

PILLING CAPACITY ASSESSMENT OF COTTON KNITTED FABRICS AFTER FINISHING PROCESS

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Abstract

This paper presents the influence of dyeing process parameters on the pilling effect of plain-weft knitted fabrics made of 50% Cotton and 50% Polyester blended yarns performed on CMS 530 E 6.2 weft flat knitting machine, Stoll, Germany. For this purpose a multiple regression method has been used with three independent variables and for pilling capacity assessment a standardized method according to BS EN ISO 12945. It was concluded that dyeing process parameters have a decisive influence on pilling capacity assessment of weft knitted fabrics and the data obtained shows that the pilling of cotton knits on row direction after finishing process was better than on wale direction.

Keywords: weft knitted fabrics, dyeing process, multiple regression method, pilling capacity assessment, pilling grade.

INTRODUCTION

Pilling is an important problem not only for textile and clothes manufacturers but also for users. The effect of the pilling process results in a significant decrease in fabric quality and a negative influence on the user's comfort. At present attempts to classify and standardize textile quality requirements for textiles devoted to clothing manufacturing pilling tendency plays a very important factor. The acceptable value of the pilling rating for woven fabrics is 3 (according to PN EN ISO 12945-2:2002; after 2000 rubs, and for knitted fabric it is also 3, but the test is carried out according to PN EN ISO 12945-1:2002; after 7200/14400 revolutions). These levels of pilling grade force producers to pay special attention to decreasing the pilling tendency [1].

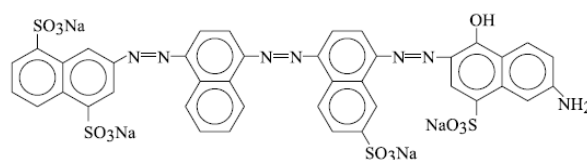
The purpose of this work is to establish the influence of dyeing process parameters on pilling effect of weft- knitted fabrics made of made of 50% Cotton and 50% Polyester blended yarns. The experiments were performed using a multiple regression method [2], taking as independent variables dyeing time process (minutes)-X1, dyeing temperature (°C)-X2 and

pH-dyeing bath noted with X3 and as dependent variable the pilling effect noted with Y [3].

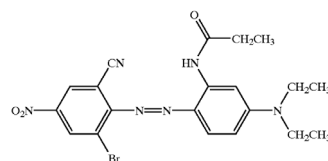
EXPERIMENTAL PART

For this study raw knitted samples made from 50% Cotton and 50% Polyester blended yarns performed on CMS 530 E 6.2 weft flat knitting machine, Stoll, Germany were used and subjected to dyeing operations using a direct dye (C. I. Direct Blue 71) and a disperse dye (C. I. Disperse Blue 183) [4, 5, 6].

The chemical structures of direct and disperse dyes are presented in Figure 1:



C.I. Direct Blue 71



C.I. Disperse Blue 183

Fig. 1. Chemical structures of C.I. Direct Blue 71 and C.I. Disperse Blue 183

The dyeing bath composition:

- 1.5% direct dye
- 1.5% disperse dye
- 10% sodium chloride
- 2g/l wetting agent
- bath ratio 1:20
- pH alkaline performed with Na_2CO_3 (sodium carbonate) and pH acid performed with CH_3COOH (acetic acid).

Dyeing operations were performed using an installation type POLYCOLOR Mathis.

Table 1 presents the values of independent variables and Table 2 presents the experimental plan and pilling grade values of knitted fabrics.

Table.1. The values of independent variables

Variable	Code	Coding value				
		-1.682	-1	0	+1	+1.682
		Real value				
Dyeing time, minute	X1	30	36	45	54	60
Dyeing temperature, °C	X2	80	88	100	112	120
pH	X3	5.5	6	6.5	7	7.5

Dyed samples were conditioned and the assessments were conducted at standard atmosphere (humidity $65 \pm 2\%$ and temperature $20 \pm 2^\circ\text{C}$) and then were tested by determining the capacity for pilling effect, using an ICI Pilling Tester which consists in two boxes on each side lined with a solitary metal plate with a cork lining. Each box was rotated at constant speed of 60 ± 2 revolutions per minutes, and after a specific period of rolling the capacity assessment of pilling effect was evaluated visually by comparison with standard photographs and using a scheme according to BS EN ISO 12945 (Table 3) [7].

