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Effect of Loop Length and Nozzle Type on Structural and Performance Properties of Single Jersey Knitted Fabrics

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Abstract
We studied the structural properties, bursting strength and pilling properties of single jersey knitted fabrics made from OE rotor spun yarns. Raw material of 100% cotton of the Urfa region of Turkey was specifically handled in the study. The yarns were produced with different nozzle types with a yarn of linear density of 19.67 tex. Five different ceramic nozzles were used in yarn production. These nozzle types are known as K4KK, K4KS, K6KF, K8KK & KSNX. Fabrics were produced by a 28 gauge 32 inch diameter circular knitting machine. The yarns were processed to single jersey knitted fabrics by adjusting the yarn loop length between 14 - 17 cm on the machine as they were the minimum and maximum values limited by the yarn type, machine and commercially accepted conditions. The purpose of this paper was to investigate the effect of fabric density and nozzle type on the structural and performance properties of single jersey knitted fabrics investigated in both a grey and dyed state. In addition, results were interpreted statistically and regression equations obtained.

Key words: *nozzle type, single jersey, knitted fabric, bursting strength, pilling resistance.*

Introduction

Knitted fabric usage has been increasing all over the world because of the simple and quick production technique, lower production costs, being more comfortable, softness of the fabric structure, as well as being appropriate to fashion and a variety of products. The quality of a garment is determined by the characteristics of each of its components, from the fibre and fabric to the very last finishing detail. Many properties help to determine fabric quality and, consequently, the quality of apparel or other products in which the fabrics are used. Textile testing procedures are often used for quality control.

The physical and mechanical properties of knitted fabrics are very important in many ways. Among these properties, the bursting strength is extremely important. Bursting strength is the force or pressure required to rupture a textile by distending it with a force that is applied at right angles to the plane of the fabric. As the force increases, the fabric distorts and forms a bubble until it finally ruptures or tears apart [1].

Among the fabric parameters that affect pilling, fabric type seems to be the most important one. We know that knitted fabrics pill more because of their loose structure since this causes easier fibre migration. Pilling is a fabric surface fault characterised by little balls or "pills" of entangled fibres clinging to the fabric surface. Unsightly pills are formed during the use and laundering of the textile product, and most often are seen in the areas of a garment [2].

In literature many studies [3 - 7] have been made on the effect of nozzle type on yarn structure, yarn surface properties and yarn quality in rotor spinning. A number of these studies were made with 100% cotton. As a result of these studies, it was found that nozzle types without grooves have an improving effect on yarn irregularity, hairness and strength.

Many researchers [8 - 13] investigated the influence of the spinning system, yarn count, raw material and other related subjects on the structural properties of knitted fabrics. According to the results of these studies, the strength and elongation of weft knitted fabrics increased with increasing density. In addition, improved softness and smoothness were observed. By increasing the weight of the fabric and the loop length, the pilling resistance and bursting strength increased. Other researchers studied [14, 15] pilling measurement systems developed using an image processing technique. Rotor spun yarn is widely used in knitted fabric production and rotor spun yarn characteristics are influenced by nozzle type within a wide range. Nevertheless in the literature there is a lack of information about the effect of nozzle type on rotor spun yarn knitted fabrics. In this study the effect of fabric density and nozzle type on the structural and performance properties of single jersey knitted fabrics were investigated for both the grey and dyed state. In addition, results were interpreted statistically and regression equations obtained.

Material and method

In this study, 100% Urfa region cotton was used as raw material. The properties of cotton were tested using an Uster HVI 900 test device and evaluated on the basis of Uster statistics [16]. The fabrics, before and after the sanforisation process, were conditioned for 24 hours preliminary to testing and measurements at the standard relative humidity 65 ± 2% and 20 ± 2 °C temperature in accordance with Standard EN ISO 139 [17]. Fibre properties are given in ***Table 1***.

During the production, five different nozzle types were used. In this study 100% Urfa cotton was converted into 5.91 ktex. Slivers were fed through rotor spinning units and produced on a rotor spinning machine. Spinning conditions and production parameters of the machine are given in ***Table 2***.

