A Comparative Strength Analysis of Denim Fabrics Made From Core-Spun Yarns Containing Textured Microfilaments

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ABSTRACT

Denim fabric is one of the most popular casual wear fabrics worldwide. The performance characteristics of denim fabrics have been improved by using functional fibers and elastane to make them comfortable to wear. Elastane fibers with high elasticity are used extensively in denim fabric production. Elastane fibers are generally used as the core part of the core-spun yarns as weft yarns. Besides elastane fibers; polyester and polyester derivatives are commonly used. This study examines the effects of filament fineness and yarn count on denim fabric performance. Textured polyester filaments with medium, fine and micro linear densities were used as the core part of the core-spun yarn and cotton fiber was used as sheath material. Yarn samples manufactured with the same production parameters at different yarn count were used as weft yarns of denim fabrics. Denim fabrics were produced with the same fabric cover factor to eliminate yarn count difference effects. Tensile, static tearing and dynamic tearing properties of denim fabrics were determined. To evaluate the effects of core part, 100 % cotton denim fabric was manufactured and tested. Statistical analysis was performed to analyze the significance of filament fineness and yarn count ratio. Results showed that there was a significant effect of filament fineness on tensile, static tearing and dynamic tearing properties of denim fabrics. In addition, it was found that yarn count had no significance effect on static tearing properties of denim fabrics.

Keywords: microfilament, textured yarn, core-spun yarn, denim fabric, fabric properties

INTRODUCTION

There are various ways of combining yarn types and manufacturing systems to produce denim fabrics with a wide variety of functional and aesthetic characteristics to meet consumer demand. Elastic denim fabrics manufactured using elastic core-spun yarns have become popular as daily wear because of their comfort characteristics. Some researchers have investigated the performance and comfort characteristics of elastic core-spun yarns and fabrics from these yarns [1-5]. Although the consumption of elastic core-spun yarns is widespread, in practice some problems occur during the fabric lifecycle. The main disadvantage of using elastane is bagging and growth of the fabric with use Elastane ratio is important to the parameters of fabrics tensile strength and tearing resistance. A higher elastane ratio, results in lower tensile and tearing resistance of fabric [6,7]. Al-ansary investigated the effect of elastane ratio on the physical and mechanical properties of fabrics. Ne 30/1 elastic core-spun yarns with different rate with elastane ratios were manufactured and 1/1 plain fabric samples were produced using these yarns as the weft. It was found that air permeability and fabric elasticity increase, but tensile strength and bagging of fabric samples decrease with higher elastane ratio [8].

In addition, polyester (PET) filament with moderate elasticity, which can be textured to make it more voluminous and elastic, polyamide, polybutylene terephthalate (PBT) and some derivatives of PET offer advantages in the production of core-spun yarn and resulting fabrics. Ziaee et al. studied fabrics with cotton covered polypropylene core-spun yarn used as the weft. Air permeability, tensile strength, crease recovery, bending properties, dynamic moisture and heat transfer of woven fabrics were compared to those properties of 100% cotton (100% CO) woven fabrics. They showed that 100% CO fabrics had lower air permeability, tensile strength and elongation, bending strength than fabrics produced using polypropylene core-spun yarns [9].

The use of microfibers in the production of apparel offers several advantages: fabrics made of microfiber have higher strength, higher water penetration capability and higher levels of comfort characteristics. These fabrics are soft, lighter, easy to wash and eco-friendly. There are also several studies in the literature dealing with the performance properties of microfilament yarns, knitted and woven fabrics [10-15].

In this study, the effects of filament fineness and yarn count (core/sheath ratio) on tensile and tearing strength of core-spun and 100 % CO denim fabrics are investigated.

MATERIALS AND METHODS

In the study, 110 dtex linear density false-twist textured PET filament yarns (PET DTY yarn) with five different filament fineness (3.05 dtex, 1.15 dtex, 0.76 dtex, 0.57 dtex and 0.33 dtex) were used as cores to manufacture cotton covered filament yarns on a modified ring spinning system. The properties of polyester filament yarns are shown in *Table I.* All yarn samples were produced at the same production parameters (8000 rpm spindle speed, Z twist wise, Ne 0.6 combed cotton roving, same cotton sheath fiber). The twist factor (α_e) was kept constant for all yarn counts. In addition, 100% combed CO yarns were produced at all yarn counts the same production parameters. The physical properties of the yarn samples are shown in *Table II.*

To determine the effect of filament fineness and yarn core/sheath ratio on denim fabric performance, Ne 20/1 conventional combed ring spun yarn was produced. The properties of cotton raw materials and yarn are shown in *Table III.*

TABLE I. Physical properties of polyester filament yarns [16].

