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Analysis on the Pilling Factors of Cashmere Knitted Fabric

Long Li* and Wei Zhou

School of Textile & Materials, Xi'an University of Engineering Science & Technology, Xi'an 710048, P. R.China
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Abstract: The effect of cashmere yarn twist, knitted fabric density, and cashmere properties on pilling rates of cashmere knitted fabric is investigated in this paper. The experimental results show that yarn twist and fabric density have little influence on pilling rates of cashmere knitted fabric for yarn 38.4 tex/2 when yarn twist varies from 234 T/m to 272 T/m, and the fabric density is 9.7, 10.7, and 11.2 yarns/inch, respectively. The length of cashmere fiber, in particular less than 7.5 mm, is responsible for the pilling rates of cashmere knitted fabric based on optimal scaling regression analysis.

Keywords: Pilling, Yarn twist, Knitted fabric density, Cashmere, Optimal scaling regression analysis

Introduction

Fabric pilling has been researched since 1950's in the field of textile technology. Cashmere, as a luxury animal fiber, is thinner in diameter and shorter in length than wool [1]. Because of small diameter, short length, and smooth surface of cashmere fiber, the pilling of cashmere knitted fabric has attracted the attention from consumers, manufacturers and researchers. Li and Zhou [2] reported the pilling test technology of cashmere knitted fabric. However, the effect factor of the pilling propensity of cashmere knitted fabric has not been reported. It is reported that the properties of textile materials, the twist of yarn, and the density of fabric influence the pilling rates of fabric [3]. In order to increase the pilling rates of cashmere knitted fabric, the designers usually increase the twist of yarn and the density of fabrics. But, the handle of cashmere knitted fabric become poor with increasing yarn twist and fabric density. In this paper, the pilling rates of cashmere knitted fabric were tested using ICI's Pilling Box, and effect of cashmere yarn twist, knitted fabric density, and cashmere properties on pilling rates of cashmere knitted fabric is investigated.

Experimental

Samples

All cashmere yarns and knitted fabrics were supplied by China ERDOS Cashmere Co. All yarns are 38.4 tex/2. All cashmere knitted fabrics are jersey stitch, and the density fabric is 9.7, 10.7, and 11.2 yarn/inch, respectively.

Pilling Rates Test

The pilling rates were tested using ICI's Pilling Box. The test time was 2 hours. The pilling of fabric was tested and rated by an experienced test person. The pilling standards used for rating the fabrics had the following scales: 5: no pills, 4: slight pilling, 3: moderate pilling, 2: severe pilling, 1: very severe pilling.

*Corresponding author: lilong2188@yahoo.com.cn

Results and Analysis

Effect of Yarn Twist on Pilling Rates

For the trade of cashmere knitted fabric, the 4 pilling rates is good product, and the 3 piling rates is poor. Buyers will refuse to the latter although the difference is only the 1 pilling rates.

Figure 1 shows the yarn twist distribution for the 3 pilling rates and the 4 pilling rates of cashmere knitted fabric. For the 3 pilling rates of fabric, maximum difference of yarn twist is 30 T/m. The max twist difference is 36 T/m for the 4 pilling rates of fabric. From the results, it is shown that yarn

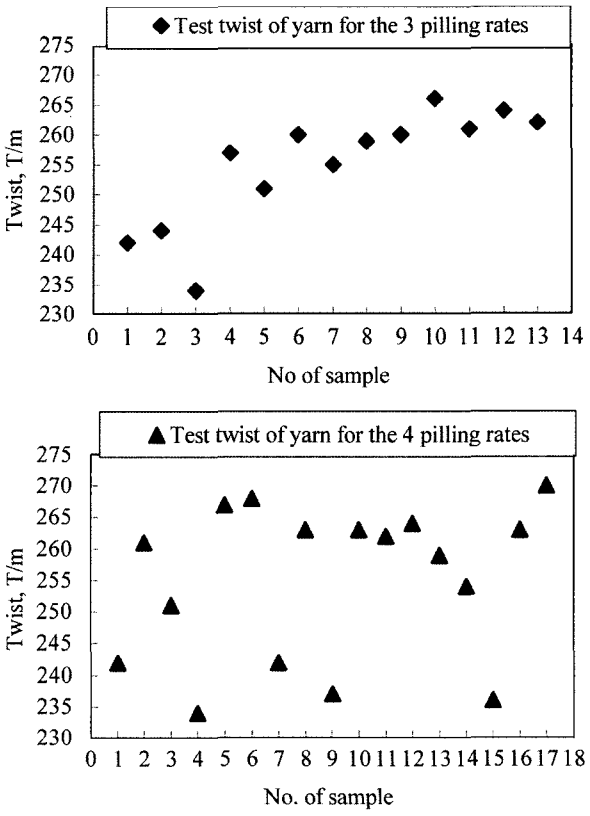

Figure 1. Effect of yarn twist on pilling rates.

twist varying from 234 T/m to 272 T/m is not directly related to the pilling rates of cashmere knitted fabrics. Therefore, it is difficult to control the pilling rates of cashmere knitted fabric only by increasing the twist of yarn.