100% cotton yarn suitable for knitting rotor groove types S and D in a diamond-

Table 1. *Fibre properties.*

Parameters	Measured values	Uster classification
Upper half mean length, mm Mean Lenght	14.33 29,35.(mm)	Medium long
Microneire, μg/inch	4.9	Medium fine
Uniformity, %	48.8	Very good
Strenght, cN/tex Elongation, %	24.83 9.9	Medium Very high
Yellow grade (+b) Brightness Color Grade	9.47 76,60 21- 4	White cotton
Number of contamination, cont/g	551	-

Table 2. Yarn and machine production parameters.

Yarn production parameters	Yarn count, tex	19.67
	Sliver number, ktex	5.91
	Number of twist, twist/m	840
	Twist factor, α_m	118
Machine production parameters	Rotor type	32 SD
	Rotor diameter, mm	32
	Rotor speed, m/min	102,360
	Opening roller type	OB 20
	Opening roller speed, m/min	7,700
	Nozzle types	K4KK,K4KS,K6KF,K8KK,KSNX

Table 3. Test results of yarn properties.

Parameters of yarn tested	Nozzle types				
	K4KK	K4KS	K6KF	K8KK	KSNX
Uniformity, Um%	12.67	12.72	12.79	12.75	12.29
Mass variation of coefficient, CVm%	15.95	16.03	16.13	16.08	15.51
Thin places, (-50%)/km	70.3	79.5	77.3	66.3	59
Thick places, (+50%)/km	111.8	117.5	115.3	111.3	76.8
Neps, (+280%)/km	22.8	63.8	21.0	24.3	10.8
Strength, cN/tex	10.22	8.69	11.47	10.14	10.04
Breaking strength, cN	201.3	171.1	225.9	199.7	197.8
Breaking work, cNxcm	264.3	208.2	306.3	251.5	261.4
Elongation, %,	4.86	4.47	5.04	4.74	4.96
Uster hairiness index (H)	5.16	7.12	4.99	5.30	5.34

Table 4. Yarn loop length on machine for fabric production (50 needle).

Density notation	1	2	3	4	5
Yarn loop length adjusted on the machine L_A, cm	14	14.8	15.5	16.2	17
Fabric classification according to yarn loop length	very high density	high density	medium density	low density	very low density

coated form on rotor spinning machines was used. In order to minimise variations, yarm production was pre-determined on the rotor unit simplyby changing the nozzle type; all other machine production parameters were kept constant.

For yarn evenness, faults and hairiness an Uster Tester 4SX test device was used and the results evaluated according to Uster statistics [18]. Yarn strength was tested in accordance with EN ISO 2062. Test results of yarn properties are give in ***Table 3***.

Table 5. Knitting machine production parameters.

Machine diameter, inch (cm)	32 (78.4)
Machine fineness, gauge	28
Number of system	102
Machine speed, m/min	26 - 28
Total number of needles on the machine	2808
Feed type	Positive
Coil position	Side

Knitting machine production parameters are given in ***Table 5***. A Mayer & Cie. Relanit 3.2. type circular knitting machine of 28 gauge and 32 inch diameter with positive feed systems was used. OE rotor spinning yarns were produced in five different yarn loop lengths for single jersey knitted fabrics. The yarn loop length on the machine for production is given in ***Table 4***.

The yarn loop length was determined in accordance with Standard EN 14970[19]. Course and wale density values per cm were taken into account for the study in accordance with Standard EN 14971[20]. Similarly the mean fabric weight per square-meter was determined in accordance with Standard EN 12127 [21]. The bursting strength of grey and dyed samples were tested using a James Heal TruBurst bursting strength tester (UK) according to Standard EN ISO 13938-2 [22]. The pilling properties of grey and dyed samples were tested in accordance with EN ISO 12945-2 using a Martindale pilling tester, starting with cycles from 125 to 7000 r.p.m. In the evaluation of pilling tendency, scale 1 means very severe pilling, 2 severe pilling, 3 moderate pilling, 4 slight pilling and 5 means no pilling [23]. The dyeing recipes of the sample fabrics, given in ***Table 6***, were used in the same conditions. An HT 11 Jumbo dyeing machine with a 1/6 rate of the dyeing process was used with liquor.

Results and discussion

Effect of adjusted yarn loop length on fabric structural parameters

Figure 1 shows the yarn loop length of grey and dyed single jersey knitted fabrics measured in relation to the adjusted yarn loop length on the machine. In the equations, x is the adjusted loop length on the machine for fabric production and y is the measured loop length in cm.

