

# Study of the tensile and impact energy absorption properties of hybrid bast and basalt fiber composites and the effect of basalt fibers size at the mechanical properties

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## Research Article

**Keywords:** Fibre Reinforced Composites, Natural Fibres, Charpy Testing, Tensile Testing

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# **Study of the tensile and impact energy absorption properties of hybrid bast and basalt fiber composites and the effect of basalt fibers size at the mechanical properties**

Yousuf Pasha shaik, Vijay Bhaskar Narlakanti, Jens Schuster

## **Abstract**

Natural Bast fiber reinforced polymer composites are attractive because of their renewability and environment friendliness. Therefore, in this work, the mechanical properties of these composites have been tried to improve by adding basalt fibers. The fiber mats were prepared by carding. After press molding, the tensile and Charpy mechanical properties of compression molded samples were studied. Moreover, the influence of basalt fibers with two different sizes was studied at the mechanical performance of the composites.

Improvement of mechanical property profile of natural fiber (bast) reinforced polymer composites is carried out by hybridization with basalt fibers.

**Keywords:** Fibre Reinforced Composites, Natural Fibres, Charpy Testing, Tensile Testing.

## **Abbreviations**

1. **PP** - Poly Propylene
2. **PE** - Polyethylene
3. **ABS** - Acrylonitrile Butadiene Styrene
4. **LDPE** - Low-density polyethylene
5. **HDPE** - High-density polyethylene
6. **MFR** - Melt Flow Rate
7. **MFI** - Melt Flow Index
8. **KF** - Kenaf & Flax
9. **DBF** - Deutsche Basalt Fibre
10. **FT** - Fibrax Basalt Fibre

# 1. INTRODUCTION

The increase in environmental consciousness and community interest, the new environmental regulations and unsustainable consumption of petroleum, led to thinking of the use of environmentally friendly materials. Natural fiber is considered one of the environmentally friendly materials which have good properties compared to synthetic fiber. A late current industry research identified that the worldwide natural fiber reinforced polymer composites industry sector reached US\$2.1 billion in 2010. Current pointers are that interest in NFPCs industry will keep on growing quickly around the world. The utilization of NFPCs has expanded considerably in the shopper merchandise as developing industry sectors throughout the last few years. As indicated by evaluations, over 5 years (2011–2016), the NFPCs industry is estimated to grow 10% worldwide.

Natural fibers in simple definition are fibers that are not synthetic or manmade. They can be sourced from plants or animals. The use of natural fiber from both resources, renewable and non-renewable such as oil palm, sisal, flax, and jute to produce composite materials, gained considerable attention in the last decades, so far. The plants, which produce cellulose fibers can be classified into bast fibers (jute, flax, ramie, hemp, and kenaf), seed fibers (cotton, coir, and kapok), leaf fibers (sisal, pineapple, and abaca), grass and reed fibers (rice, corn, and wheat), and core fibers (hemp, kenaf, and jute) as well as all other kinds (wood and roots).

## Properties of the NFPCs

There are considerable enhancement and suggestions for the natural fibers that can be implemented in order to enhance their mechanical properties resulting in high strength and structure. Once the base structures are made strong, the polymers can be easily strengthened and improved. There are number of aspects that effects of composite are performance level or activities, of which to name a few are the following;

- orientation of fiber,
- strength of fibers,
- physical properties of fibers,
- interfacial adhesion property of fibers and many more.

But,

Limited mechanical properties for some structural applications. Blending NFRC with glass or carbon fibers improve the property, profile, but decrease the renewable raw material content in the composite [1].

## Aim of the project

Improvement of the mechanical properties of Bast Fiber reinforced composites by hybridization with high performance basalt fibers (inorganic NF). In this project we have tried to improve the properties of these composites by adding basalt to them. Basalt is a natural material and advantage is that it can improve the mechanical properties just like glass fibers. However, the advantage is that basalt is a natural material. Moreover, we have studied two types of basalts, one with a size for thermosets and one with a size for thermoplastics. we have not just tried to improve the properties of composites but have also studied the effect of fiber size at these properties.

## 2. Experimental Procedure

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene. Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. Its properties are similar to polyethylene, but it is slightly harder and more heat resistant. It is a white, mechanically rugged material and has a high chemical resistance.

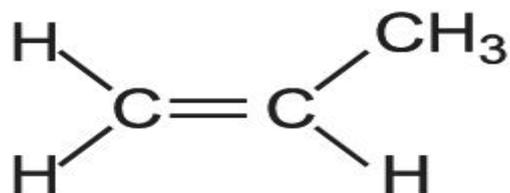


Fig.1 Structure of Propylene [2]

### **Mechanical properties:**

The density of (PP) is between 0.895 and 0.92 g/cm<sup>3</sup>. Therefore, PP is the commodity plastic with the lowest density. With lower density, moldings parts with lower weight and more parts of a certain mass of plastic can be produced. Unlike polyethylene, crystalline and amorphous regions differ only slightly in their density. However, the density of polyethylene can significantly change with fillers. [3] Young's modulus of PP is between 1300 and 1800 N/mm<sup>2</sup>. Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as acrylonitrile butadiene styrene (ABS). Polypropylene has good resistance to fatigue. [4]

### **Thermal properties:**

The melting point of polypropylene occurs in a range, so the melting point is determined by finding the highest temperature of a differential scanning calorimetry chart. Perfectly isotactic PP has a melting point of 171 °C (340 °F). Commercial isotactic PP has a melting point that ranges from 160 to 166 °C (320 to 331 °F), depending on atactic material and crystallinity. Syndiotactic PP with a crystallinity of 30% has a melting point of 130 °C (266 °F). [4] Below 0 °C, PP becomes brittle. [5] The thermal expansion of polypropylene is very large, but somewhat less than that of polyethylene. [5]

### **Chemical properties:**

Polypropylene at room temperature is resistant to fats and almost all organic solvents, apart from strong oxidants. Non-oxidizing acids and bases can be stored in containers made of PP. At elevated temperature, PP can be dissolved in nonpolar solvents such as xylene, tetralin and decalin. Due to the tertiary carbon atom PP is chemically less resistant than PE (see Markovnikov rule). [6] Most commercial polypropylene is isotactic and has an intermediate level of crystallinity between that of low-density polyethylene (LDPE) and high-density polyethylene (HDPE). Isotactic & atactic polypropylene is soluble in P-xylene at 140 °C. Isotactic precipitates when the solution is cooled to 25 °C and atactic portion remains soluble in P-xylene. The melt flow rate (MFR) or melt flow index (MFI) is a measure of molecular weight of polypropylene. The measure helps to determine how easily the molten raw material will flow during processing.

**Kenaf:** Kenaf [etymology: Persian], [7] Hibiscus cannabinus, is a plant in the family Malvaceae also called Deccan hemp and Java jute. Hibiscus cannabinus is in the genus Hibiscus and is native to southern Asia, though its exact origin is unknown. Kenaf is one of the allied fibres of jute and shows similar characteristics.



