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A Study on The Quality Characteristics of Yarns Made from Coir Fibres

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Abstarct - The spinning system employed for the spinning of coir yarn from coir fibers follows the principle of open end spinning. Coir yarn produced by manual or mechanical means is of two ply structure. The single yarn produced by the mechanized process is a an open end type of yarn where two single yarn from the adjacent spinning heads are converged together and then twisted together before winding it on a bobbin. The single yarn produced is of core yarn type and the core component is generally a mono filament polyester fiber, with coir fibers wrapped over the filament to form a sheath. Fiber length distribution, packing fraction and breaking strength of both single and two ply coir yarn were tested and analyzed.

Key words: Coir fiber, Core spun yarn, Fiber length distribution, Packing fraction, Sheath fibers, Wrapper

I. INTRODUCTION

Coir fiber is classified as one of the unconventional fibers in textiles. It is a versatile lignocellulose fiber obtained from the coconut tree. Coir fiber is extracted from the husk of coconut after the removal of the nut. It is an agro based biodegradable fiber, renewable and available in large quantities [1]. This fiber contains more lignin and less cellulose [2]. Coconut fiber is strong and has high flexural and torsional rigidity, tough and durable [3]. The fiber is extracted from husk by mechanical, chemical and biological methods [4]. For fiber extraction, mechanical means of fiber extraction have almost completely replaced the conventional water based biological retting which causes high level of pollution. Coir yarn is made by traditional manual spinning and also by mechanized spinning processes.

A. Yarn type and spinning system

Coir fiber yarns produced from the mechanized spinning process is an open end type of yarn in which two single yarn strands from adjacent spinning heads are plied and twisted together. Each single-ply yarn is a core sheath type yarn. The core component is a polyester mono filament of 120 Denier, with a sheath formed by coir fibers Coir yarn and ropes are very widely used in industry and in geo-textiles. Coir yarn is also the starting material for manufacture of brushes, mats and other household products. A schematic diagram of coir fiber spinning process is shown in Figure 1.The spinning system employed is an open end spinning system

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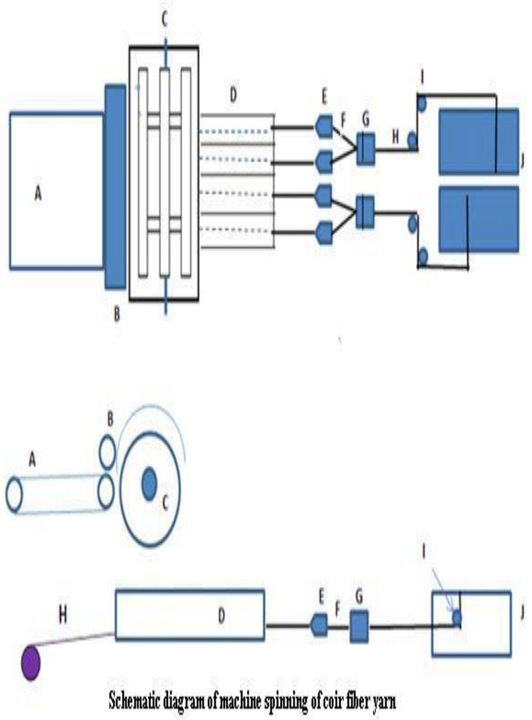

Figure.1. Schematic Diagram of Coir Fiber Spinning Process

The schematic shown represents a typical double sided coir spinning machine widely used. The beater "C" gets coir fiber from feed lattice or conveyor "A" in the form of a set of slivers or in the form of a loose fiber mat. The beater opens the fibers and the loose fibers are deposited in four V shaped collection troughs. The core filament "H" which is being twisted by the spinning head "E" and is moving through these V shaped troughs picks up the deposited fibers. The newly formed yarn picks up more and more fibers as it moves through the length of the V-shaped groove and exits the spinning head as a single strand. Two single strands are consolidated at the doubling head which also controls the speed of withdrawal of the yarns. The yarn is wound onto a spool with the reciprocating guide roller "I" laying the yarn along the length of the spool "J'.

The surface speed of the spool is kept constant by a manually adjusted friction brake. The normal delivery speed of the coir yarn spinning machine is around 10 meters per minute.A study has been made of the influence of core yarn on the final properties of the coir yarn produced by the mechanical process described earlier.

II. METHODOLOGY

Yarn samples were produced from a single bale of fibers, with coir fibers having mean length of 109 mm, mean fiber linear density of 70 Tex. The length of individual coconut fiber was measured using a steel rule. The fiber length distribution was based on measurements of 1000 fibers from the bale and yarn from the same bale respectively. Tensile properties of the fibers were also measured.