Table.2. Dyeing experimental plan and pilling grade values of knitted fabrics

Nr. exp	X_1	X_2	X_3	Y Pilling, [pilling grade]	
				Wales	Rows
1	-1	-1	-1	2	3
2	+1	-1	-1	2	3
3	-1	+1	-1	3	3
4	+1	+1	-1	2	3
5	-1	-1	+1	3	3
6	+1	-1	+1	2	3
7	-1	+1	+1	3	3
8	+1	+1	+1	2	3
9	-1.682	0	0	2	3
10	+1.682	0	0	3	4
11	0	-1.682	0	2	3
12	0	+1.682	0	2	3
13	0	0	-1.682	3	3
14	0	0	+1.682	3	3
15	0	0	0	2	3
16	0	0	0	2	3
17	0	0	0	2	3
18	0	0	0	2	3
19	0	0	0	2	3
20	0	0	0	2	3

Table. 3. Visual assessment of pilling according to BS EN ISO 12945

Grade	Description
5	No change
4	Slight surface fuzzing and/or partially formed pills
3	Moderate surface fuzzing and/or moderate pilling. Pills of varying size and density partially covering the specimen surface.
2	Distinct surface fuzzing and/or pilling. Pills of varying size and density covering a large proportion of the specimen.
1	Dense surface fuzzing and/or severe pilling. Pills of varying size and density covering the whole of the specimen surface

Based on these data, using a factorial rotatable central program of order II, the following regression equations were obtained to determine correlations between the knitted fabrics characteristic noted by Y and the independent variables considered for the study [8].

RESULTS AND DISCUSSIONS

a). Pilling capacity assessment on wale direction

The regression equation 1 describing the relation between these characteristic and dyeing process parameters is of the form:

$$Y = 2.0054 - 0.0965X_1 + 0.0731X_2 + 0.0734X_3 - 0.125X_1X_2 - 1.25X_1X_3 - 1.25X_2X_3 + 0.1438X_1^2 - 0.033X_2^2 + 0.3205X_3^2 \quad (1)$$

The regression equation it was plotted in Figures 3-9. Thus, Figure 3 presents the variation of knitted fabrics pilling grade on wale direction depending on dyeing time, temperature and pH-dyeing bath.

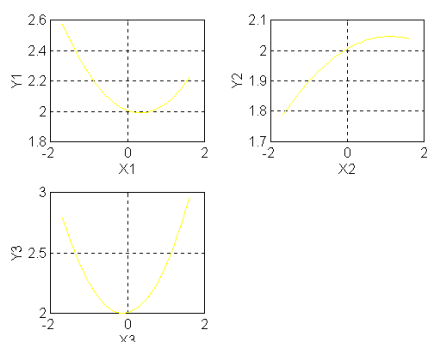


Fig. 3. The variation of knitted fabrics pilling grade on wale direction depending on dyeing time, temperature and pH - dyeing bath

It can be noted a decrease of pilling grade with increase of dyeing time up to value of 2 [pilling grade] followed by a slow increase of this characteristic. The increase of dyeing temperature leads to a slow increase of pilling grade and regarding the knitted fabrics pilling grade variation on wale direction depending on pH-dyeing bath one can notice a decrease of this characteristic, followed by a continuous increase.

Because it wants to obtain a higher pilling grade after dyeing operation, results that the optimal values of dyeing parameters to achieve this requirement are: dyeing time = 30 minutes (-1.682), temperature = 120°C (+1.682) and pH=7.5 (+1.682).

