca plant with fruit (a), the inner fiber core (b) and the outer core open as a mat (c).

Combining or mixing of at least two materials particularly contrasting which are not soluble in one another and vary in shape or substance creation makes a composite material. Subsequently Composite Material is made-up with Fiber sheets prepared in reinforcing phase in combining with other materials in matrix phase.

Luffa aegyptiaca fruit is combination of fibrils glued with natural resinous materials of plant consisting 62%,20% and 11.2% of cellulose, hemicellulose and lignin respectively [1] and is shown in Fig.1.1(a-c) with thick peel, sponge-gourd having multidirectional array of fibers core with mat

1.2 Jute as a natural fiber

Jute is obtained from the plants Corchorus Olitorious and Corchorus capsularis .These plants are native to Indian Sub-Continent & grow throughout year. It is also referred to as golden fiber due to its color and cost effectiveness

Fig-1.2

Jute Fabric and Coffee Sacks Made Of Jute.
Fig-1.2.1

1. 1.3 FABRICATION OF COMPOSITE SPECIMENS:

Here we take some proportion of fibers like 0%,10%,15%,20% by weight and the pellets are blend to obtain a homogenized mixture. The blend is then kept in a 2.5 ton capacity hydraulic plastic Injection Molding Machine, The temperature is kept at 210^{o}C and pressure is set as 1100 kgf/cm^{2}, all the specimens are developed for corresponding weight fraction of Jute and Luffaaegyptiaca vegetable fiber composites. Percentage of fiber in the composite is maintained by its weight fraction.

The check the elastic nature of fiber resin composites the standard test methods ASTM-D638M is performed and for the flexural properties of fiber-resin composites ASTM-D790m and ASTM-D256M for impact properties of fiber-resin composites, were used to prepare specimens as per dimensions.

1.4 FABRICATION OF COMPOSITE SPECIMENS (MACHINING):

The method for checking the machining characteristics of fiber-resin composite plates, to develop specimens as per the dimensions. Similarly by using injection moulding machine to check the machining characteristics of composite specimens we have developed plates of mould dimensions with that thickness and fiber contents weights percent as 0%,10%,15%,20%.And plain polypropylene specimen's plates are developed so that we can compare the results

Fig-1.4(a)

Fig-1.4(b)

Fig-1.4(c)

Figs-1.4(a),(b),(c) Shows the Fabricated Composite Specimens to perform mechanical and machining characteristic

1.5 TESTING OF COMPOSITES

TENSILE TESTING OF COMPOSITES:

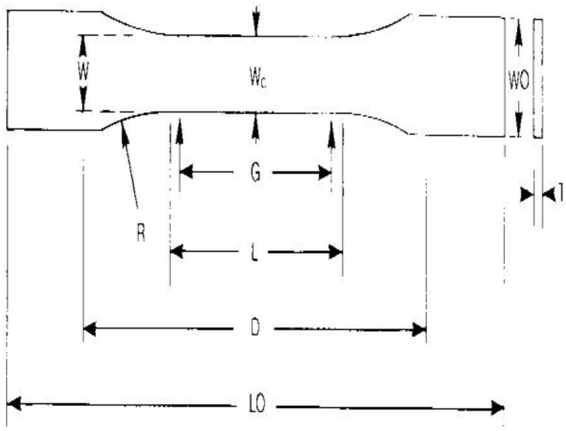
Electronic tensometer (Fig1.5(a).), having a capacity of 2 ton is used to known the tensile strength .It has the possibility to change the load cells ranging from 20Kg, 200Kg & 2000 Kg. A load cell of 2000 Kg. Here we use a load cell of 200Kg for the purpose of testing. The chuck that is used to hold is self aligned quick grip The thickness and width of specimen is measured by a digital micrometer. The tensometer is fitted in such way that one is fixed gripchuck and other is movable one ,and it can adjust 16mm wide and 8mm thick specimen.

The specimen is placed in fixed grip and the movable grip is manually moved until the specimen is held firmly .The power supply is switched on to measure the load and extension of the specimen. The movable chuck is further moved such that the load indicator just starts giving indication of loading on the specimen. At that instant the extension meter is adjusted to read zero, when the load on the specimen is zero. The speed reduction pulleys are chosen such that a cross head speed of 0.2mm/min. is applied on movable grip. Then the electric motor fitted to tensometer is started. Starting from zero, at every 0.5 mm extension the load indicated are noted until the specimen breaks.

