International Journal of Recent Advances in Multidisciplinary Topics
Volume 5, Issue 4, April 2024
https://www.ijramt.com | ISSN (Online): 2582-7839



# Fungal Deterioration Effect on Mechanical Properties of Epoxy Jute Hemp Composites

G. Pavan Kumar[1*], B. Omprakash[2]

[1]M.Tech. Student, Department of Mechanical Engineering, Jawaharlal Nehru Technological University, Anantapur, Andhra Pradesh, India
[2]Assistant Professor, Department of Mechanical Engineering, Jawaharlal Technological University, Anantapur, Andhra Pradesh, India

***Abstract*: Studies on composites play a crucial role in various engineering applications. These composites find extensive usage in aerospace, marine, automobile industries, and other industrial sectors due to their cost-effectiveness and advantageous properties such as recyclability and health benefits. Moreover, these composites are environmentally friendly, biodegradable, and sustainable. In this project, jute and hemp fibers, along with epoxy, were utilized in composite manufacturing. The hybrid jute-hemp composites were fabricated using the hand layup technique. Thanks to their low specific gravity and high strength-to-weight ratio, these composite materials outperform metallic materials. The primary objective of this project is to investigate the mechanical properties of hybrid jute-hemp composites, including tensile, impact, and flexural strength, under various conditions such as no water-fungi exposure, water immersion, and water-fungi exposure. Yeast was employed as the fungal agent in this study. Mechanical testing was conducted at intervals of 9 days, 18 days, and 27 days, respectively, in accordance with ASTM standards. The mechanical properties are to be determined through tension, impact, and flexural tests following the procedures outlined in ASTM standards. Finally, upon obtaining the test results, the values are analysed and compared.**

***Keywords*: Jute fibre, Hemp fibre, Epoxy resin.**

## 1. Introduction

The notion of composites can be delineated across a spectrum of abstraction, encompassing a breadth from the broad to the intricate. Composite materials emerge through the amalgamation of two or more substances, aiming to attain qualities wherein reinforcement (fibers, particles, flakes, or fillers) are interwoven within a matrix (polymers, metals, or ceramics). The matrix serves to encapsulate the reinforcement, shaping it to the desired form, while the reinforcement augments the overall mechanical attributes of the matrix. When crafted with precision, the resultant amalgam often surpasses the individual strengths of its constituent materials. Typically, composite materials exhibit a predominant bulk phase known as the matrix, which persists continuously, alongside a dispersed, non-continuous phase called the reinforcement, typically characterized by its hardness and robustness. The reinforcement commonly outweighs the matrix in rigidity, thereby fortifying the composite material. This reinforced stiffness is often orchestrated in a specific orientation within the matrix, yielding a material with divergent properties along different axes. This property is frequently harnessed to optimize the design, enhancing a gamut of attributes such as strength, stiffness, corrosion resistance, wear resistance, aesthetic appeal, weight, fatigue resilience, longevity, thermal insulation, thermal conductivity, and acoustical insulation. Consequently, composite materials manifest a diverse array of applications, ranging from products like porcelain enamel (glass-coated metal), laminated corrugated paper (plastic or metal), and cement fortified with fibre glass to structures like stainless steel-clad carbon steel and rubber reinforced with fibers (as in tires). The genesis of composite materials traces back to antiquity, finding utilization in myriad historical contexts. The earliest documented application of composite materials dates back thousands of years to ancient Egypt, where straw-strengthened, sun-dried clay bricks were employed in construction. Since then, remarkable advancements have been achieved in the realm of composite materials, holding the promise of novel products endowed with exceptional strength, rigidity, and resilience to chemical and thermal influences.

The most significant application of composite materials, in terms of volume, lies within civil engineering structures such as roads, bridges, and buildings, wherein ceramic (cement) matrix composites find extensive use. However, these specific composite materials are expounded upon within the context of the cement industry and are thus not considered herein. The remaining domain of composite material application can be dichotomized into two primary categories: reinforced plastics and advanced composites. The latter finds its foremost patronage in the military sector, propelled by a distinct imperative for swifter and more durable aircraft and missiles, fostering considerable innovation and progress in this domain. Moreover, owing to their exorbitant costs and protracted lead times, low-volume advanced materials have historically found favor primarily among military and civil aerospace clientele. In civilian applications, reinforced plastics dominate the composite materials market, constituting 90 percent thereof, predominantly relying on glass fiber reinforcement within commodity thermosetting resins, chiefly unsaturated polyesters and their derivatives.