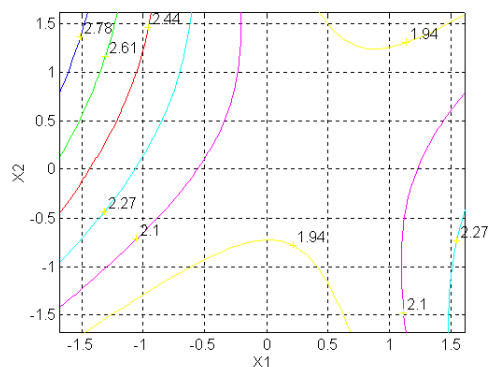


Fig. 4. In plane variation of pilling grade depending on dyeing time and temperature

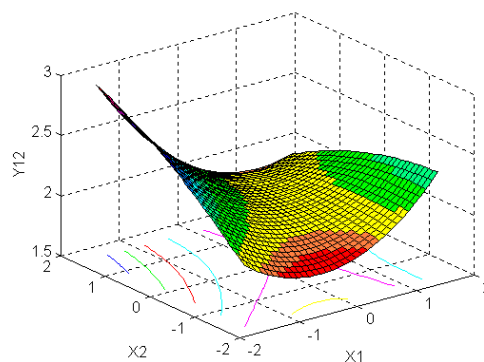


Fig. 5. In space variation of pilling grade depending on dyeing time and temperature

Figures 4 and 5 presents in plane and space variation of knitted fabrics pilling grade depending on dyeing time and temperature where it can be seen that to obtain a higher pilling grade one can dye at lower time values and elevated temperatures.

Regression equation confirms the interactions of three variables X_1X_2 (time - temperature), X_1X_3 (time - pH) and X_2X_3 (temperature - pH).

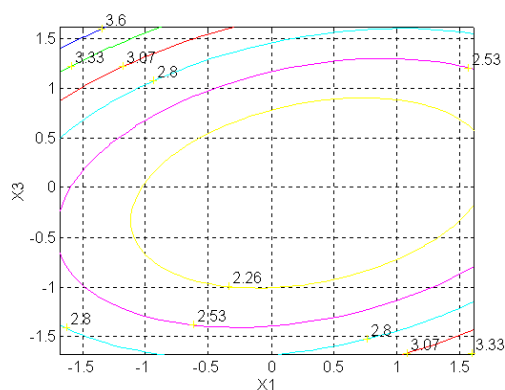


Fig. 6. In plane variation of pilling grade depending on dyeing time and pH

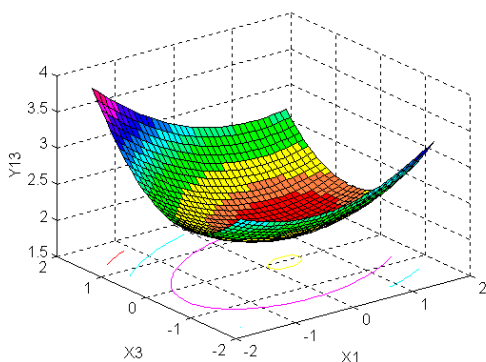


Fig. 7. In space variation of pilling grade depending on dyeing time and pH

Figures 6 and 7 presents the influence of dyeing time and pH interaction on the knitted fabrics pilling effect, where it can be noted that to obtain a higher pilling grade one can dye at lower or higher time and pH-values.

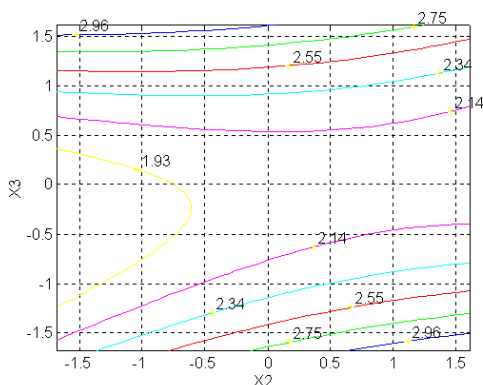


Fig. 8. In plane variation of pilling grade depending on dyeing temperature and pH

