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# Development of composite Jute fibers & its caddies and testing itstensile strength and biodegradability

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**Abstract**

Jute is one of the most commonly available and widely used fibers in packaging industries. It is widely used fiber because of its soft and silky nature. It has the ability to blend with other fibers makes it widely competent in packaging apart from cotton, the most widely used fiber. Jute wastes are nowadays quite a serious concern for many industries and proper utilization of these waste have not been done. In this paper, it has been attempted to blend jute fibers with coir fibers and form a Jute Coir composite in a Double Head 2 ply cir yarn spinning machine and tested for its tensile strength.

*Keywords*: Jute, Coir, Tensile Testing, Jute Coir Composite

## 1. Introduction

Jute fibre is a vegetable plant, obtained from genes, Corchorus olitorius. It is also known as the Golden Fibre because of its golden and silky shiny and mostly it is a marketable fibre. The Jute fibres are extracted from the bust of the jute plant and junked in submerged water for 20 days or 3 weeks. The main constituent of Jute is cellulose at around 60%, followed by hemi-cellulose at 24%, lignin at 11.5% and the rest of fats, pectin, ash etc. At present the annual global production of Jute fibre is about 3.2 million tons used for different applications. Cloth bag manufacturing industries are the biggest consumer of jute fibres. It has gained its advantage for being an eco-friendly option as compared to polythene carry bags. As a result, Jute waste is a common concern for industries as they don't dispose of all the waste. These waste remains after many different processes in industries and are discharged to boilers or used as a fuel for burning. Apart from that these wastes are also used for making paper after scouring. It is also used by local people for building roofs of their houses. These wastes are accumulated in medium to high quantities in industries [5, 6, 7]. A huge amount of jute waste fibres is wasted and disposed into the landfills every year. Several researches are going on to use the waste jute fibres for other applications.

For the spinning of a composite different methods and processes where suggested among which one study suggested that Jute, Mesta and Sun Hemp can all be machined on the jute spinning system due to almost similar properties of fibers but coir fibers are difficult to blend because of its higher rigidity compared to jute and other fibers. Test were also conducted with jute-viscose and jute-cotton blended yarns on Shirley Miniature Appartus with W2 grade Jute and it was found that 50:50 blend ratio gives the best result in terms of tenacity. One study suggest the need of modifying the Coir spinning machine which resulted in production increment by 20% along with significant improvement in yarn quality and spinning performance [4, 9, 10]. Significant difference were found when a long jute fiber was divide into 3 parts (top, middle and bottom fiber) each of 250 mm long and tested on single fiber tensile test. It was found that the middle portion exhibits high mechanical properties compared to the top and bottom fiber. So ultimately choosing the middle fiber for reinforcing a composite was found to be a

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better option. [11]

In this paper, it has been attempted to blend jute waste fibers and its caddies with coir fibers in a double headed coir yarn spinning machine in different proportions. The jute wastes and the coir fibers were treated with other agents prior to its blending. After this it has been tested for its tensile strength.

## 2. Experimental

### 2.1 Matherias

The jute waste fibers have been collected from Jute Industries, Boragaon, Guwahati and Nagaon Jute Mill. The Coconut fibers were collected from Biswanath Chariali, Assam.

### 2.2 Raw fiber treatment processes)

The Coir fibers are treated with 250 gm of Sodium Hydroxide dissolved in 5- 6 litres of water. The fibers are then washed with water and finally made to dry at room temperature.

### 2.3 Waste fibers to powder form

The jute caddies were initially treated in 5 wt% Sodium Hydroxide (NAOH) solution at 80$^0$C for 20 minutes. The fibers were then immediately dipped into a 10g/l Sodium Hypochlorite (NaOCl) solution at 160$^o$C for 20-30 minutes. The last treatment involves the use of 0.1% Sodium Sulphite (Na2SO3) solution at 160$^0$C for 20 minutes. The sample was then dried under sunlight conditions for 24 hours. The final fiber obtained was found to be in shiny and silky condition and little amount of oily layer on it. The samples were cut into powder form using a household grinder. Generally it is cut by High energy planetary ball wet milling process.