It can be seen from ***Figure 1*** that there is a linear relationship between the adjusted and measured yarn loop length values, as expected. The following expression was constructed in order to give a better understanding of the variation in yarn loop length in the grey and dyed fabric.

For grey fabric; regression ***Equation 1*** was obtained from the regression analysis

$$L_{RH} = 1.0002L_A + 0.0268 \quad R^2 = 0.9979 \qquad (1)$$

The absolute relative difference was calculated from the measured and predicted (L_{RH}) values by the following ***Equation 2***

$$B_{FH} = \frac{|L_M - L_{RH}|}{L_M} \times 100, \% \qquad (2)$$

For dyed fabric; regression ***Equation 3*** was obtained from the regression analysis

$$L_{RM} = 0.9948L_A + 0.1329 \quad R^2 = 0.9962 \qquad (3)$$

The absolute relative difference was calculated from the measured and predicted (L_{RM}) values by the following ***Equation 4***

Table 6. Dyeing recipe.

Dyeing recipe	Unit	Quantity
Yellow Dexf	%	0.0015
Red Dexf	%	0.018
Salt	g/dm^3	20
Soda	g/dm^3	15
Temperature	^{o}C	40
Colour	-	pink

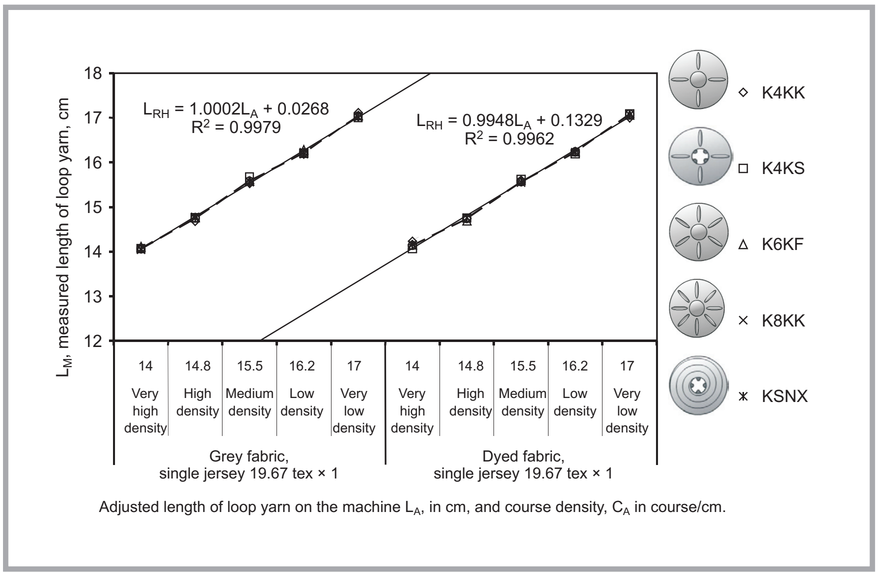

Figure 1. Yarn loop length of sample fabrics.

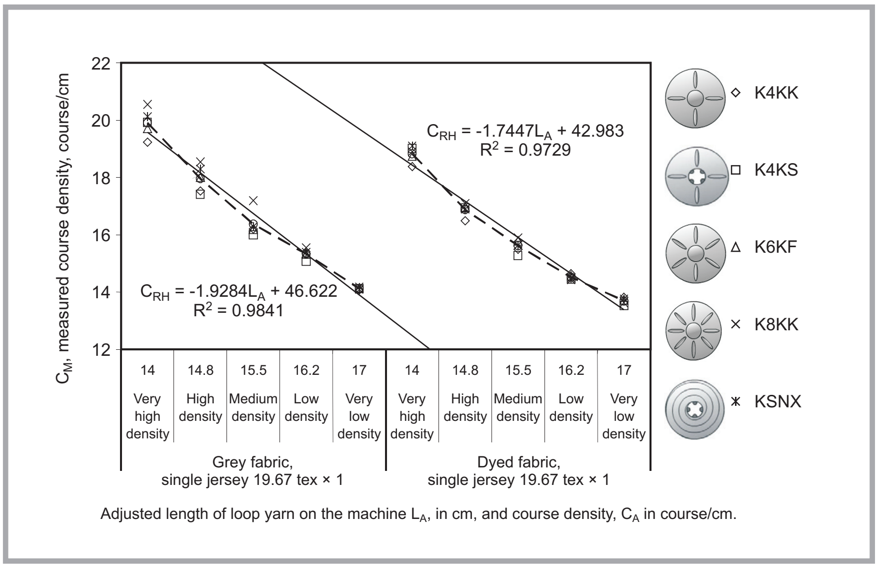

Figure 2. Course density of sample fabrics.