The core filaments used for the study were of 125 Denier and made of Polyester monofilament and Poly Vinyl Alcohol (PVA) multifilament. The rate of feed of coir fiber to the beater was set to give a linear density of 3.2 ktex for the single yarn and 6.5 ktex for the two ply yarn at an output speed of 10 mm/minute. The speed of the beater was maintained at 240 rpm, giving a surface speed of 320 meters/minute. The machine was set to impart single yarn twist of 150 turns per meter and plied yarn twist of 45 turns per meter for all the samples.

The effect of core constituent on the various properties of coir fiber yarn was studied by producing both two ply yarn and single yarn samples using Polyester monofilament as core component. Similar samples were made with Poly Vinyl Alcohol (PVA) multifilament as the core component. Two types of single yarn samples were made. One type of single yarn was obtained by untwisting and separating a two ply yarn. The other type was made by directly spinning a single ply yarn (referred to as Direct Single Yarn) after some modifications on the machine. In addition a direct single ply yarn with another core filament wrapped around its periphery (referred to as Wrapper Yarn) was produced. The number of wraps or turns of the wrapper filament was maintained at 2 wraps per cm.

Coir yarn made from PVA core filament was kept in boiling water for about 10 minutes to dissolve the core component and dried to room temperature before conditioning.

The longitudinal structures of the single and two ply of coir yarn of regular polyester core yarns were observed using a high resolution camera. The fiber tensile characteristics were determined using a standard Universal Type Strength testing machine.

Packing fraction of yarn samples were calculated by measuring the average diameters of the fiber and yarn using optical means. The breaking strength and elongation were determined at a test length of 500 mm, extension rate of 250 mm/min and pretension of 0.5 cN/Tex on a universal tensile tester. The linear mass variation of yarn samples were studied by measuring the weight of one meter cut length yarn samples. All the tests were performed after conditioning for 24 hours in a standard atmosphere of 27 ± 2 °C and 65 ± 2% RH.

III. RESULTS AND DISGUSSION

A. Fiber Length Distribution

The coir fiber characteristics measured are shown in Table 1

1. The high CV% values of breaking strength and breaking elongation can be explained by the fact that there is a very wide variation in fiber diameters, an inherent property of coir fibers

Tensile properties of coir fibre		
Parameter	**Unit**	**Value**
MeanBreaking Strength	gf	277.9
Breaking Strength Variation	CV %	59.1
MeanBreaking Elongation	%	12.4
Breaking Elongation Variation	CV%	64.5
Mean Linear Density	Tex	70
Tenacity	gf/Tex	3.97

Table 1. Properties of coir fibres

The fiber length distribution of fibres and yarn produced from the same fiber bale was studied and the results are given in Figure 2.

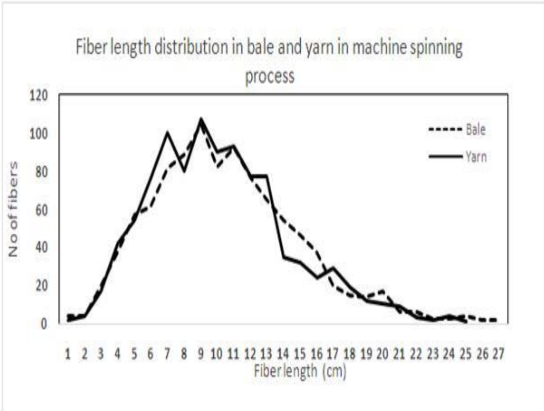

Figure.2.Fibre Length Distribution In Coir Fibre Bale And Yarn

It can be seen that the majority of fibers in the bale fall in the band of 4 to 17 cm with a mean length of 10.52 cm and that of the fibers taken from the yarn, fall in the band of 4 to 13 cm, with a mean length of 10.12 cm. This drop in length of the fibers from bale to yarn can be explained by the fact that longer fibers tend to break during the severe beating action that takes place during processing of fiber into yarn.However there is no significant difference in the Coefficient of Variation in the distribution of fiber lengths of the fibers in the bale and in the yarn.

B. Longitudinal Structure

The longitudinal structures of the single and two ply of yarn with polyester core filament are given in Figure 3 and Figure 4 respectively.

Figure.3. Longitudinal Image Of Single Coir Yarn

Figure.4. Longitudinal Image Of Two Ply Coir Yarn.

Single yarn is found to have surface wrapped fibers at various angles to the yarn axis. Also there is variation in the number of these wrapper fibers along unit length of the yarn. This behavior of fiber is typical of open end spun yarn structures.