Fig.2 Kenaf Fibre [7]

**Flax fiber:** It is extracted from the bast beneath the surface of the stem of the flax plant. Flax fiber is soft, lustrous, and flexible; bundles of fiber have the appearance of blonde hair, hence the description "flaxen" hair. It is stronger than cotton fiber, but less elastic. The best grades are used for fabrics such as damasks, lace, and sheeting. [8]



Fig.3 Flax Fibre [8]

**Basalt fiber:** It is a material made from extremely fine fibers of basalt, which is composed of the mineral's plagioclase, pyroxene, and olivine. It is like fiberglass, having better physicommechanical properties than fiberglass, but being significantly cheaper than carbon fiber. It is used as a fireproof textile in the aerospace and automotive industries and can also be used as a composite to produce products such as camera tripods. [9]



Fig.4 Basalt Fibre [9]

## Carding

Carding is a mechanical process that disentangles, cleans and intermixes fibres to produce a continuous web or silver suitable for subsequent processing. This is achieved by passing the fibres between differentially moving surfaces covered with card clothing. It breaks up locks and unorganised clumps of fibre and then aligns the individual fibres to be parallel with each other. In preparing wool fibre for spinning, carding is the step that comes after teasing. [10]

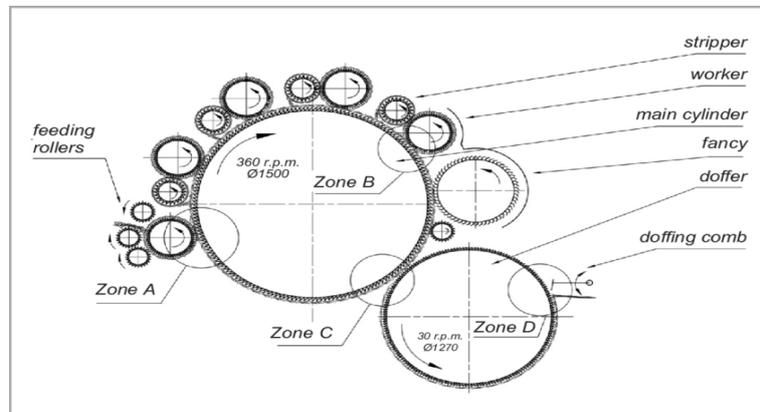


Fig.5 Carding Machine Schematic Diagram [10]

## Needle Punching

Needle punching is a nonwoven process by which the fibres are mechanically entangled to produce a nonwoven fabric by repeated penetration of barbed needles through a preformed dry fibrous web. The needle board is mounted on a beam which is given an up and down reciprocating motion by means of an eccentric crank mechanism. As a result, the fibres are mechanically interlocked, thereby providing the mechanical strength. [11]

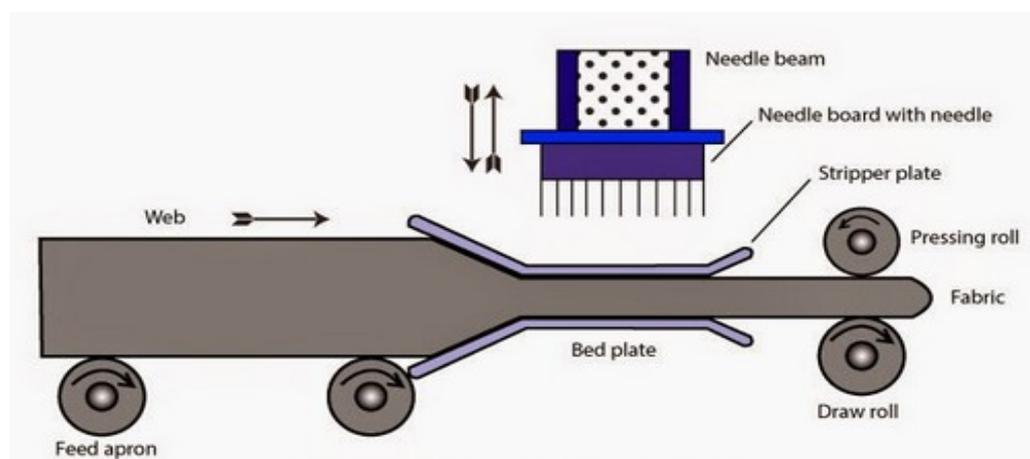


Fig.6 Needle Punching Process [11]

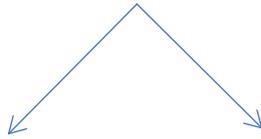
## Sample Preparation:

Sample 1 : Poly Propylene (Without Basalt)

Composition : 50% PP + 25% Kenaf+ 25% Flax

$$\text{Calculation} : 1400 = \frac{?}{700 \times 400} * 10^6$$

$$? = 392 \text{ g (material needed)}$$



196 g (PP)

196 g (K+F)

Approximated material required: 200 g PP + 100 g Kenaf + 100 g Flax

Table 1: Sequence of Carding

No. of Carding	Start (g)	Mass (g)	Loss (g)
1	400	360	30
2	180	150	25 (Discarded)
3	150	135	20 (Discarded)
4	70	50	10 (Discarded)
5	80 (40PP+40KF)	70	10

The total collected material (405 g) is separated into two samples (195 g + 210 g) and further underwent needle punching process.

### Procedure:



Fig.7 Arrangement of PP, Kenaf & Flax



Fig.8 Material after needling



Fig.9 700mm\*35mm Fibre samples for needling



Fig.10 Material after needling

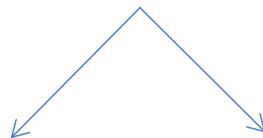
**Observation:** During the carding process it was agglomerated when compared to polypropylene fibre and even the quality of fleece was not as good as PP fibre.

Sample 2 : **Poly Propylene (with Basalt)**

Composition : 50% PP + 25% Kenaf - Flax + 25% Basalt (D.B.F)

Calculation :  $1400 = \frac{?}{700 \times 400} * 10^6$

? = 392 g (material needed)



196 g (PP)

98 g (K+F) + 98 g (Basalt)

Approximated material required: 200 g PP + 100 g (Kenaf+ Flax) + 100 g Basalt

Table 2: Sequence of Carding

No. of Carding	Start (g)	Mass (g)	Loss (g)
1	400	365	25
2	135	120	15 (Discarded)
3	240	190	30 (Discarded)

Material Addition:

Composition : 60 g PP + 30 g Kenaf - Flax + 30 Basalt (D.B.F)

Table 3: Sequence of Carding

No. of Carding	Start (g)	Mass (g)	Loss (g)
1	120	110	10
2	120	95	10 (Discarded)



Fig.11 Final Sample of Poly Propylene with Basalt (D.B.F)

Sample 3 : **Poly Propylene (with Basalt)**

Composition : 260g PP + 130g (Kenaf + Flax) + 130g Basalt (F.T)

Table 4: Sequence of Carding

No. of Carding	Start (g)	Mass (g)	Loss (g)
1	520	495	15
2	200	185	25 (Discarded)
3	245	215	20 (Discarded)

Final Sample Length - 305g

Length- 60cm

Width- 36cm

$A_w = 305 / (60 \times 36) = 1412 \text{ g/m}^2$

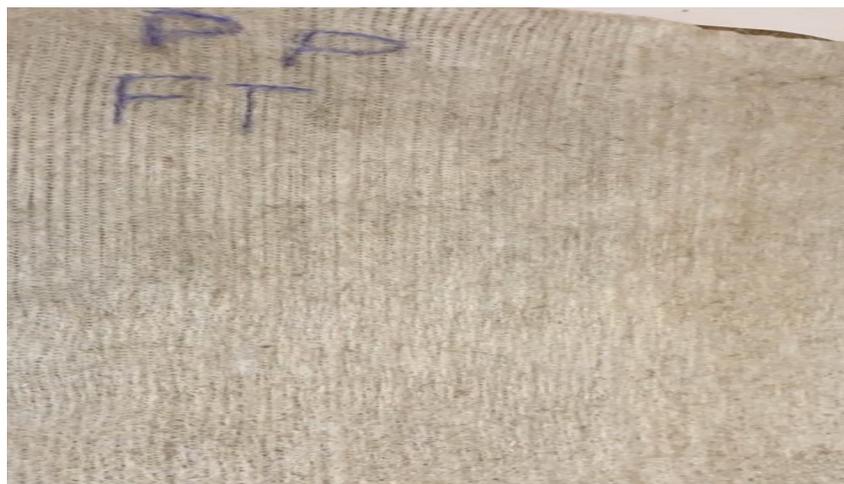


Fig.12 Final Sample of Poly Propylene with Basalt (F.T)

**Observation:**

As seen in the Figure.13 during the Carding process of Basalt (D.B.F), Basalt fibres are been stuck onto the rollers due to which we have lot of wastage in this type of Basalt (D.B.F) compared to Basalt (F.T).