Fiber-reinforced plastics have evolved to supersede traditional materials by offering superior strength, reduced weight, enhanced corrosion resistance, dimensional stability,

*Corresponding author: yaravaprakash@gmail.com

heightened dielectric strength, and augmented design flexibility. Recent years have witnessed a surge of interest in polymer composites integrating vegetable fibers, garnering attention both in academic literature and industrial realms. The burgeoning appeal of natural fiber-reinforced polymer composites stems from their commendable mechanical properties, pronounced processing advantages, economical viability, and diminished density.

## 2. Literature Survey

Radha Krishnan Beemaraj and Arun Prasanth investigated that the mechanical properties of the hemp/jute fibre reinforced polymer hybrid composites.in their project the hemp jute fibre reinforced composites were fabricated using compression molding technique. For different experiments of tensile, impact tests, they have considered ASTM standards. At the timeof result, an exclusive improvement hemp fibre shows the maximum impact strength, tensile strength than jute fibre.

Arne Schrip and Michael P. Wolcott studied on the Influence of the fungal decay and moisture absorption on mechanical properties of extruded wood plastic composites. In their project the wood plastic composites were manufactured by using hand layup method. The fungus used in this project was white rot fungus, trametes versicolor. He added 20g malt and 15g agar per one litre of water. Then he observed weight loss and moisture absorption also tested the mechanical properties of flexural strength and stiffness measurement. At the time of result this study indicates that weight loss is more sensitive of fungal decay than stiffness measurement and strength.

Pandian Amuthakkannan, Vairavan Manikandan investigated that Influence of stacking sequence on mechanical properties hybrid composites of hemp-jute fiber-reinforced polymer composites. The composites of B/B/B, J/B/J/B/J/B, B/J/J, J/J/J, B/J/B, B/B/J, J/J/B, B/J/B/J/B/J, J/J/B were made and the mechanical testing of tensile, impact and flexural testings were done on the above composites. At the time of result it was observed that B/B/J stacking order has higher tensile strength, B/J/B stacking order has better impact strength and in the flexural strength B/J/B/J/B/J having better flexural strength Gao Ma, Libo Yan has observed that mechanical properties of natural jute/hemp composites. Two types of composites were manufactured that is one is pure jute and pure hemp. There are four types of composite specimens untreated jute, alkali solution jute, untreated hemp and alkali solution treated hemp were tested. Tensile test, stress-strain graph are observed under the above conditions.it was observed that alkali treated solution has a negative impact on the tensile strength.

Nabiollah Zareei, Abdolreza Geranmayeh was investigated that The Effect of Different Configurations on the impact and bending Properties of the Composites of Aluminum- Hybrid Hemp and Jute Fibers-Epoxy. In this work the different types of stacking composites of hemp and jute were manufactured. The mechanical properties of bending and impact strengths were observed.at the end of the project it was concluded that the Al/B/B/J/J/B/B/Al hybrid composite had the maximum flexural modulus, strength and impact energy than the remaining stacking composites of jute and hemp

## 3. Methodology

In the view of the above literature, the objective of this work was set to determine the mechanical properties like tensile strength, impact strength and flexural strength of the epoxy jute hemp composites by using the hand layup fabrication method. My work carried on by combining jute and hemp fibres with epoxy resin as a composite having hand layup technique.

### A. *Experimental Procedure*

The experimental procedure for the present study takes place in two stages. They areStage-1: Selection of Materials Stage-2: Preparation of Composite

### B. *Selection of Materials*

In this project, the materials are chosen consists of

1) Jute fibre
2) Hemp fibre
3) Epoxy resin

The type of resin used in the present work is Araldite LY556 and Hardener HY951, mixed in a 10:1 weight ratio.

#### 1) *Jute Fibre*

Jute fibre is one of the most economical fibre, and it is a long, soft, shiny bast fibre that can be spun into strong, coarse threads. The jute fibre comes from the ribbon and stems from the jute plant. The fibres are extracted by retting. The retting process consists of bundling stems together and immersing them in slow running water. Production is mostly in Bangladesh and India too. Jute is also called golden fibre for its high cash value and colour.