C. Packing Fraction

Packing fraction of the yarn samples was determined and the results are given in Table 2. The packing fraction of wrapped single yarn Sample H is found to be the highest followed by the direct single yarn sample G produced in the coir spinning machine

Packing fraction of yarn samples			
Sample	**Yarn type**	**Core Component**	**Packing fraction**
A	Two ply	Polyester	0.45
B	Two ply	PVA	0.41
C	Two ply	PVA removed	0.41
D	Single yarn	Polyester	0.58
E	Single yarn	PVA	0.56
F	Single yarn	PVA removed	0.54
G	Direct single yarn	Polyester	0.64
H	Wrapped yarn	Polyester	0.76

Table 2. Packing fraction of coir yarn samples

Packing fraction of wrapped yarn is 30% higher than the regular polyester core spun of single yarn component, and 10% higher than the direct spun single yarn. There is no significant difference in the packing fraction values of the three single yarn samples D, E and F with PE core. PVA core and PVA core removed, respectively. This behavior of packing fraction is also reflected in the two ply yarn samples A, B and C, as there is no difference in the spinning process. The increase in radial pressure exerted by the external wrapper filament increases the packing fraction of wrapped yarn. In the direct single yarn due to the higher twisted inserted (than the single yarn component of the two ply yarn) the packing fraction of direct single yarn is higher than the other single yarn samples considered.

D. Yarn Strength

The tensile strength values of yarn samples are given in Table 3. Comparing the two ply yarn sample A, B and C, it can be seen that the strength of two ply yarn with polyester core is found to be the strongest one.

Sample	Yarn type	Core Component	Yarn Strength (kgf)	Strength Variation (CV%)
Polyester Core	125 Denier monofilament	-	6.32	1.2
PVA Core	125 Denier multifilament	-	2.29	3.6
A	Two ply	Polyester	24.57	10.2
B	Two ply	PVA	22.68	9.7
C	Two ply	PVA removed	20.94	9.1
D	Single yarn	Polyester	8.38	28.4
E	Single yarn	PVA	6.28	25.2
F	Single yarn	PVA removed	5.24	24.5
G	Direct single yarn	Polyester	10.18	18.2
H	Wrapped single yarn	Polyester	12.10	20.0

Table.3 Strength Values Of Coir Yarn Samples

The strength of this yarn is higher by 8.5% than the PVA core ply yarn. This is explained by fact that the core PVA monofilament is substantially lower in tensile strength than the Polyester monofilament. The PVA core dissolved two ply yarn is weaker by 17% when compared to the polyester core two ply yarn, due to the absence of a core filament.

The same pattern of strength is seen in the single yarn samples D, E and F, where the Polyester core yarn is the strongest and the PVA core dissolved yarn is the weakest.

This clearly indicates that the core monofilament does play a significant part in the single and two ply yarn strengths. A variation in strength is observed between samples D and E, both single yarns with a polyester core, though they are of the same material and linear density.

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This is explained by the fact that single yarn Sample D has been made by untwisting the two ply yarn while the direct single yarn Sample E is spun as a single yarn that also picks up the additional twist given by the doubling section of the machine. This additional twist, is also reflected in the higher packing fraction of Sample E shown in Table 2.Figure 5 shows the relationship between the strength and packing fraction of each of the yarn samples. Comparing two ply yarn Samples A, B and C, sample C with its PVA core removed is weaker than the Sample B with a PVA core, even though they have the same packing fraction. Sample A with Polyester core has a higher strength and a higher packing fraction. This indicates the role of the core filament in the strength of two-ply coir yarn. The slight reduction in the packing fraction of Samples B and C is possibly due to the higher extension values of PVA when compared to polyester. Comparing the single yarn samples D, G and H with polyester core and with same linear density, it is seen that the wrapped single yarn Sample H is the strongest, followed by direct single yarn Sample G, followed by the single yarn Sample. The highest strength of the wrapped single yarn is explained by the polyester monofilament wrapped over it, which increases surface contact between the fibers in the yarn. The increase in strength values of all these yarn samples is consistent with the increase in the packing fraction which increases surface contact between fibers. There is a positive correlation between packing fraction and yarn strength.

IV. CONCLUSIONS

Coir fiber yarn spun from machine spinning process is a two ply yarn with the single yarn component being an open end yarn with a core yarn. The core is a polyester mono filament and the sheath is of coir fibres. The spinning system follows the principle of open end spinning. The single yarn structure consists of wrapper fibers on the surface with varying distribution along the length of yarn. Two ply-coir yarn with polyester filament core yarn has the highest packing fraction value which make it stronger than the other two ply yarns considered. The strength and packing fraction of wrapped yarn sample is observed to be better than all the single yarn samples considered. There is a positive correlation between packing fraction and yarn strength. The strength of the core yarn influences the strength of single ply and two ply coir yarn. Reduction in the mean fiber length of coir fibre in yarn is observed which could be due to the mechanical processing of fibers.

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