# AN INVESTIGATION ON COTTON/NYLON66 BLENDED ROTOR-SPUN YARN PROPERTIES

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**ABSTRACT**
In this study, nylon66 and cotton slivers were blended at seven different nylon/cotton blend ratios (12/78, 24/66, 37/53, 50/50, 62/28, 75/15 and 85/5) and nylon66/cotton blended rotor-spun yarns as well as cotton and nylon rotor spun yarns were produced with yarn count of 32 tex (18.41 $N_e$) and twist factors of 3.96, 4.41, 5.19 and 5.86 values ($\alpha_e$). The physical and mechanical properties of the produced yarns including tensile strength, hairiness, abrasion resistance and evenness were measured. The results show that by increasing the nylon fiber blend ratio, the yarn elongation, abrasion resistance, tensile work of rupture and hairiness significantly increase, whereas yarn tensile modulus decrease. The results also indicate that with increase of nylon fiber blend ratio up to 62%, the yarn tensile strength decreases and then rapidly increase. It is found that at 24% nylon fiber blend ratio, the lowest yarn irregularity (CV%) and irregularity index were obtained while cotton rotor-spun yarn as well as nylon66/cotton blended rotor-spun yarn at 87% nylon fiber blend ratio exhibit the highest yarn irregularity (CV%) and irregularity index respectively. The result also revealed that with increase of yarn twist factor, the yarn tensile strength significantly increases. However, with increase of yarn twist factor, no regular trend was found for other yarn properties.
**Key words:** Rotor-spinning, nylon66/cotton fiber, blend ratio, twist factor, yarn properties

## 1. INTRODUCTION

In staple fiber yarn processing, blending is carried out for a number of reasons, including uniformity, technical and engineering, functional and aesthetic and economic aspects [1-6]. Nylon66 fiber is well-known for its strength, elasticity and abrasion resistance [7]. To obtain the desirable characteristics of blended fiber products, nylon66 fiber may be blended with cotton fibers in the cotton spinning system to give comfort, strength and good abrasion properties. In recent years, there are some trends towards the blending synthetic fibers with cotton in spinning systems. However, there is no research work to study cotton/nylon66 blended rotor-spun yarn properties. Thus, the aim of this research is investigate the effects of cotton/nylon66 blend ratio and twist factor on produced rotor-spun yarn properties.

## 2. EXPERIMENTAL

### 2.1 Materials and methods

Cotton and nylon66 fibers in carded slivers were prepared .The physical properties of This fibers are measured as follows: The specifications of cotton fiber were measured by HVI apparatus and the Single fiber tensile strength of nylon66 fiber was measured using Fafegraph apparatus. Nylon66 fiber fineness was determined using Vibromat method. Table 1 shows the mean values of cotton and nylon66 fibers specifications. In order to produce 12/88, 24/76, 37/63, 50/50, 62/38, 75/25 and 87/33 nylon66/cotton slivers, the carded nylon66 and cotton slivers with respectively linear densities of 5 and 7.6 ktex were passed through three stages of drawing processes. Then the drawn slivers were processed on a RU13-A rotor spinning machine (Schlafhorst Co.) to produce yarn of 18.4 Ne (32 tex) with four different twist factors of 3.96, 4.41, 5.19 and 5.86 ($\alpha_e$). The Rotor spinning machine specification is listed in Table 2.

