A Comparative Study on the Coir Yarn Spinning Processes

Thanabal.V[1], Saravanan.D[2]

[1]*Department of Textile Technology, Bannari Amman Institute of Technology, Sathyamangalam, India*

[2]*Department Textile Technology, Kumaraguru College of Technology, Coimbatore*

thanabalv@bitsathy.ac.in

dhapathe2001@rediffmail.com

Abstract

Coir yarns are manufactured using the hand spinning and mechanised spinning systems. Like the mule spinning, hand spinning is an intermittent process in which a fixed length of yarn is produced and these yarns are joined together to obtain a long length of two-ply coir yarns. The production of hand spinning is relative low. Single yarn made from hand spinning resembles the ring spun yarn with fibres parallel to each other and follow the helix angle of the twist inserted. Hand spun yarns are finer and have better quality over the mechanised spun yarns, due to the presence of a greater number of longer fibres in the yarn cross-section. Mechanised spinning is a continuous process and the production of one spinning machine is 5 to 6 times higher than the production of one set of 6 operators involved in hand spinning. Mechanised spinning works on the open end spinning principle and the single yarn produced from this spinning has a core sheath type yarn. The core component is a polyester mono-filament and coir fibres are wrapped over the core filament as a sheath to form the yarn. The method of fibre collection after the opening and individualization affects the orderly arrangement of fibres in the yarn structure. Due to this, spinning of finer yarns equivalent to that of the hand spinning is impossible with the existing design of the spinning machine. Furthermore, the yarn strength and yarn irregularity of mechanised spun yarns are found to be inferior compared to that of hand spinning system. The output of the both the spinning processes are a two-ply coir yarn. In the hand spinning, the two single yarns produced by the operator during the reverse movement are plied and twisted together during their forward movement and, one spinning cycle is completed. In mechanised spinning, two single yarns from the adjacent spinning heads are plied together and twisted to form the two-ply coir yarns.

Keywords: *Coir, Hand spinning, mechanised spinning, Core Yarn, Two ply yarn,*

1. Introduction

Coir is the fibre obtained from the fruit of coconut tree (Cocos nucifera). It belongs to the palm tree family (Arecaceae) grown in tropical and sub tropical countries [1]. Coconut fruit consists of exocarp (the outer layer), mesocarp (the fibrous husk), endocarp (the hard shell) and the endosperm (the meat) [2].Coir fibre is extracted from the coconut fruit after the removal of husk after the removal of the endocarp and the endosperm. The husk consists of 75% of fibre material and 25% fine material called pith [3]. Though coconut tree grows in

several countries, majority of fibre extraction takes place in countries like India, Sri Lanka and Philippines. Less than 50% of coconut husk are utilised for fibre extraction and remaining husks are used as domestic fuel and left over as waste which decomposes in due course of timer. Coir fibre consists of 43.44% of cellulose, 45.84% of lignin, 0.25% of hemi cellulose, 3.00% of pectin, 2.20% of ash and 5.25% of water soluble compounds [4]. Due to the high quantity of lignin, coir fibre is brown, stiff and has high flexural rigidity [5].

Two types of course fibres are available in the coir industry like white fibre and brown fibre [6]. Fibre obtained from the immature green husk after a long retting process of 10 to 12 month is known as white fibres. Brown fibres are extracted from matured husk with a getting process of 10 days. Spinning of coir fibres has been carried out in India, Sri Lanka and Thailand. Coir fibre yarn is produced by the traditional hand spinning process and the mechanised spinning process. Hand spinning is being carried out by women workers in the rural regions of Kerala and provides livelihood to a sizable women population. Mechanised spinning process has got its importance as the demand for coir yarns is not fulfilled by the low production of hand spinning process [7]. Most of the white fibres are processed in hand spinning and the brown fibres are processed in the mechanised spinning system.

There are twin applications of coir yarns as an intermediate product or final product. In the production of mats and mattings (coir yarn weaving), it is used as an intermediate product. These mats and mattings are major items of export from India and Sri Lanka, and has been used as an underlay for carpets. Coir mattings are used in geo textile applications to prevent soil erosion and as acoustic-proof materials. As a final product, coir yarns used in cultivation, fishing and house construction in the rural areas [8]. In this study both the coir spinning processes were studied in terms of yarn structure, quality of yarn produced and the results are discussed.

