Optimization of Process Parameters for Simultaneous Fixation of Reactive Printing and Crease Resistant Finishing using Desirability Function

Fareha Asim, Muzzaffar Mahmood, Mubashir Ali Siddiqui

***Abstract*—This work discusses the potential of process optimization for simultaneous fixation of reactive printing and crease resistant finishing with the help of desirability function. A single step process for reactive printing and crease resistant finishing of cotton fabric is described. The idea is a model based approach due to the complexity of the chemical and physical operational sequence of the combo process. The optimum conditions, including concentration of dye and crease resistant, fixation method and temperature were also investigated. Evaluations of the process were made with respect to K/S, dry and wet crease recovery, tensile and tear strength, fastness to washing, light & rubbing, resistance to abrasion and pilling. An E-Control fixation at a temperature of 135 ˚C was proved to be efficient for imparting single-step reactive print fixation and crease resistant finishing to cotton fabric.**

***Index Terms*—Crease resistance finishing, desirability function, optimization, Reactive printing.**

I. Introduction

MODERN textile processes have high demands concerning the combined application of crease resistance finishing and reactive printing. Various attempts have been made on simultaneous fixation of reactive dyeing and crease resistance finishing [1-4] but very few studies have been reported on combined application of reactive printing and creases resistance finishing [5-6]. Reports in literature revealed that a number of attempts were made for combined pigment printing and crease resistance finishing [7], due to the similar chemistry to cellulose cross linking agents and binders and the similar application conditions. However development and optimization of the process for reactive printing and crease resistance finishing is a novel approach. The concept of wet on wet fixation using an E Control process for the combined fixation of reactive printing and crease resistance finishing was investigated in this work.

The conventional optimization of the process parameters is costly in terms of time and material. Each process parameter has to be optimized one by one with several repetitions. The idea of this work is to use a model based approach due to the complexity of the chemical and physical operational sequence with the combined fixation of reactive printing and crease resistance finishing process.

This paper uses desirability function to determine the optimum parameters of simultaneous fixation of reactive printing and crease resistance finishing for optimization of K/S, dry and wet crease recovery, tensile and tear strength, fastness to washing, light & rubbing, resistance to abrasion and pilling.

The $2^1.3^3$.mixed factorial design for the four controllable factors viz. chroma, concentration of crease resistant, fixation method and fixation temperature was used for this work to find the optimum conditions of factors and levels in simultaneous fixation. The multi response optimization was attempted through desirability function. These responses can be given equal wieghtage or the wieghtage of responses can be varied according to industrial requirements. The optimization techniques like utility concept, principal component analysis etc.

II. Desirability function

A useful approach for optimization of multiple responses is to use the simultaneous optimization technique popularized by Derringer and Suich [8, 9]. Their procedure makes use of desirability function. The general approach is to first convert each response yi into an individual desirability function di that varies over the range.

$$0 \le di \le 1 \qquad (1)$$

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Where if the response yi is at its goal or target, then di = 1, and if the response is outside an acceptable region, di = 0. Then the design variables are chosen to maximize the overall desirability.

$$D = (d1.d2\ldots\ldots.dm)\ 1/m \qquad (2)$$

Where there are m responses.

If the objective or target T for the response y is a maximum value,

$$d = \begin{cases} 0 & y < L \\ \left(\frac{y-L}{T-L}\right)^r & L \leq y \leq T \\ 1 & y > T \end{cases} \qquad (3)$$

When the weight r = 1, the desirability function is linear. Choosing r > 1 places more emphasis on being close to the target value, and choosing 0 < r < 1 makes this less important. If the target for the response is a minimum value,

$$d = \begin{cases} 1 & y < T \\ \left(\frac{U-y}{U-T}\right)^r & T \leq y \leq U \\ 0 & y > U \end{cases} \qquad (4)$$

The two sided desirability function assumes that the target is located between the lower (L) and upper (U) limits, and is defined as

$$d = \begin{cases} 0 & y < L \\ \left(\frac{y-L}{T-L}\right) r_1 & L \leq y \leq T \\ \left(\frac{U-y}{U-T}\right) r_2 & T \leq y \leq U \\ 0 & y > U \end{cases} \qquad (5)$$

III. EXPERIMENTAL

A. Material

Fabric

Commercially Singed, desized, scoured, bleached and mercerized cotton fabric with satin weave structure, 40x40 s, 130 ends/inch x 73 picks/inch, and an area density of approximately 136 g/m2 was used in this research work.

