STUDY REGARDING PILLING CAPACITY ASSESSMENT OF THE FINISHED COTTON KNITTED FABRICS

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Abstract
In this experimental study, the influence of dyeing process parameters on the pilling effect of weft knitted fabrics made from 100% yarns performed on CMS 530 E 6.2 weft flat knitting machine, Stoll, Germany were investigated. For this purpose has been used multiple regression method 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 treatments was better that on wale direction.
Key words: weft knitted fabrics, dyeing process, multiple regression method, pilling capacity assessment, pilling grade

1. 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].

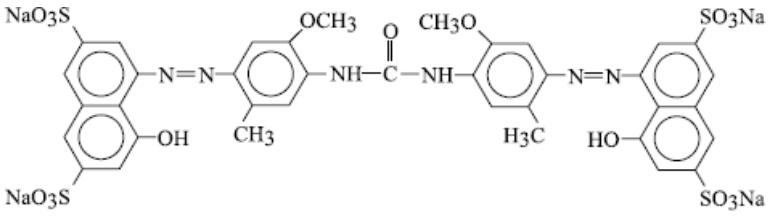
The purpose of this work is to establish the influence of dyeing process parameters on pilling effect of weft- knitted fabrics made of 100% cotton yarns.

The experiments were performed using a multiple regression method [2], taking as independent variables dyeing time process (minutes)-X_1, dyeing temperature (°C)-X_2 and pH dyeing bath noted with X_3 and as dependent variable the pilling effect noted with Y [3] .

2. Experimental part

For this study raw knitted samples made of 100% cotton yarns performed on the CMS 530 MULTIGAUGE knitting machine with 6.2 gauge of the STOLL company were used and subjected to dyeing operations using a direct dye (C.I. Direct Red 79) [4, 5, 6].

The chemical structure of direct dye is presented in Figure 1:



C.I. Direct Red 79

Fig. 1. The chemical structure of C.I. Direct Red 79

The dyeing bath composition:

- 3% dyes
- 10% sodium chloride
- bath ratio 1:20
- pH alkaline accomplished with Na_2CO_3 (sodium carbonate).

Dyeing operations were performed using an installation type POLYCOLOR Mathis, according to the following diagram (Figure 2):

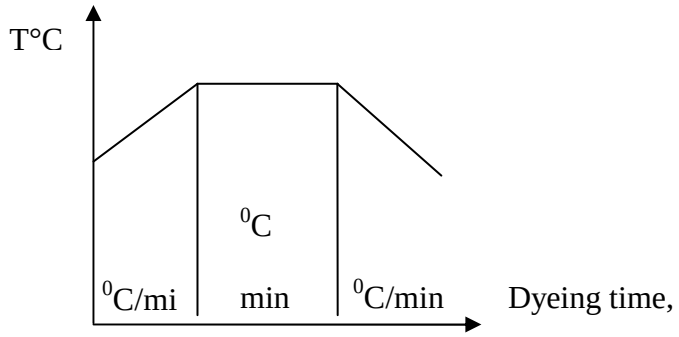


Fig. 2. Dyeing diagram of cotton knitted fabrics with direct dyes

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	84	90	96	100
pH dyeing bath	X3	6	6.5	7	7.5	8

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

Nr. exp	X_1	X_2	X_3	Y Pilling, [pilling grade]	
				Wale	Row
1	-1	-1	-1	2	3
2	+1	-1	-1	2	3
3	-1	+1	-1	2	3
4	+1	+1	-1	2	3
5	-1	-1	+1	2	3
6	+1	-1	+1	2	2
7	-1	+1	+1	2	3
8	+1	+1	+1	2	3
9	-1.682	0	0	2	3
10	+1.682	0	0	2	3
11	0	-1.682	0	2	3
12	0	+1.682	0	2	3
13	0	0	-1.682	2	3
14	0	0	+1.682	2	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

Dyed samples were conditioned and the assessments were conducted at standard atmosphere (humidity 65±2% and temperature 20±2°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. 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].

3. 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:

$$Y = 2.003 - 0.0001X_2 + 0.0001X_3 - 0.0002X_1^2 - 0.0002X_2^2 - 0.0002X_3^2 \quad (1)$$

This 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.