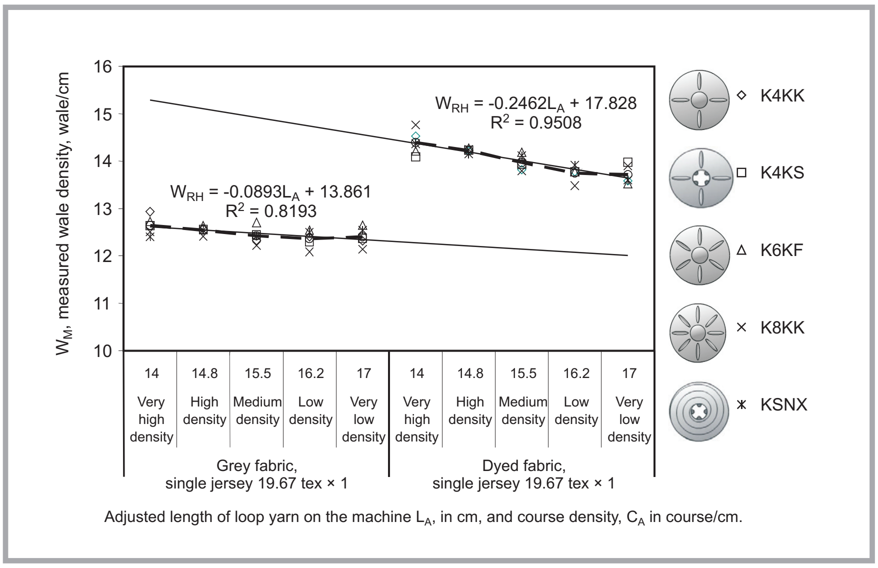

Figure 3. Wale density of sample fabrics.

$$B_{FM} = \frac{|L_M - L_{RM}|}{L_M} \times 100, \% \qquad (4)$$

Absolute relative differences for different yarn loop lengths were calculated using ***Equations 1*** and ***2***. According to absolute relative difference values, the grey fabric regression equation can predict with 99.11% accuracy. Similarly absolute relative differences for different loop yarn lengths were calculated using ***Equations 3*** and ***4***. According to absolute relative difference values for the dyed fabric, the regression equation can predict with 99.15% accuracy.

It is seen from ***Figure 2*** that there is a linear relationship between the adjusted and measured values.

For grey fabric regression ***Equation 5*** was obtained from the regression analysis

$$C_{RH} = -1.9284 L_A + 46.622$$
$$R^2 = 0.9841 \qquad (5)$$

The absolute relative difference was calculated from the measured and predicted (C_{RH}) values by following ***Equation 6***

$$B_{FH} = \frac{|C_M - C_{RH}|}{C_M} \times 100, \% \qquad (6)$$

For dyed fabric regression ***Equation 7*** was obtained from the regression analysis

$$C_{RM} = -1.7447 L_A + 42.983$$
$$R^2 = 0.9729 \qquad (7)$$

The absolute relative difference was calculated from the measured and predicted (C_{RM}) values by following ***Equation 8***

$$B_{FM} = \frac{|C_M - C_{RM}|}{C_M} \times 100, \% \qquad (8)$$

Absolute relative differences for different yarn loop lengths were calculated using ***Equations 5*** and ***6***. According to absolute relative difference values, the grey fabric regression equation can predict with 95.4% accuracy. Similarly the absolute relative differences for different loop yarn lengths were calculated using ***Equations 7*** and ***8***. According to the absolute relative difference values for dyed fabric, the regression equation can predict with 95.65% accuracy.