2. Materials and Methods

Yarn samples of identical yarn linear density were collected. In the coir industry, the yarn linear density is expressed as 'runnage'. It is an indirect method of yarn numbering and it is the number of metres of coir in a standard weight of one kilogram. 160 runnage coir yarn samples were collected from both the spinning processes for the assessment of fibre and yarn quality characteristics.

2.1 Measurement of Fibre Length and Fineness

Coir fibres are removed from the yarn samples for the measurement of fibre length and fibre fineness. The length of coir fibres are measured using a steel rule and the weight of 1000 the fibres were determined using an electronic balance. From the fibre length data, the fibre length distribution in the yarn structure of hand spun yarn and mechanised spun yarn were established for the comparative study. From the data of length and weight of thousand coir fibres, the mean fibre fineness was determined.

2.2 Analysis of Fibre Arrangement in Yarn Structure

Coir fibre yarns are coarse and having a linear density of 120 to 200 runnage. Due to this, the structural analysis of the yarn using a scanning electron microscope is not possible. So photo graphic images are analysed for the assessment fibre arrangement in the yarn structure.

2.3 Measurement of Tensile Characteristics of Fibre and Yarn

The tensile characteristics of the coir fibre and yarn samples were tested on a Universal Strength Tester Instron 5500R with a gauge length of 300 mm with strain rate of 300 mm per minute (100% strain rate).

2.4 Measurement of Yarn Mass Irregularity

Since coir yarns are coarser in nature, applicability of these instruments is very much limited for the determination of yarn irregularity and hence cutting and weighing principle was used for the determination of yarn irregularity [9, 10].

3. Results and discussions

3.1 Types of Yarn Produced

The quality characteristics of yarns made from staple fibres are strongly affected by the characteristics of fibres and their arrangement in the yarn structure, i.e. spinning process. The factors like fibre alignment, fibre disposition and number of fibres in the cross-section significantly influence the characteristics of yarn and are well documented for yarns like cotton and other staple fibres.

Yarns made from the hand spinning system look like combed ring spun cotton yarn as shown in Figure 1. In hand spun yarn most of the coir fibres in the yarn structure are parallel to each other as well as to the yarn axis, and follow the helical angle of twist insertion.

Figure 1. Hand Spun Single Yarn

Figure 2. Untwisted Hand Spun Single Yarn

Untwisting of the hand spun yarn enables the coir fibres to be separated from the yarn structure without any difficulty. The photographic image of untwisted hand spun coir yarn is shown in figure 2.

Figure 3. Mechanised Spun Single Yarn

Figure 4. Untwisted Mechanised Spun Single Yarn

In mechanised spinning, the single yarn of the two-ply yarn has predominantly a core-sheath structure, in which the core material is normally a monofilament, and the coir fibres are wrapped over the core. The coir fibre arrangement in the sheath is random in nature, and each fibre occupies a different position in the yarn structure. Due to this, coir fibres could not be separated from the yarn structure by untwisting. Figure 3 shows the single mechanised spun yarn and Figure 4shows the untwisted single yarn of mechanised spun yarn.

3.2 Fibre Length Distribution in Hand Spun and Mechanised Spun Yarns

Fibre length is one of the important fibre properties, which influence the spinning limit, process performance and yarn strength. The distribution of fibre lengths in the hand spun yarn, and the mechanised yarn were studied and are given in figure 5 and figure 6.