Decitex/Filament	Filament Fineness (dtex)	Tenacity, cN/tex	Elongation, (%)
110/36	3.05	4.11	20.97
110/96	1.15	3.77	21.04
110/144	0.76	3.69	18.85
110/192	0.57	3.77	17.16
110/333	0.33	4.17	19.44

TABLE II. Yarn properties [16].

Yarn Count, (Ne)	Filament Fineness, (dtex)	Core/ Sheath Ratio, (%)	Breaking Strength, (cN/tex)	Breaking Elongation, (%)	Unevenness, (CVm%)	Thin Places, (-40%/km)	Thick Places, (+50%/km)	Neps, (+200%/km)	Hairiness, (Uster® H)
16/1	**0 (100% CO)**	0/100	16.56	7.41	10.04	1.71	4.08	5.53	6.73
	3.05	30/70	15.17	9.03	9.36	0	6.84	7.89	7.25
	1.15	30/70	14.98	8.68	9.29	0.26	4.34	6.71	8.03
	0.76	30/70	16.64	8.87	9.26	0.13	3.9	4.63	7.44
	0.57	30/70	15.48	8.24	9.23	0.13	7.63	6.71	7.44
	0.33	30/70	18.1	9.22	9.3	0	8.75	9.03	7.59
20/1	**0 (100% CO)**	0/100	16.18	6.87	10.75	5.38	7.38	16.75	6.51
	3.05	37/63	17.89	9.41	9.92	0.5	9.88	13.63	6.92
	1.15	37/63	16.24	10.25	9.94	0.5	6.63	12.13	7.97
	0.76	37/63	17.25	10.99	9.75	0	7.13	10.88	7.21
	0.57	37/63	17.21	12.32	9.96	0.97	13.47	18.89	7.11
	0.33	37/63	18.94	9.39	10.02	1.63	9	14.5	7.38
24/1	**0 (100% CO)**	0/100	16.55	6.7	11.28	10	12	17.25	5.88
	3.05	45/55	20.79	30.4	10.68	4.23	15.5	22.13	6.56
	1.15	45/55	20.14	37.42	10.63	3.16	11.32	18.68	7.25
	0.76	45/55	20.32	36.51	10.56	1.5	20.25	25.25	6.76
	0.57	45/55	20.68	36.85	10.56	2.11	24.61	30.79	6.77
	0.33	45/55	20.58	26.22	10.52	2.24	14.08	19.74	7.06
28/1	**0 (100% CO)**	0/100	16.18	6.42	11.81	24.88	16.38	22.63	5.56
	3.05	52/48	23.81	29.55	11.65	16.38	32.13	39.38	6.68
	1.15	52/48	23.53	39.51	11.58	19.38	47.25	63.25	7.12
	0.76	52/48	23.32	37.99	11.89	21.18	43.55	43.29	7.12
	0.57	52/48	24.19	36.59	11.31	19.74	35.92	38.16	6.8
	0.33	52/48	23.65	30.41	10.77	5.14	21.53	32.5	6.38

TABLE III. CO fiber and 100% combed CO yarn properties used as warp.

Cotton Fiber HVI Results		Warp Yarn Properties	
Fiber thickness,(Micronaire)	4.84	Yarn Count,(Ne)	20/1
Length,(mm)	31.13	Breaking Strength,(cN/tex)	20.7
Strength,(g/tex)	31.6	Breaking Elongation,(%)	5.76
Elongation,(%)	7.3	Unevenness, (CVm%)	10.06
Uniformity Index,(%)	84.7	Thick Places ,(-40% /km)	3.5
Short Fiber Index (SFI),(%)	6.2	Thin Places, (+50% /km)	1.5
Brightness (Rd),(%)	75.5	Neps,(+ 200% /km)	2.33
Yellowness, (+b)	8.4	Hairiness,(Uster® H)	4.9

First, warp yarns were mercerized with caustic soda ash and then prewashed. After prewashing, yarns were dyed using a slasher indigo dyeing machine. All samples were given a final wash before slashing. Finally, warp yarns were sized with a starch sizing agent. In this study, Ne 16/1, Ne 20/1, Ne 24/1 and Ne 28/1 core-spun yarns and 100% CO yarns were used as weft yarn and Ne 20/1 combed 100% CO yarn was used as warp to obtain denim fabrics. Due to the high yarn count difference between weft yarns, predetermined weft densities were used for all yarn counts. In order to eliminate the yarn count effects, weft densities were adjusted such that all fabrics have the same cover factor. Cover factor of fabric is generally defined the level of cover provided by the warp and weft threads at the fabric surface (*Figure 1*).