Chemical and colorants

The Crease Recovery finishing agent used was Arkofix NEC (Clariant), based on modified N-methyloldihydroxy ethylene urea. Magnesium chloride ($MgCl_2$) was used to catalyze the CR finishing, Solusoft MW (Silicon softener), Ceranine-L (An ionic Softener) and Imercol PCLF (Wetting Agent).

The reactive dyes used were Drimarine Red P2B (Clariant), based on MCT reactive group. Other chemicals used in this research work were commercially available thickener Lamitex HP (sodium alginate), sodium bicarbonate, urea, Reduction Inhibitor (Revatol S) and sodium hexameta phosphate as a sequestrant.

Table I: Factors and respective levels used in $2^1.3^3$ mixed factorial design

	Factor Name	Levels		
		-1	0	+1
A	Chroma	1(%)	2 (%)	**3 (%)**
B	Conc. Of Crease Resistant	100(g/l)	150 (g/l)	**200(g/l)**
C	Fixation Method	Curing		E-Control
D	**Fixation Temperature**	**130 (°C)**	**140 (°C)**	**150 (°C)**

B. Methods

Print-finish paste manufacture

A concentration of 2.50-3.00% w/w (30g/kg) of thickener Lamitex HP (to maintain the 60-65 dPa viscosity range recommended by the supplier) was added to produce stock paste, with continuous high speed stirring, to the required volume of water. This was followed by the gradual addition of Urea 200 g/kg, sodium bi carbonate 30 g/kg, Revatol S 10 gm/kg and sodium hexa meta phosphate 5 gm/kg with continuous stirring giving a final stock paste viscosity of 60-65dPa.However urea is not added in the stock paste manufactured for the experiments conducted using E Control method for fixation. The printing pastes of different concentrations were prepared with Drimarine Red P2B as outlined in Table 1.During stock and print paste preparation a vigorous high speed stirring for 10 min was

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required to obtain a homogenous paste after adding all reagents. The viscosities of all types of pastes were measured using a Brookfield Viscometer, Type LV. The CR finishing liquor was prepared by using Magnesium Chloride 25% of CR but not greater than 30 g/l, Solusoft MW 20g/l, Ceranine-L 20g/l and Imercol, PCLF 1g/l. The final finish bath was prepared with Arkofix NEC as outlined in Table 1.

Print-finish Procedure

The combined process of reactive printing and CR finishing was carried out as follows: In the first stage the fabric was immersed in an aqueous solution of CR finish liquor, and then squeezed to obtain a 70% wet pickup. The wet fabric was then dried at 60°C for 7 min. In the second stage the treated fabric was printed by the lab scale Rotary Printing machine (Zimmer).

The printed fabric going to be fixed though Curing process was again dried at 60°C for 7 min. However, the printed fabric going to be fixed through E Control process was not dried. In the third stage, the print-finish fabric was fixed. The preparation of finish bath, printing recipe and fixation method and temperature were employed in accordance with the experimental design arrangement as stated in Table I and II. The fixed samples were finally washed in 1g/l non-ionic detergent until all un reacted dyes and chemicals were removed from the fabric surface.

