(Blending Yarn in the Twisting Process and its Effect on the Dynamometrical and Aesthetic Properties of the Plied Yarns)

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ABSTRACT
We know that the Cotton/polyester blending process is very important and it is done in the drafting machines as slivers and sometimes in the opening room as a fiber but in the twisting process as a cotton yarn with polyester filament yarn (Co/Fy), this didn't exist before, therefore, this paper investigates the possibility of producing plied blend yarns (Co/Fy) and study its mechanical properties.

Empirically in this research work, we have used: Murata high-speed double winder No. 23 machine, Toyoda Ring Twisting (RYG 812) machine, Murata cone winding machine, and a Single yarn tensile strength tester. The materials that have been used in this research work are cotton which has count Ne 30 and polyester filament which has counts 75, 180, and 400 Denier. As a result of this investigation, we have been achieved empirical prediction equations to calculate: the plied blend yarn (Co/Fy) equivalent count, blend ratio calculation, the effect of the twist factor and yarn count on the stress and on the strain, and effect of the blend ratio on the stress and on the strain as function with yarn count. From these equations: the strain increases with increasing the twist factor. The strain of the blend plied yarn decreases with increasing the twist factor and the cotton blend ratio percent. The stress of the blend plied yarn decreases with increasing the cotton blend ratio at a critical point (Co/fy 65/35) then increases with increasing the cotton blend ratio Co%. The stress of the blend plied yarn decreases with decreasing the polyester filament blend ratio Fy% at a critical point (Co/Fy 65/35) then increase with decreasing the polyester filament blend ratio. From these results it can be decided that the best blend ratio is Co/Fy 65/35.

Key words*:*
Blend plied yarn, Yarn count, Blend ratio, Stress-Strain, and Twist factor

الملخص:
من المعروف أن عمليه خلط الشعيرات لانتاج خيط مخلوط بنسب معينه تجري في مرحله السحب كشريط واحياننا في مرحله التفتيح كشعيرات ولكن في مرحله التفتيح غير دقيقه اما خلط خيط قطن مع شعيرات مستمره كخيوط الالياف الصناعية (الياف البوليستر) وحساب النسب بدقه فلم يرد من قبل, لذلک فان هذه الدراسه تبحث في امكانيه انتاج خيوط مزويه للحصول منها

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علي خيوط زخرفيه نحصل منها علي تأثيرات جماليه متنوعه من الخيط المزوي علي ان يكون من خيوط قطنيه مع شعيرات خيوط البولستر المستمره ودراسه الخواص الميكانيكيه لها.
عمليا في هذه الدراسه تم استخدام: ماكينات موراتا نمره ٢٣ ذات السرعات الفائقه للتطبيق و ماكينات الزوي الحلقي تويودا (RYG 812)للزوي وماكينات موراتا للتدوير علي كون. الاجهزه المعمليه التي استخدمت في هذه الدراسه فكانت جهاز شد الخيوط المفرده. الخامات المستخدمه كانت خيط قطن من نمره ١/٣٠ وخيوط بولسترشعيرات مستمره ولها النمر الاتيه ٧٥ و ١٥٠ و٤٠٠ دنير.
في هذا العمل البحثي توصلنا الي مجموعه من معادلات التوقع العمليه لحساب الاتي: النمره المعادله للخيط المزوي في حاله خلط خيوط قطنيه مع خيوط من الياف بوليسترمستمره و حساب نسبه الخلط و تاثيرمعامل البرم ونمره الخيط علي الجهد وكذلك تاثيرهما علي الاجهاد و تاثير نسبه الخلط علي الجهد وكذلك علي الاجهاد وهذا كداله في نمره الخيط. من هذه المعادلات توصلنا الي الاتي: الاجهاد لهذه النوعيه من الخيوط يزيد مع نقص معامل البرم. الاجهاد للخيوط المزويه المخلوطه ينقص مع زياده معامل البرم وزياده نسبه القطن حتي نقطه حرجه او نقطه انقلاب وهي ٦٥ % قطن و ٣٥% بوليستر ((Co/fy 65/35بعد هذه النقطه يزيد مع زياده نسبه القطن والعكس في حاله زياده نسبه البولستر. من

الكلمات المفتاحية:
الخيط المزوي المخلوط ،حساب النمرة المعادله، .نسب الخلط .منحني الجهد والاجهاد ،اس البرم

Introduction

The original meaning of the word "plied" In the textile arts is; in French verb plier "to fold”, and from Latin verb "plico". The manufacturing process is a process of twisting one or more strings (called strands) of yarn together to produce a stronger yarn or Strands which are twisted together in the direction opposite that in which they were spun [10]. In another meaning; ply, plied, or folded, yarns are composed of two or more single yarns twisted together. Two-ply yarn is composed of two single strands; three-ply yarn is composed of three single strands to make a plied yarn, from the individual strands [10] (As shown in figure 1). The advantages of the plied yarns compared with single yarn are: cross-section more regular, yarn appearance is better, stronger yarn, improving in the yarn hairiness index, and can be producing a fancy yarn. The twist direction may be to the right, described as Z twist, or to the left, described as S twist.

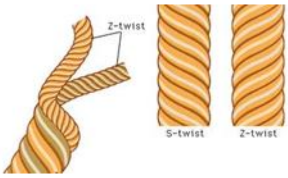

Fig 1, plied yarn

The investigation of the mechanical properties of the textile products is very important whereas, the mechanical properties of the fiber reflect on the yarn mechanical properties, and the dynamometrical yarn properties are there for reflecting on the fabric and the final product garments or blanket. There are various investigators explained the dynamometrical yarn behavior theoretically or practically. Below are some of these studies:

The effect of spinning factors on the stress-strain curve in Egyptian cotton (Giza 86) was a study to determine the effect of the spinning systems (Ring spinning, open-end, and compact) on the mechanical properties [1]. The investigator found that the compact and ring spinning systems that produce yarns are stronger, have good elasticity, and are more durable than the yarns spun by the open-end system, also reported that finer yarns are weaker and have a lower extension at break than coarser yarns [1].