**Table1.** Fiber Specifications

| Matrial | Fineness(dtex) | Tensile Strength (cN/tex) | Short Fiber Content | Effective Length (mm) | Breaking Elongation(%) |
|---|---|---|---|---|---|
| **Cotton** | 1.45 | 27.4 | 12.5 | 27.36 | 57.02 |
| **Nylon66** | 1.96 | 29.7 | - | 38.3 | 6.8 |

**Table 2** Spinning Machine Specifications

| Spinning machine parameters | Specifications |
|---|---|
| Rotor type | T40 |
| Take-up nozzle | Kn4 |
| Opening Roller Type | Ob4 for cotton & blended synthetic fibers |
| Sliver Feed Speed | 0.51 m/min |
| Main Draft | 141 |
| Rotor speed | 72000 Rpm |
| Opening roller Speed | 7600 Rpm |

## 2.2 Yarn tests

The mechanical and physical properties of produced yarns including linear density, tensile strength, evenness, hairiness, and abrasion resistance were measured. The yarn linear density and twist were measured using standard test methods [8,9]. Yarn tensile properties (strength, breaking elongation, work of rupture and modulus) were determined on an Instron tensile tester with yarn gauge length of 25 mm. The cross–head speed was determined by calculating the breaking time of yarn at 20±3 second. The yarn evenness was obtained by an Uster Evenness Tester 3. To measure yarn hairiness we used a Shirley Yarn Friction/ Hairiness Tester. The $S_3$ values (number of hairs with a length greater than or equal to 3 mm) were measured over a length of 100 mm of yarn at 50 m/min and 5 tests were conducted for each yarn. The yarn abrasion resistance was measured by using a Shirley yarn abrasion tester. A standard abradant (p2000) was used and 5 tests were conducted for each yarn sample. All tests were conducted under the standard laboratory conditions (22 ± 2°c and 65 ± 2% r.h.). The experimental results of yarn physical properties were statistically analyzed using ANOVA and Multiple Range Test methods. A summary of ANOVA statistical results is tabulated in Table 3. As shown in Table 3, the effect of blend ratio and twist factor on yarn physical properties is almost statistically significant. The results will be discussed in details.

**Table 3.** A summary of ANOVA statistical result*

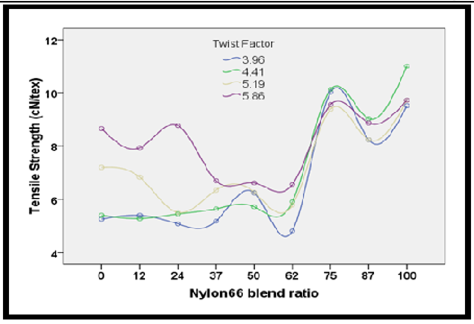
| Factor | Tensile strength | Breaking elongation | Work of rupture | Tensile modulus | Irregularity(CV%) | Index of irregularity | Hairiness | Abrasion resistance |
|---|---|---|---|---|---|---|---|---|
| Blend ratio | + | + | + | + | + | + | + | + |
| Twist factor | + | – | + | + | + | + | + | – |

**At 5% confidence limit, "+" means statistically significant and "-" means statistically in-significant.*

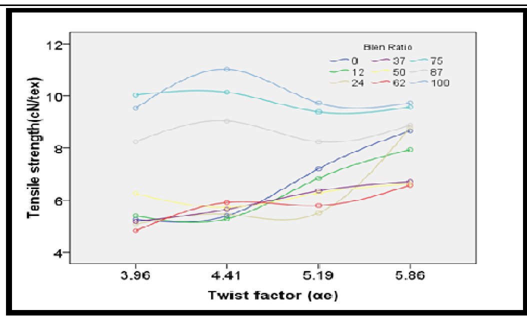
## 3. Results and Discussion

### 3.1 Tensile properties

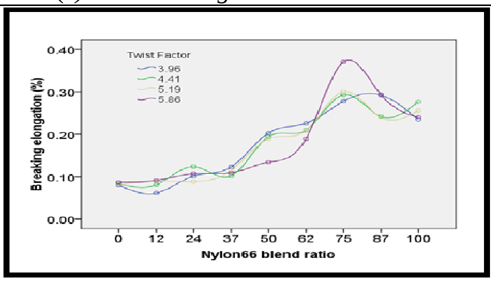
The effect of nylon66 fiber blend ratio and twist factor on nylon66/cotton blended rotor spun yarn tensile properties is illustrated in Fig.1.