Fig.13 Carding process of Basalt (D.B.F)

- By comparing the amount of starting material taken for different samples and the loss it has generated during carding it has resulted to an average of 17% for the Initial carding.

Start Mass(g)	Loss (g)	Percentage Loss (%)
400	25	16
120	10	12
520	15	34.6
80	10	8
Average (%)		17.67

Table.5 Comparison of Percentage Loss of Fibre for Initial Carding

- Coming to the second carding the amount of loss generated during carding is 7.9%

Start Mass(g)	Loss (g)	Percentage Loss (%)
200	25	8
150	20	7.5
240	30	8
135	15	9
70	10	7
Average (%)		7.9

Table.6 Comparison of Percentage Loss of Fibre for Second Carding

## Press Molding:

Compression Moulding is a method of moulding in which the moulding material, generally preheated, is first placed in an open, heated mould cavity. The mould is closed with a top force or plug member, pressure is applied to force the material into contact with all mould areas, while heat and pressure are maintained until the moulding material has cured. The process employs thermosetting resins in a partially cured stage, either in the form of granules, putty-like masses, or preforms. [12]



Fig.14 Press Molding Machine

In this Process we have three different phases which differ mainly in terms of Temperature, Pressure and Time. In the Initial phase we can only control the Pressure, where as the Temperature can be varied in the next Phases.

Phase	Temperature	Pressure	Time
Phase-1	200°C	50 bar	60 sec
Phase-2	60°C	50 bar	80 sec
Phase-3	60°C	50 bar	300 sec

Table.7 Parameters given to the Press Mold for Each Phase

### Compression Molded Samples of PP + KF (without Basalt):

After the carding process the samples are cut into the dimensions according to the Mold, the specimens are undergone for three phases in the Press Mold and after the process it is cooled to the room temperature and then they are cut into specimens to carry out Mechanical Tests (Tensile and Charpy).

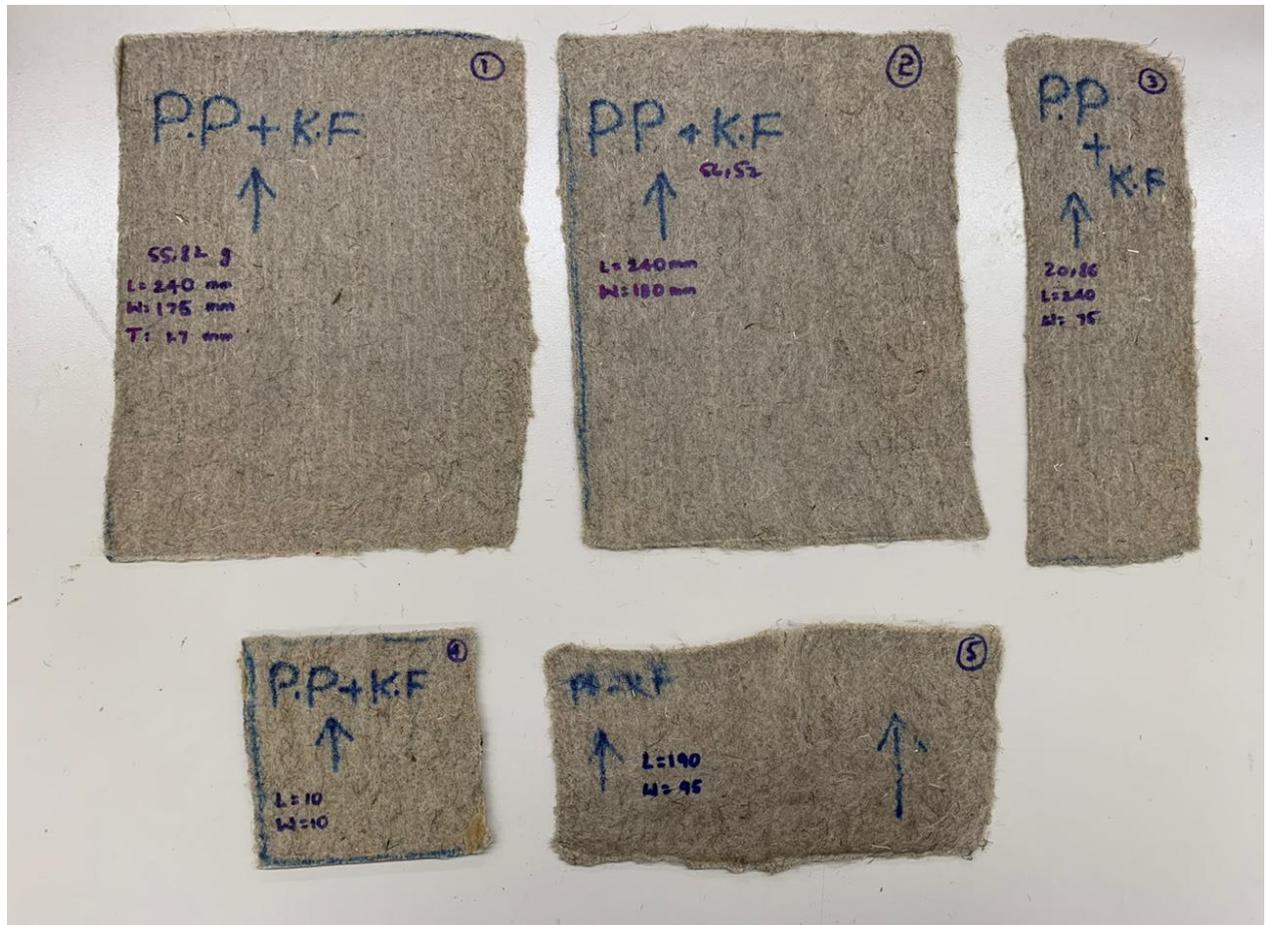


Fig.15 Press Molded Samples of PP + KF

Plate N.o.	Length	Width	Thickness
1.	240mm	175mm	1.7mm
2.	240mm	180mm	1.7mm
3.	240mm	75mm	1.7mm
4.	100mm	100mm	4.0mm
5.	190mm	95mm	1.7mm

Table.8 Press Molded Sample Dimensions of PP + KF (without Basalt)