During a study of the cotton fiber tensile stiffness and toughness they found that: Increasing the elongation of fiber, the yarn elongation is increasing, regardless of the yarn count, but this property was unrelated to fiber linear density, length, or tenacity also they reported that: There was a direct relationship between yarn count and toughness, the coarser yarns being "tougher" by virtue of their higher tenacity and elongation [5].

Malek et al [9] has been studied the bending rigidity of yarns using the beam method and reported that: This bending frame gives at least 1.6 times greater values of bending rigidity than the KES-FB-2 pure bending tester. Judith et al [3] studied the torsional stability of plied yarns and was mentioned some information about the self-plying technique and celebration curves are presented, for example, calibration curves giving twist ratio as a function of single-yarn twist factor for balanced two-ply continuous filament yarns (instantaneous playing), and other showing the effect of relaxation time.

From the above review study, there are no sufficient studies about the blending in the twisting process especially blending the cotton yarn with polyester filament yarn, for that the main objective of this study: Investigate the behavior of yarns in the dynamometrical tests.

2- Experimental

2-1- Materials

Materials used in this work were:

1- Cotton yarn (Co) with count 30 Ne, 3 twist factor, and pink color.
2- Polyester filament yarn (Fy) with count 75 Denier, zero twist factor, Embossed and white color.
3- Polyester filament yarn (Fy) with count 150-180 Denier, zero twist factor, Embossed and white color.
4- Polyester filament yarn (Fy) with count 300-400 Denier, zero twist factor, Embossed and white color.

The following tables (Table No 1, No2) clear the mechanical properties of the materials to ware used. The materials were tested in the Textile Engineering Department laboratories in the National Research Center in Cairo Egypt.

Table No.1: Statistical results of the tension and elongation of the material

Results	Cotton Ne 30		**Polyester Den 75**		**Polyester Den 180**		**Polyester Den 400**	
	Tension	Elongation	Tension	**Elongation**	**Tension**	**Elongation**	**Tension**	**Elongation**
Average	346.2	4.6	281.2	16.7	540.9	22.3	1098.0	18.3
St. Deviation	36.2	0.5	20.6	1.7	22.6	1.0	20.4	0.8
CV%	9.6	8.6	13.6	9.8	24.0	22.1	53.7	22.2
Max	400.0	5.0	320.0	19.0	600.0	23.0	1140.0	20.0
Min	300.0	4.0	230.0	13.0	520.0	20.0	1070.0	17.0
Range	100.0	1.0	90.0	6.0	80.0	3.0	70.0	3.0

Table No.2: Dynamometrical properties of materials

	Materials			
Results	Cotton Ne 30	polyester Den 75	Polyester Den 180	Polyester Den 400
Stress (g/tex)	17.59	36.15	32.45	32.94
Strain	4.56	16.69	22.27	18.30
Stiffness g.tex	386.04	216.56	145.71	180.00
Toughness g/tex	0.40	3.02	3.61	3.01
Yield stress g/tex	7	14	14.00	14
Yield strain g/tex	0.9	3	4.00	3
Initial young modulus g/Tex	778	467	350	467

2-2- Equipment's

2-2-1 Production Machines

To produce a plied yarn must be made three processes like doubling, twisting, and winding, in the following some knowledge about the machines were used.

1- Doubling Machine

In this research work has been used Murata high-speed double winder [2] No. 23 from Murata machinery LTD-Japan, this machine has (24) positions or drums on two sides every side has 12 drums. The winding speed of this machine is from 350 m/min to 400 m/min. The machine can be making doubling for 2 yarns only. The Travers drums (6 in). In this machine, a tensioner device to adjust and adapt the yarn tension during work. The winding in this machine is a spool system. The supply yarn package is 9^o - 15^o. In this machine, the drum is a stepped drum. In this machine, the main motor is 0.75 Kw 4p, and the sup. motor is 0.2 Kw 6p.

2- Twisting machine

The twisting machine was used in this study was a Toyoda Ring Twisting Frame [7] model RYG 812 – 4-HB, for 230 mm lift. The gears were used 70, 60, and 51 teeth to obtain twisted yarns with 12.24, 14.28, and 16.80 turn/inch sequentially. The machine data are 96 spindles, 75 mm spindle gauge, 230 mm lift, SKF-HF2C spindle insert, 8000: 10000 rpm spindle speed, 50 mm ring diameter and the main motor was 15 Kw 4p 1set.

3- Winding machine

The winding machine that has been used to wound the plied yarn that produced by Ring twisting machine were Murata cone winding machine [8], this machine has two sides of drums, every side have 12 drums. The width of traveler (6 in) to wound the yarn in regularity. Winding up package from 9^o - 15^o, supply yarn package is ring cope, the drum is a stepped drum. This machine was provided with yarn tenser to adjust the yarn tension during winding process. This machine is provided with a Slob catcher UAM C-3: 18d Uster classmate MK – 15: 6d to control the yarn cleaning. The speed of the production of this machine was 450-500 m/min. The main motor of this machine is 0.75 KW 4p and the sup motor is 0.2 KW 6p. This machine was modified with an inverter to control the yarn speed.

2-2-2 Laboratory Tools

The sample was taken randomly to fully represent the community. The samples are tested in a tensile strength tester gradually to be able to determine the yield point. The sample was tested at 500 mm length.

The machine type was a Single yarn tensile strength tester [6], the machine was a stand type. The specifications of the machine in the following: Load capacity: 500 g: 2000g, Min. scale: 2g: 10g, Stretch rate: 300mm/min, Raising speed: 100mm/min, Test length: 200-500mm, Elongation scale: 0-250mm, total length: About 2 meter, and a Motor 200 w, 220v, 50 Hz, and Single phase.

3-Definition and calculation:

3-1- Definition and terminology:

- **Load**

The application of a load to a specimen in its axial direction causes tension to be developed in the specimen [4].

- Breaking load

The load at which the specimen breaks, is usually expressed in grams weight or pounds weight [4].