**Fig.1:** Jute Fibers

**Fig.2:** Coir Fibers

**Fig.3:** Jute Caddies

## 3. Methodology

**Preparation of composite yarn**

1. Three different composite yarns were prepared in different ratios. The coir and the jute fibers were mixed in a ratio of 100:0, 70:30 and 50:50 by weight percentage and then cut out separately on the shredding machine. This process was repeated thrice for effective shortening of the fiber length to around 5 to 8 cm.
2. The fibers were then spread on the conveyor belt uniformly for equal and same diameter to be produced.
3. A first yarn was handmade and then tied with a sliver orange yarn that was used in spinning.
4. The yarn was then made to pass through needle shaped head which was then fed through 2 holes and finally combined the two yarns into a single yarn.
5. The machine then revolved for some seconds for effective twisting of the two yarns.
6. The single yarn was then made to pass through a bevel shaped gear by rotating the machine for some time.
7. This yarn was then finally tied on the roller for production.
8. A dead weight was placed at the ends to minimize vibrations.

**Fig.4:** Coir Jute fiber shredder machine

**Fig.5:** Double head 2-ply coir spinning machine

## 4. Data inferences

The following composites are obtained after the final processing on Coir Spinning machine and secondly a biodegradable thin film of 5% jute caddies (waste) as fillers:

**Fig.6:** Coir jute composite yarn

### 4.1 Tensile testing

For the testing of Yarns, ASTM D3039 was followed. The specimens were cut into a gauge length of 250 mm each in size. A total of 3 samples were cut from different parts of the body yarn. Then for a sample, diameter was measured which basically was the average of ten measurements that was taken at different point on the 250mm length of yarn. The diameters where measured by digital micrometer. Then the test was performed on INSTRON-Dynamic UTM as shown in the figure below. A test speed of 5mm/min was used for any standard sample. For different diameters of different composite yarn, the data was collected and analyzed as shown below.

**Table 1 :** For 100% pure Coir Yarn of D avg = 9.4867 mm:

| Sl No. | Diameter (mm) | Tensile Strain at Break (Standard) [%] | Tensile Stress at Maximum Load [MPa] | Modulus (E-Modulus) [MPa] | Maximum Load [N] | Extension at Maximum Load [mm] | Time at Maximum Load [s] |
|---|---|---|---|---|---|---|---|
| 1 | 9.447 | 34.01 | 3.475 | 14.278 | 243.589 | 35.228 | 422.750 |
| 2 | 7.801 | 27.59 | 3.924 | 38.852 | 275.048 | 32.260 | 387.150 |
| 3 | 11.212 | 51.21 | 4.757 | 12.490 | 468.681 | 50.289 | 603.50 |

From the above table, it was found that when the coir diameter increases from 7.880 mm to 9.447 mm, the tensile stress at maximum load decreases from 3.924MPa to 3.475MPa along with decrease in load carrying capacity. The extension at maximum load increases from 32.260 to 35.228 mm respectively. Similar phenomenon was observed when diameter increases from 9.447 mm to 11.212 mm.

**Table 2 :** For 70:30 composition of Coir-Jute Composite Yarn of D avg = 9.336 mm:

| Sl No. | Diameter (mm) | Tensile Strain at Break (Standard) [%] | Tensile Stress at Maximum Load [MPa] | Modulus (E-Modulus) [MPa] | Maximum Load [N] | Extension at Maximum Load [mm] | Time at Maximum Load [s] |
|---|---|---|---|---|---|---|---|
| 1 | 9.310 | 35.75 | 3.207 | 14.554 | 218.327 | 37.685 | 452.250 |
| 2 | 9.553 | 32.97 | 2.578 | 10.974 | 184.744 | 30.760 | 369.150 |
| 3 | 9.138 | 45.48 | 2.456 | 9.972 | 161.085 | 21.613 | 259.450 |

From the above table, it was found that for coir – jute fiber when varying from 9.138 mm to 9.31mm in diameter, the tensile stress at maximum load increases from 2.456MPa to 3.207MPa. The extension at maximum load was found to decrease from 21.613 mm to 37.685 mm. Similar phenomenon was not found when diameter increases from 9.31 mm to 9.553 mm. The tensile stress at maximum load was found to be decreasing from 3.207MPa to 2.577MPa along with decrease in extension at maximum load from 37.685 mm to 30.760 mm.

