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# Impact of Blend Ratio on Cotton-modal Blended Ring-spun Yarn Quality with Varying Modal Fibre Percentage

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## ARTICLE INFORMATION

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## ABSTRACT

Fibre blend ratio is an important factor that determines the properties of spun yarn. Modal is a regenerated manmade fibre and free from short fibres, neps and impurities. In this paper, the influence of modal fibre percentage on the properties of cotton-modal blended yarn was studied. Cotton-modal blended yarn with blend ratio of 80:20, 70:30 and 50:50 and 100% cotton yarns of 30 Ne were produced in ring spinning frame. The experimental results showed that the yarn quality parameters such as irregularity, thick places, thin places, neps, Imperfection Index and hairiness of 100% cotton are higher than cotton-modal blended yarn. With the increase of modal fibre percentage, the quality of blended yarns was improved than 100% cotton yarn. The unevenness of cotton-model blended yarn was decreased by 22% with the increase of model fibre proportion from 0 to 50%. In regards to the Count Strength Product (CSP) value, the cotton-modal blended yarns showed an increasing trend with increasing of modal fibre percentage in the blend ratio. It can be attributed that the absence of short fibres in modal fibre, which phenomena was contributed to the yarn properties with increasing the modal fibre percentage. Increasing modal fibre proportion was reflected in the considerable enhancement of cotton-modal fibre blended yarn quality.

**Key words:** Cotton-modal, blend ratio, neps, Um%, CVm%, imperfections, CSP

## INTRODUCTION

In the textile industry, ring spinning is a necessary process that is involved to produce ring-spun yarns of various qualities required for different applications from different natural or synthetic or regenerated fibres[1]. Cotton is a part of daily routine lives. It has hundreds of consumptions, from blue jeans to shoe strings. Clothing and household items are the most significant uses, but industrial products account for many thousands of bales. Cotton is considered one of the best fibres due to its superior physical and mechanical properties such as moisture absorbency, tensile properties, surface characteristics and its compatibility with many other natural and synthetic fibres. Technological improvement has enabled the textile industry to produce numerous types of yarns and fabrics with a special appearance by varying structure and product mix. Blending of different kinds of fibres is practiced to enhance the quality characteristics of yarn by incorporating desirable properties of constituent fibres to reduce the cost[2,3]. Fibre blend ratio is an essential factor that determines the properties of spun yarn and is specified by the types of fibres and their proportion in the resultant mixture[4-6]. Among the different blends, cotton-polyester, cotton-wool, wool-acrylic, cotton-nylon, jute-acrylic, cotton-rayon, etc. are common.

Viscose fibres are the first, modal fibres are the second and lyocell fibres are the third generation representatives of the regenerated cellulose fibres[7]. All regenerated cellulosic fibres have the same chemical composition. They differ in density, molecular mass, degree of polymerization, degree of crystallinity and orientation[8]. In the modal fibres, the fibre elements are more uniform and firmly located in the fibre cross-section and do not show the inner/outer difference. The average polymerization degree is higher than the standard viscose fibres. Therefore, modal fibre has better characteristics such as higher dry and wet tenacity, moisture absorption, length uniformity, shrinkage, softness and appearance. Modal fibre is compatible of blending with natural cotton fibre to produce cotton-modal blended yarn in different blend ratios. Modal yarn and cotton-modal blended yarn can be used to manufacture knitted fabric with desirable characteristics for various applications such as sports and casual wear, bed linen and inner wears that shrinks less, softer to touch and absorb more[9]. Comparison of quality characteristics of yarn and knitted fabrics made from 100% modal yarn and 100% cotton yarn has been reported on several works[10]. Ishtiaque *et al.*[11] stated that spinning machine parameters such as spindle speed, top roller pressure and traveler mass are influencing the ring yarn qualities such as strength, unevenness and hairiness significantly. Ghane *et al.*[12] have studied and observed that the top roller diameter significantly affects the unevenness of ring-spun polyester-cotton blended yarn quality. Khan *et al.*[13] investigated the effect of spindle speed and twist on the strength, unevenness and elongation quality of viscose-melange cotton blended spun yarn with different blend ratio. Basu and Gotipamul[14] proved that spindle speed, break draft and spacer size are influencing the imperfections and unevenness properties of polyester-cotton blend yarn. Hatamvand *et al.*[15] reported that the effects of the total draft, break draft and roller pressure on the properties of ring-spun polyester-viscose blend yarns are significant. Erdumlu *et al.*[16] revealed that vortex spun yarns have better pilling resistance and lower hairiness over the rotor and ring spun cotton, viscose and cotton modal blended yarns. Viscose rayon produced more satisfactory results in the vortex spinning system in terms of yarn strength, particularly in coarser yarn counts and hairiness. Kilic and Okur[17] compared structural, physical and mechanical properties of cotton-Tencel and cotton-Promodal blended ring, compact and vortex spun yarns. They found that increase in the ratio of regenerated cellulosic fibre content in the blend decreases unevenness, imperfections, diameter and roughness values; on the other hand, it increases braking force, elongation, density and shape values. Blended yarn qualities such as tenacity, unevenness and hairiness highly depend on the fibre-material-dependent parameters such as blend ratio of fibres and the ring frame spinning machine setting parameters such as spindle speed, traveler mass, top roller pressure and diameter, break draft and twist factor[18].