Figure 3 shows the wale density measured for the single jersey,grey and dyed fabrics. Wale density changes of grey fabrics were between 12 - 13 wales/cm,

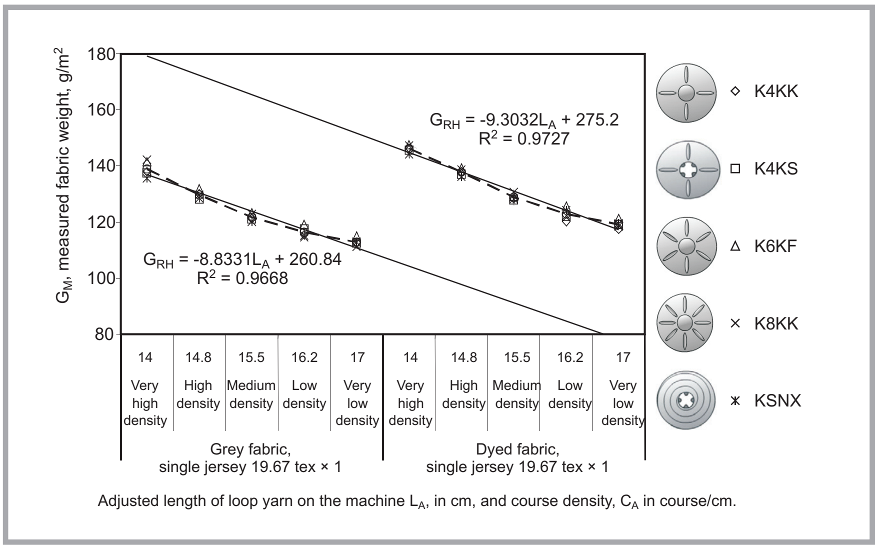

***Figure 4.** Fabric weight of sample fabrics.*

while changes of dyed fabrics were between 13 - 15 wales/cm.

For grey fabric regression ***Equation 9*** was obtained from the regression analysis

$$W_{RH} = -0.0893L_A + 13.861 \quad R^2 = 0.8193 \qquad (9)$$

The absolute relative difference was calculated from the measured and predicted (W_{RH}) values by the following ***Equation 10***

$$B_{FH} = \frac{|W_M - W_{RH}|}{W_M} \times 100, \% \qquad (10)$$

For dyed fabric regression ***Equation 11*** was obtained from the regression analysis

$$W_{RM} = -0.2462LA + 17.828 \quad R^2 = 0.9508 \qquad (11)$$

The absolute relative difference was calculated from the measured and predicted (W_{RM}) values by the following ***Equation 12***

$$B_{FM} = \frac{|W_M - W_{RM}|}{W_M} \times 100, \% \qquad (12)$$

Absolute relative differences for different loop lengths were calculated using ***Equations 9*** and ***10***. According to absolute relative difference values for grey fabric, the regression equation can predict with 97.27% accuracy. Similarly absolute relative differences for different loop lengths were calculated using ***Equations 11*** and ***12***. According to absolute relative difference values for dyed fabric, the regression equation can predict with 97.4% accuracy.

Figure 4 shows the fabric weight of sample fabrics in relation to the adjusted loop length on the machine. It can be seen from ***Figure 4*** that there is a linear relationship between the adjusted and measured weight values, as expected. Because the calculation results from the regression equations are well fitted, these equations may be used to predict the fabric weight of grey and dyed single jersey fabrics produced from 19.67 tex × 1 rotor spun yarn.

The following expression was constructed in order to give a better understanding of the variation in grey and dyed fabric weight.

For grey fabric regression ***Equation 13*** was obtained from the regression analysis

$$G_{RH} = -8.833L_A + 26084 \quad R^2 = 0.9668 \qquad (13)$$

The absolute relative difference was calculated from the measured and predicted (G_{RH}) values by following ***Equation 14***

$$B_{FH} = \frac{|G_M - G_{RH}|}{G_M} \times 100, \% \qquad (14)$$

For dyed fabric regression ***Equation 15*** was obtained from the regression analysis

$$G_{RM} = -9.3032L_A + 275.2 \quad R^2 = 0.9727 \qquad (15)$$

The absolute relative difference was calculated from the measured and predicted (G_{RM}) values by following ***Equation 16***

$$B_{FM} = \frac{|G_M - G_{RM}|}{G_M} \times 100, \% \qquad (16)$$

Absolute relative differences for different loop lengths were calculated using ***Equations 13*** and ***14***. According to absolute relative difference values for grey fabric, the regression equation can predict with 96.23% accuracy. Similarly absolute relative differences for different loop lengths were calculated using ***Equations 15*** and ***16***. According to absolute relative difference values for dyed fabric, the regression equation can predict with 96.42% accuracy.