Effect of Fabric Density on Pilling Rates

Three kinds of fabric density (9.9, 10.7, and 11.2 yarn/inch, respectively) were knitted for every cashmere yarn. Table 1 shows the properties of four kinds of cashmere yarns. Figure 2 shows the effect of fabric density on pilling rates of cashmere knitted fabric. It is shown from the result that the density of fabric has little influence on pilling rates for the same yarn when the density of fabric is 9.7, 10.7, and 11.2 yarns/inch, respectively. However, the pilling rates of the fabric is various for different cashmere yarn.

From the results, it is shown that yarn twist and fabric density have little influence on pilling rates of cashmere fabric when yarn twist and fabric density are set in a certain extent.

Table 1. The properties of cashmere yarns

Yarn	Yarn twist, T/m	Twist CV, %	Yarn evenness, %
1	234	7.71	9.77
2	260	4.54	9.47
3	233	10.67	10.63
4	261	5.0	8.46

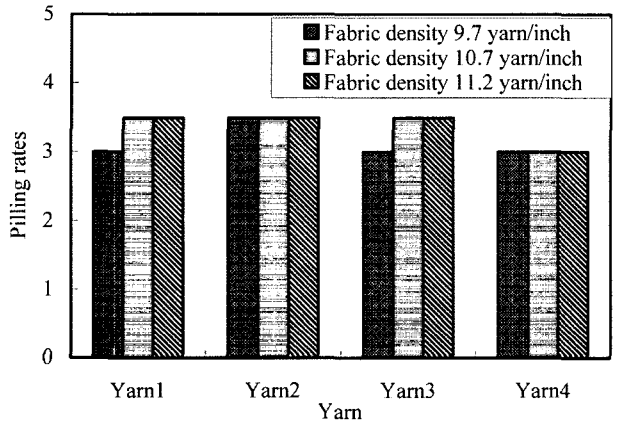

Figure 2. Effect of fabric density on pilling rates.

Effect of Materials on Pilling Rates

The properties of 15 kinds of cashmere are shown in Table 2. The yarn twist varies from 234 T/m to 268 T/m, and the fabric density varies from 10.9 to 11.5 yarns/inch. The data are analyzed by using optimal scaling regression method in SPSS statistics software. The original ordinal variables are transformed by using nonlinear transformation method, and then the equation are obtained by repeat iterating.

The convergence level is achieved after 74 iterations. R is 99.1 %, R^2 98.2 %. By adjusting optimal scaling, R^2 changes

Table 3. Coefficients

	Standardized coefficients		d_f	F	Sig.
	Beta	Std. error			
Mean diameter	.318	.056	1	32.454	.000
Diameter CV	−.571	.063	1	81.738	.000
Length CV	−.842	.113	1	55.211	.000
%<7.5 mm	−.921	.054	1	294.621	.000
%<12.5 mm	.975	.110	1	78.520	.000
X1X3	−.435	.057	1	58.092	.000

Dependent variable: pilling rates (Y).

Table 2. The properties of 15 kinds of materials

Cashmere	Mean diameter, μm (X_1)	Diameter CV, % (X_2)	Mean length, mm (X_3)	Length CV, % (X_4)	%<7.5 mm (X_5)	%<12.5 mm (X_6)	Pilling rates (Y)
1	15.1	21.60	34.70	50.20	9.67	22.70	3.00
2	15.1	22.70	32.90	48.70	9.50	26.70	4.00
3	15.2	22.10	33.60	49.80	9.55	25.40	4.00
4	15.2	21.90	33.90	49.90	8.30	22.90	4.00
5	15.2	22.10	35.30	55.50	10.80	28.60	3.00
6	15.2	22.10	35.10	53.30	8.30	27.80	4.00
7	15.2	22.19	33.90	49.90	8.30	22.90	4.00
8	15.2	22.30	36.50	48.50	10.20	22.50	3.00
9	15.2	22.60	33.10	51.00	11.10	26.80	3.00
10	15.2	22.50	33.80	50.10	12.00	26.90	3.00
11	15.2	22.10	35.30	55.50	10.80	28.60	3.00
12	15.2	22.60	33.10	51.00	11.10	26.80	3.00
13	15.3	21.90	34.60	52.40	10.70	25.90	3.00
14	15.3	22.90	33.50	52.40	8.90	28.00	4.00
15	15.4	21.80	32.70	53.60	12.40	30.70	4.00

into 96.4 %.

Under significant level 5 %, all the P values of the independent variables are less than 0.05 except that of the mean length and the interaction of the mean length and the mean diameter. So, the mean length and the interaction of the mean length and the mean diameter have little influence on pilling rate.

If the mean length is removed from the equation, the convergence test value is reached after 24 iterations. R is 99.1 %, R^2 98.2 %. By adjusting optimal scaling, R^2 changes into 96.9 %.

