

CONSEQUENCE OF TWIST ON YARN PROPERTIES IN TEXTILES

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ABSTRACT

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The yarn twisting parameter has great influence on the mechanical properties of yarn. Twist angle, twist per inch (TPI) or meter, twist contraction, twist factor are the main parameters of twist has been studied in this research. Twist effect on yarn strength, rupture behaviour, tenacity has been observed. The strength of yarn decreases as the twist increases. TPI 11 shows the highest strength in both staple and continuous filament yarn. The twist angle of yarn depends on twist factor and twist contraction. Twist factor has a more influential effect on specific volume of yarn.

Key words: twist angle, twist contraction, twist factor, strength, tenacity, and specific volume

INTRODUCTION

Twist plays an important role in affecting the arrangement of fibres or filaments in the yarn cross section. In staple yarns, twist is essential to hold the fibres together and to impart some degree of cohesiveness to structure. On the other hand, the filaments in a multifilament yarn would fray away if there were no cohesive forces holding them together. When the number of fibres or filaments in a continuous strand are twisted, radial forces develop which in turn affect the relative position of the fibres in the yarn structure, leading to close packing of all components in a given cross section. Thus the insertion of twist in fiber assemblies affects, in addition to the tensile properties, the diameter and the specific volume in other words softness or hardness of yarns (Goswami *et al.* 1977; Merrill *et al.* 1959).

The change in the fiber packing in turn determines the cover of fabric and such other properties as warmth, crease recovery, permeability and various other related characteristics. Twist also affects the hairiness of yarns, which is a very important property in determining the pilling behaviour and the economics of the singeing process. The study of twist, therefore, is very important to understanding the structure and behaviour of yarns and their ultimate influence on the end-use properties of fabrics (Hadina *et al.* 1998; Kovacevic 2002).

THEORETICAL PART

Twist Amount

The amount of twist varies with fibre length, yarn size and its intended use. Increasing twist amount to the point of perfect fibre-to-fibre cohesion increases the yarn strength. But, excess twists may induce shearing action between fibres and hence the yarn loses strength. The amount of yarn twist has a considerable effect on luster: Low-twist yarns of smooth filament have a high luster, while high-twist yarns such as crepe yarns give a duller, matte effect and a lively, drapable fabric.

Classification of Twist Amount:

1. Zero Twist

This only exists in raw reeled silk (filament) yarns where the silk gum can hold the filaments together.

2. Very Low Twist

1-2 turns per centimeters or 3-5 per inch.

3. Napping Twist

Napping twist in spun yarns produces lofty yarns. They are of 6-8 turns per inch.

4. Medium Twist

8-10 turns per centimeters or 20-25 turns per inch, used for most spun yarns.

5. Voile Twist (Hard twist)

12-17 turns per centimeters or 30-40 turns per inch used to give the firmness voile.

6. Crepe Twist

17-30 turns per centimeters or 40-75 turns per inch, the highest twist of all.

Twist angle

This is the angle of fibres to yarn axis, and this angle varies throughout yarn, from zero at centre to maximum at yarn surface. The fibres on yarn surface are the most important, as they bind the others into the yarn.

While it is not common practice to measure the yarn twist angle, the surface twist angle made by the surface fibres in relation to yarn axis is a very important parameter. It determines the essential yarn characteristics such as yarn softness, yarn bulk etc, which in turn govern many essential fabric properties. The following example illustrates the point.

In Figure 1, yarn 1 and yarn 2 have the same twist level-one turn each. But the surface fibre on the thicker yarn is obviously stretched more to accommodate this twist. This would mean the thicker yarn is more closely

packed. As a consequence, yarn 2 will not be as soft as yarn 1. In other words, even though the twist level is the same in these two yarns, the yarn characteristics are quite different. Therefore, we can not simply use twist level to represent yarn character. However, the surface twist angles of yarn 1 (θ_1) and yarn 2 (θ_2) are different. They can better reflect the yarn characteristics, regardless of the difference in yarn thickness.

When two ends of a straight strand are rotated relative to one another, the fibres on the surface of the yarn lie in helices about the yarn axis. In other words, a yarn is twisted when fibres on the surface, which were originally parallel to the axis of the yarn, are now deformed so that they make a twist angle θ with the axis and the amount of twist is a function of this angle.