The experimental results were statistically evaluated using Design Expert Analysis of Variance (ANOVA) software with F values at a significance level of α = 0.005 with the intention of exploring whether there is any statistically significant difference between the variations obtained. We evaluated the results based on the F ratio and the probability thereof (prob > F). The lower the probability of the F-ratio, the stronger the contribution of the variation and the more significant the variable.

Table 7 summerises the statical significance analysis for loop length as well as course, wale and fabric weight, evaluated separately. In the ***Table 7*** variables are the nozzle type as well as the adjusted loop length and interactions of these two parameters.

As a result of this study, we can state that the type of nozzle (*NT*), measured for grey and dyed fabrics, loop length (L_{MH}, L_{MM}), course density (C_{MH}, C_{MM}), wale density (W_{MH}, W_{MM}), and fabric weight (G_{MH}, G_{MM}) did not have a significant effect. Loop length was determined to have a significant impact on the properties of the fabric measured. Fabric characteristics of bilateral interactions of the factors did not have a significant impact.

Bursting strength variation

Figure 5 shows the bursting strength of fabric samples, and linear regression equations are also given.

For grey fabric regression ***Equation 17*** was obtained from the regression analysis

$$S_{RH} = -20.976L_A + 796.76 \quad R^2 = 0.9979 \qquad (17)$$

The absolute relative difference was calculated from the measured and predicted (S_{RH}) values by following ***Equation 18***

$$B_{FH} = \frac{|S_M - S_{RH}|}{S_M} \times 100, \% \quad (18)$$

For dyed fabric regression ***Equation 19*** was obtained from the regression analysis

$$S_{RM} = -23.363 L_A + 810.65 \quad R^2 = 0.9776 \quad (19)$$

The absolute relative difference was calculated from the measured and predicted (S_{RM}) values by following ***Equation 20***

$$B_{FM} = \frac{|S_M - S_{RM}|}{S_M} \times 100, \% \quad (20)$$

Absolute relative differences for different loop lengths were calculated using ***Equations 17*** and ***18***. According to absolute relative difference values for grey fabric, the regression equation can predict with 91.08% accuracy. Similarly absolute relative differences for different loop yarn lengths were calculated using ***Equations 19*** and ***20***. According to absolute relative difference values for dyed fabric, the regression equation can predict with 93.43% accuracy.

Figure 5 illustrates that an increase in fabric weight or course density has an increasing effect on the fabric bursting strength. In addition, the yarns examined were produced under the same conditions with the same fibres. Test results of yarn strength are given in this paper (***Table 3***), which show that the K6KF nozzle type produces the strongest yarn strength. Hence, as shown in ***Figure 5***, the strength of yarns produced form the different nozzle types was also an important paremeter determining fabric strength. ***Table 8*** summarizses data obtained from the statistical significance analysis for bursting strength.

As a result of this study, we can conclude that the type of nozzle (*NT*), loop length (L_A), and bursting strength measured (S_{MH} and S_{MM}) werefound to have a significant impact on grey and dyed fabric. Fabric characteristics of bilateral interactions of the factors did not have a significant impact.

Pilling resistance

The pilling resistance of samples was tested using a Mardindale Pilling&Abrasion Tester usingthe standard (ISO 12945-2:2000) "Textiles - Determination of fabric propensity to surface fuzzing and to pilling - Part 2: Modified Martindale method". The pilling standards used for rating the fabrics had the following scales: 5 - no pilling, 4 - slight pilling, 3 - moderate pilling, 2 - severe pilling and 1 - very severe pilling. These assessments were carried out under D65, artificial daylight, using EMPA Standard photography as a pilling assessment viewer (***Figure 9***).

The results (***Figure 9***) of these experimental studies were evaluated by a Design-Expert 6.0.1 statistical software package with one-way analysis of variance (ANOVA), where for factor F a level of significance of α = 0.05 was preferred. ***Table 10***) gives the statistical significance analysis for the pilling data. The nozzle type and loop length have no significant influence on pilling properties. Hence in this study they are considered as minor factors. The higher the pilling cycles, the more severe or very severe the pilling is for the fabrics.