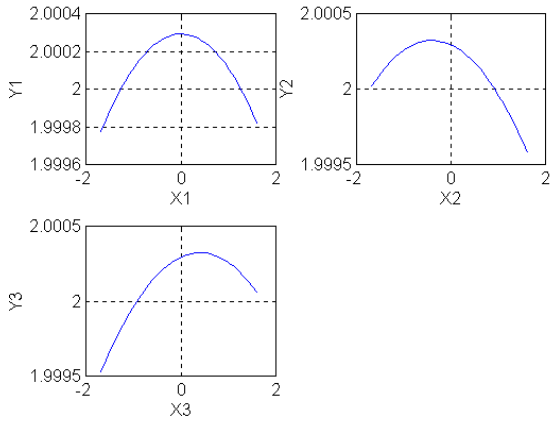


Fig. 3. The variation of knitted fabrics pilling grade on wale direction depending on dyeing time, temperature and pH - dyeing bath

It can be noted an increase of pilling grade with increase of dyeing time up to value of 2.003 [pilling grade] followed by a continuous decrease of pilling grade.
Regarding the variation of knitted fabrics pilling grade on wale direction depending on dyeing temperature it can be noted that there is a slow increase of this with increase of dyeing temperature followed by a decrease of pilling grade. The increase of pH-dyeing bath leads to an increase of pilling grade, followed by a decrease of this.
Because it wants to obtain higher pilling grade after dyeing operation, results that the optimal values of dyeing parameters to achieving this requirement are: dyeing time = 45 minutes (0), temperature = 84°C (-1) and pH=7.5 (+1).
To determine the regression equation, with t test were eliminated insignificant coefficients and for this reason the interactions those three variables X_1X_2 (time- temperature), X_1X_3 (time - pH) and X_2X_3 (temperature - pH) do not appear explicitly. However, the analysis of graphs 3-9 confirms the conclusions drawn from the study of the curves represented in Figure 3.
Figures 4, 6 and 8 presents the influence of dyeing time and temperature interaction (X_1X_2), dyeing time and pH (X_1X_3) and dyeing temperature and pH (X_2X_3) on the knitted fabrics pilling effect, where it can be seen that the best result are achieved in the central area of dyeing time, temperature and pH-values.
In space representation on these interactions (Figures 5, 7 and 9) are presented in the form of second degree curves concave dish.

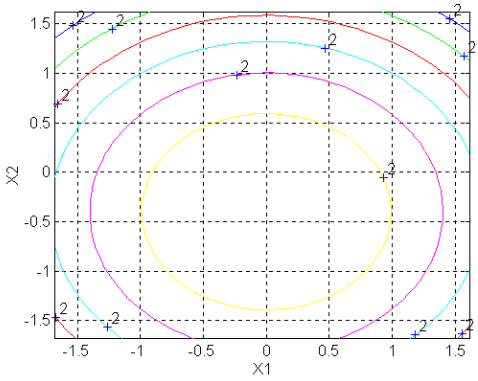


Fig. 4. In plane variation of pilling grade depending on dyeing time and temperature

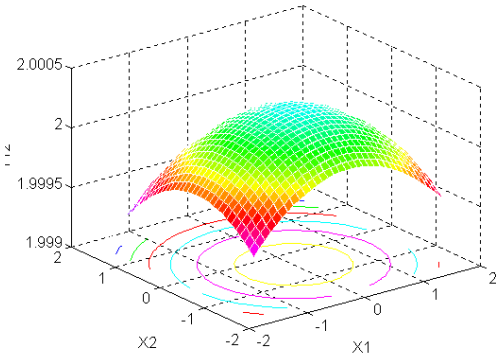


Fig. 5. In space variation of pilling grade depending on dyeing time and temperature