- **Stress**

Where we want to compare fine and coarse yarns suitable units must be chosen. In engineering, the term "stress" is used [4].

$$Stress = \frac{Force\ applied}{Cross - sectional\ area}$$

- **Mass stress**

The cross-section of the fibers and their structures are irregular in shape and difficult to measure, thus in textile engineering we use linear density [4] as following.

$$\boldsymbol{Mass\ stress = \frac{force\ applied}{linear\ density}}$$

- **Tenacity or specific strength**

The tenacity of Fibers and yarns at the breaking force per unit linear density is expressed in terms of g/ tex [6]. The tenacity of material is the mass stress at break [4].

Breaking length

- The "breaking length" is the length of the yarn that will just break under its own weight when hung vertically [4].

- **Elongation**

Elongation-at break (Δl) is defined as the difference between the final lengths at break of yarns and the original lengths of yarns when the string is stretched, and can be calculated in mm or percent. The elongation at break value is used as a basis for calculating the stiffness. [6]

- **Strain**

When a load is applied to a sample, a certain amount of stretching takes place [4].

$$Strain = \frac{Elongation}{Initial\ length}$$

- **The load-elongation curve**

This curve describes the comportment of the sample from zero loads and elongation, it was calculated as the ratio of breaking tenacity to the breaking extension ratio at breaking point. From this curve, much important information can be gained as, initial young modulus, work of rupture, and yield point, etc. [4].

- **Yield point**

The straight part (at the proportional limit point) of the curve or the elastic region, the yield point may be defined in terms of the yield stress and yield strain [4].

3- 2- Yarn count equivalent, and blend ratio calculation

The equivalent plied yarn count was calculated as follow:

The plied yarn Consists of cotton yarn with yarn count (Ne) and continues filament yarn with yarn count tex or (D). The normal plied yarn count equation (Ne) is;

Put $\frac{1}{N} = \frac{1}{N_1} + \frac{1}{N_2} + \cdots \frac{1}{N_n},$ ---------------(1)

$Ne = \frac{590.5}{tex}$---,-----------------------------(2)

And

$tex = \frac{D}{9}$--------------------------------------(3)

And if N_1 in English system (Ne) and N_2 in (tex) or denier (D)

From equation 2, 3 and substituting in eq. 1

$\therefore \frac{1}{N} = \frac{1}{N_1} + \frac{tex}{590.5}$ ---------------------------(4)

$\frac{1}{N} = \frac{1}{N_1} + \frac{D}{9 \times 590.5}$-------------------------(5)

The blend ratio of the plied yarn was calculated according to the yarn count in Denier (D). If the first yarn N1 is cotton and have a cotton count (Ne) and the second N2 is polyester filament yarn and have a count in Denier (D), in this case, N1must be converted to Denier and calculate the ratio between them, follows: $N_1(D): N_2\ (D)$------------------------------------(6)

$\frac{9 \times 590.5}{N_1(N_e)} : N_2(D)$------------------------------------(7)

By dividing the both sides of the equation 7 on the minimum N_n

$\frac{9 \times 590.5}{N_1(N_e) \times N_2\ (D)} : 1$

$\frac{5314.5}{N_1(N_e) \times N_2(D)} : 1$ --------------------------------(8)

For example, a plied blend yarn composed of Ne 30 + 76 D

From equation 4 and 5, it can be deduced that the equivalent yarn count is:

N_e=21.5, Tex=27.5 and D=247

From equation 8 the blend ratio can be calculated like that

$\frac{Co\%}{Fy\%} = N_1 : N_2 = 2.33 : 1$

$\therefore Fy\% = 30\%\ and\ Co\% = 70\%$

From the experimental work of this research work, the blend ratio of cotton/filament polyester (Co/Fy) were determined and calculated, also the yarn count in the English yarn count system (Ne) and its equivalent with the Tex (Tex) and Denier (D) were calculated. The results were indicated in the following table (3). The table clarification showed the yarn count with different systems for different blend ratios of cotton/polyester filament yarns (Co/Fy) like 30/70, 50/50, and 70/30. In this research work; the yarn count has been converted from English yarn count (Ne) to Denier (D) yarn count to facilitate the calculation of the blend ratio.

Table No. 3: Yarn count in various systems

Yarn count systems	Blend ratio Co/Fy		
	30/70	50/50	70/30
English (Ne)	21.50	16.24	11.13
Tex (tex)	27.46	36.36	53.04
Denier (D)	247.17	327.28	477.40

4- Results and discussion

4-1- Statistical results of the blend plied yarns

4-1-1 Tension and elongation

According to the tensile strength test of the yarns (tension and elongation), an ANOVA statistical study was realized and the results were indicated, in Table 4 for different yarns which have different counts (21.5, 16.24, and 11.13Ne), different blend ratios of cotton/polyester filament (Co/Fy 70/30, 50/50 and 70/30) and different turns/inch (zero, 12.24, 14.28, and 16.8 T/In). The ANOVA statistical study like average ($\bar{x}$), standard deviation (SD), coefficient of variation (CV %) maximum (max), minimum (min), and the range was indicated also in the table.

Table 4 group (a) explains the statistical results of the plied blend yarn which has zero twists. From the indicated results in the table, it can be noticed that the coefficient of variation (CV%) of the yarn tension and yarn elongation of the yarns which have blend ratio Co/Fy 70/30 less than the yarn which have Co/Fy 30/70 and close to yarns which have Co/Fy 50/50. The range of the yarn tension and yarn elongation of the yarns with blend ratio Co/Fy 50/50 is less than the other yarns. From these results; it can be reported that the better blend ratio of yarns with zero-twist is Co/Fy 50/50.

Statistical results (average, standard deviation, coefficient of variation, and range) of the yarn tension and yarn elongation of a blend plied yarns with a turns/inch 12.24 and different blend ratios as indicated in table 4 group (b). From the table the following results can be appreciated: The tension of the yarn with blend ratio Co/Fy 70/30 have CV% less than the yarns with blend ratio 50/50 and yarns with blend ratio 30/70. The elongation of the yarn with blend ratio 30/70 less than the others. The yarn tension and yarn elongation of the yarns with a blend ratio of 50/50 have a range less than the others. Thus, it can be decided that: The best blend ratio, in this case, is Co/Fy 50/50

Table 4. Statistical results of the tension and elongation of the blend plied yarns.