**Compression Molded Samples of PP + DBF (with Basalt):**

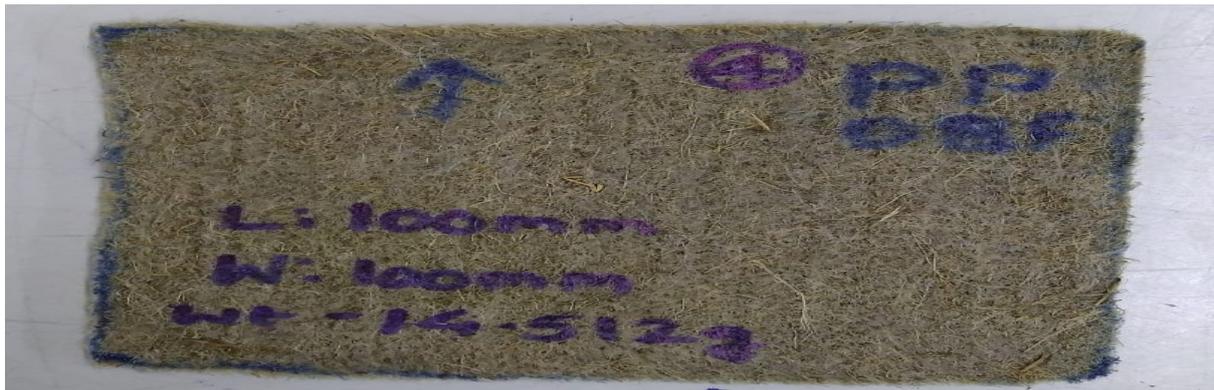


Fig.16 Press Molded Samples of **PP + DBF**

Plate N.o.	Length	Width	Thickness
1.	210mm	175mm	1.7mm
2.	250mm	190mm	1.7mm
3.	220mm	90mm	1.7mm
4.	100mm	100mm	4.0mm

Table.9 Samples Dimension of **PP + DBF** (with Basalt)

**Compression Molded Samples of PP + FT (with Basalt):**



Fig.17 Press Molded Samples of **PP + FT**

Plate N.o.	Length	Width	Thickness
1.	255mm	180mm	1.7mm
2.	250mm	170mm	1.7mm
3.	190mm	60mm	1.7mm
4.	100mm	100mm	4.0mm

Table.10 Samples Dimension of **PP + FT** (with Basalt)

## MECHANICAL TESTS

### Experimental Setup:

Following tests were conducted in the present work,

- Tensile Test
- Impact Test (Charpy)

The tests were conducted using a calibrated Universal Testing Machine (UTM). Different tests were conducted, such as the Tensile test and Impact test carried (Charpy type) on Impact machine.

### TENSILE TEST:

One of the most fundamental mechanical tests that can be performed on a material is the tensile test. Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. These tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, reduction in area, tensile strength, yield point, yield strength, and other tensile properties. [13]



Fig.18 Tensile Testing Machine [13]

**Procedure:**

- The specimens were chosen, care is to be taken to ensure that the specimens did not have any notching or cracks from manufacturing or any surface defects that would adversely affect the tensile tests.
- Before loading the specimens in the Tensile machine, the computer system connected to the machine was set up by inputting the necessary information of gauge length and width of the specimen. The computer system was then prepared to record data and output necessary load-deflection graphs.
- The specimens were loaded into the Instron machine, and a tensile test was performed. The data was recorded electronically in text files shown in Appendix B and the load-deflection curve was shown on the computer screen as a visual representation. Fig.18 gives a visual representation of the apparatus and the set-up used for testing.