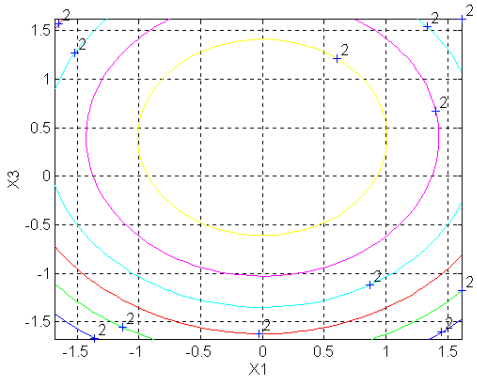


Fig. 6. In plane variation of pilling grade depending on dyeing time and pH

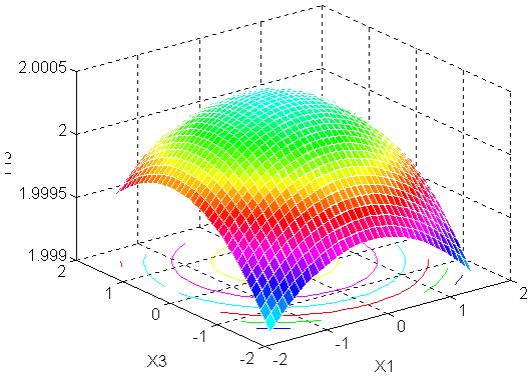


Fig. 7. In space variation of pilling grade depending on dyeing time and pH

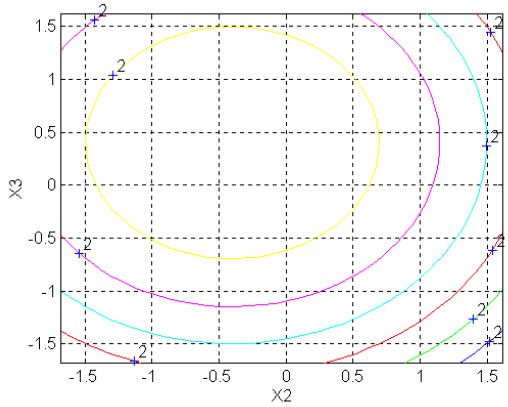


Fig.8. In plane variation of pilling grade depending on dyeing temperature and pH

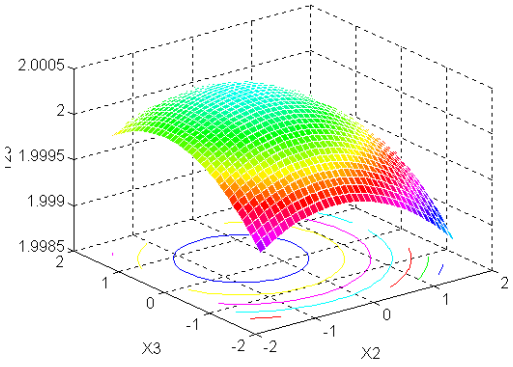


Fig.9. In space variation of pilling grade depending on dyeing temperature and pH depending on dyeing temperature and p

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:

$$Y = 3.0045 - 0.0732X_1 + 0.073X_2 - 0.073X_3 + 0.125X_1X_2 - 0.125X_1X_3 + 0.125X_2X_3 - 0.0267X_1^2 - 0.0267X_2^2 - 0.0267X_3^2 \quad (2)$$

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

Thus, Figure 1 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).

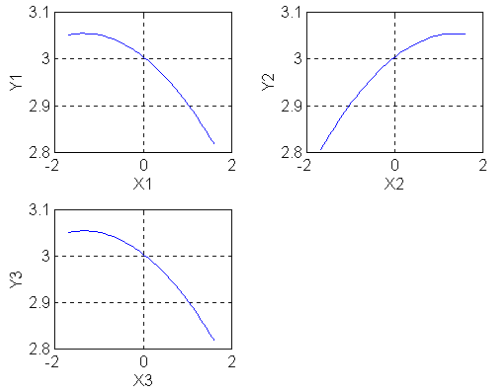


Fig. 10. The variation of the knitted fabrics pilling grade on the row direction depending on dyeing time, temperature and pH

It can be noted a continuous decrease of pilling grade with increasing of dyeing time and pH-dyeing bath. Instead the increase of dyeing temperature leads to an increase of pilling grade up to value of 3.07 [pilling grade].

Given the fact that it wants to obtain higher pilling grade, results that the optimal values of dyeing process parameters to achieve this requirement are: dyeing time= 30min (-1.682), temperature= 100□C (+1.682) and pH= 6 (-1.682).

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

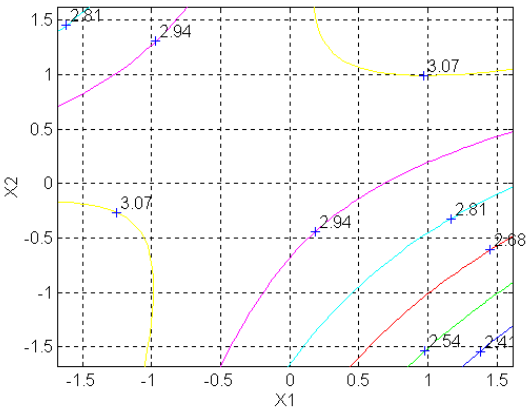


Fig. 11. In plane variation of pilling grade depending on dyeing time and temperature