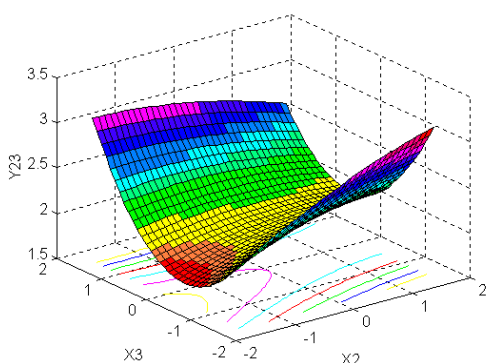


Fig. 9. In space variation of pilling grade depending on dyeing temperature and pH

Figures 8 and 9 shows the influence of dyeing temperature and pH interaction on the knitted fabrics pilling effect on wale direction, where one can notice that to achieve a higher pilling grade one can dye either at elevated temperatures

and lower pH-values, either at elevated or lower temperatures but at higher pH-values.

b). Pilling capacity assessment on row direction

Regression equation 2 which establishes the relation between this characteristic and the dyeing parameters is of the form:

$$Y = 3.0062 + 0.1232X_1 - 0.0002X_2 + 0.0002X_3 + 0.1392X_1^2 - 0.0376X_2^2 - 0.0376X_3^2 \quad (1)$$

The influence of dyeing process parameters on the knitted fabrics pilling effect are plotted Figures 10-16.

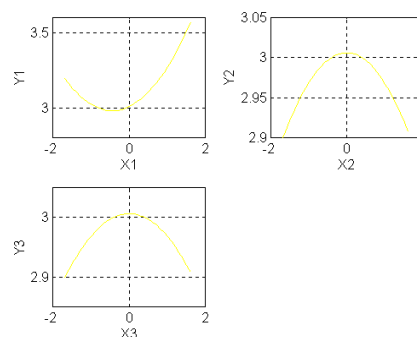


Fig. 10. The variation of the knitted fabrics pilling grade on row direction depending on dyeing time, temperature and pH

Thus, Figure 10 presents the variation of the knitted fabrics pilling grade on row direction depending on dyeing time (X_1), temperature (X_2) and pH- dyeing bath (X_3).

Regarding the knitted fabrics pilling grade variation on row direction depending on dyeing temperature and pH- dyeing bath one can notice an increase of pilling grade with increase of process parameters up to value of 3 [pilling grade] and then this characteristic decreases.

Given the fact that it wants to obtain a higher pilling grade, results that the optimal values of dyeing process parameters to achieve this requirement are: dyeing time= 60min (+1.682), temperature= 100°C (0) and pH= 6.5 (0).

Figures 11 and 12 presents the influence of dyeing time and temperature interaction (X_1X_2) on the knitted fabrics pilling effect, where it can be seen that a higher pilling grade one can achieve after dyeing operation at lower temperature values and at lower or higher time values.

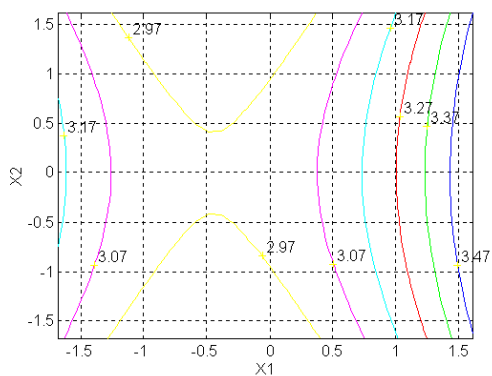


Fig. 11. In plane variation of pilling grade depending on dyeing time and temperature