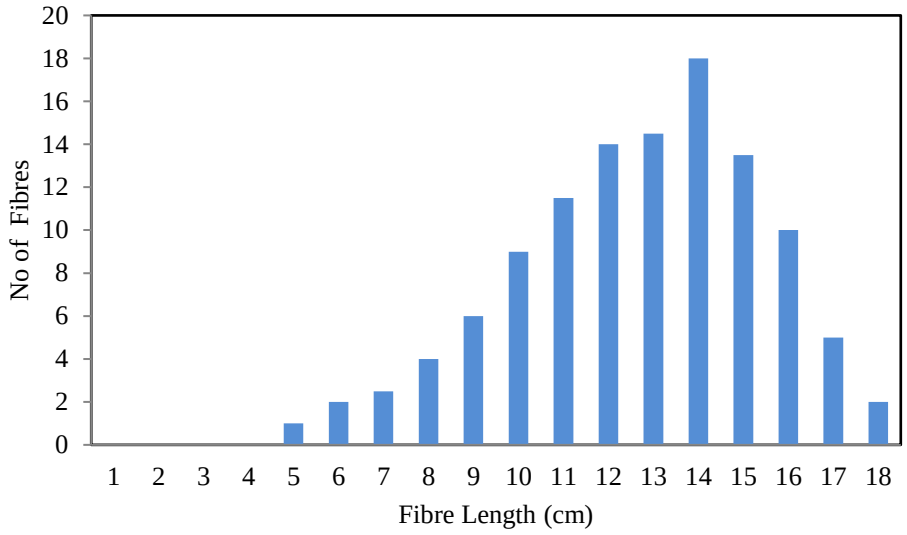

Figure 5. Fibre Length Distribution in Hand Spun Single Yarn

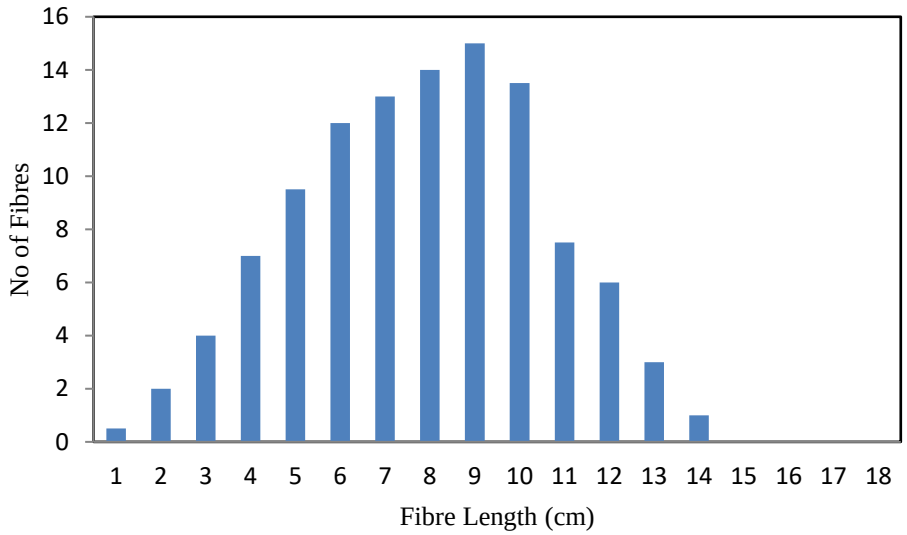

Figure 6. Fibre Length Distribution in Mechanised Spun Single Yarn

In hand spun yarn, the majority of the coir fibres fall in the fibre length range of 9 cm to 16 cm. Before the spinning process, the spinner/worker removes the short length coir fibres using a hand comb. Because of this, the proportion of short fibres was found to be less in hand spun yarn. This could be the reason that relatively finer yarns can be spun from the hand spinning process. In case of mechanised spun yarn, it could be observed that more than 60% of fibres fall in the fibre length, ranging between 3 cm to 12 cm. Since the presence of short length fibres are more, the hairiness of the mechanised yarns is relative higher compared to the hand spun yarn.

3.3 Tensile Strength, Elongation and CV% of Mass Variation of Coir Yarns

The strength, elongation and the mass irregularity values of the single and two-ply yarns of hand spun and mechanised spun yarns are given in Figures7,8 and 9 respectively. It could be observed that yarn strength and yarn elongation of hand spun yarns are found to be higher than that of mechanised spun yarn. Furthermore, yarn mass variation (CVm %) is found to lower in hand spun yarn. Presence of longer fibre and a regular arrangement of fibres in the yarn structure help in the reduction of yarn mass irregularity. The low irregularity (CVm %) could be the combined effect of the greater number of longer fibres present in the yarn and the low production rate by the workers. Doubling or plying of single yarns will result in the improvement of yarn quality parameters like yarn strength, yarn elongation and yarn irregularity.