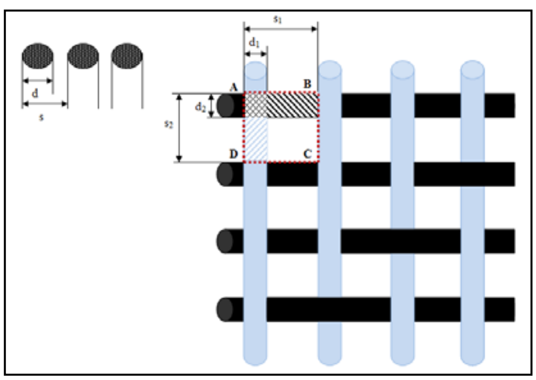

FIGURE 1. Calculation of the cover factor [17].

To calculate the fabric cover factor, both warp and weft yarn cover factor must be determined separately. The area covered by warp and weft threads yields cover factor of the fabric (*Figure 1)*. As seen in *Figure 1*, the repeat unit of the weaving is ABDC which is drawn as a dotted line. To calculate the cover factor of fabric, warp and weft yarns cover factors must be determined at first [18].

From *Figure 1*,

d_1=warp thread diameter (cm),
d_2=weft thread diameter (cm),
s_1=warp thread diameter+ the gap between two warp thread (cm) and
s_2=weft thread diameter+ the gap between two weft thread (cm).

$$Covering\ area = d_2 s_1 + d_1 s_2 - d_1 d_2 \tag{1}$$

$$Total\ area\ (Area\ of\ ABCD) = s_1 s_2 \tag{2}$$

Then for warp and weft yarns,

$$Cover\ Factor\ (c_{warp,weft}) = \frac{d}{s} \tag{3}$$

$$Yarn\ Sett\ (number/cm)\ n = \frac{1}{s} \tag{4}$$

$$Cover\ Factor\ (c_{warp,weft}) = d \times n \tag{5}$$

$$Fabric\ cover\ factor\ (c) = c_{warp} + c_{weft} - c_{warp} c_{weft} \tag{6}$$

The yarn diameter both warp and weft threads were calculated for staple yarns as given below [19],

$$d = 4{,}44 \times 10^{-3} \sqrt{\frac{T_{tex}}{\rho}}\,(cm) \tag{7}$$

where
d= yarn diameter (cm),
T_{tex}= yarn linear density (g/km),
ρ= fiber density (g/cm^3).

In this study, warp sett was determined as 36 warps/cm. The density of cotton fiber was taken as 1.52 g/cm^3 and the weft sett with respect to constant cover factor density for polyester fiber calculated to be 1.38 g/cm^3 [20]. For blended core-spun yarns the approximate density of yarn was calculated according to the core/sheath ratio theoretically. The fabric cover factor was set at 20 wefts/cm for Ne 16/1 yarn. Thus, weft setts were determined for the other yarn counts (Ne 20/1, Ne 24/1 and Ne 28/1) at the same fabric cover factor. Denim fabric production parameters and weaving machine settings are presented in *Table IV*.

TABLE IV. Woven denim fabric production parameters.

Parameter	Properties	
Weaving Machine	Picanol Gam-Max, rapier	
Machine Speed, (rev/min)	525	
Warp Thread	Ne 20/1 combed CO yarn	
Weft Thread	Ne 16/1 core-spun yarn	
	Ne 20/1 core-spun yarn	
	Ne 24/1 core-spun yarn	
	Ne 28/1 core-spun yarn	
	100% combed CO yarn	
Weave Type	Twill 3/1 Z	
Reed Number, (dents/1dm)	90/ 4 thread in each dent	
Reed Width, (cm)	190	
Warp Sett, (warps/cm)	36	
Weft Sett, (wefts/cm)	Ne 16/1	20 wefts/cm
	Ne 20/1	22 wefts/cm
	Ne 24/1	24 wefts/cm
	Ne 28/1	26 wefts/cm

A total of 24 denim fabrics were produced. Fabric thickness, fabric weight, fabric crimp, warp and weft set of fabric, tensile properties, static and dynamic tearing strength of sample fabrics were determined after the singeing, de-sizing and finishing processes and thermal fixation. Tests were carried out after conditioning the specimens in a standard atmosphere at 20°C ± 2°C temperature and 65% ± 4% relative humidity for 24 hours according to the standard of BS EN ISO 139:2005+A1:2011- Textiles- Standard atmosphere for conditioning and testing.