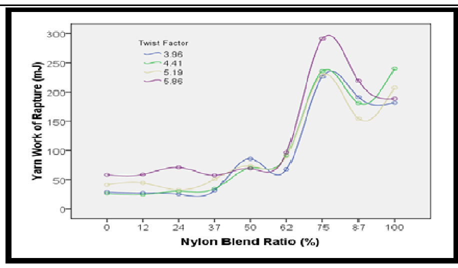

(a)*Tensile strength versus blend ratio*



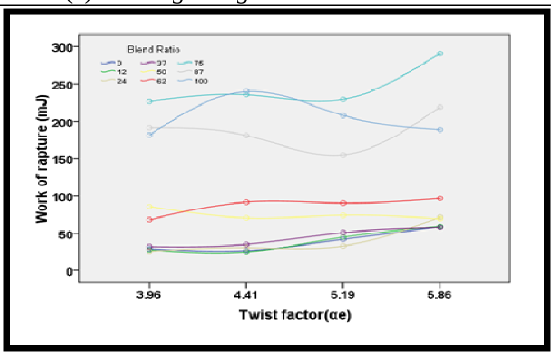

(b)*Tensile strength versus twist factor*



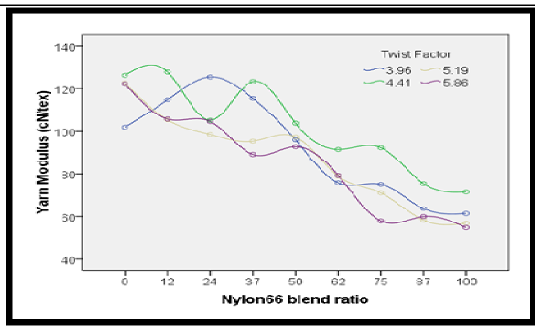

(c)*breaking elongation versus blend ratio*



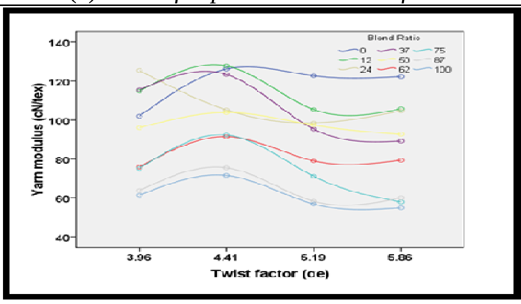

(d)*work of rupture versus blend ratio*




(e) *work of rupture versus twist factor*




(f)*Tensile modulus versus blend ratio*




(g)*Tensile modulus versus twist factor*

**Figure 1**. Effect of nylon66 fiber blend ratio and twist factor on the nylon66/cotton rotor spun yarn tensile properties.

It is shown (Fig.1*a*) that the tensile strength of nylon66/cotton blended rotor spun yarn at 62% and 100% nylon66 fiber blend ratio is significantly lower and higher than all of other blended yarns respectively. The result also indicates that with increase of nylon66 fiber blend ratio up to 62%, the yarn tensile strength decreases and then rapidly increases. This result is due to the different nylon66 and cotton fibers breaking elongation and presumably due to higher tensile strength as well as effective length of nylon66 fibers compared with cotton fibers. The effect of yarn twist on the tensile strength of nylon66/cotton blended rotor yarns in different blend ratios is shown in Fig.1b. It is indicated that by increasing of twist factor the tensile strength almost increases. However, at higher nylon66 blend ratio (75,87and 100%) the yarn tensile strength varies with twist factor in a different way. This result is presumably due to the higher nylon66 fiber crimp and elongation.

As shown in Fig.1c, with increase of nylon66 blend ratio, the yarn breaking elongation significantly increases. This result is obviously attributed to the higher tensile elongation of nylon66 fiber compared with cotton fiber. As indicated in Table 3, the yarn twist has no significant influence on the breaking elongation of nylon66/cotton rotor spun yarn.

