# THE EFFECT OF INTERMINGLING PROCESS ON THE SYNTHETIC YARN STABILITY AND UNIFORMITY

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**ABSTRACT**

Intermingling is one of the best alternative methods to make the filament yarns more resistant against high volume stress. This method has started to substitute conventional methods such as sizing and twisting to maintain durability of the filament yarns. The intermingling or alias commingling process mixes multifilament yarns along with knots and open sections alternately throughout the length of the yarns. This technique makes the strength of multifilament yarns totally different from the each separate filament. This study tries to define the effect of commingling on the filament yarn strength.

**Keywords:** Intermingling, entanglement point, tensile values, filament yarn

## 1. INTRODUCTION

Friction force among the fibers is the only force holding the fibers together in staple fiber spun yarns. This friction force provides the staple fiber yarns to withstand tensions in the process of manufacturing yarn and fabric. Random placement of staple fibers and twisting process make the friction force stronger and so staple fiber yarns can withstand different kinds of tensions in the production.

However, filament yarns do not have any important cohesion force like friction because of parallel settlement of fibers. Due to the lack of enough cohesion force among the filament fibers, many problems come out in the processes of yarn winding, unwinding, knitting, weaving, tufting, and similar fabric manufacturing processes. Filament yarns could not withstand tensions because of the parallel settlement of fibers. This settlement causes tension irregularities in the yarn structure. Depending on high textile manufacturing speeds, tension differences cause the yarn break and malfunction in the processing.

In order to prevent yarn breakages, it is necessary to have a cohesion force among the synthetic filaments. Here is, intermingling is one of the best way make the filament yarns more resistant against high volume tensions. It is also accepted one of the best alternative technique in comparison with the conventional techniques such as sizing and twisting. Intermingling may also be called interlacing; commingling, splicing and entanglement point is also called fixed point, knot and nip in this study and other many researches [1].

In this article, PES and PA6 synthetic filament yarns with various linear densities are used to find out the effect of yarn count and yarn speed to the strength of intermingled yarns and intermingling uniformity. With this study, we aim to give an idea about intermingled yarn strength and compound to synthetic yarn manufacturers in especially hosiery and weaving sectors. In this way, the manufacturers may prevent yarn breakages and also machine stops choosing the best alternative yarn type according to the machine speeds.

Alagirusamy et al. (2005) reported a study about air pressure enhancement which gives rise to increase the degree of interlacing of commingled yarns [2].

It is observed principle of intermingling process with knots and fluffy areas in Figure 1 [2]. Visual inspections indicate that knots are more visible and uniform in elastic blended (guipe) samples rather than plain samples in our experimental work.

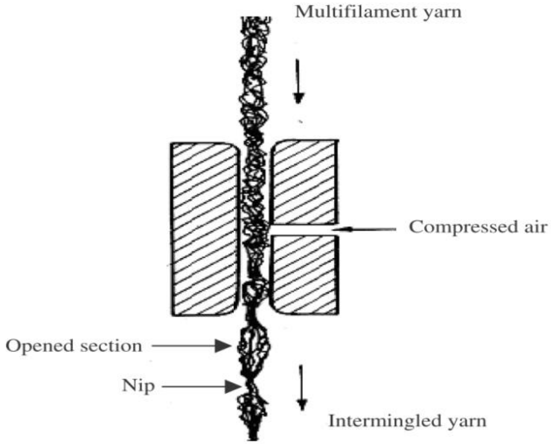


**Figure 1.** Principle of intermingling process

Özkan and Baykal (2012) performed a study on intermingling parameters and filament properties effect to the stability of knots. They found that a positive linear correlation exists between air pressure and knot stability. This correlation was also found statistically significant. This study also described that less yarn linear density values has positive linear relationship with knot stability and this relationship is statistically significant as well [3].

Kravaev *et al.* (2013) presented a new method to analyze the blending quality along the length of commingled yarns. It is claimed that this new method can be applied for the manufacturing process of thermoplastic composites [4].

Webb *et al.* (2009) performed a work about relationship between splicing performance and yarn count. The study reported that as yarn count was varied, industry-standard and experimental splicers with various configurations changed in performance. This study concluded that when yarn counts increase sufficiently, it is needed to enhance three variables to acquire optimum splicing. These three variables are cross section of the splicing chamber, airflow, and the knife separation [5].

## 2. MATERIALS and METHODS

In this study, PES texturized intermingled filament synthetic yarns with the linear densities of 50, 70, 100,150 denier and PA6 texturized intermingled filament synthetic yarns with the linear densities of 40, 70, 100, 140 denier were used. We also used air covered elastic PES guipe(elastic yarn blended samples) yarns with the compound of 50/20, 70/20, 100/20, 150/20 and air covered elastic PA6 guipe yarns with the compound of 40/20, 70/20, 100/20, 140/20. In these compounds, first parts symbolize PES and PA6 yarn counts, second part (20) symbolize elasthane yarn count in all samples. In this experiment, Creora® brand elasthane was used as elastic yarn inside of air covered guipe yarns. In this way, sixteen different yarns were used. The elasthane yarn draft value is 2.8 which mean the elasthane yarn stretch to the 280% value of its first length. All samples were produced in an air cover machine which has approximately 5 bars air pressure value. Three different machine speeds were used to separate the samples in three different groups which are low intermingled, medium intermingled and high intermingled. The machine speed also called yarn speed values are 500, 600 and 700 meters per minute. It is claimed that while the yarn speed value increases, entanglement point number which determines intermingling level will decrease theoretically. In practical experiments, it is stated that there are 70 to 90 knots in a meter of the yarn depending on air pressure value and yarn speed. However, there are more than 100 knots in a meter of the yarn in our experimental study. It is thought that this case is a result of excessive air pressure application and raw material variety. In addition, experimental results generally demonstrate us that high level intermingled yarns were produced in the speed of 500, medium level intermingled yarns were produced in the speed of 600 and lastly low level intermingled yarns were produced in the speed of 700 according to number of knots in a meter of the yarn.