Although some research efforts have been made on different process parameters, there was a lack of detailed research on the influence of modal fibre percentage in blend ratio on the quality of cotton-modal blended yarn. In this work, an attempt has been taken to investigate and analyze the impact of modal fibre proportion in blend ratio on the properties of cotton-modal blended yarn and is compared with 100% cotton yarn manufactured in the ring-spinning system alone with the remaining other machine parameters fixed.

## MATERIAL AND METHODS

**Experimental site:** The study was carried out at Square Textile Mills Ltd., located at Sardagonj, Kashimpur, Gazipur, Dhaka, Bangladesh. It took 20 days to do the experimental work in September 2019.

**Materials:** Cotton from USA and modal from Austria were used as the raw materials to prepare cotton-modal blended yarn. The natural cotton fibre properties tested with the help of Uster HVI and Uster AFIS Pro, according to the standard testing conditions[19] and the properties of modal fibre provided by the suppliers. Properties of cotton and modal fibres are shown in Table 1.

**Research procedure:** The cotton and modal fibres were manually blended at the ratio of 80 and 20%, respectively. The blended fibres were processed in blow room section where fibres were opened and cleaned. Then processed fibres were fed to carding machine from which cotton-modal blended slivers produced with the hank of 4.9 ktex at 150 m min$^{-1}$ delivery speed, that was fed to breaker draw frame to produce 4.9 ktex breaker drawn slivers with 6 (six) doublings. After that, the produced slivers passed through finisher draw frame with 8 (eight) doublings and produced 4.82 ktex finisher drawn slivers. Finisher drawn slivers were fed into simplex machine to produce roving of 0.80 Ne with TM of 0.98. Then 30 Ne (80:20) cotton-modal yarn manufactured with TM of 3.5 in ring frame. The same procedure was carried out for producing

Table 1: Properties of cotton and modal fibres

| Fibre | Origin | Length (mm) | Strength (g/tex) | Fineness (µg/inch) |
|---|---|---|---|---|
| Cotton | USA | 30.33 | 30.7 | 4.67 |
| Modal | Austria | 38.00 | 35.2 | 3.60 |

Table 2: Cotton-modal blend ratio of produced yarn

| Sr. No. | Blend ratio (Cotton: Modal) |
|---|---|
| 1 | 100:0 |
| 2 | 80:20 |
| 3 | 70:30 |
| 4 | 50:50 |

different blend ratio of cotton-modal yarn along with 100% cotton yarn, as shown in Table 2, keeping all other machine parameters fixed.

**Data collection:** Following the yarn production, yarn samples were conditioned at (20±3)°C temperature and (65±2)% RH according to the standard[19]. Incipiently, yarn unevenness tests were carried out using Uster Tester-4. After then, tensile strength was done with the help of lea strength tester machine according to the standards.

**Experimental design:** There are several ways to blend different fibre materials. Still, over time, three ways have become well-known for blending manmade fibres in the modern spinning mill: tuft blending at the start of blow room process, tuft blending at the end of blow room process and sliver blending at drawing stage[20]. In this work tuft blending at the start of the blow room process was used. The process flowchart for producing cotton-modal yarn is shown in Fig. 1.