At the end of the test, the final load and elongation is also noted from the electronic indicator display. It is also confirmed that the specimen failed at a section within the gauge length of all the specimens. For each specimen the type of failure and any other such observations pertaining to failure are noted. The tests are conducted at 240 c and 50 % relative humidity in the laboratory atmosphere.

Five identical specimens of each weight fraction are tested. To check the tensile properties of composites the standard method is used and specimens are made as per dimensions shown.

Fig-1.5(a)



Specimens are made in the Dumbbell Shape to heck as per the Type I ASTM D638

Dimensional values in Dumbbell Shaped Specimen

Parameter Denoted by	**Dimension**	**Value in mm &(in)**
T	Thickness	7mm (0.28in)
W	Narrow section width	13 (0.5)
L	Narrow section length	57 (2.25)
WO	Overall width	19 (0.75)
LO	Overall length	165 (6.5)
G	Gauge length	50 (2.00)
D	Distance between grips	115 (4.5)
R	Fillet radius	76(3.00)

1.6 FLEXURAL TESTING OF COMPOSITES:

The flexural testing of composites is done by a three point bend test as per ASTM D790M test method 1, Procedure A to measure flexural properties. The examples taken are of are 98mm long by 10mm width by 4mm thick .As per the above specified method five indistinguishable specimens are tested for a value at a strain rate of 0.2mm/min

The flexural modulus,

$E = L3m/4bt3$

And the maximum fiber stress,

$S = 3PL/2bt2$

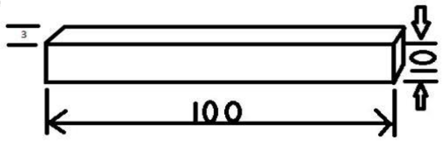


Fig-1.6

Dimension Value	
Thickness (T)	3 mm
Width of narrow section (b)	10 mm
Length of span (L)	100 mm

Where L is the support span (64mm), b is the width and t is the thickness, P is the maximum load and slope of the initial straight line portion of the load-deflection curve is denoted by m.

1.7 IMPACT TESTING OF COMPOSITES

To check the impact properties we used analog Izod/chirpy impact tester shown in fig 1.7, The Instrument has four working ranges of impact strength and are 0-2.71 J, 0-5.42 J, 0-10.84 J and 0-21.68 J, with a minimum resolution on each scale of 0.02 J, 0.05 J, 0.1 J and 0.2 J, respectively. Four scales and the corresponding four hammers(R1, R2, R3 and R4) are provided for all the above working ranges

Fig-1.7 Impact testing machine

DimensionValue	
Thickness	(T)10 mm
Width of narrow section (b)	12.5 mm
Length of span	**(L)** 100 mm
Angle of notch	45 degrees

2. RESULTS AND DISCUSSION

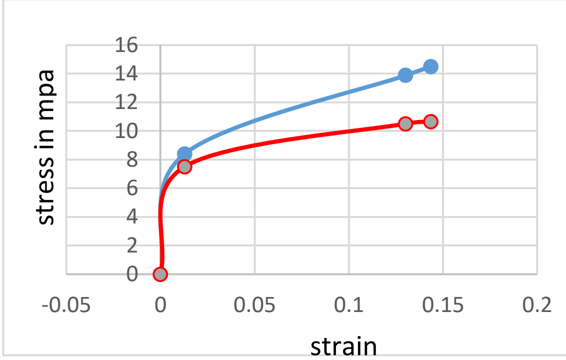
INTRODUCTION

The composites are molded with polypropylene resin matrix reinforced with different weight fractions (10%,15%,20%) of Luffa aegyptiaca and jutefiber,two specimens are prepared for each weight fraction and are tested as per the methods and the results are plotted in the graphs and discussed below