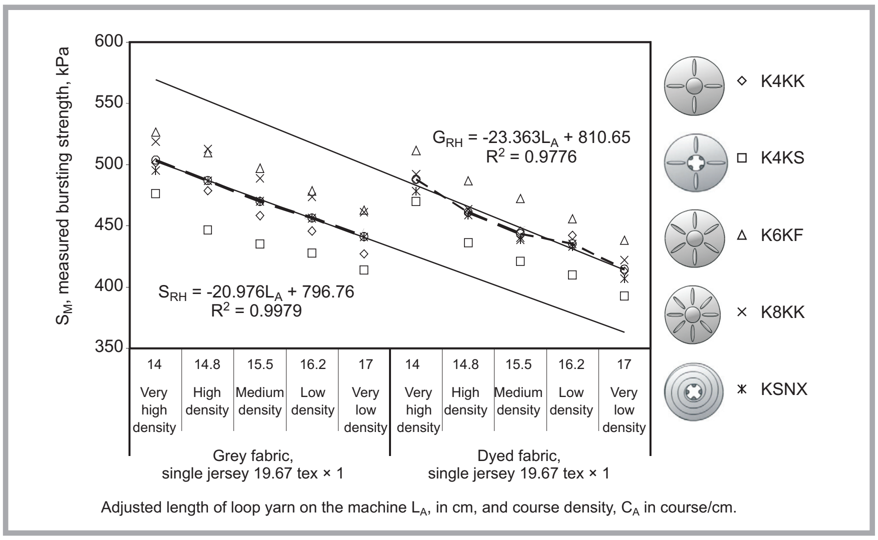

Figure 5. *Bursting strength of sample fabrics.*

Table 7. *Statistical significance analysis for structural properties of sample fabrics; F-V: F value, P-V: P value, C % is the contribution in percent.*

Fabric properties	Nozzle type (NT)			Machine adjusted loop length (L_A)			Bilateral interaction NTxL_A	Undetermined effect, %
	F-V	P-V	C, %	F-V	P-V	C, %	C, %	
L_{MH}, cm	0.53	0.7143	0.038	1395	0.0001	99.34	0.17	0.45
L_{MM}, cm	0.095	0.9832	0.011	854.6	0.0001	99.02	0.25	0.72
C_{MH}, course/cm	5.92	0.0017	1.65	344.0,	0.0001	95.56	1.06	1.74
C_{MM}, course/cm	0.75	0.5684	0.21	342.2	0.0001	97.25	0.76	1.78
W_{MH}, wale/cm	1.14	0.3522	8.92	3.44	0.0706	7.29	5.07	78.72
W_{MM}, wale/cm	0.041	0.9967	0.22	30.81	0.0001	42.94	17.31	39.52
G_{MH}, g/m²	7.72	0.0003	1.66	446.2	0.0001	95.67	1.33	1.34
G_{MM}, g/m²	14.85	0.0001	0.89	1631	0.0001	97.81	0.93	0.37

Table 8. *Statistical significance analysis for bursting strength of sample fabrics.*

Fabric properties	Nozzle type (NT)			Machine adjusted loop length (L_A)			Bilateral interaction NT×L_A	Undetermined effect, %
	F-V	P-V	C, %	F-V	P-V	C, %	C, %	
S_{MH}	206.36	0.0001	50.45	191.72	0.0001	46.87	1.27	1.41
S_{MM}	158.80	0.0001	26.58	426.08	0.0001	71.33	1.05	1.05

Conclusion

The following conclusions can be drawn from the results of this experimental study.

