STANDARDIZATION OF CHEMICAL TREATMENT PARAMETERS FOR THE DEVELOPMENT OF CREASE RESISTANT AND HIGH DRAPE SOFT SILK FABRICS

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ABSTRACT

Imparting bulkiness in raw silk by chemical treatment has been established by research studies carried out by CSTRI. Soft silk fabrics are extensively used for the production of dress materials and soft sarees. The perennial problem in soft silk fabrics is the wrinkle resistance and drape ability. CSTRI has developed new technology for the production of wrinkle resistant and high drape degummed soft silk fabrics using chemical treatment. For this purpose using Box and Behnken design of experiment, standardization of chemical concentration, treatment temperature and duration for degummed soft silk fabrics have been carried out with 20 combinations. The soft silk fabrics have been analysed for various fabric characteristics viz., crease recovery, drape coefficient, bending and tensile characteristics. Based on the studies it could be found that chemical treatments of soft silk fabrics significantly influence the fabrics quality characteristics particularly wrinkle resistance and drapeability. The results were analyzed for response optimization and observed that chemical concentration of 6% in association with treatment temperature of 75ºC for 3 minutes treatment duration has been found suitable for soft silk fabrics of 55 GSM to improve the characteristics of the fabrics viz., drapeability and crease resistance compared to untreated fabrics.

Key words: Soft silk fabrics, Degumming, Chemical treatment, Wrinkle resistant, Drapeability.

1. INTRODUCTION

Silk is a high valued textile fiber of animal origin used almost entirely for the production of high quality silk fabrics in India. India has numbers of outlets for the sale of silk sarees and fabrics. Most of these shops always look for different varieties of silk fabrics for marketing as unique products. CSTRI always work in this direction to provide varieties of silk yarns and fabrics for silk industry, which can be easily producible and adoptable with eco friendly tag. CSTRI under its research studies has tried various chemicals for improving the bulkiness of raw silk for production of silk sarees with better comfort properties. In one such attempt as pilot study, Initial studies carried by Japanese scientist have not given required results as reported (Natsuki Ikegami, et al, 1998). CSTRI has developed a technology for increasing the bulkiness of twisted silk to the extent of three times using a chemical (Hariraj et al, 2015). Similar studies were conducted on silk fabrics also to impart bulkiness (Hariraj et al, 2017). In the present study, the standardization of chemical concentration, treatment temperature and duration of treatment were carried out based on the preliminary studies for improving the winkle resistance and drapeability of soft silk fabrics.

MATERIALS AND METHODS

Raw material: Raw silk produced from bivoltine cocoons (CSR2 x CSR4 race) is used for the development of soft silk fabrics in power looms. The raw silk was having 20 ~ 22 denier single ply. The raw silk was single twisted and doubled and then double twisted and used as warp, whereas the raw silk was directly doubled and twisted and used as weft. The bivoltine raw silk was woven in power loom to produce soft silk fabrics having 50 ~ 60 grams per square meter. About 25 meters of fabrics have been developed for the purpose and used for experimentation. The fabric characteristics in raw stage and after degumming are given in Table 1.

Table 1. Soft silk fabric characteristics before and after degumming

Particulars	Raw fabric	Degummed fabric
Fabric characteristics		
Fabric mass (g/m2)	51.0 (0.158)	45.0 (0.179)
Fabric thickness (mm)	20.0 (0.707)	14.9 (0.447)
Ends per inch	104 (0.000)	105 (1.095)
Picks per inch	78 (0.000)	90 (0.894)
Warp denier	40.1 (0.493)	34.7 (1.506)
Weft denier	121 (0.753)	65.5 (1.951)
Warp crimp	4.80 (0.000)	4.80 (0.000)
Weft crimp	1.60 (0.000)	4.80 (0.000)
Warp twist	941 (13.13)	1023(14.25)
Weft twist	132 (3.09)	124 (4.96)

Values in the parenthesis are the Standard deviation of the test results (Average of 5 readings).

Degumming of fabrics: The raw soft silk fabrics produced on power loom was taken for degumming at 90°C for about 45 minutes using soap 4 gpl and soda 1gpl. The material liquor ratio was maintained as 1:30. The degummed fabrics are hot washed followed by cold washed and dried in shade before taken for experimentation.

Design of experiment: The soft silk fabrics have been subjected to chemical treatments with varying temperature, durations and concentration of chemical. The variables selected for the study are given in Table 2.