Fig. 1. Jute fibre

Table 1
Physical properties of jute fibre

| S.No. | Physical Properties | Jute Fibre |
|---|---|---|
| 1 | Density ($g/cm^3$) | 1.4 |
| 2 | Elongation at break (%) | 1.8 |
| 3 | Cellulose content (%) | 50-57 |
| 4 | Lignin content (%) | 8-10 |
| 5 | Tensile strength (MPa) | 700-800 |
| 6 | Young‟s modulus (GPa) | 30 |

#### 2) *Hemp Fibres*

Hemp fiber is derived from the fine fibers of the hemp plant. Hemp fibers share similarities with fiberglass but offer superior physicomechanical properties compared to fiberglass and are more economical than carbon fiber. Extracting hemp fiber from hemp involves a single-stage process: the hemp is melted and homogenized, undergoing heating only once. The processing of hemp composite fibers into materials utilizes cold technologies with low energy costs. Hemp fiber is obtained from a singular material—the hemp plant. The melting point of hemp fibers is approximately 1500°C

Fig. 2. Hemp fibre

Table 2
Physical properties of Hemp

| S.No | Physical Properties | Hemp Fibre |
|---|---|---|
| 1 | Density (g/cm$^3$) | 1.55 |
| 2 | Specific weight (KN/m$^3$) | 1.4 - 1.5 |
| 3 | Tensile strength (MPa) | 550 - 900 |
| 4 | Modulus of elasticity (GPa) | 70 - 80 |

*3) Epoxy Resin*

Araldite adhesives set by the interaction of a resin with a hardener. Heat is not necessary, although warming will reduce the curing time and improve the strength of the bond. It is available in many different forms, the commonly two different tubes, one each for the resin and the hardener.

Fig. 3. Epoxy Resin (LY556)

Table 3
Properties of Epoxy resin

| S.No | Epoxy | | Density (gm/cm$^3$) | Flash point |
|---|---|---|---|---|
| 1 | Araldite | LY556 | 1.15 | >200 |
| 2 | Hardener | HY951 | 0.97 | 110-120 |

## C. Composite Preparation

Here, an attempt is made to fabricate composite laminates by combining the jute and hemp composites. The mechanical properties like tensile, flexural and impact resistance can be analysed.

*Fabrication procedure manufacturing method for composite hand lay-up:*

It is a manual fabrication process. It involves building up layers of jute and hemp with catalyzed resin around a suitable mold. The reinforcement is then rolled for better wet-out and removing trapped air. Resin is mixed with a hardener if working with epoxy, otherwise, it will not cure (harden) for days/ weeks. Next, the mold is wetted out with the mixture. The sheets of hemp fibre are placed over the mold and rolled down into the mold using steel rollers. The material must be securely attached to the mold. Air must not be trapped in between the fibre glass and the mold

## D. Preparation of composite material

The composite laminates used for this investigation are prepared by hand lay-up technique as it is easy and commercially more economical than other techniques. Initially, jute fibre each mat with 2mm thickness is taken. Jute fibre is treated with NAOH to soften the fibre and make it suitable for composite preparation. Cut the mats by 200mm*200mm dimension. Then place a miller sheet with 75microns on the work table and apply epoxy resin mix on the sheet for mat dimension to stick the mat on the sheet firmly. Place a hemp fibre on the sheet and brush the epoxy throughout the mat. The same procedure is carried out for other layers of fibre till required thickness is obtained. Finally place another miller sheet on the top of the prepared composite to gain smooth surface. Similarly make the same for all the other composites. Then the composite laminates to prepared are dried at room temperature for 18 hours. The most curing is carried out in sunlight for 3 hours on each side of the laminate.