Group	Turns/in	$\frac{Co/Fy}{Ne}$	Tension-Elongation	Statistical Results					
				$\bar{x}$(g)	SD	CV%	max	min	Range
a	Zero	$\frac{70/30}{21.5}$	Ten. (g)	361.0	38.7	9.3	390.0	300.0	90.0
			Elong. (%)	17.1	1.4	11.8	20.0	15.0	5.0
		$\frac{50/50}{16.24}$	Ten. (g)	520.0	12.6	41.1	530.0	500.0	30.0
			Elong. (%)	19.3	1.5	12.8	22.0	18.0	4.0
		$\frac{30/70}{11.13}$	Ten. (g)	1100.0	21.6	50.9	1130.0	1080.0	50.0
			Elong. (%)	20.0	1.6	12.2	22.0	18.0	4.0

b	12.24 T/in	70/30	Ten. (g)	485.0	50.9	9.5	530.0	400.0	130.0
		21.5	Elong. (%)	8.6	0.5	18.0	9.2	8.2	1.0
		50/50	Ten. (g)	520.0	12.6	41.1	530.0	500.0	30.0
		16.24	Elong. (%)	10.1	1.1	9.6	11.2	9.0	2.2
		30/70	Ten. (g)	28.5	6.0	4.8	33.0	18.0	15.0
		11.13	Elong. (%)	28.5	6.0	4.8	33.0	18.0	15.0
c	14.28 T/in	70/30	Ten. (g)	487.1	25.6	19.0	510.0	450.0	60.0
		21.5	Elong. (%)	7.9	1.4	5.8	10.0	6.0	4.0
		50/50	Ten. (g)	648.0	17.9	36.2	670.0	620.0	50.0
		16.24	Elong. (%)	11.4	1.5	7.5	13.0	10.0	3.0
		30/70	Ten. (g)	1040.0	163.8	6.3	1200.0	720.0	480.0
		11.13	Elong. (%)	23.4	10.3	2.3	33.0	8.0	25.0
d	16.8 T/in	70/30	Ten. (g)	568.0	68.3	8.3	620.0	450.0	170.0
		21.5	Elong. (%)	8.0	1.0	8.4	9.0	7.0	2.0
		50/50	Ten. (g)	756.0	36.5	20.7	800.0	700.0	100.0
		16.24	Elong. (%)	9.2	0.4	20.6	10.0	9.0	1.0
		30/70	Ten. (g)	1188.0	35.6	33.3	1220.0	1150.0	70.0
		11.13	Elong. (%)	17.6	6.1	2.9	28.0	13.0	15.0

Tension and elongation results of the plied blend yarn which have twist 14.28 T/in, which was indicated in table 4 group (c). From these results we found that: The tension of the plied blend yarn which has a blend ratio of 30/70 has a CV% less than the yarns that have 50/50 and the yarns which have a blend ratio70/30. The elongation of the plied blend yarns which have a blend ratio of Co/ Fy 30/70 has a coefficient of variation (CV %) less than the others. The tension of the plied blend yarn which has a blend ratio of 50/50 has a less range than the others and the elongation of the plied blend yarn which has a blend ratio of 50/50 has a less range than the others.

The tension and elongation result of the plied blend yarn that has a twist of 16.8 T/In is indicated in table 4 group (d). From these results we found that: The tension of the plied blend yarn which has a blend ratio of 70/30 has a CV% less than the yarns which have Co/Fy which have 50/50 and the yarns which have Co/Fy 30/70. The elongation of the yarn which has a blend ratio of 30/70 has a CV% less than the others. The tension of the plied blend yarn which has a blend ratio of 30/70 has a less others and the elongation of the plied blend yarn which has a blend ratio of 50/50 has a less range than the others.

4-2- Dynamometrical properties

4-2-1- Stress Strain curves of the plied blind yarn

From this research work, Stress-Strain curves of plied blend yarns with different counts, different twist factors, and different blend ratios were deduced.

Figure (2) explains a Stress-Strain curve of plied blend yarns which have yarn count 21.5 Ne, blend ratio Co/Fy 70/30, and different turns/inch (zero, 12.24, 14.28, and 16.8 t/in). From the figure; it can be noticed that: The behavior of the plied blend yarns with different twist factors are the same until the proportional limit point (10g/Tex stress, strain 1-2%) in the elastic zone in the curves. After the proportional limit point and the yield point, the performance of the plied blend yarns changes with the changing of the twist factor in the plastic zone of the curves. The elongation of the yarns which have different twist factors have the same elongation (8%) but in the case of zero-twist, it has elongation higher than the yarns with a twist non-zero. From the same figure; it can be noticed that increasing the turns/inch increases the stress.