Tensile strength values are averages of 10 tests on specimens of the warp and weft of each fabric were tested in accordance with ISO 13934-1:2013-Textiles - Tensile properties of fabrics - Part 1. Tensile properties were measured using Titan 2 device. For static tearing strength values of tests of 10 specimens of the warp and weft of each fabric according to ISO 13937-2: 2000-Textiles - Tear properties of fabrics - Part 2. Tear strength of specimens was determined using a using Titan 2 device. Dynamic tearing strength tests were performed by means of Elmetear test device according to ISO 13937-1:2000-Textiles- Tear properties of fabrics - Part 1: Determination of tear force using ballistic pendulum method (Elmendorf) standard. Ten tests were performed on the warp and weft of the each fabric and averaged to obtain reported values.

Statistical Analysis

To determine the relationship between independent variables (filament fineness and yarn count) and the response variables (tensile properties, static and dynamic strength), the Design-Expert statistical software package was used. The experimental design for statistical analysis is illustrated in *Table V.* In the table, yarn count was taken as the independent parameter instead of weft sett since weft setts were determined as dependent parameters of the yarn counts.

General Factorial Design was selected in the case of non-equal level of the independent variables to achieve regression models and Analysis of Variation (ANOVA). Fabric samples made of 100% CO yarns were hereby taken as the "0" value because of the absence of filament in the cross section of the weft yarn.

TABLE V. Experimental Design of Fabric.

Response Variables	Independent Variables	
	Filament Fineness, (dtex)	Yarn Count, (Ne)
	A	B
Tensile Strength	0*	
	3.05	16
	1.15	20
Elongation	0.76	24
Static Tearing Strength	0.57	28
Dynamic Tearing Strength	0.33	

*100 % CO fabric

To estimate the regression equation and perform variance analysis, a general factorial design is a more appropriate model for response variables than multiple regressions. In some cases in multiple regressions, certain independent variables do not adequately explain the effects on response variables. In such circumstances, non-contributing terms are removed from the regression model (p>0.05) for response variables. In this study, non-contribution terms in the model were removed using the hierarchical backward elimination method. In performing backward elimination by taking into consideration the hierarchical principle, all effects contained in a significant interaction term must remain in the model, even if these effects are not conditionally significant, i.e., if the interaction term A^2B or AB^2 is significant, the main effects A and B as well as the AB interaction must remain in the model [21].

RESULTS AND DISCUSSION

Structural properties of fabric samples are shown in *Table VI*. Warp and weft setts of the end products are higher than the woven values because of the expected shrinkage in both sides of the fabrics following singeing, de-sizing, finishing and thermal fixation. Tensile properties, static and dynamic tearing strength of fabric samples were tested in the warp and weft direction. These physical properties of the denim fabrics are illustrated in *Table VII*.

Tensile Properties

Tensile strength and elongation of denim fabric samples produced from core-spun yarns and 100 % CO yarns are shown in *Figure 2* and *Figure 3*, respectively.

TABLE VI. Structural properties of denim fabrics.

Yarn Count, (Ne)	Filament Fineness, (dtex)	Warp Sett, (warps/cm)	Weft Sett, (wefts/cm)	Fabric Weight, (g/m^2)	Fabric Thickness, (mm)	Warp Crimp, (%)	Weft Crimp, (%)	Fabric Cover Factor
16/1	0 (100% CO)	41	22	215.18	0.44	10.00	6.40	0.834
	3.05	41	22	217.18	0.44	10.00	6.44	0.836
	1.15	41	22	217.78	0.44	10.20	6.70	0.836
	0.76	40	22	219.23	0.44	10.00	6.10	0.836
	0.57	42	22	219.30	0.44	9.80	6.14	0.836
	0.33	41	22	216.90	0.44	10.30	6.37	0.836
20/1	0 (100% CO)	42	24	204.37	0.41	10.00	6.65	0.832
	3.05	41	24	206.53	0.41	10.00	6.35	0.834
	1.15	42	24	209.17	0.41	9.60	6.73	0.834
	0.76	42	24	210.17	0.42	9.80	6.25	0.834
	0.57	42	24	211.46	0.42	10.00	6.79	0.834
	0.33	41	24	204.88	0.41	10.00	6.69	0.834
24/1	0 (100% CO)	41	26	201.11	0.40	9.80	6.54	0.832
	3.05	41	26	201.43	0.40	9.80	6.39	0.834
	1.15	41	26	205.22	0.41	9.80	6.50	0.834
	0.76	42	26	205.56	0.41	9.80	6.62	0.834
	0.57	42	26	207.10	0.41	9.80	6.01	0.834
	0.33	41	26	205.72	0.41	9.80	6.35	0.834
28/1	0 (100% CO)	42	28	198.07	0.39	10.00	6.43	0.832
	3.05	41	28	198.18	0.39	10.00	6.37	0.835
	1.15	41	28	201.81	0.39	10.00	6.75	0.835
	0.76	41	28	201.91	0.39	9.80	6.52	0.835
	0.57	41	28	203.16	0.39	9.80	6.56	0.835
	0.33	41	28	200.69	0.38	10.00	6.69	0.835

TABLE VII. Physical properties of denim fabric samples.