Fig. 4. Hand lay-up technique

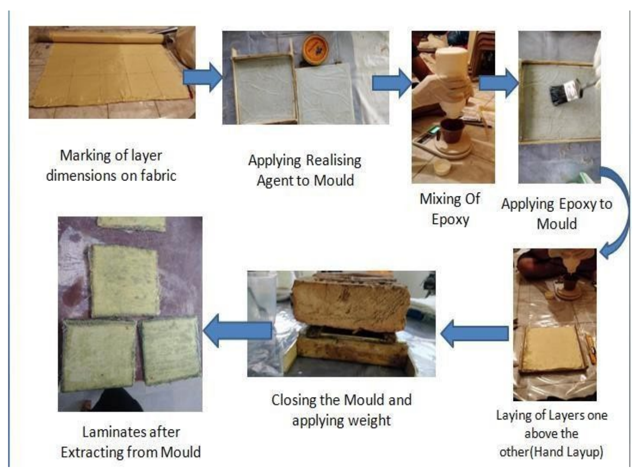


Fig. 5. Fabrication procedure

The mould size is taken as,
Length (mm) = 100mm
Width (mm) =200mm
Thickness (mm) =5mm

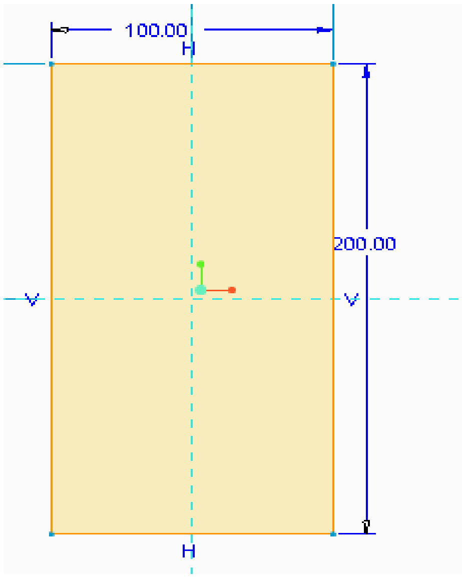

Fig. 6. Mould size

*Fungus:*

Fungi are about 1,44,000 known specimens of organisms of the kingdom fungi, which includes the yeasts, rusts, smuts, mildews, molds and mushrooms. In this project the fungus usedwas yeast (Saccharomyces cerevisiae). The yeast is about 0.075mm in diameter and have any forms. This yeast cause plant pathogens that means it causes a disease on plant. So, when yeast acts on a composite how the composites are reacted has to be analysed. The amount of yeast applied on the specimen is about 10 grams per one liter of water.


Fig. 7. Yeast (Saccharomyces cerevisiae)

## 4. Testing of Hybrid Polymer Composites

### A. *Testing of Composites*

The mechanical testing of composite laminates to obtain parameters like strength, stiffness, hardness, toughness etc. is time consuming and somewhat difficult. To obtain these parametric values the test methods have been simplified by introducing some testing equipment's. The values obtained from these testing methods can then be directly related with varying degrees of simplicity and accuracy

*1) Preparation of test specimens*

After the preparation of composite laminates completed, the laminates need to be cut according to ASTM standards for conducting mechanical tests. The standards will be varied for different types of tests that are being conducted. The required standards are explained below.

Table 4
ASTM standards

| S.No. | Name of the Test | Specifications |
|---|---|---|
| 1 | Tensile Test | ASTM D-638 |
| 2 | Impact Test (Charpy) | ASTM D-256 |
| 3 | Flexural Test | ASTM D-790 |

*2) Tensile test*

This is fundamental material testing for all the materials in the composite field, the sample is subjected to a tension until failure.

*Procedure:*

The tensile test involves placing the specimen in the universal testing machine and extends it slowly until it fractures. Initially mark the gauge length and insert suitable jaws in the grips later select a suitable load scale on the testing machine. Fix the extensometer on the test piece and set its scale dial at zero position. Also set the vertical column of the machine to zero position to take readings in the plastic range. Start the machine and take readings of the extensometer dial for particular value of load. Continue applying of load till the specimen break.

The particular value of tensile strength can be calculated according to the following formula.

$$\sigma t=p/bh \quad (1)$$

*3) Impact test*

The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. It is usually used to test the toughness of metals, but similar tests are used for polymers, ceramics and composites. The notched test specimen is broken by the impact of a heavy pendulum or hammer, falling at a predetermined velocity through affixed distance. The test measures the energy absorbed by the fractured specimen. The impact test can be carried out in two different ways.

*Charpy impact test principle:*

The charpy impact test is a dynamic test in which a test piece V-notched in the middle and supported at each end, is broken by a single blow of freely swing pendulum. The energy absorbed is measured. This absorbed energy is a measure of the impact strength of a material.