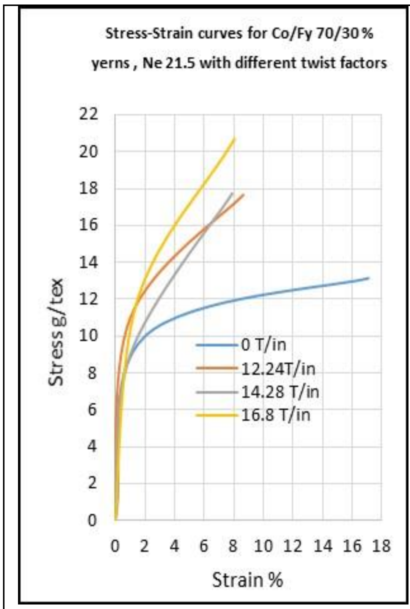

Fig 2. Stress-Strain curves of a yarn with count 21.5 Ne and Co/Fy 70/30

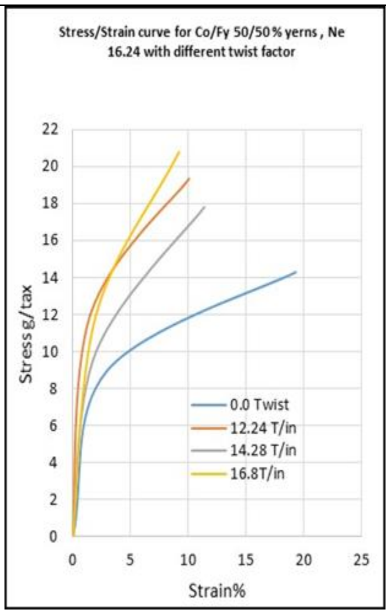

Fig 3. Stress-Strain curve of plied blend yarns with Ne16.24 and Co/Fy 50/50

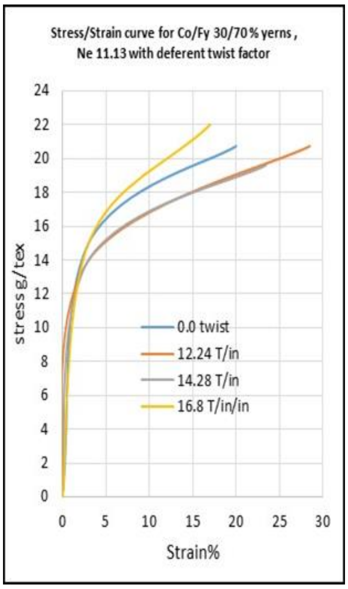

Fig 4. Stress-Strain curve of plied blend yarns with Ne11.13 and Co/Fy 70/30

Figure (3) describes Stress-Strain curves for plied blend yarns which have yarn count 16.24 Ne, blend ratio Co/Fy 50/50, and different turns/inch (zero, 12.24, 14.28, and 16.8 t/in). Plied blend yarns with a twist (12.24, 14.28, and 16.8 t/in) have a strain from10 to12% approximately while the blend plied yarn without twist higher than the yarns with a twist (18% strain). The comportment of the stress-strain curve of plied blend yarns that have a twist is different than the behavior of the stress-strain curve of plied blend yarns without a twist. From figure (3), it can be noticed that increasing the t/in leads to increasing stress.

Figure 4 illustrates stress-strain curves of yarns which have a count of 11.13 (Ne), blend ratio Co/Fy 70/30, and different turns/inch as zero, 12.24, 14.28, and 16.8 t/in. From figure (4), the stress increases with increasing the strain (all the yarns). From the curve the proportional limit point at 10 g/Tex stress and 1.5-2% strain. The yield point of these curves is 14-16 g/Tex stress and 2-4% strain. The fraction point changes with changing the twist factor. The following are more dynamometrical properties relations. By comparing the three figures together; it can be noticed that the elastic zone increases with increasing the yarn count (Ne) and increasing polyester ratio (Fy %), this is due to the thickness of the thread and the flexibility of the polyester filaments.

4-2-2- Effect of the twist factor on the stress:

In this study, we provide the relationships between the twist factor and the yarn stress of yarns with different counts and different blend ratios.

4-2-2-1- The behavior of the blend plied yarn which has a blend ratio Co/Fy 70/30

According to the mathematical, regression, and correlation study of the relation between the twist factor and the stress, we found that the relation follows up a parabolic equation or polynomial equation as follows (Eq.9 and fig 5), with a strong correlation due to r=0.94.

$\boldsymbol{\sigma_{70/30} = 0.052(TF\sqrt{Ne}\,)^2}$ **- 0.8** $\boldsymbol{TF\sqrt{Ne}}$ **+ 19.3----------------(9)**

Where:

$\boldsymbol{\sigma_{70/30} = the\ stress\ of\ the\ plied\ blend\ yaren\ with \frac{Co}{Fy} 70/30}$

$\boldsymbol{TF = Twist\ factor}$

$\boldsymbol{Ne = Yarn\ count\ in\ English\ system}$

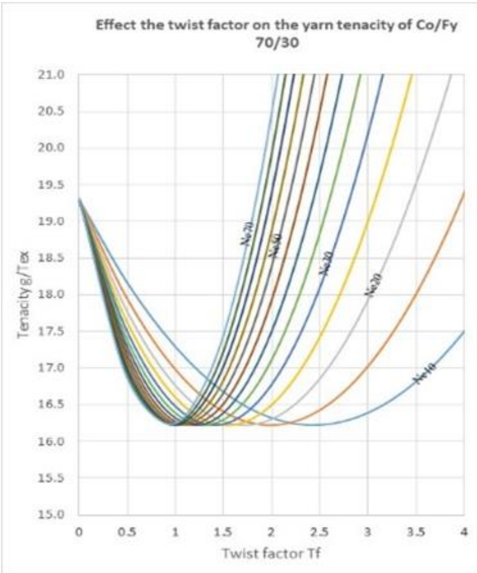

Fig. 5. Relation between twist factors and yarn tenacity of different yarn counts

From figure 5 we can see that: Increasing the twist factor (Tf) decreases the tenacity (g/Tex) from zero twist factor until a critical point, then the twist factor increase can lead to increasing the stress for all the counts of yarn, this behavior due to the twist angle inclination. The critical point change with changing the yarn count. The critical point of the twist factor increases with decreasing the yarn count, for example, the twist factor critical point of the yarn count Ne 10, 30, 70 equal 2.5, 1.5, and 1 respectively. The stress critical point was at 16.25 g/Tex for all the yarn counts. This chart (fig. 5) is very important to predict the plied blend yarn stress value which has a blend ratio Co/Fy 70/30 according to the yarn count and twist factor.

4-2-2-2 The behavior of the blend plied yarn which has a blend ratio Co/Fy 50/50

The behavior of the blend plied yarns which have a blend ratio Co/Fy 50/50 and different yarns counts, we have been derived that this relation pertinence a regression linear equation (Eq. 10) as a relationship between the twist factor and the stress. The correlation in this relationship was strong due to r=0.9. The relation between the stress and the twist factor of the plied blend yarns which have a blend ratio Co/Fy 50/50 is explained throw equation 10 and figure 6.