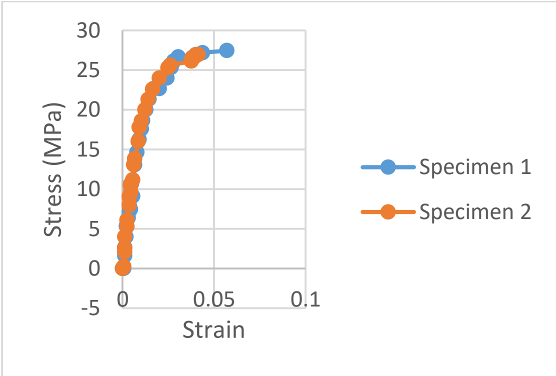
2.1 RESULTS AND DISCUSSION

Tensile properties

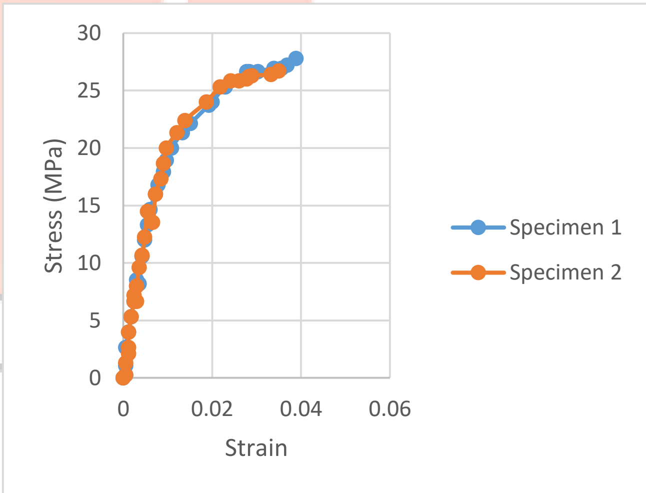
The stress verses strain curve for two specimens of pure polypropylene are shown in Graph 2.1.1 The results of tensile test for two specimens of Luffa aegyptiaca and jutePP composites for each weight fraction are shown in Graph 2.1.1 to 2.1.4



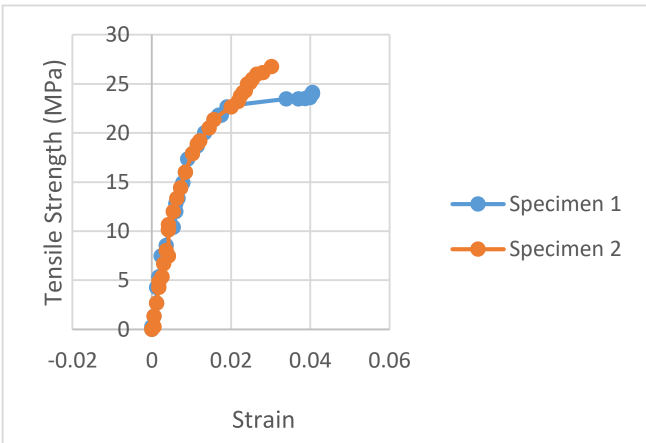
Graph 2.1.1 Stress- Strain Curves for Pure propylene



- Graph 2.1.2 Stress – Strain Curve for 10% Luffa aegyptiaca and jute/ PP Composites.



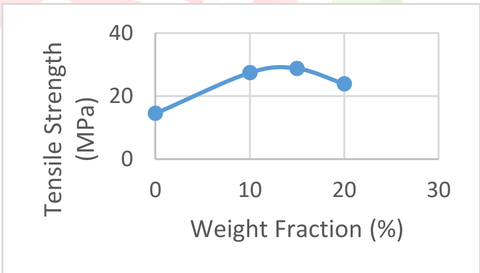
- Graph 2.1.3 Stress – Strain Curve for 15% Luffa aegyptiaca and jute/ PP Composites



- Graph 2.1.4 Stress – Strain Curve for 20 % Luffa aegyptiaca and jute/ PP Composites
- The calculation of mean tensile strength and the calculation of modulus is made by the following.
- Tensile strength = Maximum Load (N) / cross – sectional area (mm^2)
- Tensile Modulus = Stress / strain
- The tensile strength and modulus of the pure polypropylene (Graph 2.1.1)are determined as 12.536 MPa and 88 MPa, respectively. The average tensile strength and modulus of Luffa aegyptiaca and jutePP composites of the present work calculated from stress strain curves and plotted with respect to fiber weight fraction are shown in graphs and table below.