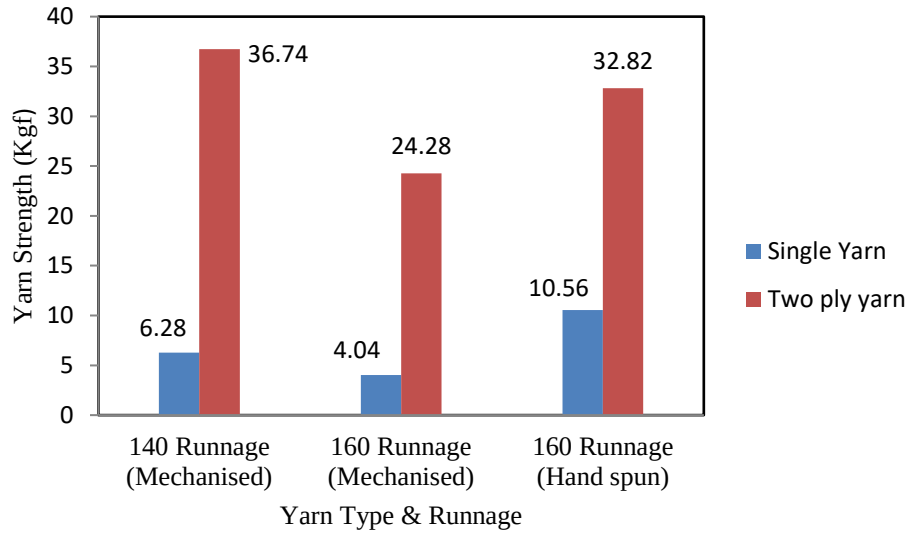

Figure 7. Tensile Strength of Single and Two ply Coir Yarns

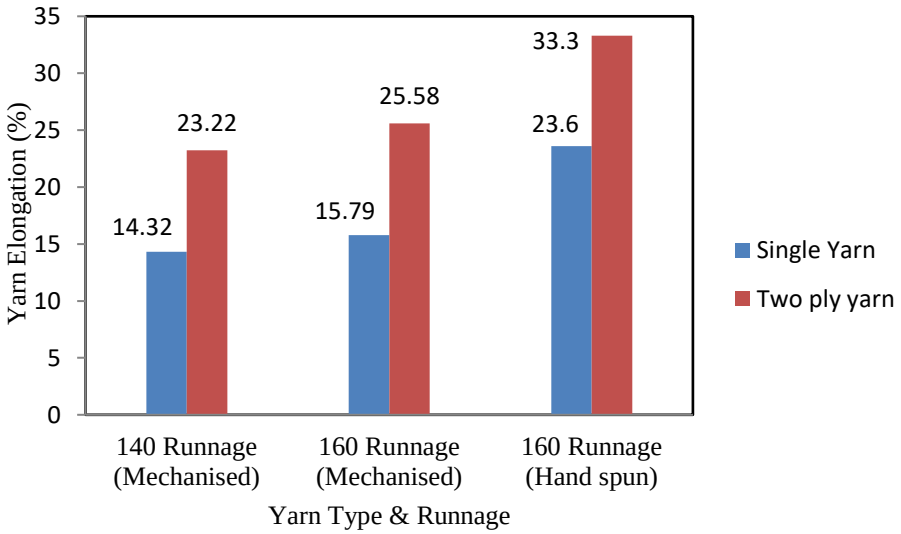

Figure 8. Elongation of Single and Two ply Coir Yarns

Since coir yarns are two-ply yarns, the effect of plying or doubling on the tensile characteristics, and the yarn irregularity were studied. The effects of plying two single coir yarns on the yarn strength, elongation and yarn irregularity were studied from the results given in figures 7, 8 and 9. The increase in yarn strength due to plying is about four times in hand spun yarns and about six times in the case of mechanised spun yarn. Higher yarn twist in the single yarns made from mechanised spun yarn provides more frictional resistance for the single yarns, and this could be the reason for higher yarn strength and elongation values of two-ply yarns.