The standardized coefficients of the variables included in the equation are shown in Table 3. The all significance of the well-chosen variables is less than 0.0001, which negatives the assumption that the partial regression coefficient is 0. So, the equation has statistic significance. Based on the coefficients and the meaning of the original variables, it is got that the thinner the mean diameter and the higher the diameter CV, the lower the pilling rates. The less the length CV and the higher the pilling rates. And, the more the short fiber (%<7.5 mm), the lower the pilling rates.

The effect of cashmere properties on pilling rates of cashmere knitted fabric as follows:

$$Y = 0.318X_1 - 0.571X_2 - 0.842X_4 - 0.921X_5 + 0.975X_6 - 0.435X_1X_3$$

In which, the meanings of Y, X_i are shown in Table 2.

The correlations index and the tolerance index of all independent variables are shown in Table 4. The tolerance of the other independents is bigger than 0.5 except the tolerance of the length CV and the short fiber (%<12.5 mm). From the importance of independent variables shown in Table 4, the short fiber (%<7.5 mm) is firstly important in the equation, then the interaction of fiber length and fiber diameter. Based on the partial correlations in Table 4, there is a good relationship between the independent variables (Xi) in the equation and the dependent variable (Y). The correlations between the short fiber content (%<7.5 mm) and the pilling rates is the highest, then the diameter CV, length CV, the interaction of the mean length and the mean diameter, the short fiber content (%<12.5 mm), mean diameter.

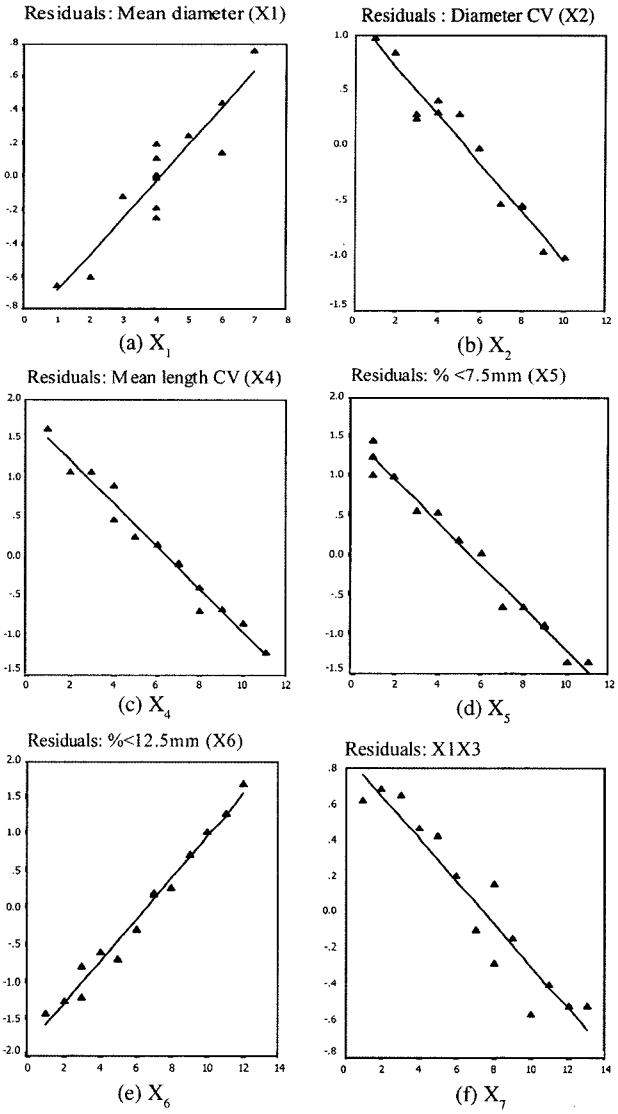

Figure 3. Residuals plot; (▲) Residuals labeled by case numbers, (–) Unnormalized quantification.

Figure 3 is the residual plots of the independent variables.

Table 4. Correlations and tolerance

	Correlations			Importance	Tolerance	
	Zero-Order	Partial	Part		After transformation	Before transformation
Mean diameter,	.098	.896	.269	.032	.713	.713
Diameter CV	.031	–.954	–.426	–.018	.557	.557
Length CV	–.209	–.935	–.350	.179	.173	.173
%<7.5 mm	–.659	–.987	–.809	.618	.772	.772
%<12.5 mm	.031	.953	.418	.031	.184	.184
X1X3	–.354	–.938	–.359	.157	.682	.682

Dependent variable: pilling rates (Y).

It is shown that all the residuals plots are linearity. So the normal distribution assumption of the error is reasonable.

Conclusions

Cashmere yarn twist and knitted fabric density have little effect on pilling rate of cashmere knitwear when yarn twist varies from 234 T/m to 272 T/m, and the fabric density is 9.7, 10.7, and 11.2 yarns/inch. The properties of cashmere influence the pilling rates, especially the short fiber content (%<7.5 mm) and the length CV have a significant influence on the pilling rates of cashmere knitted fabric. To improve the pill-resistance of cashmere knitwear, fiber breakage in carding and fiber damage in dyeing must be decreased.

Acknowledgements

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