Yarn Count, (Ne)	Filament Fineness, (dtex)	Tensile Strength, (N)		Elongation, (%)		Static Tearing Strength, (N)		Dynamic Tearing Strength, (N)	
		Warp Wise	Weft Wise	Warp Wise	Weft Wise	Warp Wise	Weft Wise	Warp Wise	Weft Wise
16/1	0 (100% CO)	1339.91	663.26	11.19	7.97	46.49	35.66	63.04	61.27
	3.05	1346.64	632.81	15.03	14.20	43.59	47.77	65.39	64.78
	1.15	1342.45	625.65	15.07	16.03	45.21	49.94	65.75	64.05
	0.76	1365.18	641.90	15.61	16.94	45.14	49.71	64.32	64.17
	0.57	1353.21	649.04	15.19	15.59	43.64	49.41	64.88	64.53
	0.33	1327.19	678.13	14.73	13.74	46.06	48.54	64.06	64.62
20/1	0 (100% CO)	1304.49	567.19	13.60	10.23	48.14	29.28	62.60	55.88
	3.05	1309.36	597.62	14.01	22.61	43.44	47.56	61.67	61.09
	1.15	1298.66	577.74	13.24	19.08	42.05	46.36	62.25	61.58
	0.76	1343.45	595.36	14.44	18.29	42.76	45.25	61.69	61.61
	0.57	1323.57	605.44	15.26	18.84	42.46	46.50	61.44	60.86
	0.33	1330.55	643.00	15.30	18.12	42.89	44.09	61.42	61.74
24/1	0 (100% CO)	1247.39	487.14	13.12	11.82	45.74	25.36	60.79	51.26
	3.05	1296.29	639.46	15.76	31.11	39.11	47.58	60.93	59.71
	1.15	1287.18	610.66	14.32	38.21	37.69	45.79	60.70	59.02
	0.76	1306.35	616.55	14.35	33.82	38.32	44.53	60.33	58.90
	0.57	1309.34	639.90	14.38	32.28	38.60	42.76	60.48	60.25
	0.33	1295.19	646.29	14.15	21.39	38.54	40.65	60.18	59.60
28/1	0 (100% CO)	1261.99	482.32	12.46	10.66	39.87	21.99	59.18	48.79
	3.05	1304.51	681.59	13.79	32.64	37.89	52.16	59.52	59.24
	1.15	1329.36	659.50	14.79	38.26	36.99	52.22	59.26	58.68
	0.76	1312.09	665.01	14.31	42.31	36.50	51.94	59.18	57.77
	0.57	1343.16	675.84	14.99	40.66	35.93	49.13	59.10	57.86
	0.33	1359.05	677.79	14.39	28.48	36.68	42.19	58.87	58.35

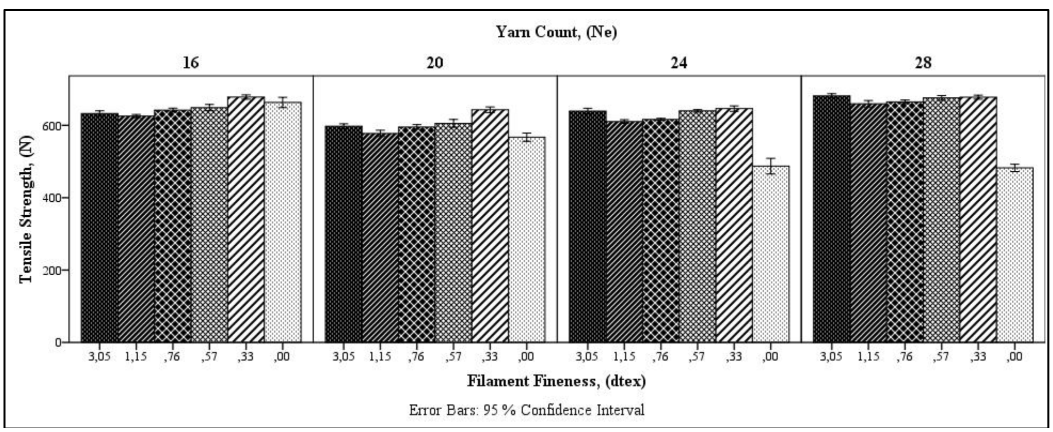

FIGURE 2. Weft wise tensile strength of denim fabrics.