It is also shown (Fig.1d) that the work of rupture nylon66/cotton blended rotor-spun yarns has a similar trend to yarn breaking elongation. In addition, the variation trend of yarn work of rupture with twist factor (Fig. 1e) is similar to that of yarn tensile strength. It is indicated that by increasing of twist factor the work of rupture almost gradually increases. However, at higher nylon66 blend ratio (75,87and 100%) its variation trend is different.

Yarn modulus is affected by the fiber components modulus. By increasing the nylon66 blend ratio the blended rotor spun yarn modulus decreases because of the lower nylon66 fiber modulus compared with cotton fiber (Fig.1f). The nylon66/cotton rotor spun yarn modulus is also influenced by the twist factor (Fig.1g). To some extent, it is shown that the highest amount of yarn modulus can be obtained at 4.41 twist factor value.

### 3.2 Evenness

The effect of nylon66 blend ratio on yarn irregularity (CV%) and Index of Irregularity (I) of blended rotor spun yarn are shown in Fig.2 and 3. Obviously, the trend variation is almost similar in these figures. It is found that at 24% nylon66 fiber blend ratio, the lowest yarn irregularity (CV%) and irregularity index were obtained while cotton rotor-spun yarn as well as nylon66/cotton blended rotor-spun yarn at 87% nylon fiber blend ratio exhibit the highest yarn irregularity (CV%) and irregularity index respectively.

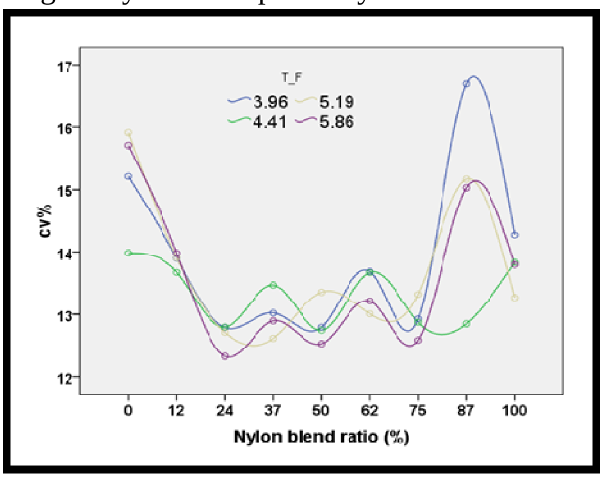



**Figure 2.** Effect of nylon66 blend ratio on nylon66/cotton blended rotor spun yarn irregularity (CV%).

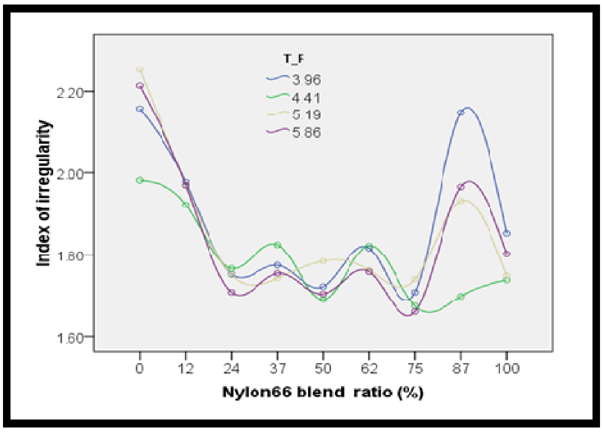



**Figure 3.** Effect of nylon66 blend ratio on nylon66/cotton blended rotor spun yarn irregularity index (I).

The high amount of irregularity of 100% cotton rotor spun yarn is attributed to the high amount of short fiber content as well as to the relative short effective length of cotton fiber compared to nylon66. It is deduced that existing the wrapper fibers around the yarn body are an undesired factor which in turn increases the yarn irregularity.

