# Mechanical and Tribological behavior of hemp Fiber Reinforced Polymeric Composites

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**Abstract**

**In recent years, there has been an increasing interest in finding new applications for natural fibre-reinforced composites that are traditionally used for making ropes, mats, carpets, fancy articles and others. This work presents the evaluation of mechanical and tribological behaviour of hemp fiber reinforced epoxy composites. The composites were prepared by varying the weight percentage (wt %) 30%, 40% and 50% wt %of chopped fibre of 10mm length. The specimens are expurgated as per the ASTM standards. The Mechanical properties such as flexural strength, impact strength and hardness were revealed of the fabricated hemp fiber reinforced composite. The test results show that the higher value of hardness and impact was obtained at 50wt. % of fiber loading. The Flexural and Tensile strength value is higher in 40wt. % of fiber loading. It has a wide scope in the areas of construction, auto motives and aviation industries.**

***Keywords: Hemp fiber, Compression molding, Mechanical Properties, Polymer matric composite.***

## INTRODUCTION

Natural fiber has been an increasing environmental consciousness and awareness of the need for sustainable development, which has raised interest in using natural fibres as reinforcements in polymer composites to replace synthetic fibres such as glass. The advantages of natural fibres include low price, low density, unlimited and sustainable availability, and low abrasive wear of processing machinery[1, 2].Natural fibres have been used to reinforce materials for over 3000 years. More currently they have been employed in combination with plastics. Many types of natural fibres have been investigated for use in plastics including flax, hemp, jute, sisal and banana. The use of natural fiber reduces weight by 10% and lowers the energy needed for production by 80%, while the cost of the component is 5% lower than the comparable fiber glass-reinforced component. Natural fibres have many advantages compared to glass fibres, for example they have low density, and they are recyclable and biodegradable [3].Fibers from hemp stems have been widely used in the production of cords and clothing, and have potential for reinforcement in polymer–matrix composites (PMCs). Recently, car manufacturers have started manufacturing non-structural components using hemp and flax fibres due to their higher specific strength and lower price compared to conventional reinforcements [4].

The mechanical properties of banana fiber based epoxy composite and it was observed that the tensile strength is increased by 90% of the pseudo-stem banana fiber reinforced epoxy composite associated to virgin epoxy. In his results the impact strength of pseudo-stem banana fiber improved

by approximately 40% compare to the impact strength of neat epoxy [5]. The maximum tensile strength was observed at 30 mm fiber length while maximum impact strength was observed at 40 mm fiber length. Incorporation of 40% untreated fibers provides a 20% increase in the tensile strength and a 34% increase in impact strength [6].
Jute fiber lengths were up to10 mm maximum and the fiber loadings were 30, 40, 50, and 60 wt %, and at each fiber loading, compatibilizer doses were 0, 1, 2, 3 and 4 wt %. Interface studies were earned out by SEM to investigate the fiber surface morphology, fiber pull-out, and fiber-polymer interface [7].The ultimate tensile strength value maximum at 15% of banana fiber with increasing in fiber starting from 15% to 20% [8].Banana fiber reinforced polyester composites and found that the optimum content of banana fiber is 40% [9]. A pin-on-disc test apparatus was used to investigate the dry sliding wear characteristics of the composites as per ASTM G99-95 standards The glass fabric layers in the composites are parallel to the contact surface and to the sliding direction. The surface (6mmx6mm) of the composites specimen makes contact to the counter surface [10]. Hemp fiber used in, construction, automotive, and packaging applications. For example, vehicle interior parts such as door trim panels made from natural fiber-polypropylene (PP) and exterior parts such as engine and transmission covers from natural fiber-polyester resins are used [11].

## EXPERIMENTAL

### Materials

Reinforcement resources Hemp fibers (cannabis sativa) were supplied by Chandra Prakash &company, Jaipur, India. The matrix material epoxy (103) and hardener (HY951) were purchased from Leo enterprises, Nagercoil, India. Epoxy resin mixed with hardener in the ratio10:1.

### Specimen preparation

The specimens are equipped by different weight fraction. The mold was closed with cover plate, and hydraulic pressure machines were used for the compression. The composites were fabricated in the form of a flat plate with a size of 180*160*3mm.The matrix solution was applied on the mold and fiber is spread over there in, air bubbles were removed carefully with a roller. Composite plates were prepared for various fiber weight percentage% of 30, 40 and 50wt%in the length of10mm fiber length.