Fig.19 Sample of **PP + K.F** before Tensile Test

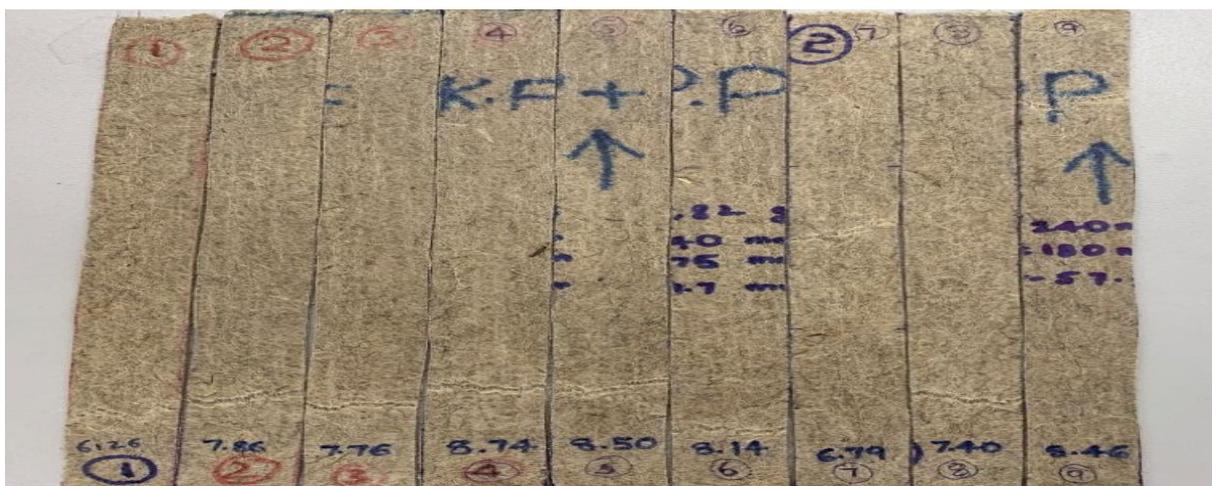


Fig.20 Sample of **PP + K.F** After Tensile Test



Fig.21 Sample of **PP + D.B.F** Before Tensile Test



Fig.22 Sample of **PP + D.B.F** After Tensile Test



Fig.23 Sample of **PP + F.T** Before Tensile Test

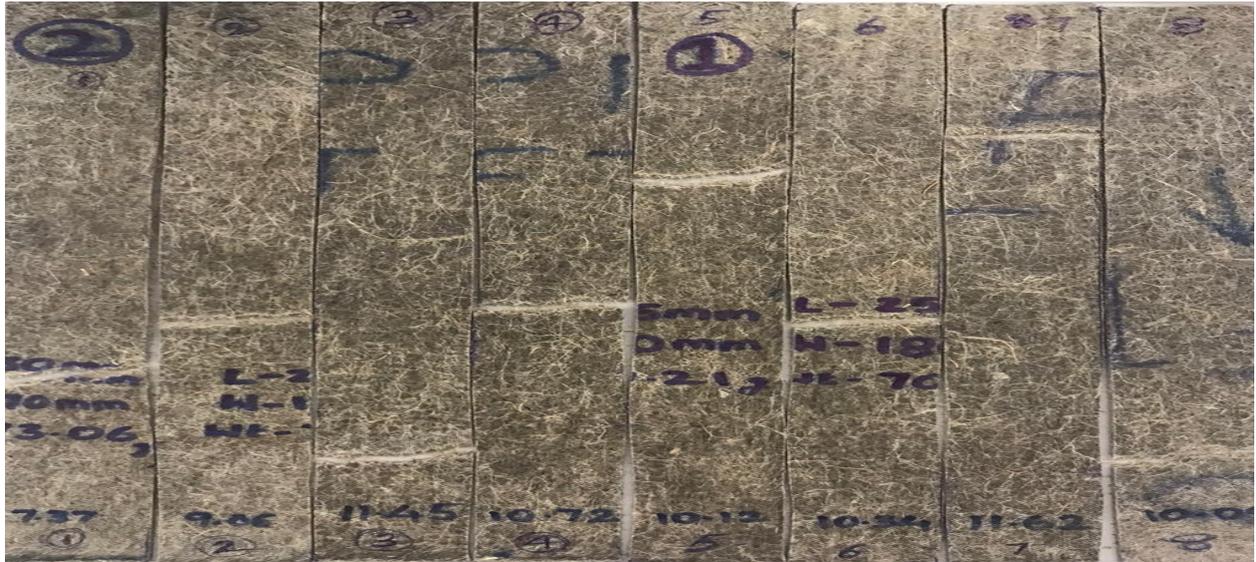


Fig.24 Sample of PP + F.T After Tensile Test

### CHARPY IMPACT TEST:

The Charpy test is measured by allowing a pendulum to strike a grooved machined test piece and measuring the energy absorbed in the break. The Charpy test measures the energy absorbed by a standard notched specimen while breaking under an impact load. This test continues to be used as an economical quality control method to determine the notch sensitivity and impact toughness of engineering materials. The Charpy test was is commonly used on metals, but it also applied to composites, ceramics, and polymers. It is one of the most commonly evaluates the relative toughness of a material. This test consists of striking a suitable specimen with a hammer on a pendulum arm while the specimen is held securely at each end. The hammer strikes opposite the notch. The energy absorbed by the specimen is determined by precisely measuring in the motion of the pendulum arm. Important factors that affect the toughness of a material include low temperature, high strain rates (by impact or pressurization), and stress concentrators such as notches, cracks, and voids.

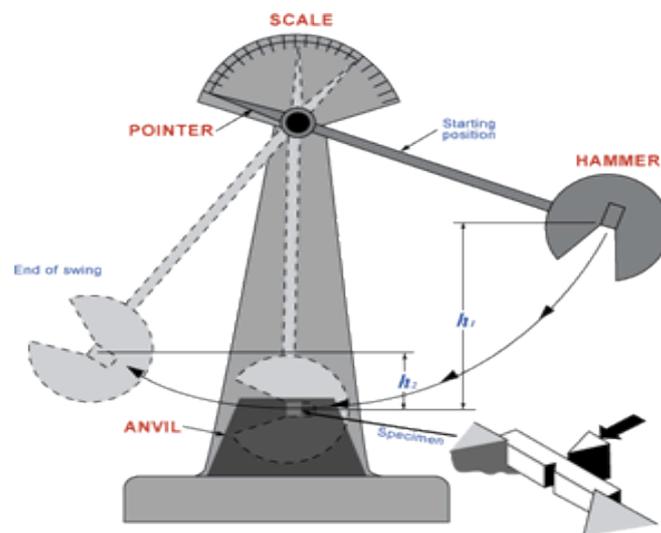


Fig.25 Charpy Testing Machine [14]



Fig.26 Sample of PP + K.F before Impact Test



Fig.27 Sample of PP + K.F After Impact Test



Fig.28 Sample of PP + D.B.F Before Impact Test



Fig.29 Sample of **PP + D.B.F** Before Impact Test

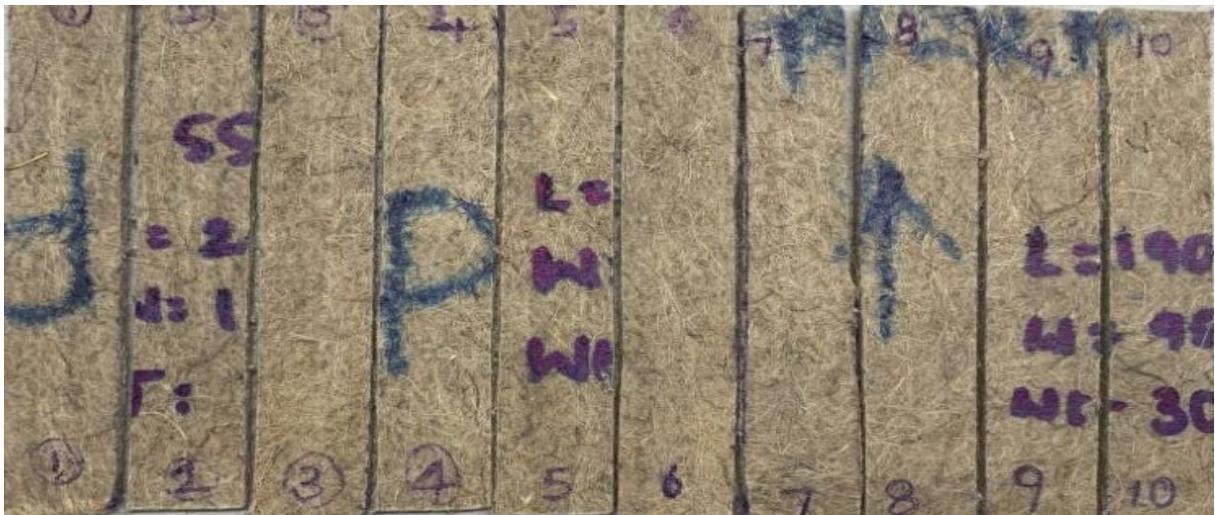


Fig.30 Sample of **PP + F.T** Before Impact Test



Fig.31 Sample of **PP + F.T** After Impact Test

### 3. Results and Discussions

After conducting the tests, the results have been tabulated and compared with other samples. Even the Stress-Strain curves are also extracted form the results.

#### TENSILE TEST:

Sample 1 : Poly Propylene (PP + K.F)

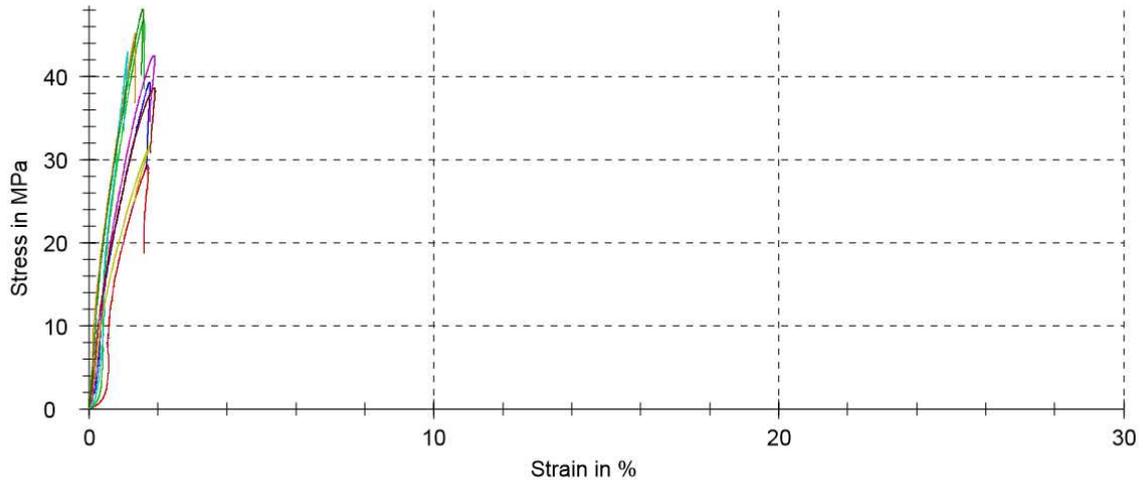


Fig.32 Stress-Strain graph of PP + K.F samples

Specimen No.	$\sigma$ low (MPa)	$\sigma$ High (MPa)	Et (MPa)
1.	0.102	0.523	203.87
2.	0.168	1.071	440.02
3.	0.587	4.340	1728.39
4.	1.955	14.82	6985.66
5.	0.594	6.302	3177.59
6.	0.247	2.726	1286.13
7.	0.944	6.891	3072.81
8.	1.405	9.395	4029.71
9.	1.763	13.27	5922.94