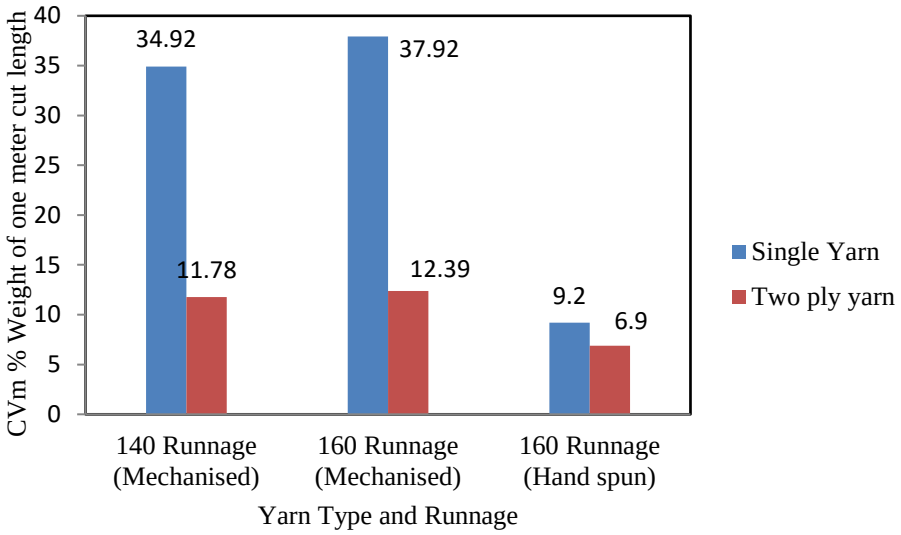

Figure 9. CV% of One Meter Cut Length of Single and Two ply Coir Yarns

In hand spinning, the very low reduction in the CVm% of two-ply yarns due to doubling could be due to the low mass variation in the single yarns and the better evenness of the yarn structure.

3.4 Effect of Type of Core Component on the Tensile Strength of Core Yarns

Mechanised spinning produces a two-ply yarn. The single yarn component of the two-ply yarn is a core sheath type yarn. In coir spinning industry, a polyester mono filament is used as the core component and the coir fibres are wrapped over the core filament. The effects of the type of core yarn used on the tensile strengths of the coir yarns were studied by producing coir yarn sample using a spun yarn made from Poly Vinyl Alcohol (PVA). The tensile strength of yarn samples are given in figure 10.

From the figure 10, it could be observed that use of PVA as core yarn in the coir yarn the yarn strength increases though the strength of PVA yarn is low. This could be due to the fact that during the yarn formation the individual fibres wrapped over the core filament to form the yarn structure. Since the surface of PVA yarn provides frictional resistance for the coir fibres for sliding over the filament. This could provide an improved fibre consolidation of the yarn structure. An improved fibre packing results in a stronger yarn than the yarn made from polyester filament as the core. With the PVA yarn as the core, the resultant yarn was found to be coarser than that made from polyester coir yarns.