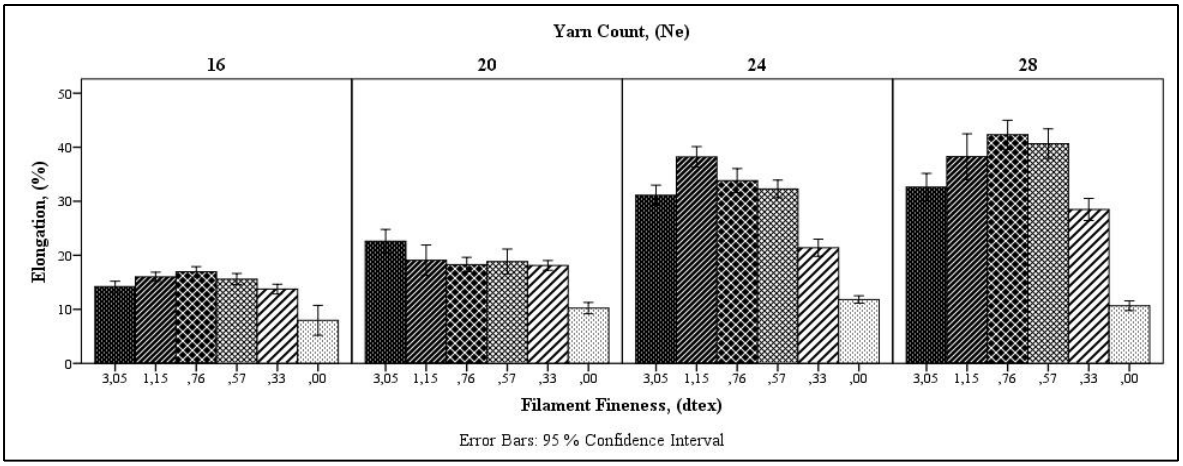

FIGURE 3. Weft wise elongation of denim fabrics

In *Figure 2* bar charts with error bars drawn at 95 % confidence interval are shown with filament fineness and yarn count as independent variables. Weft sett is the dependent variable based on yarn count, so evaluations and statistical analysis were done according to yarn count. The "0" value represents denim fabric samples made of 100 % CO yarn weft wise. From the bar charts of 100 % denim fabric samples, it is clear that weft tensile strength decreases from Ne 16/1 to Ne 28/1.

Filament core composition contributes the tensile strength of denim fabrics in the weft direction. When the yarn becomes finer, core ratio increases and this affects the tensile strength positively. Therefore, an incremental tensile strength difference between 100 % CO denim fabric samples and denim fabric samples made from filament core-spun yarns was expected [9]. The tensile strength of denim fabrics produced from micro filament core spun yarns between 0.33 and 0.76 dtex increases with respect to filament fineness or the number of filaments in the cross section of the yarn.

From *Figure 2*, in general, tensile strength of denim fabrics is affected positively as filament fineness from conventional to "micro". As the number of filaments in the cross section of the yarn increases, the resistance against the tensile force applied to fabric also increases. Thus, more force is required to break the fabric. The exception noted for fabrics made from 3.05 dtex PET is due to higher fiber tensile strength (*Table I*).

The multiple regression analysis and ANOVA analysis using the hierarchical backward elimination method shows that the effects of filament fineness and yarn count on denim fabric tensile strength are statistically significant (p<0.0001) with an adjusted R^2 value of 74 percent. This means that there is a relationship between filament fineness, yarn count and tensile strength. The regression equation for the tensile strength is shown as Eq. (8) in *Table VIII*.

Bar charts with error bars drawn at 95 % confidence interval of weft wise elongation as a function of filament fineness and yarn count are presented in *Figure 3.* In general, presence of a second filament in the core yarn increases fabric elongation in the weft direction compared to that of a fabric made from 100% CO yarn. Further, as yarn count increases from Ne 16/1 to Ne 28/1 the difference in elongation of fabrics made using core-spun yarns and the 100% CO yarn. Finally, increasing the amount of the core portion of the yarn affects elongation at break positively [6,8].

TABLE VIII. Statistical analysis of denim fabric samples in weft wise.