Based on the statistical analysis results, the lowest yarn irregularity and irregularity index were obtained at 5.86 and 4.41 twist factor values respectively. However, with increase of yarn twist factor, no regular trend was found for yarn irregularity properties (Fig.4 and 5).

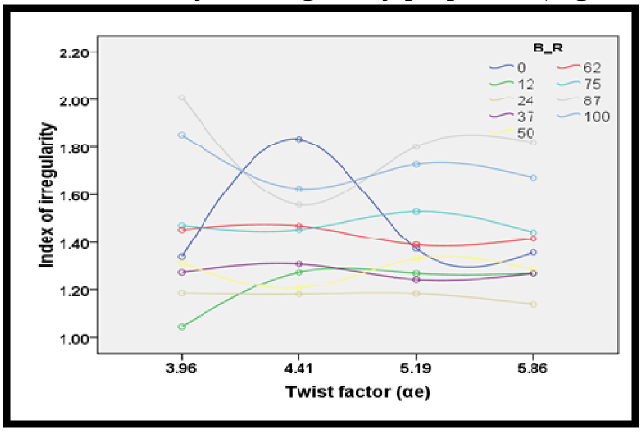



**Figure 4**. Effect of twist factor on the Index of irregularity of nylon66/cotton rotor spun yarn.

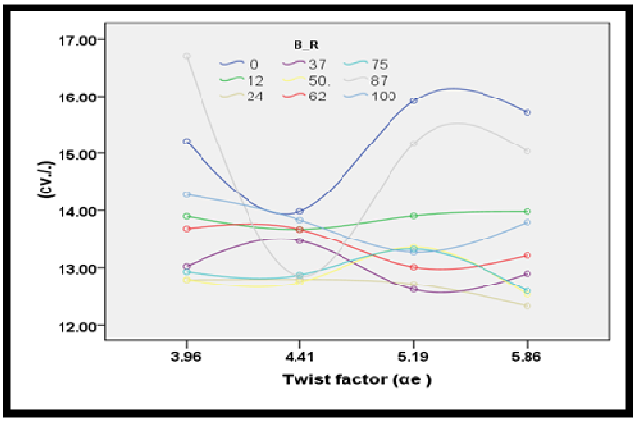
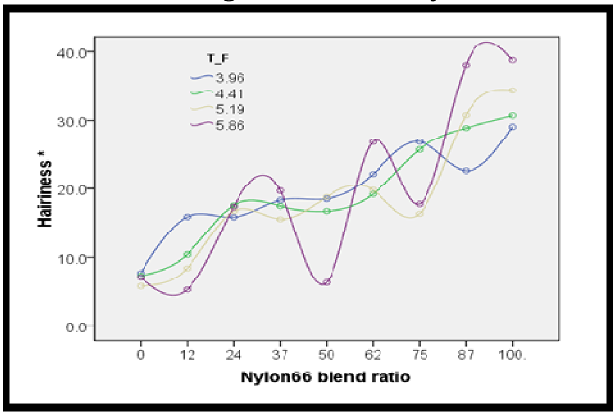