**Parameter measured:** The produced 30 Ne cotton-modal blended yarn of different ratio and 100% cotton ring-spun yarn were tested for their uniformity, imperfection and hairiness by using Uster Tester-4.

**Unevenness:** Unevenness percentage is the mass deviation of the unit length of material. It is caused by uneven fibre distribution along the length of the yarn.

$$\text{Unevenness (Um\%)} = \frac{\text{Mean deviation}}{\text{Mean}} \times 100\% \quad (1)$$

The Coefficient of Variation (CVm%) is commonly used to define variability in handling large quantities of data statistically. It is currently possibly the most widely known way of quantifying the unevenness.

$$\text{Coefficient of variation (CVm\%)} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100\% \quad (2)$$

**Imperfection index:** Imperfection index is the sum of thick places, thin places and neps per km of yarn.

Mixing bale opener
↓
Uniclean
↓
Unimix
↓
Uniflex
↓
Foregn material separator
↓
Condenser
↓
Carding
↓
Breaker draw frame
↓
Finisher draw frame
↓
Simplex
↓
Ring frame

Fig. 1: Flowchart for yarn production

$$\text{Imperfection index} = \text{Thick places}(+50\%)/\text{km} + \text{Thin places}(-50\%)/\text{km} + \text{neps}(200\%)/\text{km} \quad (3)$$

**Thin place (-50%):** A place in the yarn that exceeds -50% with respect to mean yarn cross-section and length is 10 mm.

**Thick place (+50%):** A place in the yarn that exceeds +50% with respect to mean yarn cross-section and length is 10 mm.

**Neps (+200%):** A place in the yarn that exceeds +200% with respect to mean yarn cross-section and length is up to 4 mm.

**Hairiness:** Hairiness is the total length of protruding fibres within the measurement field of 1 cm length.

**Count and strength:** Yarn count was determined using Auto Sorter-5 and it gave a direct reading. Lea strength of yarn was calculated using lea strength tester. The Count Strength Product (CSP) was calculated by using the following equation.

$$\text{Yarn strength} = \text{Yarn count}(\text{Ne}) \times \text{Lea strength}(\text{pound}) \quad (4)$$

**Statistical analysis:** Data were evaluated and summarized by using Microsoft excel and necessary statistical equations were used to determine the frequencies of variation in cotton-modal yarn thickness to identify the quality parameters.

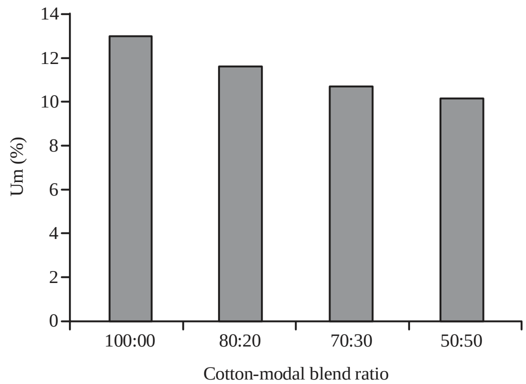


Fig. 2: Impact of blend ratio on Um% of cotton-modal blended yarn

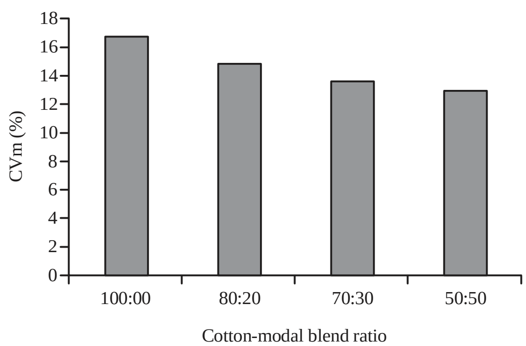


Fig. 3: Impact of blend ratio on CVm% of cotton-modal blended yarn

## RESULTS

The properties of produced different ratio cotton-modal yarn are given in Fig. 2 to 9.

**Unevenness of cotton-modal blended yarn:** In Fig. 2 and 3, 100% cotton yarn has the highest value of Um% and CVm%. Whereas 50:50 cotton-modal yarn has the lowest value in comparison to other blended yarn. A clear decreasing trend is seen in the unevenness of yarn with the increase of modal fibre percentage. The Um% and CVm% of yarn were found to be decreased about 22% with the increase of modal fibre.