Table 2: The variables selected for the study

Particulars	Range
Soft silk fabrics (Degummed)	50 ~ 60 GSM
Duration of treatment (X1)	3 ~ 15 min
Temperature of treatment (X2)	60 ~ 90° C
Concentration of chemical (X3)	2 ~ 10%

Standard test methods to study the properties of fabrics: The chemically treated fabrics of different combinations were tested for various characteristics following the standard testing procedures viz., Threads in cloth IS 1963:1981, Count of warp / weft IS 3442:1980, Crimp percentage of warp / weft IS 1963:1981, Tensile strength IS 1969:1985, Crease recovery IS 4681:1981, Flexural rigidity ASTM D 1388-96, Option A, Drape coefficient percentage IS 8357:1977, Air permeability IS 11056:1984, Fabric thickness IS 7702:1975 (Bureau of Indian standards IS 6936, (1984)).

Data collected: The various fabric characteristics viz., fabric mass, fabric thickness, EPI, PPI, warp and weft count, cover factor, crimp warp / weft, twist warp / weft, tensile strength viz., breaking load and elongation warp / weft, crease recovery, flexural rigidity and drape coefficient of chemically treated soft silk fabrics were studied. The data were analyzed using Minitab 19 version software statistical package.

RESULTS AND DISCUSSIONS

In order to standardize the process parameters for the production of chemically treated soft silk fabrics this experiment was taken up. For this purpose, the process variables like chemical concentration, chemical treatment temperature and duration was altered as per the Box and Behnken design of experiment. Based on the design of experiments the actual factors used for the experiment and the coded factors are given in Table 3. The treated samples were conditioned for 24 hours and weighed to study the weight loss based on the initial weight taken. The fabric samples were tested for various characteristics.

Table 3: Actual factor level for the Box-Behnken designs with three factors

Standard Order	Run Order	Duration (min)	Temperature (° C)	Concentration (%)
9	1	3.0	75.0	6.0
1	2	5.5	66.0	3.6
5	3	5.5	66.0	8.4
3	4	5.5	84.0	3.6
7	5	5.5	84.0	8.4
11	6	9.0	60.0	6.0
13	7	9.0	75.0	2.0
16	8	9.0	75.0	6.0
19	9	9.0	75.0	6.0
18	10	9.0	75.0	6.0
15	11	9.0	75.0	6.0
20	12	9.0	75.0	6.0
17	13	9.0	75.0	6.0
14	14	9.0	75.0	10.0
12	15	9.0	90.0	6.0
2	16	12.5	66.0	3.6
6	17	12.5	66.0	8.4
4	18	12.5	84.0	3.6
8	19	12.5	84.0	8.4
10	20	15.0	75.0	6.0

Box and Behnken design of experiment has been adopted to formulate the experimental design in which 20 different combination are formed. This method also offers the advantage of being rotatable which mean the fitted modal estimates the precision at all points in the factor space that are estimated from the centre.

A quadratic polynomial was used to analyze the relationship of each response with the four independent variables as given below.

$$Y = bo + \sum_{i=1} bixi + \sum_{i=1} bixi^2 + \sum_{i=1} bijxixj + \sum$$
$$i<j \qquad j<k$$

Where bo, bi, bii, bij are the coefficient of the regression equations. The i and j are the integers and y is the response of the dependent variable.

Table 4. Influence of factors of chemical treatments on fabric characteristics

Run Order	Crease recovery angle (°)	Drape Coefficient (%)	Flexural Rigidity (mg – cm)		Breaking load (Kg)		Elongation Percentage (%)	
			Warp	Weft	Warp	Weft	Warp	Weft
1	255.0	25.69	0.005	0.018	22.57	39.93	20.50	15.03
2	247.8	27.01	0.004	0.013	24.00	43.67	20.20	15.00
3	254.6	25.19	0.004	0.017	24.30	43.10	19.80	12.93
4.	249.6	26.68	0.003	0.015	24.30	44.60	17.60	14.53
5.	260.2	25.85	0.003	0.012	23.37	41.27	18.53	12.43
6.	248.6	25.52	0.005	0.016	24.70	42.33	18.53	13.67
7.	248.8	24.86	0.004	0.013	25.20	39.97	20.00	15.13
8.	255.1	23.20	0.004	0.014	24.79	40.60	18.47	11.35
9.	254.6	23.45	0.004	0.014	25.00	40.57	18.33	11.33
10.	255.7	23.48	0.004	0.014	24.77	40.90	18.17	11.47
11.	254.0	23.70	0.004	0.014	25.12	41.38	18.47	11.65
12.	254.0	23.56	0.004	0.014	24.53	41.10	18.60	11.63
13.	254.2	24.05	0.004	0.014	24.70	40.63	18.07	11.27
14.	258.9	21.72	0.004	0.015	26.00	42.27	21.13	14.60
15.	259.3	25.00	0.004	0.015	24.20	40.70	17.40	13.63
16.	245.9	27.51	0.005	0.016	24.23	40.57	17.80	13.70
17.	257.8	26.56	0.005	0.022	23.33	41.20	18.20	14.83
18.	246.6	27.51	0.004	0.012	23.40	35.07	17.50	12.33
19.	258.0	23.71	0.004	0.014	23.57	42.27	19.33	14.80
20.	250.6	27.84	0.004	0.015	25.50	40.57	20.87	15.40