1. For grey and dyed samples the yarn loop length can be treatedas one of the decisive and main machine parameters determined.
2. For grey and dyed samples the adjusted loop length has a significant effect on the loop length, course density,

Table 9. *Pilling resistance of sample fabrics; GF: grey fabric, DF: dyed fabric.* ***Abbreviations****: pilling cycles of grey and dyed fabric measured (P_H, P_M).*

Nozzle types	Pilling cycles, r.p.m.	Yarn loop length adjusted on machine L_A, cm									
		14		14.8		15.5		16.2		17	
		GF	DF	GF	DF	GF	DF	GF	DF	GF	DF
K4KK	125	5	5	5	5	5	5	5	5	5	5
	500	4 - 5	5	4	5	4	4 - 5	4	4	4	4
	1,000	4	4 - 5	4	4 - 5	3 - 4	4	3	3 - 4	3	3 - 4
	2,000	3	4	3	4	3	3 - 4	3	3 - 4	2 - 3	3
	5,000	2	3 - 4	2	3 - 4	2	3	2	3	2	2 - 3
	7,000	2	3 - 4	2	3	2	2 - 3	2	2 - 3	2	2 - 3
K4KS	125	5	5	4 - 5	5	4 - 5	5	5	5	5	5
	500	4 - 5	5	4	5	4	5	4	4 - 5	4	4 - 5
	1,000	4	4 - 5	3 - 4	4 - 5	3 - 4	4 - 5	3 - 4	4	3 - 4	4
	2,000	3	4	3	4	3	4	3	3 - 4	3	3 - 4
	5,000	2 - 3	3	2 - 3	3	2 - 3	3	2 - 3	3	2 - 3	3
	7,000	2	3	2	3	2	3	2	2 - 3	2	2 - 3
K6KF	125	5	5	5	5	5	5	5	5	5	5
	500	4 - 5	5	4	5	4	5	4	4 - 5	4	4 - 5
	1,000	3 - 4	4 - 5	3 - 4	4 - 5	4	4	3 - 4	4	4	4
	2,000	3	4	3	4	3 - 4	4	3	4	3	3 - 4
	5,000	2 - 3	3 - 4	2 - 3	3 - 4	3	3 - 4	2 - 3	3	2	2 - 3
	7,000	2	3	2	3	2	3	2	3	2	2 - 3
K8KK	125	5	5	5	5	5	5	4 - 5	5	4 - 5	5
	500	4 - 5	5	4 - 5	5	4	4 - 5	4	4 - 5	4	4 - 5
	1,000	4	4 - 5	3 - 4	4 - 5	3 - 4	4	3 - 4	4	3	4
	2,000	3 - 4	4	3	4	3	4	3	3 - 4	2 - 3	3
	5,000	3	3 - 4	2 - 3	4	2	3	2	3	2	2 - 3
	7,000	2	3 - 4	2	3	2	3	2	2 - 3	1 - 2	2 - 3
KSNX	125	5	5	5	5	5	5	5	5	5	5
	500	4 - 5	5	4 - 5	5	4	4 - 5	4	4 - 5	4 - 5	4 - 5
	1,000	4	4 - 5	4	4 - 5	3	4 - 5	3 - 4	4	4	4
	2,000	3 - 4	4	3	4	3	3 - 4	3	3 - 4	3	3 - 4
	5,000	2 - 3	3 - 4	2 - 3	3 - 4	2	3	2 - 3	3	2	3
	7,000	2	3 - 4	2	3	2	2 - 3	2	2 - 3	1 - 2	2 - 3

Table 10. *Statistical significance analysis for pilling resistance of sample fabrics.*

Fabric propery	Nozzle type (NT)			Machine adjusted loop length (L_A)			Number of pilling cycles (PC)			I	L
	F-V	P-V	C, %	F-V	P-V	C, %	F-V	P-V	C, %	C %	C %
P_H	12.10	<0.0001	0.61	30.94	<0.0001	1.56	1486.73	<0.0001	93.81	0.62	-
P_M	13.59	<0.0001	1.00	104.46	<0.0001	7.65	900.04	<0.0001	82.39	1.24	2.60

fabric weight and bursting strength measured but an insignificant one on the wale density.

3. On the other hand, the nozzle type has an insignificant effect on the yarn loop length, course density, wale density and fabric weight measured for grey and dyed samples, while it has a significant effect on the bursting strength.
4. The nozzle type and loop length do not have a significant influence on pilling properties. Hence in this study they are considered as minor factors. The higher the pilling cycles, the more severe or very severe the pilling is for grey and dyed sample fabrics. As the number of pilling cycle increases from 125 to 7000, the pilling of dyed and grey fabrics increases.

It was observed that the dying process has a significant effect on the bursting strength and pilling resistance.

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