Tensile test results

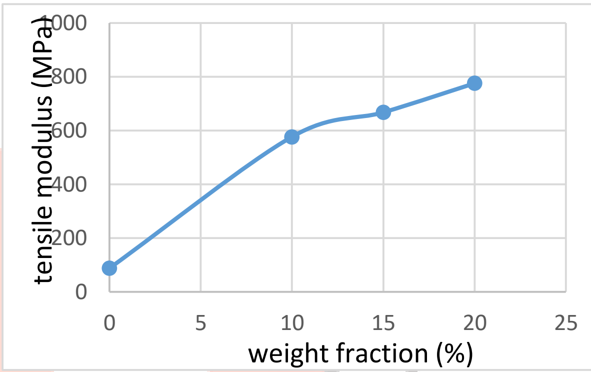
Si No	Weight Fraction (%)	Yield strength in (MPa)	Tensile strength in (MPa)	Tensile modulus in (MPa)
1	0%	6.103	14.78	88.10
2	10%	19	27.46	577
3	15%	17	28.78	668
4	20%	15.68	23.87	776



Graph 2.1.5
Tensile Strength at different fiber weight percentages of Luffa aegyptiaca and jute/ PP Composites

The tensile strength of the Luffa aegyptiaca and jute fiber reinforced PP composites polypropylene at different fiber loading is shown in Graph 2.1.5. The tensile strength is found to be increasing up to 15% fiber (by weight) and then decreases. The tensile strength and tensile modulus of the pure polypropylene is calculated as 14.58 MPa and 88 MPa respectively. A tensile strength of 28.78 MPa is noted at 15 weight % of Luffa aegyptiaca and jute fiber PP composite. The incorporation of fibers into thermoplastics leads to poor dispersion of fibers due to strong inter fiber hydrogen bonding which holds the fibers together. Improper adhesion hinders the considerable increment of tensile strength. Thus, as fiber percentage increases, gathering of fibers takes place instead of dispersion and melted polypropylene cannot wet them properly due to non-entrance of melt through the adjacent two fibers. Since no adhesion is present between the fibers and fibers are also not bonded with matrix, failure occurs before attaining the theoretical strength of composite.

Improved interfacial adhesion between the fibers and the matrix, there will be an increase in the strength which results in efficient stress transfer from the matrix to the fiber. From the results of Graph 2.1.5.It is observed that all composites have shown a moderate increase in tensile strength.



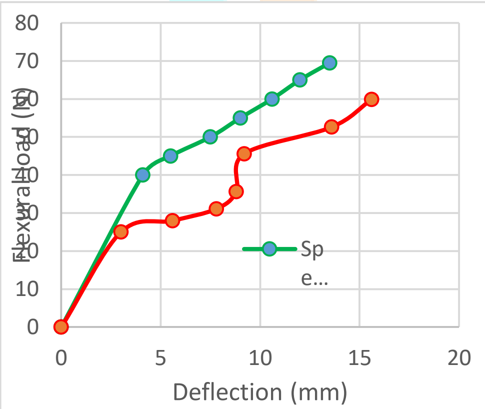
Graph 2.1.6 Tensile Modulus at different fiber weight percentages of Luffa aegyptiaca and jute/ PP Composites

Graph 2.1.6 shows the variation in tensile modulus with respect to fiber weight fraction. It is observed that the tensile modulus which is an indication of load bearing capacity increases with fiber weight fraction. During the tensile loading, partially separated micro spaces are created, which obstructs stress propagation between the fiber and matrix. As the fiber load increases, the degree of obstruction increases, which consequently increases the stiffness. As fiber is the stiffer component in the composite, resistance towards deformation increases with increase in fiber content, this consequently increases the stiffness of the composite. The tensile modulus of the pure polypropylene is calculated as 88.3MPa.The tensile modulus for Luffa aegyptiaca and jute fiber reinforced PP composites for composite is compare to 11.5 % higher than pure PP. For both the composites higher tensile modulus value is observed at 20% fiber weight fraction