**Table 3 :** For 50:50 composition of Coir-Jute Composite Yarn of D avg = 6.705 mm

| Sl No. | Diameter (mm) | Tensile Strain at Break (Standard) [%] | Tensile Stress at Maximum Load [MPa] | Modulus (E-Modulus) [MPa] | Maximum Load [N] | Extension at Maximum Load [mm] | Time at Maximum Load [s] |
|---|---|---|---|---|---|---|---|
| 1 | 5.189 | 23.30 | 5.901 | 45.299 | 124.788 | 10.236 | 122.850 |
| 2 | 7.144 | 16.03 | 4.867 | 36.216 | 195.081 | 19.255 | 231.10 |
| 3 | 7.781 | 30.45 | 4.666 | 19.569 | 221.861 | 27.964 | 335.60 |

From the above table, it was found that for coir–jute fiber when varying from 5.189 mm to 7.144mm in diameter, the tensile stress at maximum load decreases from 5.901MPa to 4.867MPa. The extension at maximum load was found to increase from 10.236 mm to 19.2552 mm. Similar phenomenon was not found when diameter increases from 7.144 mm to 7.781 mm. The tensile stress at maximum load was found to be decreasing from 4.867MPa to 4.665MPa but extension at maximum load increases from 19.255 mm to 27.964 mm.