Table.1fiber weight percentage of the composite samples

| Specimen No | Resin Wt % | Fiber wt % | Fiber weight g |
|---|---|---|---|
| 1 | 100 | 0 | 0 |
| 2 | 70 | 30 | 28.5 |
| 3 | 60 | 40 | 38.01 |
| 4 | 50 | 50 | 47.52 |

### Mechanical Testing

**Impact test**

The impact test specimens are prepared according to the required dimension following the ASTM-A370 standard. During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. The effect of strain rate on fracture and ductility of the material can be analysed by using the impact test.

Table.2 Experimental Impact strength of the composite samples

| Sample no | Samples | Trial 1 | Trial 2 | Average (kJ/mm$^2$) |
|---|---|---|---|---|
| S1 | 30% hemp fiber + 70% Epoxy resin | 5.197 | 4.867 | 5.032 |
| S2 | 40% hemp fiber + 60% Epoxy resin | 4.816 | 6.561 | 5.688 |
| S3 | 50% hemp fiber + 50% Epoxy resin | 7.651 | 7.123 | 7.387 |

**Tensile test**

The Tensile test specimens are prepared according to the required dimension following the ASTM-D638 standard. During the testing process, the specimen must be elongated and get fractures or breaks. The effect of elongation rate on ductility fracture and of the material can be analysed by using the tensile testing machine.

Table.3 Experimental Tensile strength of the composite samples

| Sample no | Samples | Trial 1 | Trial 2 | Average (N/mm$^2$) |
|---|---|---|---|---|
| T1 | 30% hemp fiber + 70% Epoxy resin | 42.30 | 46.57 | 44.43 |
| T2 | 40% hemp fiber + 60% Epoxy resin | 60.67 | 51.25 | 55.96 |
| T3 | 50% hemp fiber + 50% Epoxy resin | 57.86 | 37.19 | 47.52 |

**Flexural test**

The flexural specimens are prepared as per the ASTM D790 standards and the test has been carried out using the same UTM. The 3-point flexural test is the most common flexural test and used in this experiment for checking the bending strength of the composite materials. The testing process involves placing the test specimen in the UTM and applying force to it until it fractures and breaks.

Table.4 Experimental flexural strength of the composite samples

| Sample no | Samples | Trial 1 | Trial 2 | Average(N/mm$^2$) |
|---|---|---|---|---|
| F1 | 30% hemp fiber + 70% Epoxy resin | 29.983 | 39.266 | 34.62 |
| F2 | 40% hemp fiber + 60% Epoxy resin | 49.65 | 45.25 | 47.45 |
| F3 | 50% hemp fiber + 50% Epoxy resin | 25.35 | 27.55 | 26.45 |

**Hardness test**

The Hardness of the test specimen was calculated using Shore'D Hardness Tester. The apparatus is a sharp ended tip type and the Hardness value was noted. The standard method is ASTM D2240.

Table.5 Experimental hardness strength of the composite samples

| S.No | Samples | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Average |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| H1 | 30% hemp fiber + 70% Epoxy | 59.1 | 55.2 | 59.3 | 57.8 | 57.85 |
| H2 | 40% hemp fiber + 60% Epoxy | 56.6 | 60.3 | 56.7 | 58.2 | 57.95 |
| H3 | 50% hemp fiber + 50% Epoxy | 60.2 | 58.7 | 61.3 | 60.7 | 60.22 |

## RESULTS AND DISCUSSION

### IMPACT TEST

The energy observed in impact test goes increases with increase in fiber loading. The Impact strength comparison of the different combination of hemp fiber reinforced polymer composites is presented in Fig. 1. From the figure it can be observed that, the 50% hemp fiber and 50% epoxy resin polymer composites are performing better than the other composite combinations tested which can hold the impact load of 0.189 J/mm$^2$.