$\boldsymbol{\sigma_{50/50}} = 15 + 0{,}3024Tf\sqrt{Ne}$---------------------------------(10)

Where

$$\sigma_{50/50} = the\ stress\ of the\ plied\ blend\ yaren\ with \frac{Co}{Fy} 50/50$$

Figure 6 illustrates the relationship between twist factor and stress (g/Tex) of plied blend yarns with blend ratio 50/50 and different yarn counts (10, 30, and 60 Ne), as a coarse yarn, medium yarn, and fine yarn respectively. From the curve, it has been deduced that the stress (g/Tex) increases with increasing the twist factor of the plied blend yarns, and the stress increases with decreasing the yarn cross-section.

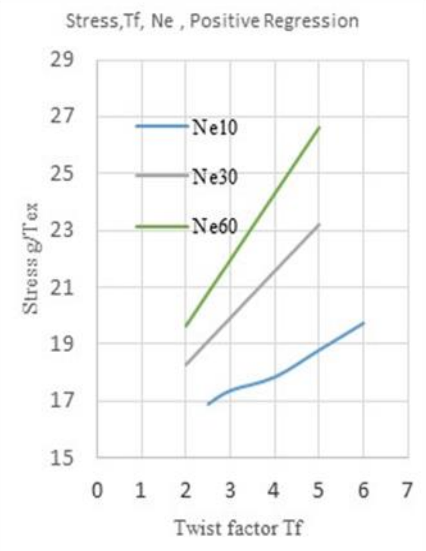

Fig.6. Relation between twist factor and stress of plied blend yarns with blend ratio Co/Fy50/50

4-2-2-3- Performance of the blend plied yarn which has a blend ratio Co/Fy 30/70

From the study of the performance of the blend plied yarns with blend ratio Co/Fy 30/70 as a relation between the twist factor and stress, we have been provided that this relation follows up a parabolic or polynomial equation with a very strong correlation due to r=0.97. From equation 11 we have realized the relation between yarn count and stress.

$$\sigma_{30/70} = 0.0233(Tf\sqrt{Ne})^2 - 0.3(Tf\sqrt{Ne}) + 20{,}746 \text{------(11)}$$

Where:

$$\sigma_{30/70} = the\ stress\ of the\ plied\ blend\ yaren\ with \frac{Co}{Fy} 30/70$$

From equation (11) we have deduced figure 7, as a relation between the twist factors and stress (g/Tex) corresponding to the yarn count. From the figure it can be shown that the stress increases with increasing the twist factor but the rate of increase is different from one yarn count to another. With decreasing the yarn count (Ne) the stress (g/Tex) increases. The rate of increase of the stress increases with the yarn count (Ne) increase.

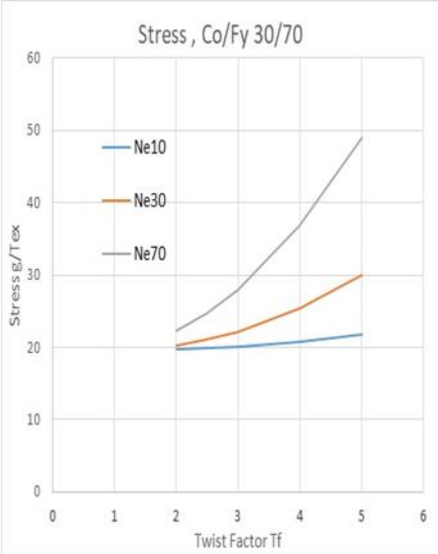

Fig. 7. Effect of twist factor on the stress g/Tex Of yarn with blend ratio Co/Fy 30/70

4-2-3- Effect of the twist factor on the strain:

4-2-3-1 Behavior of the plied blend yarns with blend ratio Co/Fy 70/30

According to the behavior of the plied blend yarns with blend ratio Co/Fy 30/70 in the strain test; from the results, we obtained a negative regression equation (12) as a relation between the strain ($\varepsilon_{30/70}$), twist factor (Tf), and yarn count (Ne). The correlation in this relation was very strong due to that the coefficient of correlation (r) equals 0.98.

$\boldsymbol{\varepsilon_{70/30} = 16,765 - 0,59Tf\sqrt{Ne}}$**----------------(12)**

Where:

$\boldsymbol{\varepsilon_{30/70}}$ ***is the strain of the plied yarn with blend ratio Co/Fy* 30/7**

From the equation (12) we have achieved figure 8, from the figure it can be noticed that the strain of the plied blend yarns which have a blend ratio of 30/70 decreases with increasing the twist factor, this for all yarn counts (ie as; fine yarn count 70Ne, medium yarn count 30Ne, and coarse yarn count Ne10). Decreasing the yarn count (Ne) increases the strain.

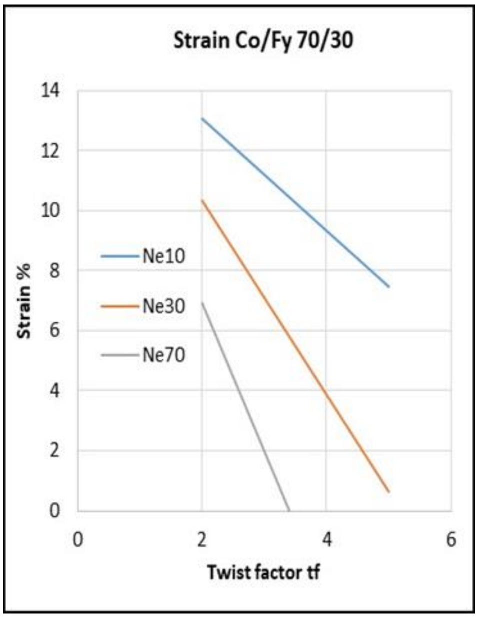

Fig. 8. Relation between twist factor, strain, and yarn count of plied yarns with blend ratio 70/30

Behavior of the plied blend yarns which have a blend ratio Co/Fy 50/50

According to the regression and correlation study of the relation between the twist factor, and the strain; from this study, we found that this relation has a negative regression (Eq. 13) and a correlation very strong because of the coefficient of correlation (r) equivalent 0.97.