All samples were tested in a tensile test device which is called Uster Tensorapid 3. These tests were repeated twice and mean values were taken as the final tensile value. Test speed is 500 mm/min and pre tension value is 4.3 cN in this test device. Tensile test unit was taken as cN/tex in the test device. Before the tensile test, all yarn samples were unwinded about 300 meters to prevent yarn unevenness in upper parts of the yarns. All yarns were acclimatized in the standard atmosphere conditions during 72 hours before testing.

Figure 2 shows tensile test process of this study in the automatic tensile tester called Uster Tensorapid 3. Tensile tests can be soundly achieved in all types of filament yarns from 20 denier to 300 denier counts with this device. Mean value of two tests was taken as the final tensile value in this study.


**Figure 2.** Automatic multiple tensile test

## 2.1. Tensile Test Results

Average tenacity values of intermingled PA6 composition yarns concluded with meaningless results which could come out owing to using different raw materials in the tensile tests. In 40/1 PA6 samples, meaningless tenacity results could occur owing to short linear density value and raw material based low strength value. In 40/20 PA6 guipe samples, the tenacity results increase from the yarn speed of 700 m/min to 500 m/min as expected. The interesting point is all tenacity results are around 40 cN/tex except 140/20 PA6 guipe yarns. These yarns have twofold strength value which is about 80 cN/tex compared to the other samples. The PA6 test results concluded that tenacity values don't vary linearly with the increase in thickness of the yarns. Table 1 shows some of tenacity test results and average knot numbers of commingled PA6 and PES yarns.

**Table 1.** Tenacity values and knot numbers

| Yarn Compound | Tensile Strength of Sample 1(cN/tex) | Tensile Strength of Sample 2(cN/tex) | Average knot number /meter |
|---|---|---|---|
| 40/1 PA6 (700 mt/min) | 33.15 | 38.36 | 95 |
| 40/20 PA6 guipe (700 mt/min) | 33.96 | 33.50 | 110 |
| 50/1 PES (700 mt/min) | 32.98 | 35.19 | 100 |
| 50/20 PES guipe (700 mt/min) | 34.39 | 30.97 | 135 |

PES yarns have more pointless tenacity results compared to PA6 yarns. It is thought that these pointless results exist because of raw material variety and color difference. There is no tenacity increase in 150/20 PES guipe yarns as in the 140/20 PA6 guipe yarns. Insomuch that, 150/20 PES guipe samples include almost the lowest tenacity values.

## 3. RESULTS and DISCUSSION

The test results were evaluated statistically with ANOVA. While the machine speed and yarn type values were selected as independent variables, tensile strength and knot number values were selected as dependent variables.

ANOVA evaluation of the results demonstrated that machine speed value had a statistically significant effect on knot number value (95% significance level $F = 3.644$, $p = 0.030$). Post Hoc test also showed that a significant difference existed between only 700 m/min and 500 m/min although there wasn't any statistical significant result between the machine speed values of 500, 600 and 600, 700.

The statistical results showed that machine speed value had not a statistically significant effect on tensile strength value (95% significance level $F = 0.034$, $p = 0.967$).

The ANOVA evaluation results indicated that yarn type had a statistically significant influence on knot number value (95% significance level $F = 9.650$, $p = 0.000$). Post Hoc test also showed that there was a statistically significant difference between the yarn types of 40/1 PA6 and 40/20 PA6, 40/1 PA6 and 50/20 PES, 40/20 PA6 and 70/1 PA6, 40/20 PA6 and 100/1 PA6, 40/20 PA6 and 150/1 PES, 70/20 PA6 and 150/1 PES, 50/20 PES and 150/20 PES.

The ANOVA evaluation results demonstrated that yarn type had a statistically significant influence on tensile strength value (95% significance level $F = 96.978$, $p = 0.000$). Post Hoc test also showed that there was a statistically significant difference between the yarn types of 40/1 PA6 and 70/20 PA6, 140/1 PA6, 140/20 PA6; 40/20 PA6 and 140/1 PA6, 140/20 PA6; 70/1 PA6 and 140/1 PA6, 140/20 PA6, 150/1 PES; 100/1 PA6 and 140/20 PA6, 50/20 PES, 150/1 PES; 100/1 PES and 140/1 PA6, 140/20 PA6; 100/20 PES and 70/20 PA6.

## 4. CONCLUSION

Commingling uniformity and stability can be affected from various factors like yarn count, air pressure, machine speed and raw material. In this study, PES and PA6 synthetic filament yarns with various linear densities are used to find out the effect of yarn count and yarn speed to the strength of intermingled yarns and intermingling uniformity. Our experimental observations revealed that strong relationships exist between the variables of yarn type and machine speed with final yarn strength and knot numbers. It is known that knot number directly affects the yarn strength in a positive way. Furthermore, it is also observed that as machine speed increases, knot number will generally decrease due to less amount of air pressure exposure to the yarn. Eventually, it is accepted that the commingling is an innovative answer to make the filament yarns more durable against high volume tensions and yarn breakages in the manufacturing stages of multifilament yarns. It is obvious that further work is required in this area to examine carefully the intermingling process with more parameters to reach the aim of uniform and stable intermingling.

### ACKNOWLEDGEMENTS

This work was funded by Uşak University Coordination Unit of Scientific Research Projects. The authors would also like to thank Turkish Standards Institution Denizli Textile Laboratory for their contributions to maintain the tensile tests.

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