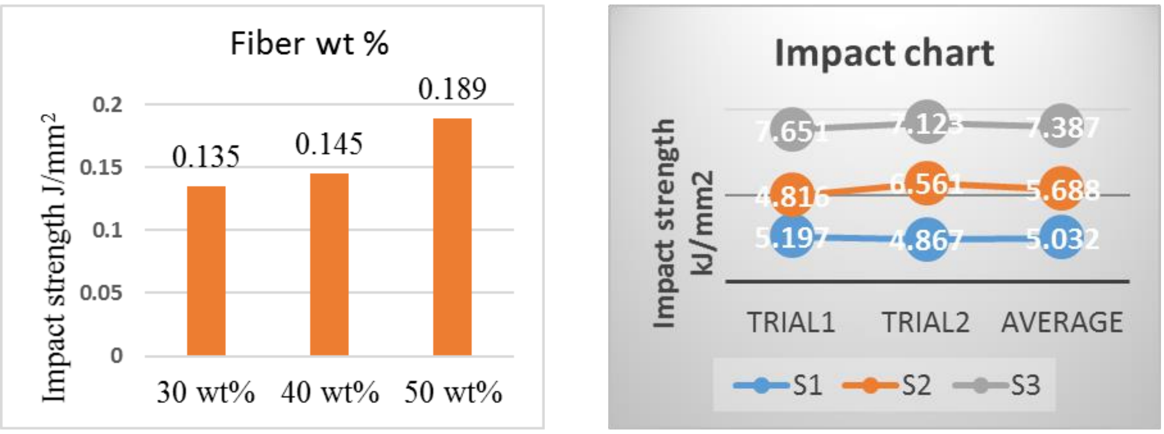



Fig. 1Impact strength comparison of the hemp fiber composite samples

### TENSILE TEST

The Tensile strength comparison of the different combination of hemp fiber reinforced polymer composites is presented in Figure 2 shows the Tensile test results and 40%hemp fiber and 60% epoxy resin polymer composites are performing better than the other composite combinations fiber.40wt%fiber value is 55.96N/mm$^2$

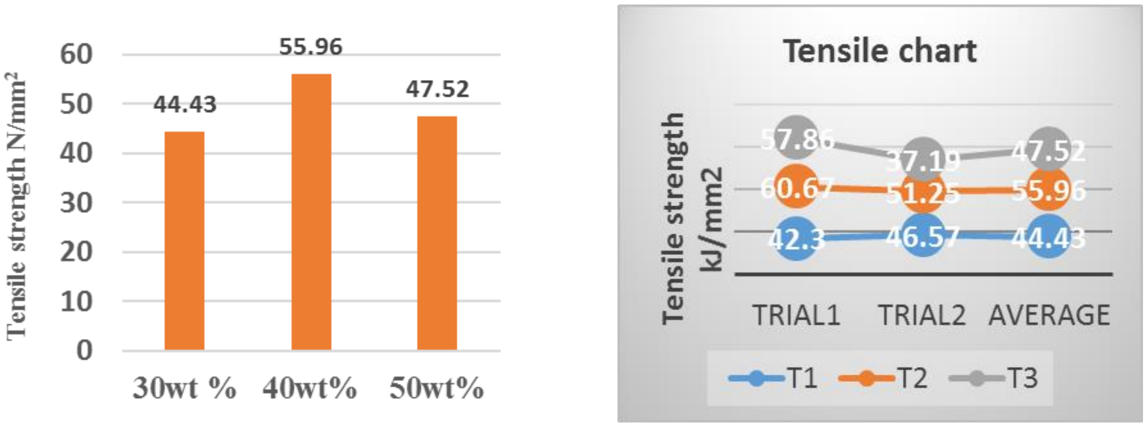
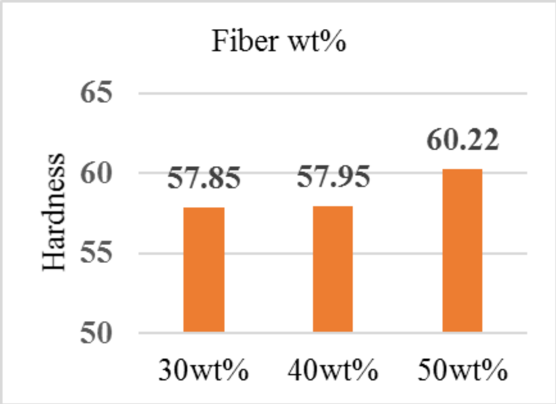



Fig. 2 Tensile strength comparison of the hemp fiber composite samples

### HARDNESS TEST

The Hardness strength comparison of the different combination of hemp fiber reinforced polymer composites is presented in Figure 3 shows the hardness test results and 50%hemp fiber and 50% epoxy resin polymer composites are performing better than the other composite combinations fiber.50wt%fiber value is 60.22.