Table.11 Experimental values of PP + K.F samples

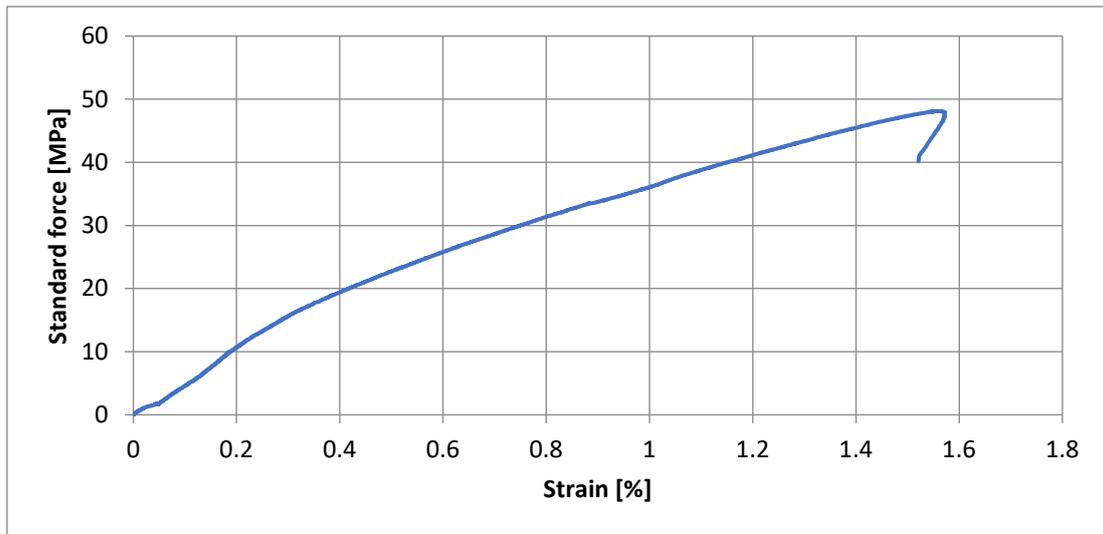


Fig.33 Standard Force vs Strain graph of **PP + K.F** samples

Sample 2 : **Poly Propylene (with Basalt D.B.F)**

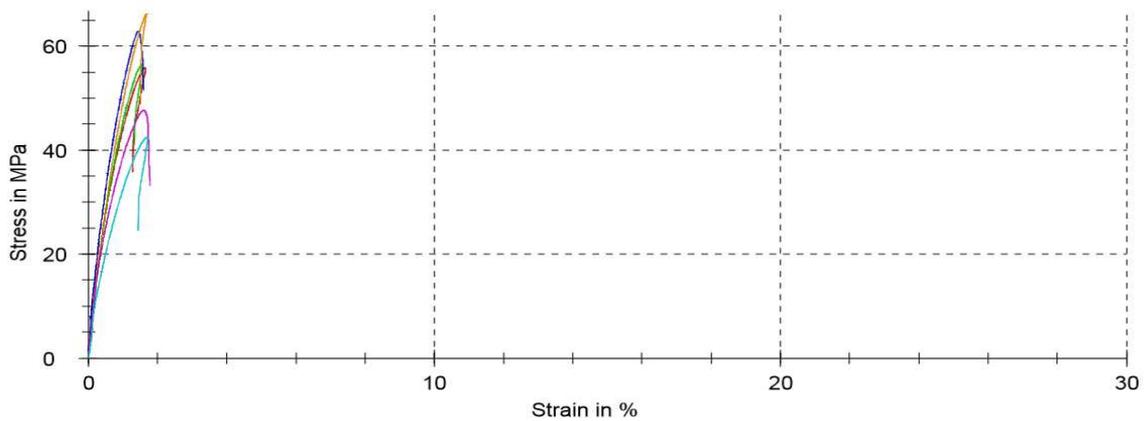


Fig.34 Stress-Strain graph of **PP + D.B.F** samples

Specimen No.	$\sigma$ low (MPa)	$\sigma$ High (MPa)	Et (MPa)
1.	3.577	16.27	6754.42
2.	2.860	15.89	6882.67
3.	3.640	19.08	7307.67
4.	2.908	16.01	6809.90
5.	3.181	15.58	6692.27
6.	1.905	12.34	5793.92