$\boldsymbol{\varepsilon_{50/50} = 19{,}055 - 0{,}61Tf\sqrt{Ne}}$**------------------(13)**

Which:

$\boldsymbol{\varepsilon_{50/50}}$ =The strain of the plied blend yarn with blend ratio 50/50

From equation 13 we have deduced the following figure (fig.9); from the figure it can be seen that the increase of the twist factor leads to decreasing the strain. At a fixed point of twist factor (ie as 3). The strain increases with decreasing the yarn count (Ne), on another hand the thick yarns (Ne 10) have a strain more than the fine yarns (Ne 70) with the same twist factor. The figure also explains that the inclination angle of the regression line is different from one yarn count to another.

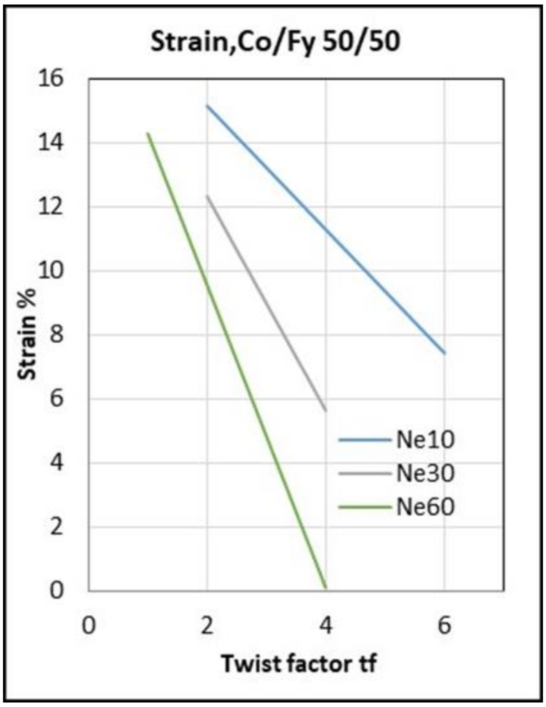

Fig. 9. Relation between twist factor, strain and yarn count of plied yarns with blend ratio 50/50

4-2-3-3 The behavior of the plied blend yarns which have a blend ratio Co/Fy 30/70

From the study of the relationship between turns/inch and the strain of the blend plied yarns which have a blend ratio of cotton/polyester filament yarn 30/70; we deduced a regression equation (Eq.14) as a relation between the twist factor, strain, and yarn count (Ne).

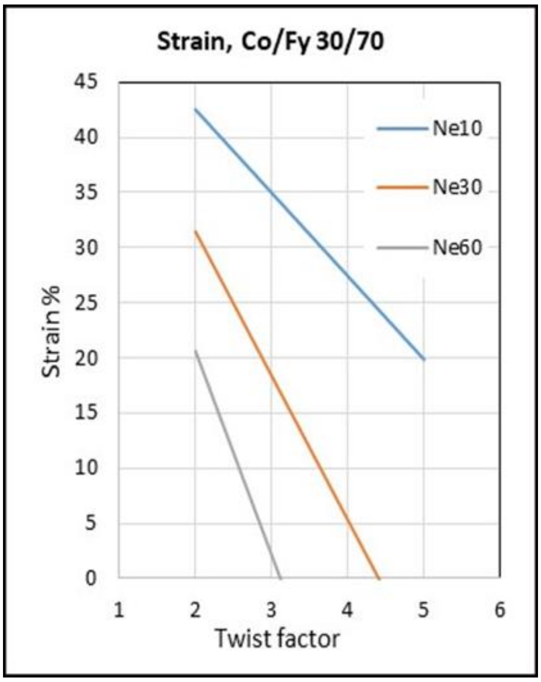

Fig. 10. Relation between twist factor, strain, and yarn count of plied yarns with blend ratio 30/70

From this equation (Eq. 14), we found that: This relationship is negative, regression relation with a correlation is very strong due to the correlation coefficient (r) equivalent of 0.98.

.$\boldsymbol{\varepsilon_{30/70} = 57.85 - 2.39Tf\sqrt{Ne}}$**--------------------(14)**

Where:

$\varepsilon_{30/70} = strain\ of\ the\ plied\ blend\ yarns \frac{Co}{Fy} = \frac{30}{70}$

From equation 14 and by using different twist factors (2,3,4, and 5) and different yarn counts (10, 30, and 60Ne) we have deduced figure 10 as a relation between the twist factor, strain, and yarn counts. From the figure it can be shown that the strain decreases with increasing the twist factor. From the figure, the thick yarns have strain more than the fine yarns. The inclination angle of the regression lines is different from one yarn count to another, this is due to the different twist.

<u>4-2-4- Effect of the blend ratio on the stress and strain</u>

<u>4-2-4-1- Effect of the blend ratio on the stress</u>

From the equations 9, 10, 11, and by computer, we have provided parabolic equations (Eq. 15, 16) and a parabolic regression curve (figure 11). This achieved equation provides that: The stress is a function in the cotton/polyester filament yarn blend ratio. This equation has 3 constants k1, K2, and k3, these constants are different from yarn count to another, and the following table clears these constants according to the yarn count (Ne). The correlation factors (r) are different from yarn count (Ne) to another. The values of the square of the correlation factor (R2) have been indicated in table 5. From the table it can be shown that the correlation factor decreases with increasing the yarn count (Ne), thus it can be decided that this equation can be applied very well for thick and medium yarns.