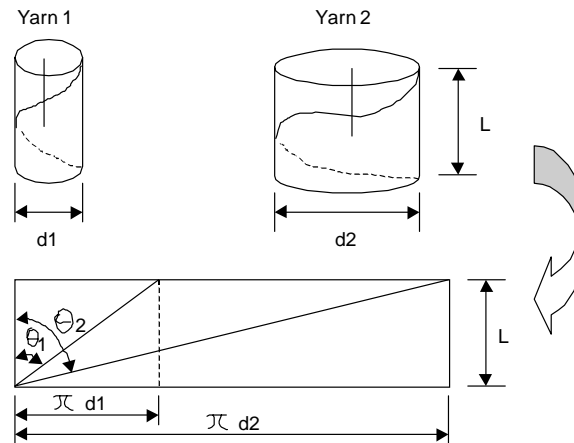


Figure 1. Two yarns of the same twist level, but different surface twist angles

Twist contraction

When a bundle of parallel fibres is twisted, the distance between the two ends of a fibre will decrease, particularly for fibres near the surface of the twisted bundle (Balasubramanian and Bhatnagar, 1970; Lin and Chang, 2004). As a result, the overall length of the twisted bundle is shorter than its length before twist insertion. The reduction in length due to twist insertion is known as twist contraction.

The following formula is used to calculate the amount of twist contraction:

$$\% \text{ contraction} = \frac{L_o - L_f}{L_o} \times 100 \%$$

Where, L_o = original length before twisting
 L_f = final length after twisting

It should be noted that because of twist contraction and the associated change in length, the count of a yarn will change slightly when twist in the yarn is changed. Twist contraction increases yarn count (tex), because the weight of the yarn is distributed over a shorter length. The following formula can be used

$$N_f = \frac{N_o}{1 - C}$$

Where, N_o = count (tex) before twisting
 N_f = count (tex) after twisting
 C = %contraction

Twist factor (Twist multiplier)

This is a very important factor that relates to the angle of twist helix the surface fibres have in a yarn. This factor is very important for a spinner because of the following reasons:

- Like surface twist angle, it governs the yarn characteristics.
- It is used to work out the twist to use in spinning, in order to maintain the same surface twist angle and similar yarn characteristics when the yarn count is changed. The twist worked out from twist factor is also needed for setting up the spinning machine.

Relation between twist level (TPI) and twist angle:

From figure 1, we get,

$$\tan \theta = \frac{\pi d}{L}$$

Also from figure 1, the height (pitch) of one turn of twist is L. Since the twist level is normally specified as the number of turns per metre, the twist level in one metre of the yarn would be:

$$twist = \frac{1}{L}$$

So,

$$\tan \theta = \pi d \times twist \quad (1)$$

We can relate yarn diameter to yarn count using the expression below:

Cubic density (ρ) = linear density (Tex) / cross-sectional area (A)

Assuming a circular cross section for the yarn, we get,

$$\rho (g/m^3) = \frac{Tex \times 10^{-3} (g/m)}{A (m^2)} = \frac{Tex \times 10^{-3}}{\pi d^2/4}$$

Solve for d:

$$d^2 = \frac{4Tex \times 10^{-3}}{\rho\pi} \quad (2)$$

Combining equations (1) and (2):

$$twist = \frac{\tan \theta}{2\pi \sqrt{tex \times 10^{-3} / \rho\pi}}$$

$$\text{or } twist = \frac{K}{\sqrt{tex}} \text{ where } K = 0.5 \tan \theta \sqrt{\rho 10^3 / \pi} \quad (t.p.m \sqrt{tex})$$

K is called the twist factor, and is proportional to θ if ρ remains constant.

Thus, K is a factor relating twist level to yarn count. The derivation shows that if two yarns have the same twist factor, they will have the same surface twist angle, regardless of count. Since surface twist angle is the main factor determining yarn character, then twist factor can be used to define the character of a yarn (Lord 1979).

Nevertheless, the relationship we have just derived between twist, twist factor and yarn count is one of the most important in the study of yarn technology. This relationship is expressed in different ways for different yarn count systems.