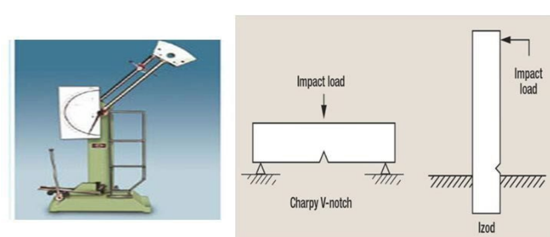

Fig. 8. Charpy impact test equipment


Fig. 9. Impact test equipment and specimen

*Procedure:*

The charpy impact V notch test was carried on impact tester. Prepare a test specimen as per ASTM D-256.Measure the dimensions of the specimen by means of some measuring instruments. During the test the notched specimen is supported at both ends, as a simple beam in simply supported orientation, and is broken by a freely falling pendulum on the opposite to and immediately behind the notch. Then the energy absorbed as determined by the subsequent rise of pendulum, is a measure of impact strength or material toughness and expressed in terms of Joules.

*4) Flexural test*

Fig. 10. Flexural test equipment

The flexural test provides values of the modulus elasticity in bending, flexural stress, flexural strain and the flexural stress-strain response of the material. The main advantage of the three-point bending is the ease of the specimen preparation and testing. However, this method has also some disadvantages: the results of the testing method are sensitive to specimen and loading geometry and strain rate. The test method for conducting the test usually involves a specified test fixture on a universal testing machine. Details of the test preparation, conditioning, and conduct affect the test results. The sample is placed on two supporting pins a set distance apart and a third loading pin is lowered from above at a constant rate until sample failure

*Procedure:*

The flexural test or three-point bending test was carried out on UTM capacity of 60tons for the test specimens that are prepared as per the ASTM D-790 standard. The test specimen is placed on the supporting jaws. The loading is held in the middle of the specimen. At a particular load the deflection at the centre of the beam is determine by using a dial gauge.

Fig. 11. Flexural test

Weight calculations:
Sample prepared in the ratios of,

| S.No. | Jute (%wt) | Hemp (%wt) | Epoxy (%) | Hardner (%) |
|---|---|---|---|---|
| 1 | 30 | 30 | 35 | 5 |

Weight of jute in the composite
= 100mm*200mm*316g/m^2
= 0.1m*0.2m*316g/m^2
= 6.32gms

Composite = 100mm*200mm*300gm/m^2
= 0.1m*0.2*300gm/m^2
= 6gms

Weight of epoxy in the composite
= 100mm*200mm*504gm/m^2
= 0.1m*0.2m*504gm/m^2
= 10.08gm

Weight of hardner in the composite
= 100mm*200mm*54gm/m^2
= 0.1m*0.2m*54gm/m^2
= 1.08gm

Total weight of the composite = 6.32+6.00+10.08+1.08
= 23.48gms

## 5. Results

The work investigates the mechanical properties of fabricated hybrid jute hemp composite laminates with epoxy resin as matrix material using hand lay-up technic. Later the composite laminates are cut into test specimens as per ASTM stands and conduct mechanical tests such as tensile test (ASTM D-3039), Charpy impact V notch test (ASTM d- 256) and three-point bending flexural test (ASTM D-790) under different conditions.

1. No water, no fungi
2. Only water
3. Water along with fungi

The testings were done 9,18,27 days respectively. By conducting the tests, the specimens exhibit the following discussed results. Through the final results, determination of laminate, which produces better mechanical properties, is done.

### A. *Tensile Test*

Here the tensile test is conducted on UTM of capacity 60 tons. The test specimen is prepared as per ASTM D-3039 standard. The test results are tabulated as follows. The strength will be calculated by the equation σt = p/bh.