$\boldsymbol{\sigma_{blend\ ratio} = k_1(Co.)^2 - k_2Co. + k_3}$**------------------(15)**

$\sigma_{blend\ ratio} = k_1(10^2 - Fy)^2$-$k_2(10^2 - Fy)$+$k_3$---------(16)

Table 5 Constants and square of correlation value

Ne	k_1	k_2	k_3	R^2
10	0.0027	0.4507	33.508	0.98
20	0.0023	0.3823	32.064	0.96
30	0.0020	0.3287	31.148	0.91
40	0.0022	0.3137	30.900	0,8o
50	0.0025	0.3086	31.198	0.64
60	0.0030	0.3328	32.100	0.53

Where:
K is constants
Co. is the cotton percent = 100-Fy%
Fy is the filament yarn percent
From the equation, we have carried out a group of curves (figure 11), as a relationship between the blend ratio and stress (g/Tex) as a function of the yarn count. From the figure it can be noticed that the stress decreases with increasing the cotton blend ratio at a critical point (Co/Fy at 65/35), then increases with increasing the cotton blend ratio. This result has been deduced at the value of twist factor equal 3. The stress decreases with decreasing the polyester filament (Fy) blend ratio at a critical point (Co/Fy at 65/35), after this ratio the stress increases with decreasing the polyester filament (Fy) blend ratio. From these results it can be decided that the best blend ratio of cotton/polyester filament Co/Fy is 65/35. These curves are very well to predict the stress of any plied blend yarn which has any count and any blend ratio

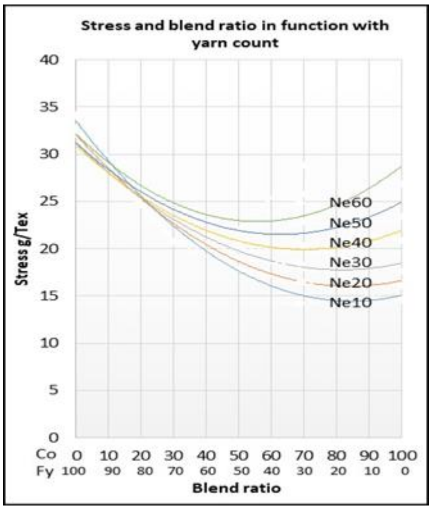

Fig. 11. Relationship of the blend ratio and the stress in function with yarn count (Ne)

4-2-4-2- Effect of the blend ratio on the strain

From the equations 12, 13, and 14 and by computer we have extracted a lineal equation (Eq. 17, 18) to calculate the relation between the blend ratio and the Strain, in function with the yarn count. Equations (Eq.17, 18) have constants (K1 and K2), these constants are different from yarn count to another. These equations proved that the regression is negative and the correlations are good with thick yarns but moderate with threads of medium thickness, at the same time, it is very weak with fine threads.

$\varepsilon = k_2 - k_1\,Co$**----------------------(17)**

If Fy%=100-Co%

$\varepsilon = K_2 - K_1(10^2 - Fy\%)$**-------(18)**

Table 6. Constants and square of correlation R2

Yarn count	K_1	K_2	R^2
Ne < 20	0.26	29.5	0.81
20 < Ne < 30	0.21	23.7	0.75
30 <Ne < 40	0.11	21.0	0.50
40 < Ne < 50	0.09	18.5	0.30

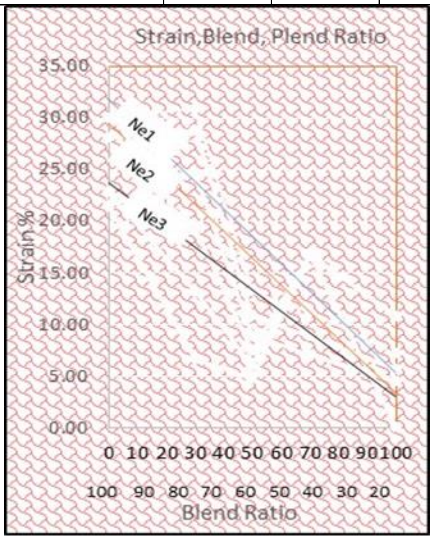

Fig.12. Relation between the blend ratio and strain percent in function with the yarn count

From table (6) it can be seen that increasing the yarn count (Ne) decreases the constants (K1, K2), also from the table the correlation (r) increases with decreasing the yarn count (Ne).
From equations 17 and 18, and by the programing we deduced Figure 12, as a relationship between the blend and strain ratio, from this figure (fig 12) it can be seen that the stress decreases with the increase in the proportion of cotton blend, and on the other hand, the increase in the proportion of polyester plied blend yarn, increases the strain ratio, from the figure also we can determine that thicker threads bear more stress than medium threads. The figure can be considered as a good way to predict the stress value according to the blend ratio and the yarn count.

5- Conclusion

- In this paper we have predicted an equation (eq. 5) to determine the equivalent yarn count for the yarns composed from cotton count (Ne) and polyester filament thread which have the count in denier (D), also we predicted an equation to calculate the blend ratio for the cotton and polyester (eq.8).
- From this research work, we have studied the Stress-Strain curves for different yarns with different blend ratios, different yarn counts, and various twist factors. From these curves, we

found that the stress increases with increasing the twist factor, but the strain increases with increasing the polyester filament yarns ratio.

➢ During an empirical study of the effect of the twist factor on the stress, we predicted equations to calculate the strain as a function in the twist factor and yarn counts, these equations was 9, 10, and 11, for the plied blend yarns of cotton yarn/polyester filament yarns Co/Fy 70/30, 50/50, and 30/70 respectively. As a result of this study, the correlation between the twist factor and stress was very strong. From this study, the regression was positive, the rates of regression are different, due to the yarn count.

➢ According to the behavior study of the plied blend yarns during the strain, we have predicted some lineal equations (Eq. 12, 13, and 14), to calculate the strain % according to the twist factor, and the yarn count. From this study, we found a negative regression with different angles due to different yarn counts. In this study also, the correlation between the turn/inch and the strain was very strong due to the correlation coefficient (r) equivalent of 0.97-0.98.

➢ In this paper, we have achieved prediction equations (15 and 17) to study the effect of the blend ratio of the plied blend yarns on the stress and on the strain. The relation between the blend ratio and the stress belongs to a polynomial equation, while the relation between the blend ratio and the strain belongs to a linear equation. The correlation coefficient (r) of the blend ratio with the stress and with the strain decreases with increasing the yarn count (Ne).

➢ From the curves (fig 11), it has been deduced that the best blend ratio, preferable blend ratio Co/Fy 65/35 due to the prediction studies and according to the Anuva statistical study of the results.

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