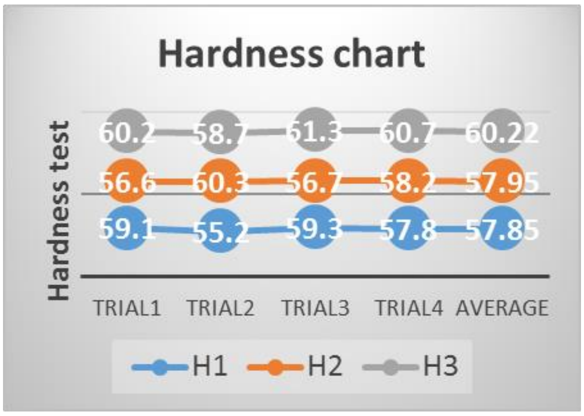
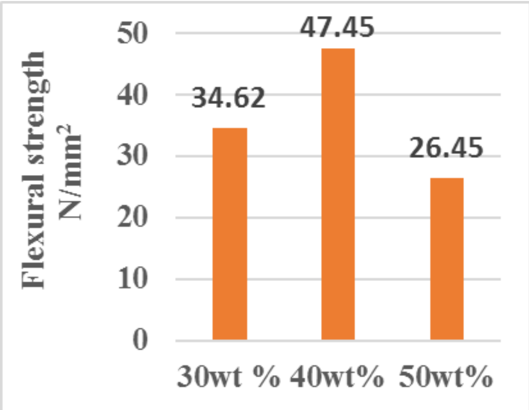




Fig. 3 Hardness strength comparison of the hemp fiber composite samples

## FLEXURAL TEST

The flexural strength comparison of the different combinations of the hemp fiber epoxy composites are presented in Fig.4.The result indicated that the 40% hemp fiber and 60% epoxy resin polymer composites are performing better than the other composite combinations tested which can withstand the flexural load of 47.45N/mm$^2$



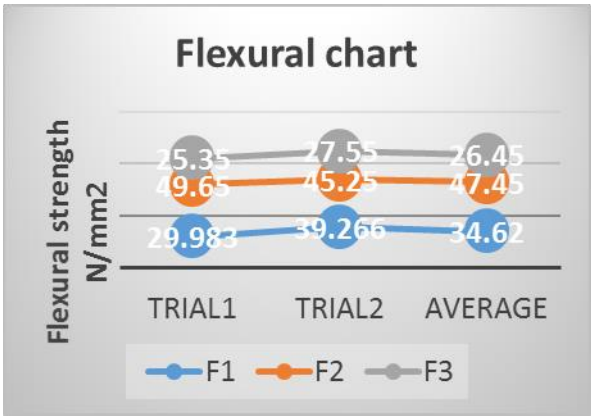




Fig. 4 Flexural strength comparison of the hemp fiber composite samples

## CONCULSION

In the experimental study, the hemp fibers are used as a reinforcing material with epoxy matrix, the composite shave been fabricated and physical characteristics of these materials are examined. From the experiment, the following conclusions have been drawn.

- The maximum Hardness strength is hold by the 50% hemp fiber and 50% epoxy resin composites is 60.22.

- The maximum impact strength is hold by the 50% hemp fiber and 50% epoxy resin composites is 5.032 kJ/mm$^2$.
- The maximum Tensile strength is holds by the 40% hemp fiber and 60% epoxy resin composites is 55.96 N/mm$^2$.
- The maximum flexural strength is 47.45 N/mm$^2$and this also holds by the 40% hemp fiber and 60% epoxy resin combination of the composite samples.
- From the experimental study it can be suggested that, the 50% hemp fiber and 50% epoxy resin composite materials can with stand the higher loads when compared to the other combinations and used as an alternate materials for conventional fiber reinforced polymer composites.

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