Table.12 Experimental values of **PP + D.B.F** samples

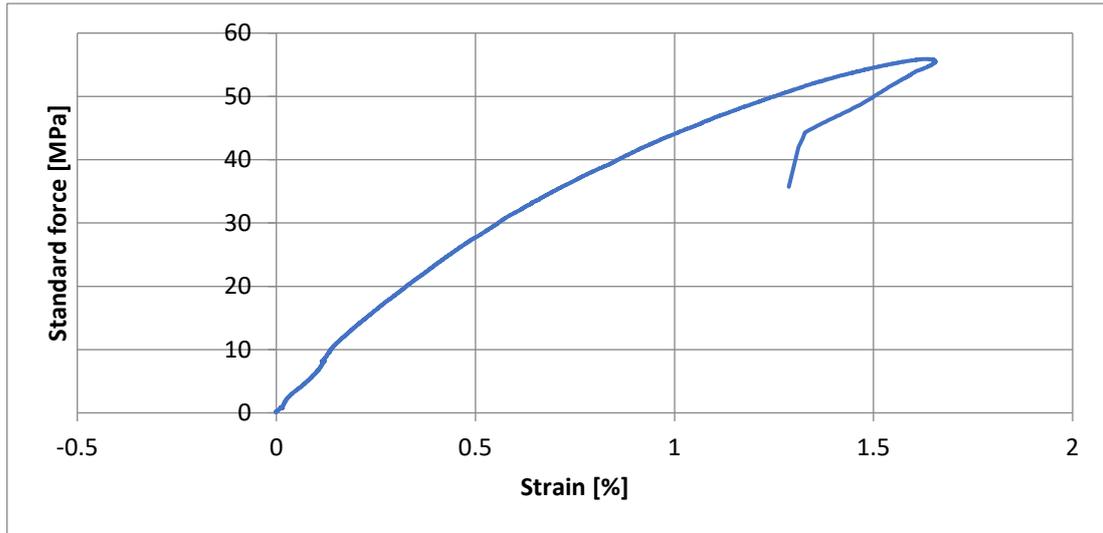


Fig.35 Standard Force vs Strain graph of **PP + D.B.F** samples

Sample 3 : **Poly Propylene (with Basalt F.T)**

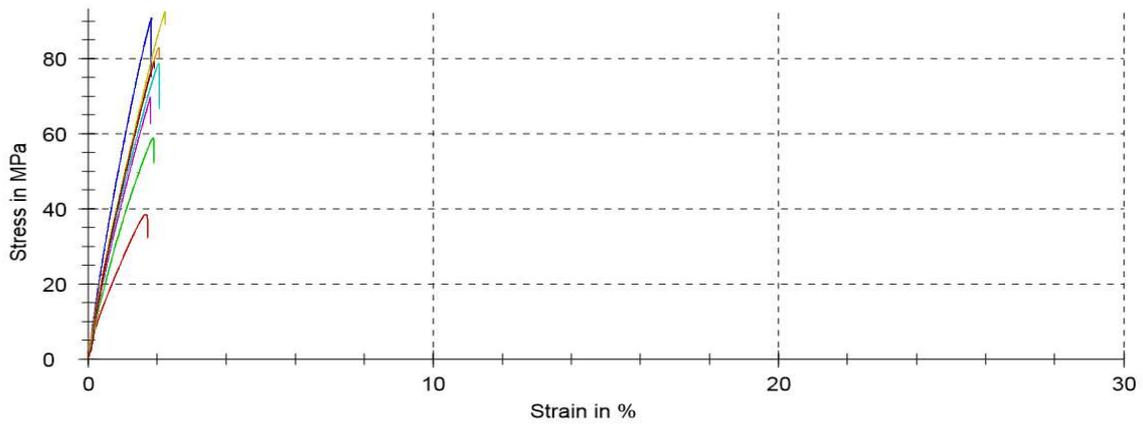


Fig.36 Stress-Strain graph of **PP + F.T** samples

Specimen No.	$\sigma$ low (MPa)	$\sigma$ High (MPa)	Et (MPa)
1.	1.465	9.161	4193.71
2.	2.038	10.880	4588.14
3.	2.428	16.123	6887.87
4.	3.007	14.252	5678.02
5.	1.868	11.951	5079.50
6.	2.060	12.740	5435.59
7.	1.793	12.467	5312.78
8.	1.688	12.818	6629.01

Table.13 Experimental values of **PP + F.T** samples

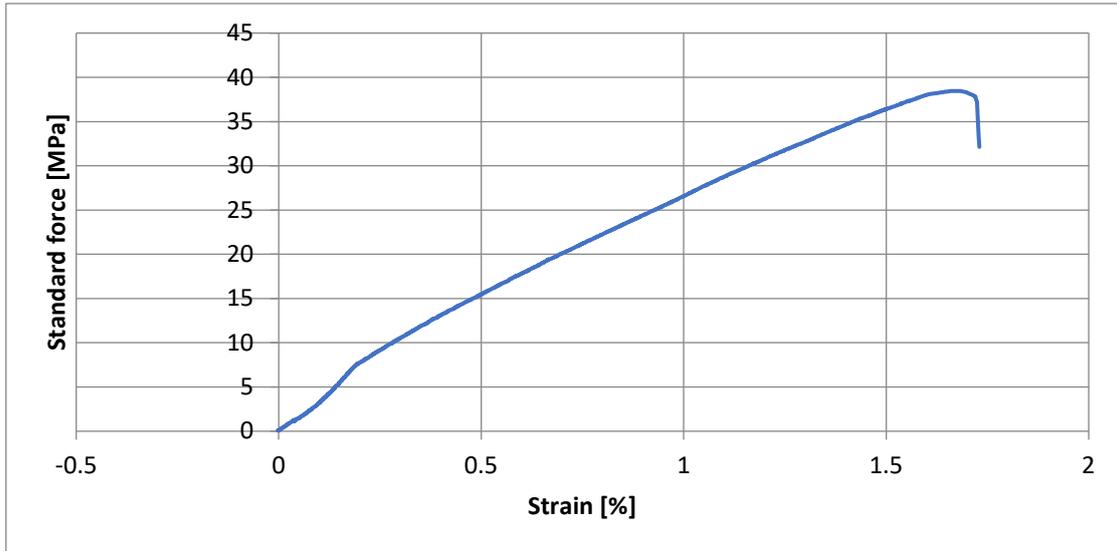
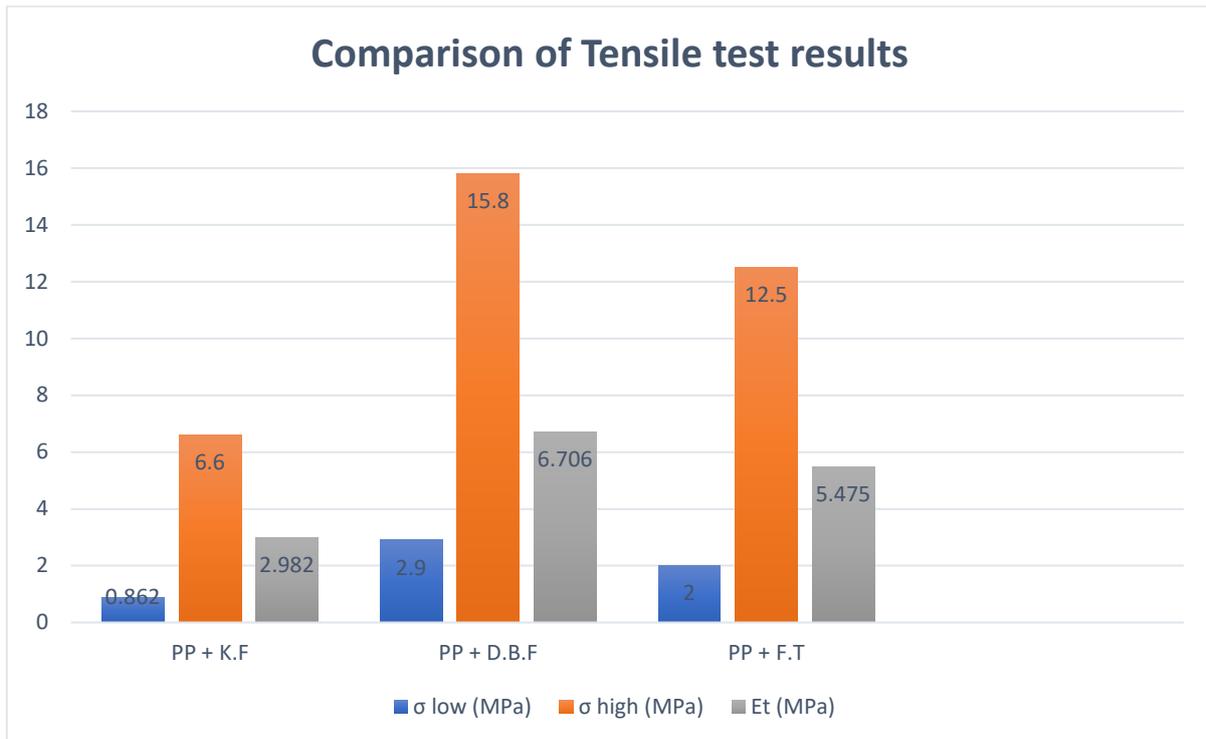


Fig.37 Standard Force vs Strain graph of PP + F.T samples



**All mechanical properties show a gradual increase by the increase of basalt content.**

### CHARPY IMPACT TEST:

Sample 1 : Poly Propylene (PP + K.F)

Sample No.	L (mm)	B (mm)	H (mm)	Mass (g)	Aw (g/m <sup>2</sup> )	D (g/cm <sup>3</sup> )	E (KJ/m <sup>2</sup> )	SP IE
1.	79.10	14.90	1.50	1.61	1368.92	0.91	28.56	32.45
2.	79.70	14.80	1.50	1.56	1320.15	0.88	26.22	33.07
3.	79.80	14.30	1.60	1.45	1268.91	0.79	23.24	30.85
4.	78.40	14.60	1.60	1.38	1205.62	0.75	27.71	31.19
5.	79.20	14.30	1.60	1.61	1421.56	0.89	32.56	33.66
6.	79.30	14.60	1.50	1.68	1451.05	0.97	30.06	30.89
7.	80.10	13.40	1.80	1.88	1751.54	0.97	28.39	30.31
8.	79.60	15.50	1.80	2.08	1685.85	0.94	34.50	35.46
9.	79.50	15.30	1.80	2.13	1751.14	0.97	36.54	34.45
10.	79.30	14.20	1.70	2.03	1802.75	1.06	34.24	33.56
<b>Mean</b>	<b>79.40</b>	<b>14.59</b>	<b>1.64</b>	<b>1.74</b>	<b>1502.75</b>	<b>0.91</b>	<b>29.75</b>	<b>32.00</b>
S	0.46	0.60	0.13	0.27	223.76	0.09	4.16	1.80
S (%)	0.58	4.09	7.71	15.51	14.89	9.92	14.0	5.56