Evaluation of Fabric properties

The easy-care properties imparted by the CR finish were evaluated by measuring the dry crease recovery angles (DCRA) using AATCC-66. The fabric strength properties were assessed by measuring the breaking load of fabric using the standard test procedure ASTM D 5035. The tear strength of fabric was evaluated using ASTM D1424. The standard test procedures adopted for color fastness properties included: (a) color staining to rubbing, AATCC-08; (b) the loss of color and staining to washing, ISO C2S; and (c) color fastness to light, ISO 105-B02. Each value reported for DCRA and breaking load is the mean of two samples tested, each having a coefficient of variance not more than +/- 5%.The fabric pilling and abrasion resistance was examined using ISO -12945-2 (100 cycles) and ISO 12947 @ 2500 rubs respectively. Shade depth values were assessed spectrophotometrically and expressed in terms of the Kubelka-Munk (K/S) relationship. The samples processed with simultaneous fixation were compared with those produced from a standard two step process of printing and finishing.

C. Experiment design

$2^1.3^3$. mixed full factorial design was used to explore the effect of different factors namely: (i) chroma, (ii) concentration of crease resistant, (iii) fixation method and (iv) fixation temperature on combined reactive printing and crease resistance finishing. A $2^1.3^3$ mixed factorial design with two replicates was run according to the design matrix as shown in Table II. The experiments were performed in random order. The results were analyzed and optimized using software Design Expert 8.0. The responses investigated were the K/S, dry and wet crease recovery, tensile and tear strength, fastness to washing, light & rubbing, resistance to abrasion and pilling.

D. Experimental Results

The experiments were conducted according to the design matrix (Table II). The responses were consequently expressed in form of regression equations “(6)” to “(18)”.

$$K/S = 6.28 + 3.16A - 0.98B + 0.85C - 0.13D - 0.47AB + 0.56AC - 0.26AD + 0.57BC - 0.33BD - 1.03CD - 0.10A2 + 0.93B2 - 0.17D2 \quad (6)$$

$$\text{DCRA Warp} = 125.09 + 1.59A + 1.90B + 4.33C + 3.66D - 2.32AB - 1.97AC + 3.56AD + 0.62BC - 0.14BD - 4.12CD - 1.23A2 - 0.67B2 - 3.35D2 \quad (7)$$

$$\text{DCRA Weft} = 126.01 - 1.56A + 0.72B + 0.66C + 8.51D - 5.58AB - 5.04AC + 1.16AD + 2.49BC + 1.29BD - 3.04CD + 1.49A2 + 0.15B2 + 7.21D2 \quad (8)$$

$$\text{Tensile Strength Warp} = 433.61 - 1.86A + 3.92B - 13.40C + 3.14D + 10.46AB - 0.25AC - 6.79AD - 12.65BC - 1.94BD + 2.57CD - 18.22A2 + 4.72B2 + 22.02D2 \quad (9)$$

$$\text{Tensile Strength Weft} = 200.48 + 2.38A - 1.19B - 8.00C + 0.56D + 1.28AB + 0.92AC - 8.55AD - 5.53BC + 2.97BD + 6.74CD - 16.45A2 + 4.73B2 + 14.31D2 \quad (10)$$

$$\text{Tear Strength Warp} = 28.83 + 1.25A - 0.69B - 0.65C - 1.81D + 0.78AB + 2.37AC - 2.04AD - 1.15BC + 0.94BD + 2.34CD - 1.84A2 + 2.29B2 - 1.86D2 \quad (11)$$