**Figure 5.** Effect of twist factor on nylon66/cotton blended rotor spun yarn irregularity (CV%).

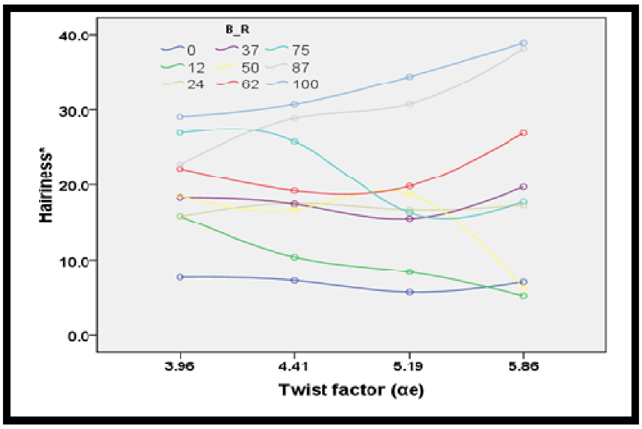
### 3.3. Hairiness

Fig.6 shows the effect of nylon66 blend ratio on the nylon66/cotton blended rotor spun yarn hairiness (S3 value). It is indicated that the yarn hairiness significantly increases by increasing the nylon66 blend ratio. This result is presumably due to the greater linear density of nylon66 fiber compared with cotton fiber that causes these fibers migrates to the outer layers of yarn body. Furthermore poor finishing of nylon66 fiber causes static electricity and increases the yarn hairiness. The high nylon fiber elasticity can cause nylon fiber to be migrated during drafting processes and hence increases yarn hairiness. Thus 100% cotton and 100% nylon66 rotor spun yarns exhibit the lowest and highest amount of yarn hairiness respectively.




*number of hairs with a length greater than or equal to 3 mm

**Figure 6**. Effect of nylon66 blend ratio on the nylon66/cotton rotor spun yarn hairiness




*number of hairs with a length greater than or equal to 3 mm

**Figure 7**. Effect of twist on the nylon66/cotton rotor spun yarn hairiness

### 3.4. Abrasion resistance

Effect of nylon66 blend ratio on the abrasion resistance of blended rotor spun yarn is shown in Fig.8. It is shown that by increasing the nylon66 blend ratio the yarn abrasion resistance significantly increases. Obviously this result is attributed to the higher abrasion resistance of nylon66 fiber compared with cotton fiber. However, statistical analysis results (Table 3) has shown that twist factor has no significant effect on yarn abrasion resistance.

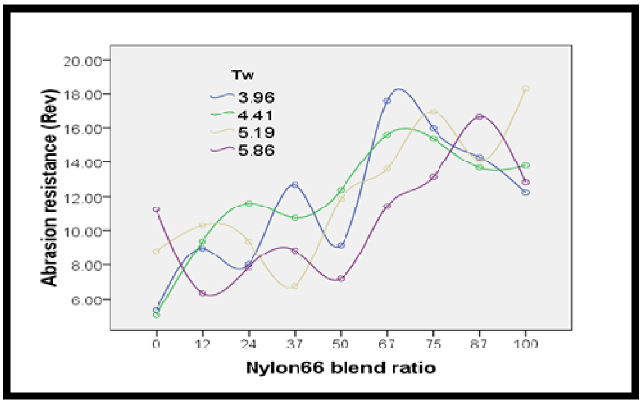



**Figure 8**. Effect of nylon66 blend ratio on the abrasion resistance of nylon66/cotton rotor yarn

## 4. Conclusion

In this work, carded nylon66 and cotton slivers were blended at seven different blend ratios (12/88, 24/76, 37/63, 50/50, 62/38, 75/25 and 87/33) in the draw-frame process and then nylon66/cotton blended yarn as well as cotton and nylon66 rotor spun yarns were produced with four different twist factors. The physical and mechanical properties of the produced yarns were then measured and analyzed.

The results show that by increasing the nylon66 fiber blend ratio, the yarn elongation, abrasion resistance, tensile work of rupture and hairiness significantly increase, whereas yarn tensile modulus decrease. The results also indicate that with increase of nylon66 fiber blend ratio up to 62%, the yarn tensile strength decreases and then rapidly increase. It is found that at 24% nylon66 fiber blend ratio, the lowest yarn irregularity (CV%) and irregularity index were obtained while cotton rotor-spun yarn as well as nylon66/cotton blended rotor-spun yarn at 87% nylon66 fiber blend ratio exhibit the highest yarn irregularity (CV%) and irregularity index (I) respectively. The result also revealed that with increase of yarn twist factor, the yarn tensile strength significantly increases. However, with increase of yarn twist factor, no regular trend was found for other yarn properties. Further studies are needed to investigate the cross-sectional fiber migration and blend irregularity nylon66/cotton rotor-spun yarns.

## 5. REFFRENCES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