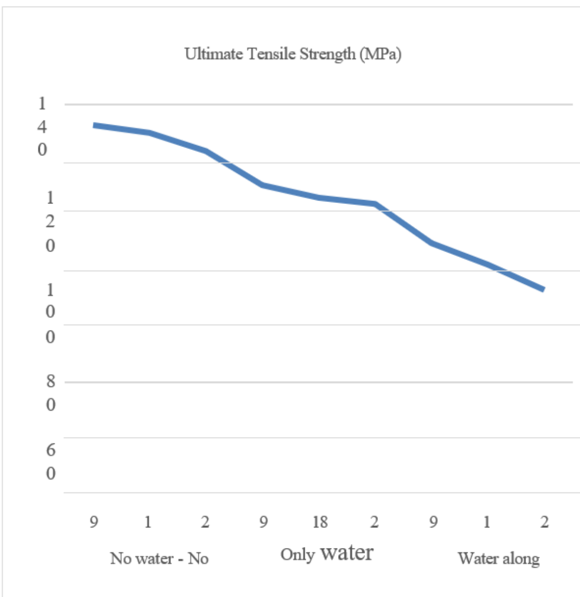


Fig. 12. Ultimate tensile strength under different conditions of aging

### B. *Charpy Impact V Notch Test*

The charpy impact V notch test was carried on impact tester. Prepare a test specimen as per ASTM D-256. The energy absorbed as determined by the subsequent rise of pendulum, is a measure of impact strength or material toughness and expressed in terms of Joules. The impact values that are obtained from the experiment are shown in the table 6.

### C. *Flexural Test*

The flexural test or three-point bending test was carried out on UTM capacity of tons for the test specimens that are prepared as per the ASTM D-790 standard. The results obtained from the experiment are shown in the following tabular column. The flexural strength of the beam can be determined by known values of w, 1, and I using the following formula,

$$\text{Flexural Strength} = \frac{3F^{l}}{2bd^{2}}$$

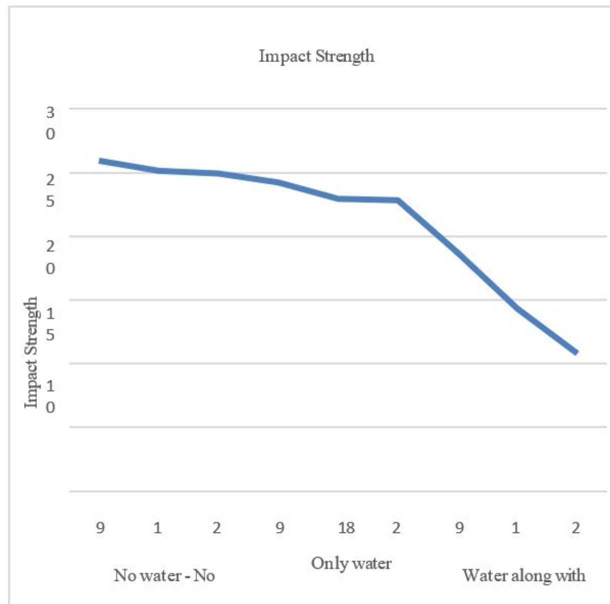


Fig. 13. Impact strength under different conditions of aging

Table 5
Tensile strength values

| S.No. | Specimen Label | Days | Load Break | Ultimate Tensile Strength (MPa) |
|---|---|---|---|---|
| 1 | Jute-hemp (no water-no fungi) | 9 | 7419.44 | 132.49 |
| 2 | | 18 | 7262.32 | 129.72 |
| 3 | | 27 | 6899.6 | 123.21 |
| 4 | Jute-hemp (only water) | 9 | 6214.32 | 110.97 |
| 5 | | 18 | 5959.52 | 106.42 |
| 6 | | 27 | 5835.76 | 104.21 |
| 7 | Jute-hemp (water along with fungi) | 9 | 5046.72 | 90.12 |
| 8 | | 18 | 4617.76 | 82.46 |
| 9 | | 27 | 4099.76 | 73.41 |

Table 6
Impact strength values

| S.No. | Sample Label | Days | Energy Absorbed (J) |
|---|---|---|---|
| 1 | Jute-hemp (no water-no fungi) | 9 | 25.9 |
| 2 | | 18 | 25.1 |
| 3 | | 27 | 24.9 |
| 4 | Jute-hemp (only water) | 9 | 24.2 |
| 5 | | 18 | 22.9 |
| 6 | | 27 | 22.8 |
| 7 | Jute-hemp (water along with fungi) | 9 | 18.7 |
| 8 | | 18 | 14.3 |
| 9 | | 27 | 10.8 |