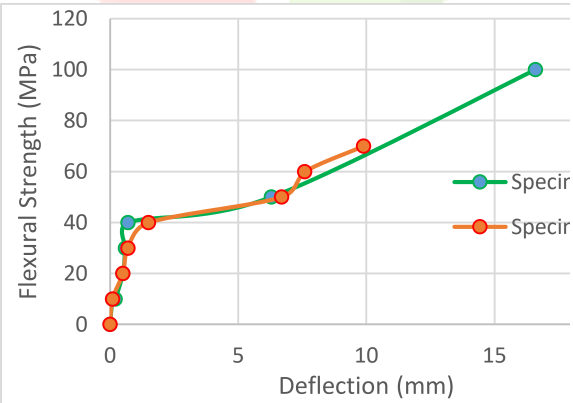
It is evident that the tensile strength of Luffa aegyptiaca and jute polypropylene composite increased rapidly from 10 % to 20 % fiber weight fraction (Graph 2.1.5) and then dropped below the strength of PP at 20 % fiber weight fraction. It is also observed that the tensile modulus (Graph 2.1.6) increased gradually up to 20 % fiber weight fraction. From the above observations and analysis, it can be concluded that the optimum value of fiber weight fraction for reinforcement of Luffa aegyptiaca and jute in PP composites is 20 %.

3-Flexural properties

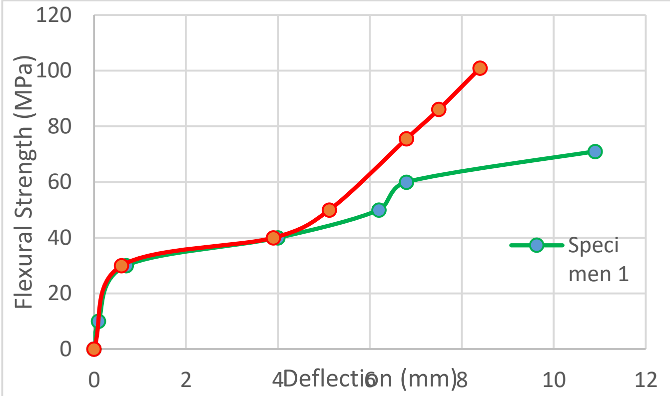
The load verses deflection curve for two specimens of pure polypropylene are shown in Graph 3.1 the results of flexural test for 2 specimens of Luffa aegyptiaca and jute PP composites for each weight fraction are shown in Graph 3.2 to Graph 3.3



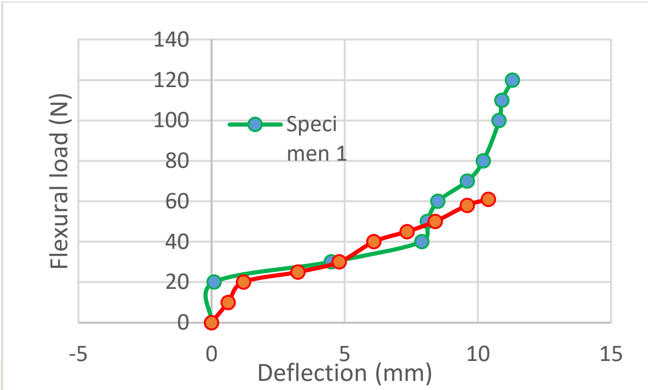
Graph 3.2 Flexural Load Vs Deflection curves for pure polypropylene



Graph 3.3Flexural LoadVsDeflection Curve for 10 % Luffaaegyptiaca and jute/ PP Composites



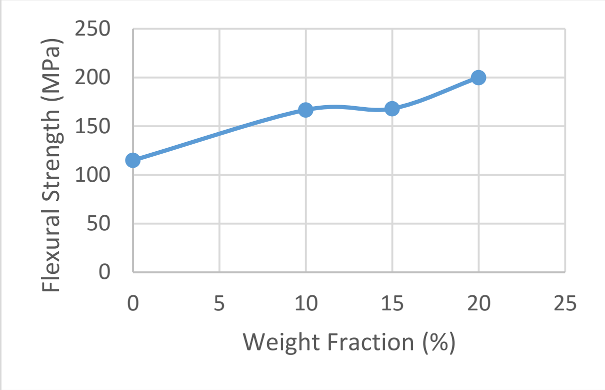
Graph 3.4 Flexural LoadVsDeflection Curve for 15% Luffaaegyptiaca and jute/ PP Composites



Graph 3.5 Flexural LoadVsDeflection Curve for 20 % Luffaaegyptiaca and jute/ PP Composites

The Flexural strength and modulus of pure polypropylene considered in the present work are 115 MPa and 4.295GPa, respectively.