For the tex system:

$$Twist (turns per metre) = \frac{Twist Factor (K_t)}{\sqrt{tex}}$$

For the metric count (Nm) system (the twist factor for the metric count system is also known as alpha metric- α_m):

$$Twist (turns per metre) = Twist Alpha (\alpha_m) \sqrt{Nm}$$

For English cotton (Nec) count system:

$$Twist (turns per inch) = Twist Factor (K_e) \sqrt{Nec}$$

For worsted count (Nw) system:

$$Twist (turns per inch) = Twist Factor (K_w) \sqrt{Nw}$$

MATERIALS AND METHODS

Nylon, Terylene, Acetate yarn have been investigated. Tensile strength, rupture behavior and tenacity of different yarns have been observed.

RESULTS AND DISCUSSION

Twist factor and twist angle

The dependence of twist angle of yarn on twist factor and specific volume is shown in Table 1.

Twist factor increases as twist angle increases with different specific volume of yarn.

Table 1. Twist factor and twist angle

Specific volume (Cm3/g)	Twist factor, Tex ^{1/2} Turns/cm						
	0	20	40	60	80	100	120
	Twist angles (degrees)						
0.5	0	9	18	25	32	38	44
1.0	0	13	24	34	42	48	53
1.5	0	15	29	39	48	54	59

Continuous Filament Yarn Strength vs. Twist

The agreement between the theoretically calculated relationship of the tensile strength and twist and the experimentally obtained values of strength has been demonstrated by Platt in 1950. Figure 2 shows a plot of yarn strength of an acetate continuous filament yarn calculated theoretically from Platt’s expression (variation of strength with COS²α) and the corresponding experimentally determined values as a function of twist level.

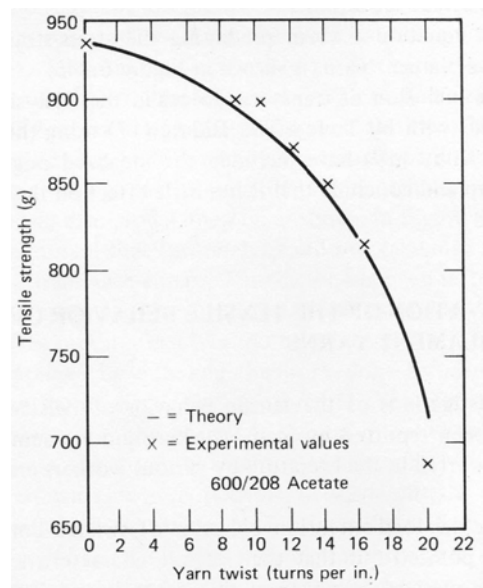


Figure 2. Yarn strength vs. twist (Platt 1950)

Rupture behaviour of continuous filament yarn

The effect of twist on rupture can be seen in Figure 3. Whereas the high twist factor yarns show a sharp partial drop, the rupture point in low twisted yarns has an extended form with complete absence of sharpness at the lowest twist factor.

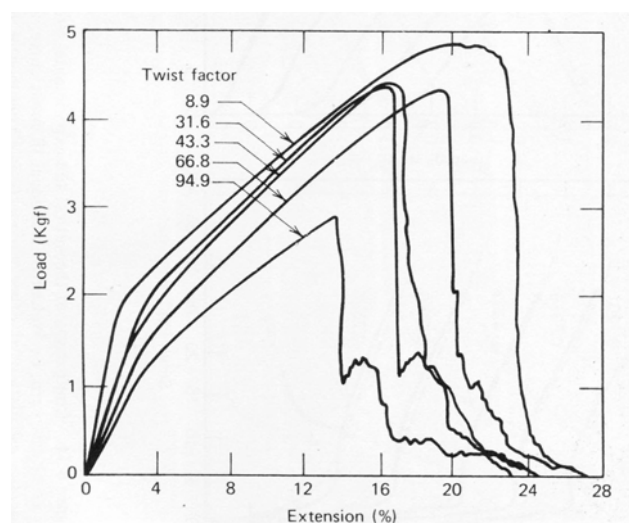


Figure 3. Load-extension curves of continuous filament yarns of various twist factor (Hearle and Thakur, 1961)

Twist vs. Tenacity

Figure 4 shows the experimental variation of tenacity with twist (Hearle *et al.* 1959). The tenacity, in general, first increases and then decreases with increase in twist of Nylon and Terylene yarn.