	Sum of Squares	DF	Mean Square	F Value	Prob > p	R-Squared	Adjusted R-Squared
Tensile Strength, (N)	**53284.6**	**7**	**7612.09**	**10.45**	**< 0.0001**	**0.8205**	**0.742**
Elongation, (%)	**2456.83**	**8**	**307.1**	**34.05**	**< 0.0001**	**0.9478**	**0.92**
Static Tearing Strength, (N)	**1487.21**	**8**	**185.9**	**61.75**	**< 0.0001**	**0.9705**	**0.9548**
Dynamic Tearing Strength, (N)	**323.21**	**7**	**46.17**	**33.27**	**< 0.0001**	**0.9357**	**0.9076**

A= Filament fineness, B= yarn count

Tensile Strength, (N) $= 1421.83855-168.02888A-69.44217B-215.05852A^2+1.31898B^2+22.71755A*B+79.16924A^3-5.75763A^2*B$ (8)

Elongation, (% $= 329.34822-16.30279A-46.50304B-15.07932A^2+2.17824B^2+2.76624A*B+6.35879A^3-0.032937B^3-0.78584A^2*B$ (9)

Static Tearing Strength, (N) $= -4.63159+17.66151A+9.62599B-34.30290A^2 - 0.61914B^2 + 1.67847AB + 8.99826A^3 + 0.011156B^3-0.40325A^2*B$ (10)

Dynamic Tearing Strength, (N) $= 90.04067+6.07920A-2.35649B-14.60852A^2 +0.032844B^2+0.66022A*B+4.01497A^3-0.16808.A^2*B$ (11)

As seen in *Figure 3*, the elongations of the denim fabrics produced from 0.33 dtex PET microfilament core cotton covered weft yarns are lower than those of the other filament core yarns for each yarn count. The statistical analysis shows that the effects of filament fineness and yarn count on denim fabric elongation are statistically significant (p<0.0001) with adjusted R^2 values of 92 percent. This indicates a strong relationship between filament fineness, yarn count and elongation at break. The regression equation of the elongation is illustrated as Eq. (9) in *Table VIII*.

Static Tearing Strength

Weft wise static tearing strength bar charts with error bars drawn at 95 % confidence interval are shown in *Figure 4*. Core-spun yarns at each yarn count yield fabrics with higher static tearing strength in the weft direction than 100% CO denim fabrics. For fabrics made from 100% CO yarn, weft wise static tearing strength decreased as a function of yarn count and weft density. As weft density decreases, the yarns are freer to displace themselves within the fabric structure so the static tearing strength will be decreased [22, 23]. However, this is not the case for denim fabrics with filament core cotton covered core-spun yarns as the weft yarn.

From the statistical analysis of static tearing strength, it is clearly seen that yarn count has no significant effect (p>0.05) but it was not removed from the regression equation because the interaction terms of yarn count were significant. Thus for the regression equation given in *Table VIII* the hierarchical backward elimination method was used. In *Table VIII*, the fitted model for filament fineness and yarn count shows that these parameters have significant effects on static tearing strength, with and adjusted R^2 value of 95 percent. The regression equation is shown as Eq. (10) in *Table VIII.*

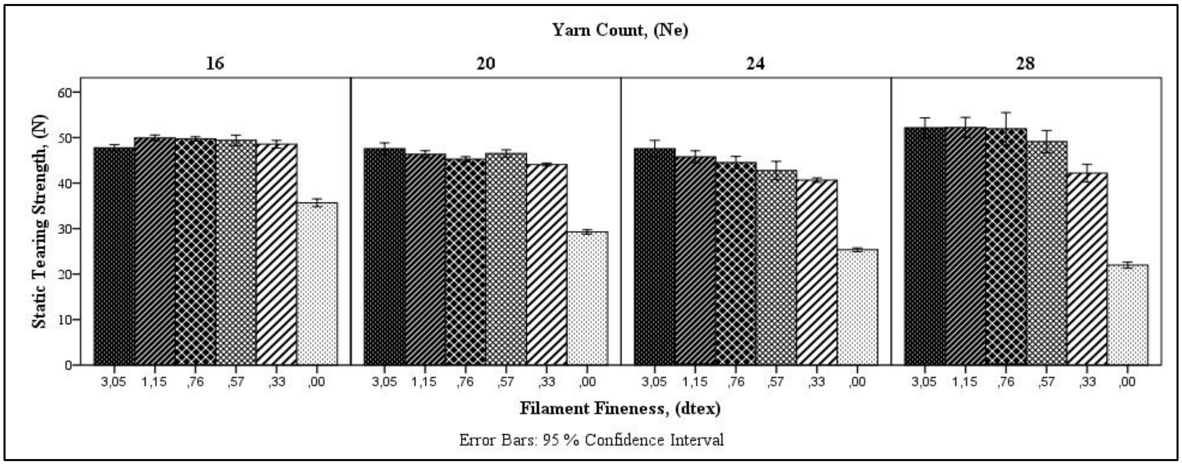

FIGURE 4. Weft wise static tearing strength of denim fabrics.