Table 5. Response surface equations of fabric properties of chemically treated soft silk fabrics

Characteristics	Regression equation	R^2	ANOVA p Value
Crease Recovery Angle – Total	$Y1 = 187.6 + 2.33\ X1 + 1.14\ X2 + 0.51\ X3 - 0.0648\ X1*X1 - 0.00539\ X2*X2 - 0.08815\ X3*X3 - 0.0258\ X1*X2 + 0.0886\ X1*X3 + 0.0193\ X2*X3$	**89.26**	0.000**
Drape Coefficient (%)	$Y2 = 80.2 - 0.683\ X1 - 1.415\ X2 + 0.43\ X3 + 0.1060\ X1*X1 + 0.01044\ X2*X2 + 0.0231\ X3*X3 - 0.01265\ X1*X2 - 0.315\ X3 - 0.0109\ X2*X3$	**87.23**	0.002**
Elongation - Warp (%)	$Y3 = 22.0 - 2.436\ X1 + 0.425\ X2 - 2.44\ X3 + 0.0461\ X1*X1 - 0.00487\ X2*X2 + 0.0948\ X3*X3 + 0.01865\ X1*X2 + 0.0255\ X1*X3 + 0.0162\ X2*X3$	**78.08**	0.021*
Elongation - Weft (%)	$Y4 = 76.5 - 2.163\ X1 - 1.148\ X2 - 3.819\ X3 + 0.0901\ X1*X1 + 0.00732\ X2*X2 + 0.1795\ X3*X3 - 0.00172\ X1*X2 + 0.1166\ X1*X3 + 0.00759\ X2*X3$	**92.50**	0.000**

Note: X1 = Duration, X2 = Temperature of treatment, X3 = Concentration of chemical

Influence of chemical treatment parameters on degummed soft silk fabric characteristics

Influence of factors of chemically treated soft silk fabrics characteristics using Box and Behnken design of experiment are given in Table 4 and the response surface equations derived from the analysis of chemically treated soft silk fabrics characteristics are given in Table 5. The data were analyzed using Minitab 19 version software statistical package and it was found that temperature of treatment and concentration of chemical plays an important role in deciding the fabrics characteristics. The analysis revealed that crease recovery, drape and elongation characteristics were significantly influenced by the process variables. Whereas the Flexural rigidity, tensile characteristics were not significantly affected by chemical treatments. The results are shown in Fig. 1 to 4.

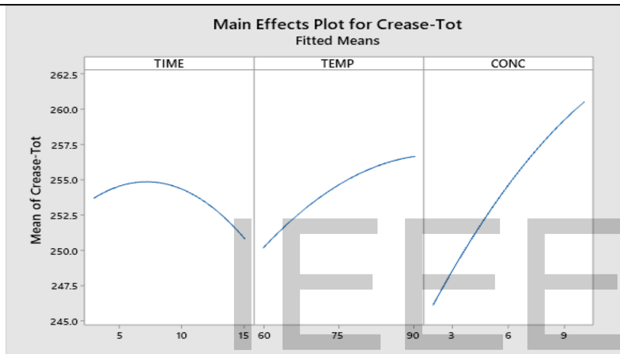

Fig. 1. Factorial plots of crease recovery (Total) with reference to different temperature, duration and concentration of chemical.

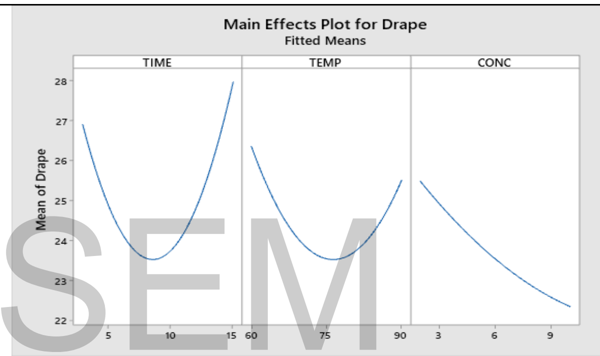

Fig. 2. Factorial plots of drape coefficient with reference to different temperature, duration and concentration of chemical.