SI No	Weight fraction (%)	Flexural strength in (MPa)	Slop	Flexural modulus in (GPa)
1	0	115	4.6389	4.295
2	10	166.65	4.8664	5.191
3	15	168.	7.985	9.259
4	20	200	8.396	6.610



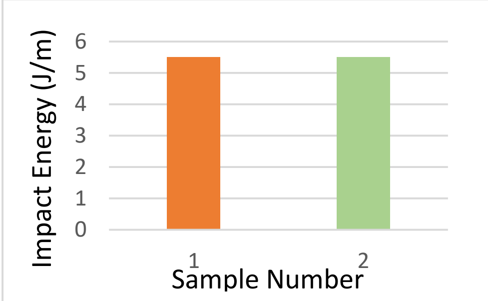
Graph 3.6 Flexural Strength at different fiber weight percentages of Luffaaegyptiaca / PP Composites

Flexural strength of the Luffaaegyptiaca and jutefiber reinforced polypropylene composites at a different percentages of fiber loading is shown in Graphs. The flexural strength increased with fiber loading up to 10% weight fraction of the fiber, and there was a decrement after 15% fiber loaded composites, and there was a increment after 15% fiber loaded composites.The reasons for the lower flexural properties at higher fiber fractions are possibly due to the lower fiber to fiber interaction, void and poor dispersion of fiber in the matrix. The flexural strength of the pure polypropylene is 48.42 MPa. The maximum flexural strength of the Luffaaegyptiaca and jutefiber polypropylene composite is 200 MPa, The percentage increase in the flexural strength is 20% for composite treated when compared to pure polypropylene.

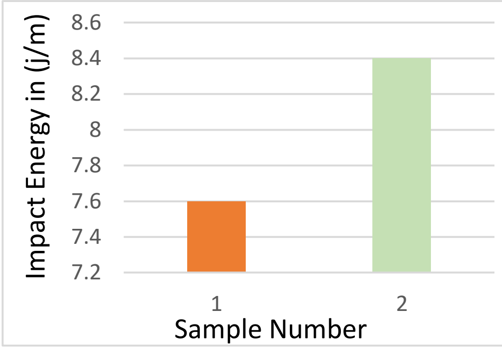
The decrease in flexural strength at high fiber loading is probably due to incompatibility of the fibers within the matrix, which promoted micro crack formation at the interface as well as non uniform stress transfer due to fiber agglomeration in the matrix. Therefore, the bond between fiber and matrix often dictates whether the fiber will improve the properties of composites by transferring the applied load. The load transfer between matrix and fibers in a composite is not only determined by the intrinsic properties of the fiber and matrix, but also affected by the geometric parameters and fiber arrangement within the matrix such as fiber distribution

4- Impact properties

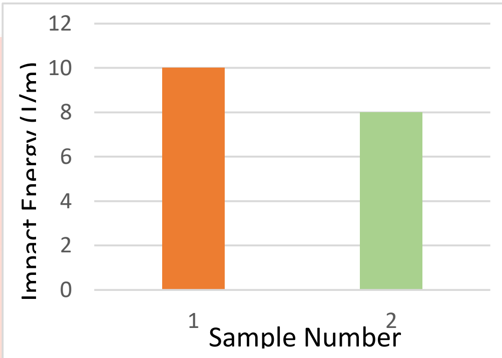
- The impact strength for two specimens of pure polypropylene are shown in Graph 2.2.1. The results of Impact test for two specimens of Luffa aegyptiaca and jute PP composites for each weight fraction are shown in Graph. 2.2.1 To Graph. 2.2.4