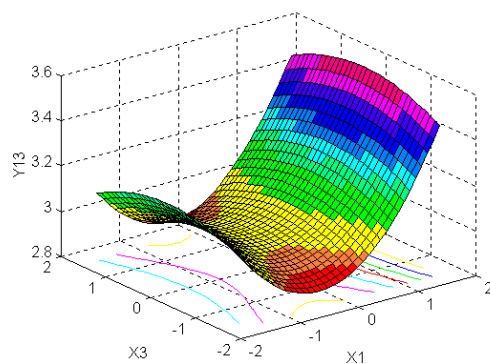


Fig. 14. In space variation of pilling depending on dyeing time and pH grade

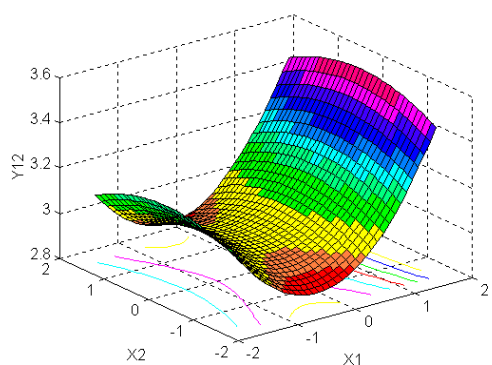


Fig. 12. In space variation of pilling grade depending on dyeing time and temperature

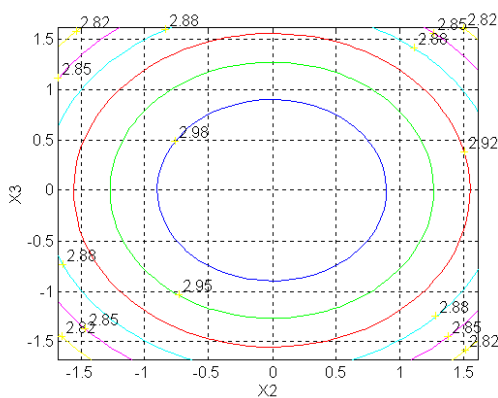


Fig. 15. In plane variation of pilling grade depending on dyeing temperature and pH

The analysis of the influence of dyeing time and pH interaction (X_1X_3) plotted in Figures 13 and 14, one can notice that a higher pilling grade one can achieve after dyeing process at higher time values and at pH-values as close to value of 0 (pH=6.5), the centre of experimental field.

The influence of dyeing temperature and pH interaction (X_2X_3) plotted in Figures 15 shows that the best results one can achieve in the central area of dyeing temperature and pH-values.

In space representation of the interaction (X_2X_3) plotted in Figures 16 are presented in the form of second degree curves concave dish.

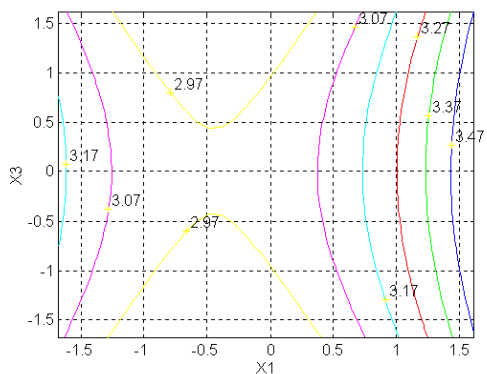


Fig. 13. In plane variation of pilling grade depending on dyeing time and pH

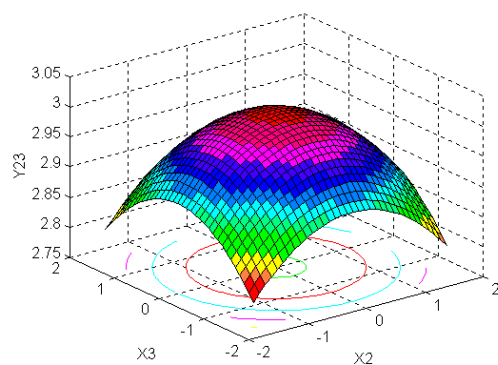


Fig. 16. In space variation of pilling grade depending on dyeing temperature and pH

CONCLUSIONS

The variation of cotton knitted fabrics pilling grade subjected to dyeing operation were analyzed, changing the following parameters: time (minutes), temperature (°C) and pH -dyeing bath.

The optimum values of these parameters were specified for the knitted fabric integrity support to be protected during dyeing treatments.

According to the results obtained, the pilling of cotton knits on row direction after finishing treatments was better than on wale direction.

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