### 4.2 Graphs

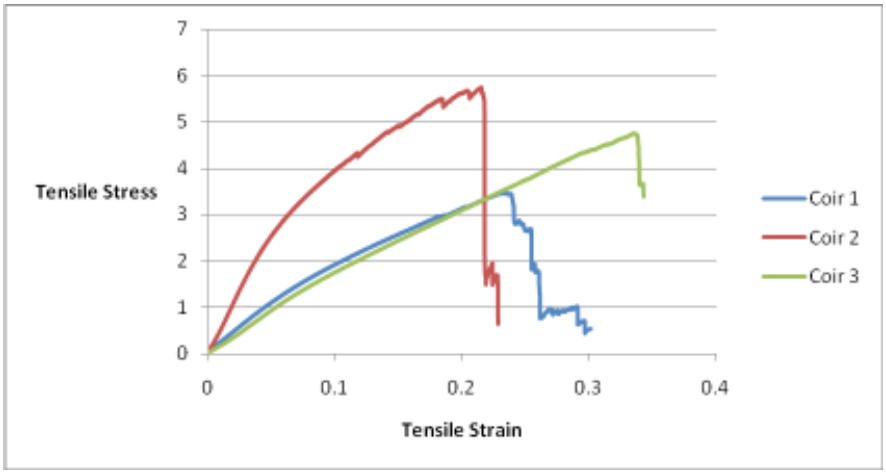


**Fig.7:** Coir Yarn Stress-Strain variation

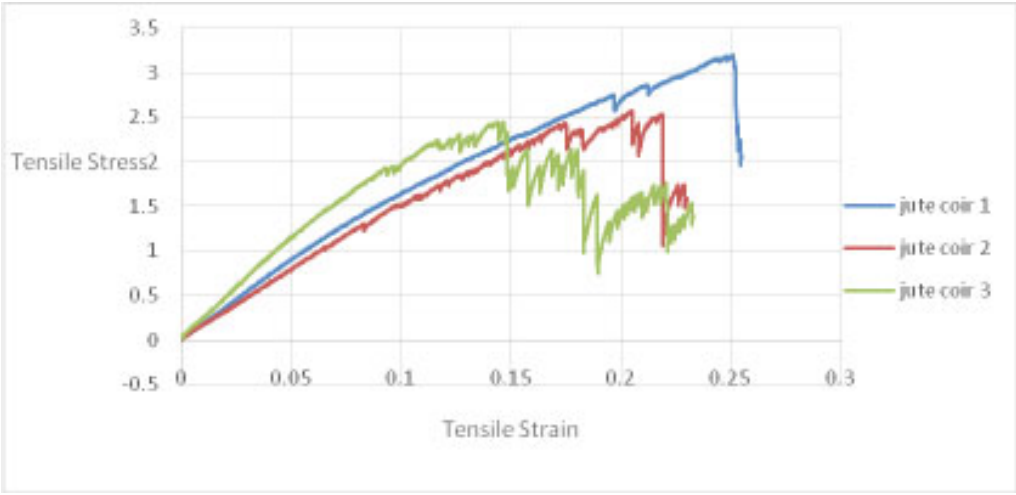


**Fig.8 :** Coir-Jute (70:30) Yarn Stress Strain variation

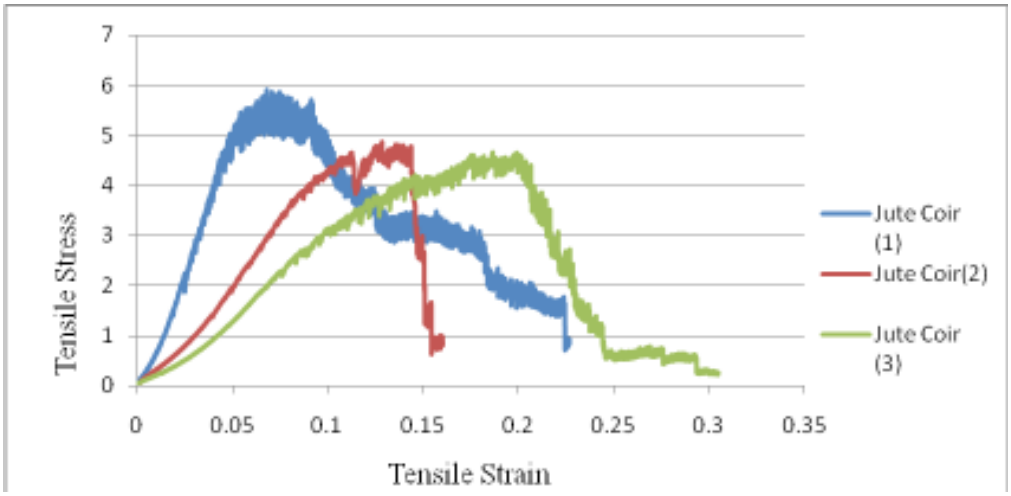


**Fig.9:** Coir-Jute (50:50) Yarn Stress Strain Curve Variation

From the above graphs, it can be found that the tensile strength of coir fiber at maximum load is equal to 4.757 MPa at diameter of 11.212mm. compared to Coir-Jute Composite Yarn at 3.207 MPa of diameter 9.31mm. Similarly, composite of 70:30 jute coir composite shows decrease in strength by nearly 33% whereas the jute fiber composition at 50:50 wt%, actually shows increase in tensile strength by almost 120% compared to coir yarn of maximum tensile stress of 4.757MPa at 11.212 mm diameter to 5.901MPa at 5.189 mm diameter of Coir Jute Yarn.

## 5. Conclusion

It was found that fiber treatments are necessary in certain amounts before being dried and tested out on the Coir spinning machines. Although composite of coir- jute at 50 wt% shows better tensile stress values compared to pure coir yarn at different diameters but the load carrying capacity decreases to around 200N. It was also found that a quantity below 5% wt of Sodium Hydroxide for fiber surface treatment was void as it doesnot alter any tensile properties of fibers. The waste fibers can be recycled in the powder form and can be added to any base material for film production. Better preparation can be done on High Energy planetary Ball Mill to make the waste completely to powder form. The jute waste and coir can be blended together but before blending, the properties of the fibers and their strength needs to be noted out, so that when carrying out spinning, both the fibers should show equal extension in order to maximize tensile strength output.

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