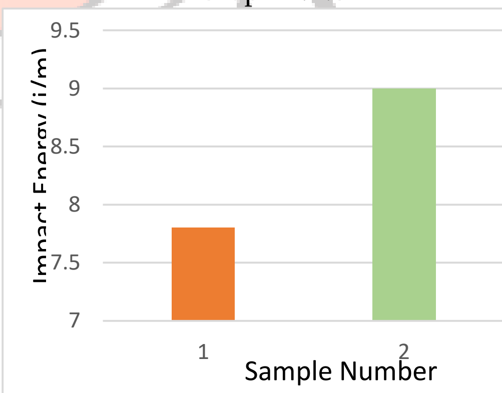
Graph 4.1.1



Graph 4.2.2



Graph 4.2.3

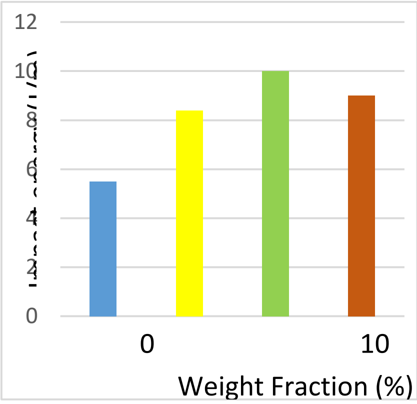


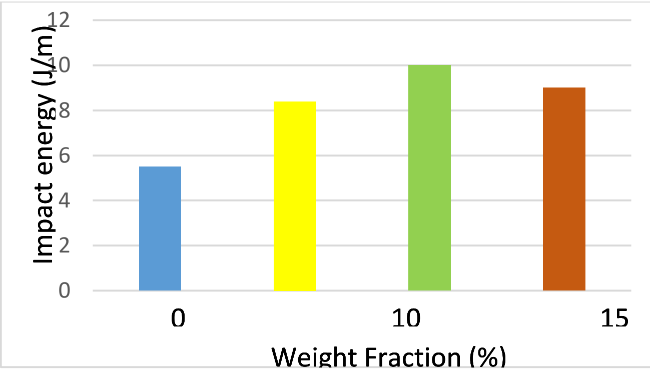
Graph 4.2.4

- Graph 4.2.1 Impact Strength for pure polypropylene
- Graph. 4.2.2 Impact Strength for 10 % Luffa aegyptiaca and jute / PP Composites
- Graph 4.2.3 Impact Strength for 15 % Luffa aegyptiaca and jute / PP Composites

- Graph. 4.2.4 Impact Strength for 20 % Luffa aegyptiaca and jute/ PP Composites

Impact test results





Graph 4.2.5 Impact Strength at different fiber weight percentages of Luffa aegyptiaca and jute / PP Composites

Sl no	Weight fraction (%)	Impact energy in (J/m)
1	0	5.5
2	10	8.4
3	15	10
4	20	9

The Impact Strength of the pure polypropylene (Graph 4.2.1) is 5.5 J/m. The average impact strength of two specimens at different fiber weight fraction for Luffa aegyptiaca and jute reinforced polypropylene composites is shown in Graph.4.2.5. It is observed that the impact strength increases with the increase in the fiber content up to 15% weight fraction of fibers and then decreases. Impact strength of 10 J/m is noted at 15 weight % of Luffa aegyptiaca and jute fiber PP composite, the impact strength has increased by 55% higher than pure polypropylene at 15 %weight fiber.The energy dissipation mechanisms operating during impact fractureare matrix and fiber fracture, fiber–matrix deboning and fiber pull out. Fiber fracture dissipates lesser energy compared to fiber pull out and is the common mechanism of fracture in fiber reinforced composites. As the main failure mechanism in these composites are fiber pull out, impact strength increases with fiber loading. High fiber content increases the probability of fiber agglomeration which results in regions of stress concentration requiring less energy for crack propagation. This results in lower energy dissipation and hence impact strength decreases.

CONCLUSIONS

The main objective of this investigation is to gauge the possibility of utilizing the Luffa aegyptiaca and jute which is abundantly available as an alternative filler material in a polypropylene matrix as compatibilizer to increase the bonding between fibers and matrix. The following conclusions are made basing on the above analysis.

The tensile strength is increasing up to 15% fiber and then decreases and the tensile strength of 20 weight percentage of luffa aegyptiaca and jute fiber reinforced composites is 27.2 MPa, The tensile modulus of the pure poly propylene is calculated as 88MPa, and the maximum tensile Modulus is obtained by luffa aegyptiaca and jute fiber reinforced composites is 776 MPa.

The Flexural strength & Flexural modulus of the pure poly propylene is calculated as 115 MPa &4.295GPa,The Flexural strength & flexural Modulus are 200 MPa & 9.259GPa.

The impact strength of pure polypropylene is 5.5 J/m and luffa aegyptiaca and jute fiber reinforced composites is 10 J/m.

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