Table 7
Flexural strength values

| S.No. | Specimen Label | Days | Max Load (N) | Flexural Strength (N/mm$^2$) |
|---|---|---|---|---|
| 1 | Jute-hemp (no water-no fungi) | 9 | 1195.27 | 172.23 |
| 2 | | 18 | 1143.02 | 164.71 |
| 3 | | 27 | 1054.26 | 151.92 |
| 4 | Jute-hemp (only water) | 9 | 1042.40 | 150.21 |
| 5 | | 18 | 980.49 | 141.29 |
| 6 | | 27 | 956.21 | 137.79 |
| 7 | Jute-hemp (water along with fungi) | 9 | 938.86 | 135.24 |
| 8 | | 18 | 897.91 | 129.39 |
| 9 | | 27 | 681.60 | 98.23 |

## 6. Conclusion

In the present investigation jute and hemp composites were fabricated by using hand layup method and different mechanical testings were done on the composites. In this experimental investigation the mechanical behavior of jute and hemp composites under different conditions were studied. Based on experimental results the following conclusions were observed. The composites of jute hemp under no water no fungi condition at 9 days will exhibits more tensile strength and jute-hemp composites water along with fungus at 27 days exhibits poor tensile strength. The composites of jute hemp under no water no fungi condition at 9 days will exhibits more impact strength and jute-hemp composites water along with fungus at 27 days exhibits poor impact strength. The composites of jute hemp under no water no fungi condition at 9 days will exhibits more flexural strength and jute-hemp composites water along with fungus at 27 days exhibits poor flexural strength. By observing all the tests, it concludes that all tensile strength, impact strength and flexural strength at no water no fungi condition at 9 days were comparatively high when compared with the remaining composites.

## References


[1] Holmes, S. The 787 Encounters Turbulence: Technical Glitches and Manufacturing Woes could Delay Boeing's Breakthrough. Business Week, 19 June 2006.

[2] Strong, A.B.; Ploskonka, C.A. Fundamentals of Composites Manufacturing: Materials, Methods and Applications; Society of Manufacturing Engineers, Publications Development Department: Dearborn, MI, USA, 1989.

[3] Boisse, P.; Hamila, N.; Vidal-Sallé, E.; Dumont, F. Simulation of wrinkling during textile composite reinforcement forming. Influence of tensile, in-plane shear and bending stiffnesses. Compos. Sci. Technol. 2001, 71, 683–692.

[4] Kazmierski, C. Growth Opportunities in Global Composites Industry, 2012–2017; Keynote Presentation of the Composites Exhibition and Convention: Las Vegas, NV, USA, 2012.

[5] Chattopadhyay, S.K.; Ghoshal, A.K.; Khandal, R.K.; Niyogi, U.K.; Pramanik, N.; Singh, S.; Uppaluri, R. Biodegradability studies on natural fibres reinforced polypropylene composites. J. Appl. Polym. sci. 2011, 121, 2226–2232.

[6] Célino, A.; Gonçalves, O.; Jacquemin, F.; Fréour, S. Qualitative and quantitative assessment of water sorption in natural fibres using ATR-FTIR spectroscopy. Carbohydr. Polym. 2014, 101, 163–170.

[7] Gassan, J.; Bledzki, A. Possibilities to improve the properties of natural fibre reinforced plastics by fibre modification–Jute polypropylene composites. Appl. Compos. Mater. 2000, 7, 373–385.

[8] Lau, K.-T.; Hung, P.-Y.; Zhu, M.-H.; Hui, D. Properties of natural fibre composites for structural engineering applications. Compos. Part B Eng. 2018, 136, 222–233.

[9] Fernandes, R.; De Moura, M.; Moreira, R. Effect of moisture on pure mode I and II fracture behaviour of composite bonded joints. Int. J. Adhes. Adhes. 2016, 68, 30–38.

[10] Thakur, V.K.; Thakur, M.K. Processing and characterization of natural cellulose fibres/thermoset polymer composites. Carbohydr. Polym. 2014, 109, 102–117.

[11] Kabir, M.M.; Wang, H.; Lau, K.T.; Cardona, F. Chemical treatments on plant-based natural fibre reinforced polymer composites: An overview. Compos. Part B Eng. 2012, 43, 2883–2892.

[12] Van de Weyenberg, I.; Truong, T.C.; Vangrimde, B.; Verpoest, I. Improving the properties of UD flax fibre reinforced composites by applying an alkaline fibre treatment. Compos. Part A Appl. Sci. Manuf. 2006, 37, 1368–1376.