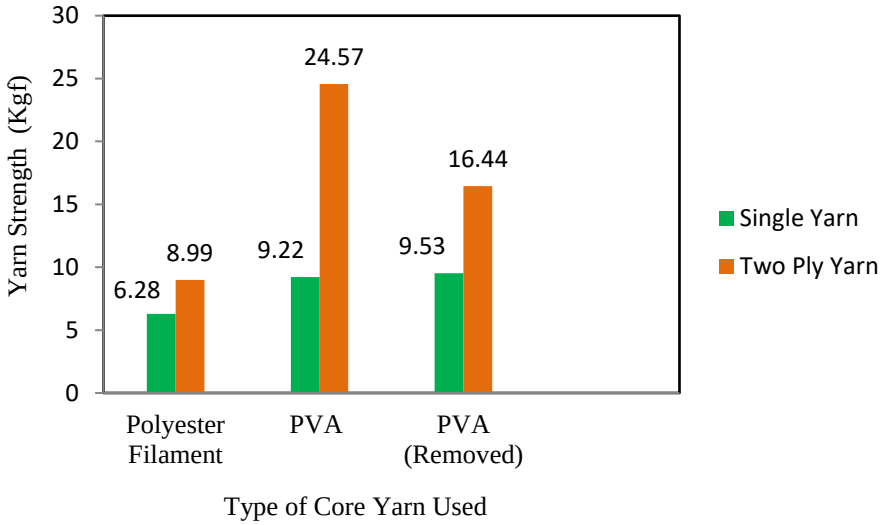

Figure 10. Effect of Core Component on the Tensile Strength of Coir Yarns

The PVA Core yarn sample was kept in boiled water for about 20 minutes to dissolve the PVA. The sample is then dried, conditioned in the standard atmospheric condition for testing the strength of yarn. After the removal of the PVA, there is slight improvement in single yarn strength, which could be due to the increased inter fibre friction. The reduction in the two-ply yarn strength could be the distortion of the yarn structure during the boiling of PVA core coir yarn.

4. Conclusions

Coir yarns are made from the traditional hand and mechanised spinning processes and two-ply coir yarn is the output of both systems. Hand spinning is an intermittent process, and in terms of manual activities with very low production rates, relatively continuous spinning of coir fibres is carried out in mechanised spinning with higher productivity. Plying of single yarns increases the yarn strength by at least four times in hand spun yarns and six times in mechanised spun yarns. Poor strength of single yarn is obviously due to the lack of inter-fibre cohesion, friction and slippage of fibres. The reduction in the yarn mass irregularity in hand spun yarns due to plying is very low compared to that of mechanised spun yarns. The better uniformity in the single yarn of the hand spinning could be the reason. The reduction in yarn irregularity is in the range of 20% to 40% with mechanised spun yarns. Structure of hand spun single yarns is analogous to that of ring spun yarn with the fibres arranged in an orderly manner along the longitudinal direction of yarn. The single yarn of mechanised spinning has a core sheath type structure with polyester mono filament as the core over which coir fibres are wrapped as a sheath. Finer yarns (runnage) can be produced in the hand spinning process. The method of fibre collection during yarn formation in the mechanised spinning limits the manufacture of finer yarns. From the survey, it was found that yarn with 180 runnage is the finest yarn produced in the mechanised spinning with the present level of machinery. Hand spun yarn consists of greater number if longer fibre since short fibres is removed before the spinning process. This results in reduction in yarn irregularity than the mechanised spun yarn.

References

[1] *S.Sengupta, G.Basu, R.Chakraborty and C.J.Thampi, Stochastic analysis of major physical properties of coconut fibre Indian Journal of Fibre and Textile Research, 39(1),**(2014),**pp 14-23.*

[2] *http://agritech.tnau.ac.in/horticulture/horti_pcrops_coconut_botany.html (2014)*

[3] *J. Raviv and Heinrich Lieth, Soilless Culture : Theory and Practice, Elsevier Science, **(2007).***

[4] *D.S.Varma, M.Varma and I.K.Varma,Thermal Behaviour Coir Fibres Thermochin Acta, 108,**(1986**), pp199-210.*

[5] *H.D.Rozman, K.W.Tan, R.N.Kumar, A.Abubakar, Z.A.Mohd. Ishak and H.Ismail, The effect of lignin as a compatibilizer on the physical properties of coconut fiber – polypropylene composites Europen Polymer Journal, 36(7),**(2000),**pp.1483-1494.*

[6] *Meenatchisundaram R I, Retting of Coir – A review, Ceylon Cocon. Plrs. Rev. 7,**(1980),** pp.20-28.*

[7] *Leena Mishra, Gautam Basu and Asish Kumar Samanta, Effect of Chemical Softening of coconut Fibres on Structure and properties of its blended yarn with Jute, Fibres and Polymers, 18(2),**(2016),**pp 357-368*

[8] *Majid Ali, Coconut fibre: A versatile material and its applications in engineering, Journal of Civil Engineering and Construction Technology,2(9), 189, (2011), pp.189-197.*

[9] *J.E.Booth, Principles of Textile Testing, , Butterworth, Heinemann Ltd, UK**.(1996).***

[10] *B K Chakrabarti, Weight Measurement of Yarn Irregularity', Technological Research Laboratories, Indian Central Jute Committee, Calcutta, 99 **(1953).***