Table.14 Experimental values of PP + K.F samples

Sample 2 : Poly Propylene (with Basalt D.B.F)

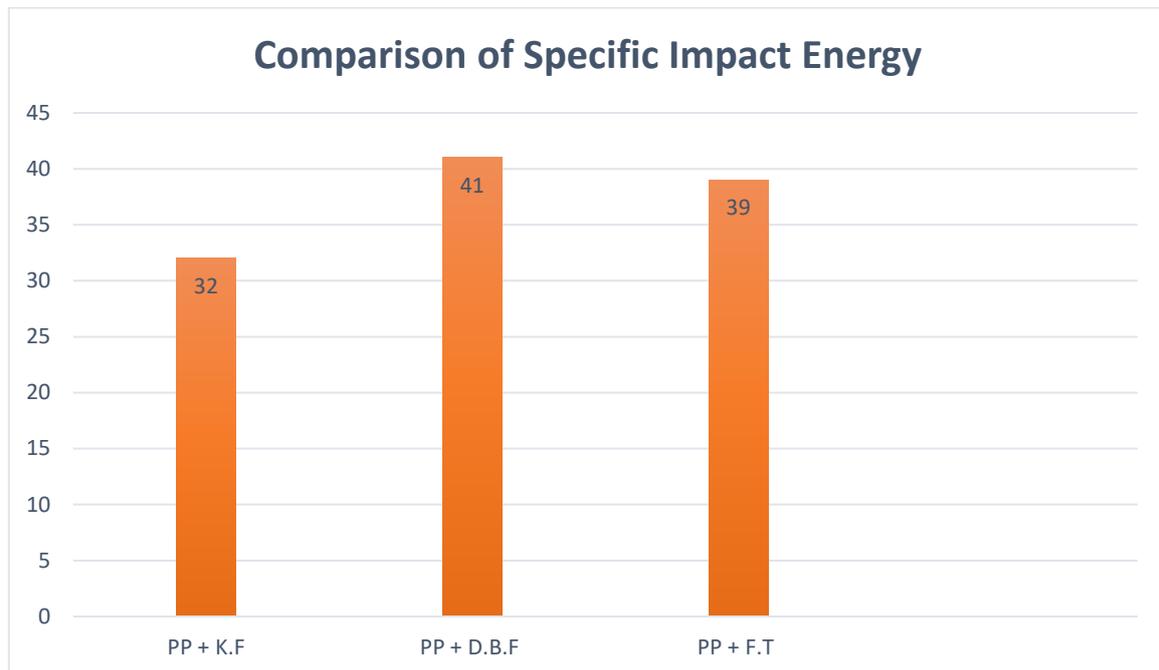
Sample No.	L (mm)	B (mm)	H (mm)	Mass (g)	Aw (g/m <sup>2</sup> )	D (g/cm <sup>3</sup> )	E (KJ/m <sup>2</sup> )	SP IE
1.	79.60	14.90	1.70	1.32	1112.95	0.65	23.69	36.18
2.	79.00	14.90	1.50	1.27	1078.92	0.72	23.80	33.09
3.	80.00	14.20	1.50	1.30	1144.37	0.76	59.25	34.08
4.	79.30	14.20	1.70	1.20	1065.66	0.63	18.27	29.14
5.	78.80	14.70	1.50	1.17	1010.05	0.67	19.24	28.57
6.	79.40	14.90	1.50	1.36	1149.56	0.77	28.04	36.59
7.	80.40	14.80	1.80	1.28	1075.70	0.60	16.59	27.76
8.	79.60	15.80	1.90	1.43	1137.01	0.60	32.98	29.18
9.	79.50	13.90	1.90	1.30	1176.42	0.62	23.59	38.10
10.	78.80	13.90	1.80	1.30	1186.87	0.66	28.98	43.95
<b>Mean</b>	<b>79.53</b>	<b>14.71</b>	<b>1.72</b>	<b>1.40</b>	<b>1190.32</b>	<b>0.69</b>	<b>27.44</b>	<b>41.00</b>
S	0.50	0.57	0.17	0.26	196.27	0.09	12.28	15.40
S (%)	0.63	3.85	10.19	18.52	16.49	13.06	44.74	37.92

Table.15 Experimental values of PP + D.B.F samples

Sample 3 : Poly Propylene (with Basalt F.T)

Sample No.	L (mm)	B (mm)	H (mm)	Mass (g)	Aw (g/m <sup>2</sup> )	D (g/cm <sup>3</sup> )	E (KJ/m <sup>2</sup> )	SP IE
1.	79.30	15.00	1.90	2.10	1765.45	0.93	32.14	34.59
2.	79.60	13.90	1.80	1.90	1717.22	0.95	37.97	39.80
3.	79.50	15.00	1.80	2.04	1710.22	0.95	37.26	39.20
4.	79.40	15.20	1.90	1.49	1234.59	0.65	23.51	36.18
5.	80.00	14.90	1.90	1.70	1426.17	0.76	33.19	43.50
6.	79.30	14.70	1.90	1.69	1449.76	0.60	32.46	54.37
7.	78.90	14.30	1.90	1.28	1134.48	0.68	23.04	33.90
8.	80.00	14.20	1.80	1.39	1223.59	0.68	26.00	38.24
9.	79.30	14.90	1.90	1.15	973.28	0.51	19.60	38.27
10.	79.80	14.30	1.80	1.23	1077.87	0.60	20.67	34.52
<b>Mean</b>	<b>79.51</b>	<b>14.64</b>	<b>1.86</b>	<b>1.60</b>	<b>1371.31</b>	<b>0.73</b>	<b>28.58</b>	<b>39</b>
S	0.35	0.43	0.05	0.34	286.84	0.16	6.82	6.06
S (%)	0.44	2.95	2.78	21.38	20.92	22.01	23.86	15.45

Table.16 Experimental values of PP + F.T samples



**Not just tensile and flexural properties, basalt fibers have improved simultaneously the energy absorption of the composites.**

## 4. Conclusion

- Successful production of homogenous fiber mats with evenly distributed fibers. SEM analysis of the samples confirmed the quality of fiber mats.
- Compression molded test specimens were analysed for their mechanical properties.
- Basalt fibers were gradually introduced into the plant fiber reinforced polypropylene. The mechanical properties manifest significantly increase by the increasing concentration of basalt fibers.
- Basalt fibers have excellent potential to improve the mechanical performance of NF reinforced composites without reducing their renewable material content.
- Hybrid bast and bast polymer composites have great potential to replace, if not fully, but partially, non-renewable fiber reinforced polymer composites in structural, load bearing and shock absorption applications.
- It can be inferred from the above test results that basalt fibers of **D.B.F** have greater improvement in the tensile and flexural properties; energy absorption of the composites compared to other samples.

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