Dynamic Tearing Strength

The bar charts with error bars of weft wise dynamic tearing strength of denim fabrics as a function of yarn count and fiber fineness are illustrated in *Figure 5.* From *Figure 5,* it is clearly seen that there is a decrease in dynamic strength of the 100% CO denim fabric as the yarn becomes finer [22,24,25]. As the weft density increases, there is less space for individual yarn elongation and thus less resistance to dynamic tearing forces [26]. The dynamic tearing strengths of denim fabrics manufactured from filament core-spun yarns are seen to be similar as a function of fiber fineness, but are higher than those of 100% CO denim fabrics at all yarn count considered. It can be also noted that for the fabrics woven from filament core-spun yarns the lower the yarn count of the fabric, the higher the dynamic tearing resistance difference.

Variance analysis and regression equations (Eq. 11) for dynamic tearing strength are shown in *Table VIII.* Both the filament fineness and yarn count have statistically significant (p<0.0001) effects on dynamic tearing strength, with adjusted R^2 value of 91 percent.

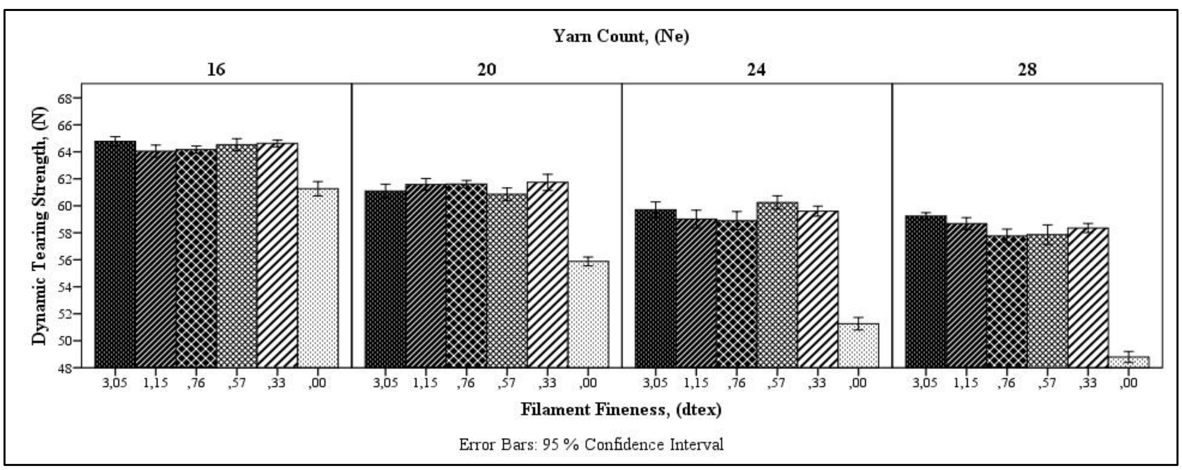

FIGURE 5. Weft wise dynamic tearing strength of denim fabrics.

CONCLUSION

A decrease in weft direction tensile strength of 100% CO denim fabrics was observed with increasing weft density (higher yarn count). The highest tensile strength was observed for fabrics with 37%/63% core/sheath ratio. Statistical analysis shows that filament fineness and yarn count have significant effects on the tensile strength of denim fabrics.

Using PET textured filament as the core part of the yarn positively affects the elasticity of the denim fabric in the weft direction at all yarn counts and fiber finesses considered in this study.

In general, the behavior of 100% CO denim fabrics under static and dynamic tearing forces is influenced by the yarn count changes-the higher the yarn count the lower the static and dynamic tearing resistance It was found that yarn count had no significant on static the tearing resistance of the 100% CO and the filament core spun yarn fabrics. Denim fabric samples made from Ne 28/1 filament core spun yarns showed higher static tearing strength than Ne 24/1 denim fabrics made from filament core spun yarns. In this case, it can be said that it is related to the filament effect in the core. Thus for Ne 16/1 and Ne 20/1 filament core denim fabrics the sheath has a greater effect on static tearing resistance, while for Ne 24/1 and Ne 28/1 filament core denim fabrics, the core contribution is more significant.

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