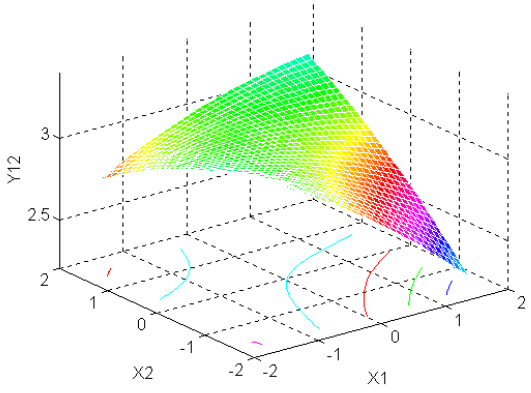


Fig. 12. In space variation of pilling grade depending on dyeing time and temperature

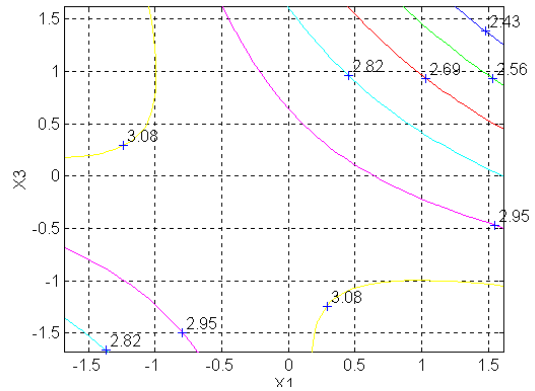


Fig.13. In plane variation of pilling grade depending on dyeing time and pH

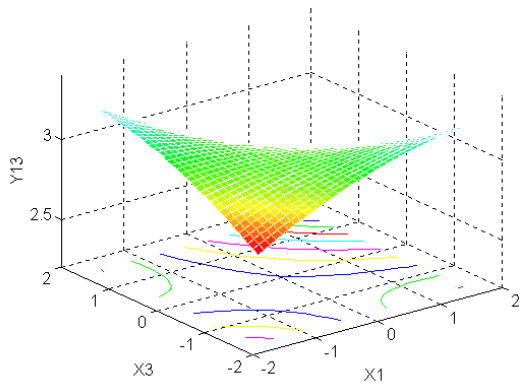


Fig. 14. In space variation of pilling grade depending on dyeing time and pH

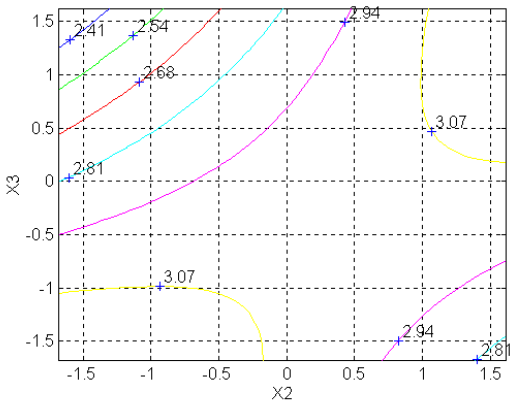


Fig. 15. In plane variation of pilling grade depending on dyeing temperature and pH

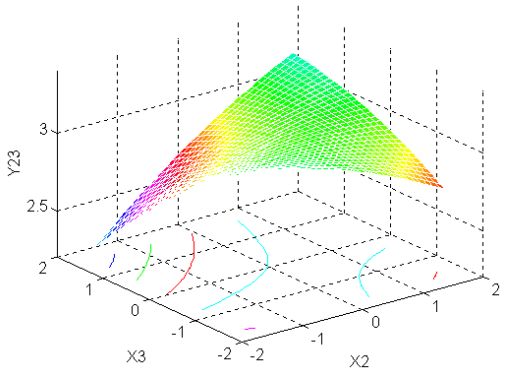


Fig.16. In space variation of pilling grade depending on dyeing temperature and pH depending on dyeing temperature and pH

Figures 2 and 3 presents the interaction between dyeing time and temperature on the pilling effect, where it can be seen that to obtain higher pilling grade one can dye either minimum or maximum dyeing time and at temperature values as close to the centre of experimental field.
Figures 4 and 5 presents in plane and space variation of pilling grade values depending on dyeing time and pH- dyeing bath and it can be seen that to obtain higher pilling grade one can dye at dyeing time and pH- values as close to the centre of experimental field (45 minutes and pH= 7).
Figures 6 and 7 presents the interaction between dyeing temperature and pH-dyeing bath on the knitted fabrics pilling effect where it can be concluded that to obtain higher pilling grade one can dye at lower or higher dyeing temperatures and at pH- values as close to the value of 0 (pH=7), the centre of experimental field.

4. Conclusions

- The variation of 100% 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 cotton 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 that on wale direction.

5. References

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