**Imperfections of cotton-modal blended yarn:** Figure 4 to 7 depicted the imperfections of yarn. In all cases, cotton–modal blended yarn imperfections ((thick places (+50%), thin places (–50%) and neps (+200%)) decrease with the increase of modal fibre portion in blending ratio. The imperfections index value was decreased tremendously to 77%, by increasing the modal fibre from 0 to 50%.

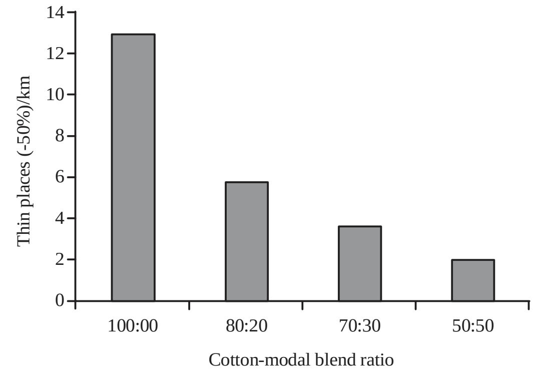


Fig. 4: Impact of blend ratio on thin places (-50%)/km of cotton-modal blended yarn

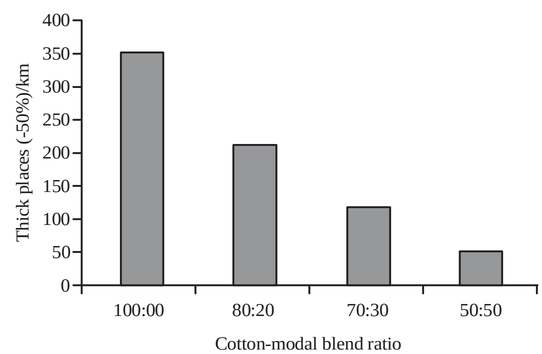


Fig. 5: Impact of blend ratio on thick places (+50%)/km of cotton-modal blended yarn

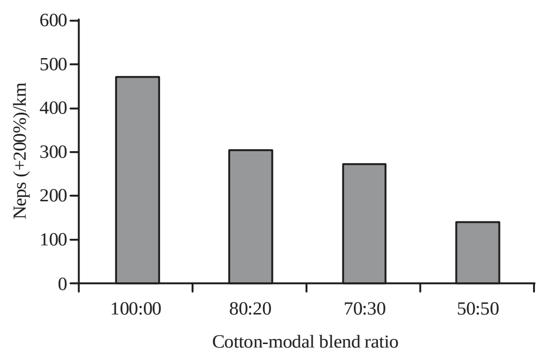


Fig. 6: Impact of blend ratio on Neps (+200%)/km of cotton-modal blended yarn

**Hairiness of cotton-modal blended yarn:** In Fig. 8, it is shown that when modal fibre portion was 0%, the hairiness was 5.40, on the other hand when modal fibre portion was 50%, then the hairiness was 4.74. By observing the graph, it can be said that the variation of modal fibre in cotton-modal ratio affects the hairiness of the cotton-modal blended yarn.