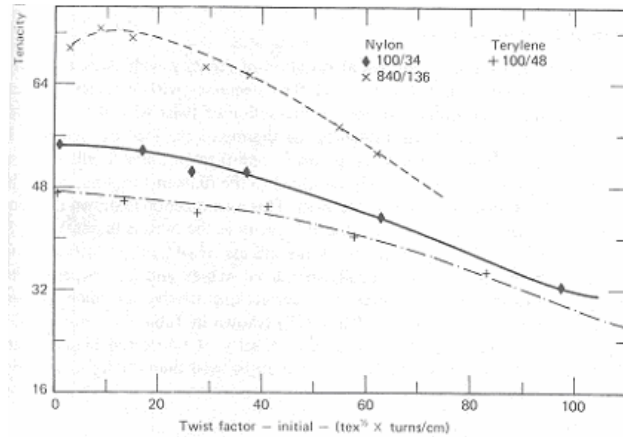


Figure 4. Effect of twist on tenacity

Experimental studies of staple and continuous filament yarn strength vs. Twist per inch (T.P.I.)

The effect of fibre length and twist on the load extension properties of acetate yarns is shown in Figure 5. An examination of these curves reveals that the staple yarns show a lower tension at all points of extension and a significantly lower strength and breaking extension than the corresponding continuous filament yarns. For the staple yarns, there is a smoothing out of the yield point. Increase of twist and decrease of staple length have the effect of causing a reduction of tension at a given extension.

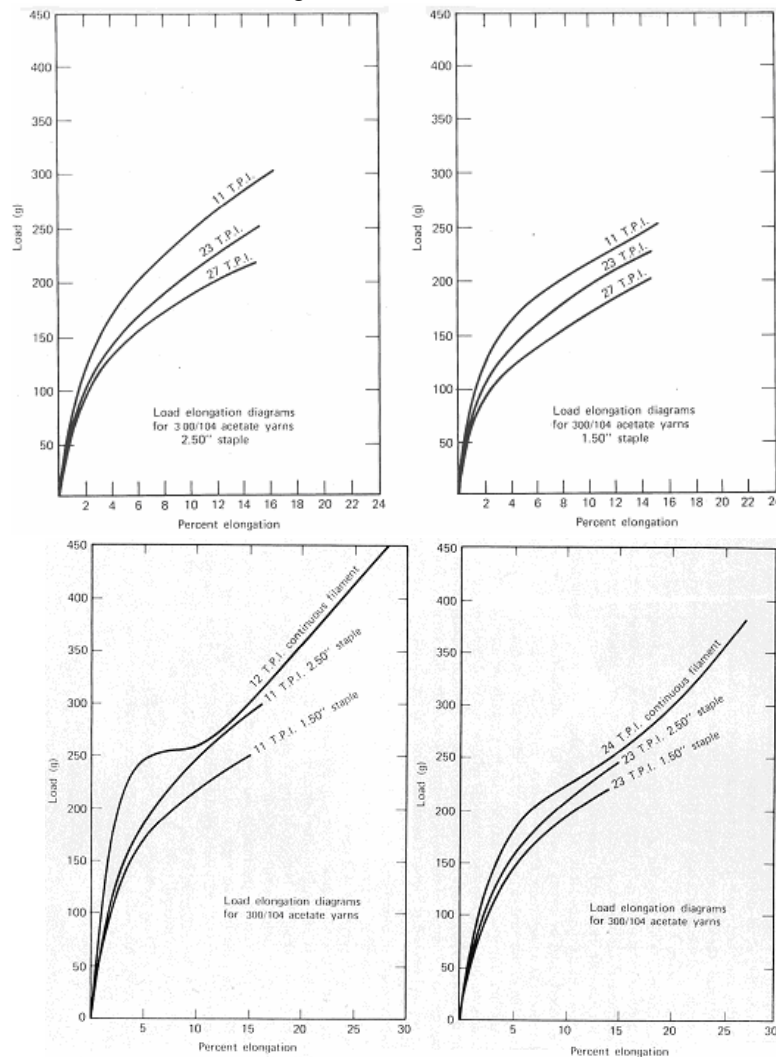


Figure 5. Load-elongation curves of continuous filament and staple acetate yarn

CONCLUSION

This research had the object to find the influence of twist on mechanical properties of yarn, while different yarns were used. The yarn breaking force depends on the TPI, thus a higher TPI causes a higher breaking force. In comparison with the staple yarn, the continuous filament yarn has higher breaking strength, elongation with the same TPI.

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