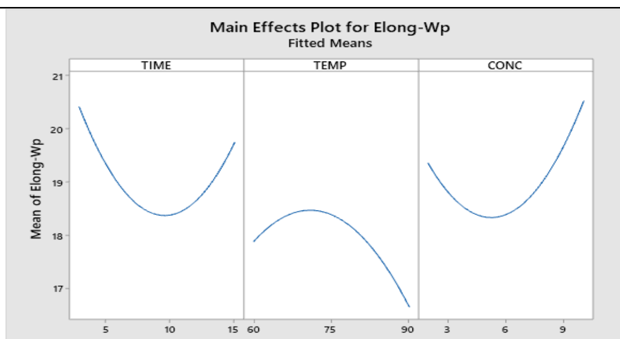

Fig. 3. Factorial plots of elongation (warp) with reference to different temperature, duration and concentration of chemical.

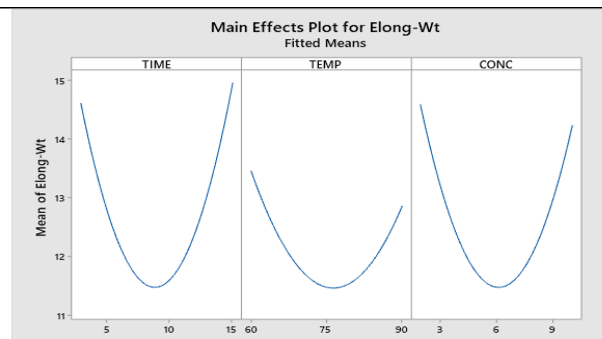

Fig. 4. Factorial plots of drape coefficient with reference to different temperature, duration and concentration of chemical.

Crease recovery angle (Total): Crease recovery angle of the chemically treated fabrics was estimated based on the average of crease recovery warp and weft. It showed values varying from

245.9º to 260.2º for various process variables (Table 4). The factorial plots of crease recover angle are shown in Fig 1. The estimated regression co-efficient on crease recovery angle showed significant influence on process variables with R^2 value of 89.26 as shown in Table 5. From the analysis of variance results it is observed that the regression equation indicates the square effect is significant at 1% level and having the p value of 0.000 as shown in Table 5.

Drape coefficient: Drape coefficient of the chemically treated fabrics indicate the way fabric hangs under its own weight. It showed values varying from 21.72 to 27.84 for various process variables (Table 4). The factorial plots of drape coefficient are shown in Fig 2. The estimated regression equation on crease recovery angle showed significant influence on process variables with R^2 value of 87.23 as shown in Table 5. From the analysis of variance results it is observed that the regression equation indicates the square effect is significant at 1% level and having the p value of 0.002 as shown in Table 5.

Elongation percentage (Warp): Elongation percentage of the warp direction of fabric is measured in Instron tester. It showed values varying from 17.4% to 20.87% for various process variables (Table 4). The factorial plots of elongation percentage of warp are shown in Fig 3. The estimated regression equation on crease recovery angle showed significant influence on process variables with R^2 value of 78.08 as shown in Table 5. From the analysis of variance results it is observed that the regression equation indicates the square effect is significant at 5% level and having the p value of 0.021 as shown in Table 5.

Elongation percentage (Weft): Elongation percentage of the warp direction of fabric is measured in Instron tester. It showed values varying from 11.27% to 15.4% for various process variables (Table 4). The factorial plots of elongation percentage of warp are shown in Fig 4. The estimated regression equation on crease recovery angle showed significant influence on process variables with R^2 value of 92.5 as shown in Table 5. From the analysis of variance results it is observed that the regression equation indicates the square effect is significant at 1% level and having the p value of 0.000 as shown in Table 5.

Thus it was observed that chemical treatment of the soft silk fabrics significantly increase the crease recovery, drapeability and elongation characteristics. Based on the optimization analysis, it was found that 6% concentration of chemical treated at 75°C temperature for 9 minutes have shown significant improvement fabric characteristics compared to degummed soft silk fabrics.

Conclusion

Based on the above studies it was found that process variables temperature of treatment, duration and chemical concentration used were having significant influence on fabric characteristics. The soft silk fabrics found to improve crease recovery, drape coefficient, elongation characteristics of soft silk fabrics due to chemical treatment. The study also revealed that 6% concentration of chemical treated at 75°C temperature for 9 minutes have shown significant improvement fabric characteristics compared to degummed soft silk fabrics. The study clearly indicated that by treating the soft silk fabrics using the chemical, the wrinkle resistant and drapeability could be improved significantly.

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