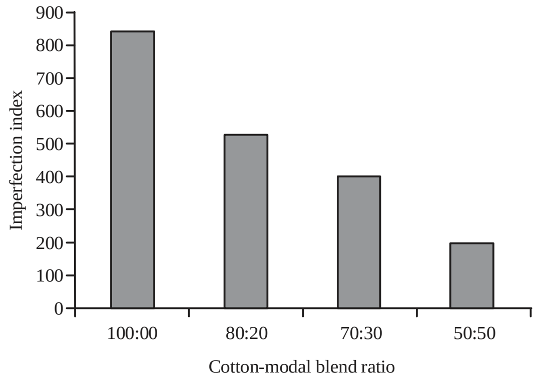


Fig. 7: Impact of blend ratio on imperfection index of cotton-modal blended yarn

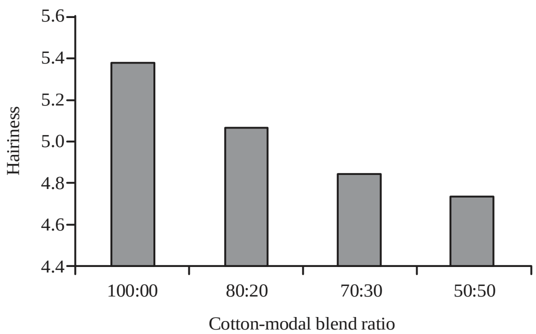


Fig. 8: Impact of blend ratio on hairiness of cotton-modal blended yarn

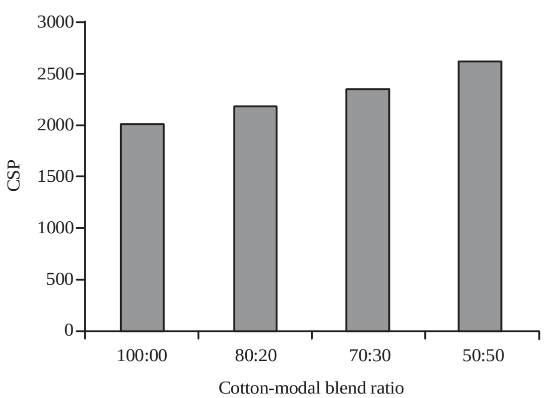


Fig. 9: Impact of blend ratio on CSP of cotton-modal blended yarn

**Strength of cotton-modal blended yarn:** Figure 9 provides a significant impact on the yarn strength with the increase of modal fibre. From this graph, it is observed that with the increase of modal fibre, strength (CSP) of the cotton-modal blended yarn was increased.

## DISCUSSION

The quality of the cotton-modal blended yarn improved with the increase of modal fibre in the blend ratio. The Um% and CVm% of cotton-modal blended yarn (Fig. 2, 3) were decreased by 22% with the increase of modal fibre from 0 to 50%. The reason behind that was the length variation of cotton and modal fibre. This trend was contributed by the higher length uniformity and absence of short fibres in modal fibre compared to cotton fibre[10]. Thin places and thick places (Fig. 4, 5) were higher in 100% cotton yarns and gradually decreased with the increase of modal fibre percentage in the blended yarn. Short fibres content, which creates more floating fibres in the drafting system, is not present in modal fibre and this leads to lower yarn thin places and thick places[21]. Cotton fibre contains considerable amount of neps where modal fibre contains no neps[9] as a result, neps as shown in Fig. 6 decreased with the increase of modal fibre percentage. Higher length and length uniformity, absence of short fibre and neps present in modal fibre reflected on imperfection index[15] (Fig. 7) of cotton-modal blended yarn which showed a decreasing trend with the incorporation of modal fibre portion in blended yarn. Length and length uniformity index of modal fibre is higher than cotton fibre[22] and this fibre property affects the hairiness of cotton-modal blended yarn. The hairiness of cotton-modal blended yarn (Fig. 8) decreased near about 12%, as the percentage of modal fibre increase in the blend ratio. The strength of cotton-modal blended yarn (Fig. 8) increased with the increase of modal fibre. The high strength, length and length uniformity of modal fibres contribute directly towards yarn strength[10]. In addition to this, modal fibre was also finer than cotton fibre (Table 1). The number of finer modal fibre in blended yarn also increased as the proportion of modal fibre increase in the blend ratio and that leads to the improvement of tenacity. Increasing modal fibre proportion was reflected in the considerable enhancement of cotton-modal fibre blended yarn quality.

## CONCLUSION

In this work, three different cotton-modal blend yarns were manufactured and their characteristics was compared with 100% cotton yarn. Modal is a regenerated manmade fibre and it has no short fibres, neps, impurities compared to cotton. Yarn quality parameters such as Um%, CVm%, thick places (+50%)/km, thin places (-50%)/km, neps (+200%)/km and hairiness were analysed. The 100% cotton yarn was exhibited inferior quality than cotton-modal blended yarns. With the increase of modal percentage, yarn parameters were showed a better result than 100% cotton yarn. The CSP value of the cotton-modal blended yarn was showed an increasing trend with the increase of modal fibre percentage than 100% cotton yarn. The length and strength of modal fibres are higher than cotton fibre that was directly reflected on the properties of cotton-modal blended yarn.

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