Table II: Experimental Data

RUN No	Chroma (%)	Conc. of CR (g/l)	Fixation Mode	Fixation Temp (˚C)	K/S	DCRA Warp (˚)	DCRA Weft (˚)	Tensile Strength Warp (N)	Tensile Strength Weft (N)	Tear Strength Warp (N)	Tear Strength Weft (N)	Pilling	Wash fastness	Dry Rub	Wet Rub	Light Fastness	Abrasion Resistance
1	3	150	E-Control	130	13	125	115	358	220	33.1	19.1	3	4.5	5	2.5	4	3.5
2	3	100	Curing	150	12.7	140	160	411	186	20.8	14.3	3.5	4	4.5	3	3.5	4.5
3	2	100	E-Control	130	9.2	115	120	467	224	32.1	22.8	4.5	4.5	5	4	3	4
4	2	100	E-Control	150	8.7	118	145	448	215	28.5	15.8	3.5	4.5	4.5	4.5	3.5	4
5	2	150	Curing	140	4.8	125	115	409	186	33.1	17.0	2.5	4.5	5	4	2.5	3.5
6	2	200	E-Control	150	8.2	120	135	413	235	27.5	14.6	3.5	4	5	3	3	4
7	3	100	Curing	130	9.5	122	140	438	221	33.3	19.0	3.5	4	5	3	4	4
8	1	100	E-Control	140	4.7	135	145	422	178	22.8	14.8	3.5	4	5	3.5	3	4.5
9	3	200	Curing	130	5	95	105	447	221	31.3	18.8	2.5	4.5	5	4	3	4
10	1	100	E-Control	150	3.3	127	140	479	212	33.5	23.3	4.5	3.5	5	5	3	3.5
11	1	200	Curing	140	2.7	118	125	516	210	30.8	17.9	3	4.5	5	4	2.5	3.5
12	3	200	Curing	150	5	120	140	502	203	23.3	15.5	2.5	4	4.5	3	2.5	4
13	1	150	E-Control	150	4.6	115	150	449	210	26.9	21.6	3.5	4.5	5	4	3.5	3.5
14	1	150	E-Control	130	3.7	120	145	435	201	18.1	12.3	4.5	4.5	5	3.5	2.5	4
15	2	200	E-Control	130	7	135	147	447.8	230	32	18.4	3.5	4	5	3.5	3	4
16	1	150	E-Control	140	3	135	115	402	135	18.6	11.2	3	4.5	5	4	2.5	4
17	2	200	E-Control	140	7.5	140	115	475	195	29.2	14.9	3.5	4	5	3.5	3.5	4.5
18	1	150	Curing	130	2.2	110	113	373	182	30.9	20.8	4.5	4.5	4.5	4.5	2.5	4
19	2	150	E-Control	140	5.5	115	125	475	206	32.8	15.3	4.5	4.5	5	4	3.5	3.5
20	3	150	Curing	150	10.9	135	155	424	194	14.8	13.6	4.5	3.5	5	3	3	4
21	2	100	Curing	150	10	118	152	477	212	20.3	15.0	3	4.5	5	5	3.5	4
22	1	100	Curing	150	3.4	115	125	477	207	32.5	18.8	3	4.5	5	5	2.5	3.5
23	2	200	Curing	140	5.5	135	125	410	205	34.3	19.9	4	4.5	5	4	3	3.5
24	1	200	E-Control	150	3.1	115	135	402	205.4	23.0	19.5	4	3.5	5	4	3	3.5
25	3	150	Curing	140	8.9	125	150	513	218	30	18.1	3.5	4.5	5	4	3.5	3.5
26	2	150	E-Control	130	8	120	135	458	209	33.4	19.7	4.5	4.5	5	4	3.5	3.5
27	2	150	Curing	150	6.5	135	125	418	174	16.3	13.0	2.5	4	5	3	2.5	4
28	1	200	Curing	130	2.2	110	125	483	226	32	19.9	3	4.5	5	5	2.5	3.5
29	3	100	E-Control	130	14.2	115	150	415	192	31.9	20.8	3	4.5	5	3.5	3.5	3.5
30	3	100	E-Control	140	12.7	130	120	401	178	31.4	20.8	4.5	4.5	5	3.5	4	4
31	2	200	Curing	150	5.5	120	140	498	230	29.5	16.5	4	4	5	3	2.5	4
32	1	100	Curing	140	3.7	100	115	446	224	33.0	18.8	3	4.5	5	4.5	2.5	3.5
33	1	100	E-Control	130	5	125	115	454	159	26.4	14.6	3	4.5	5	3	2.5	4
34	1	150	Curing	140	2.7	112	128	401	158	25.0	16.3	4.5	4.5	5	4.5	2.5	4
35	2	200	Curing	130	5.5	100	135	530.7	238.6	32.4	22.0	3.5	4	5	3.5	2.5	4
36	3	200	E-Control	150	7.2	135	165	421	201	28.2	17.2	3	4.5	5	3	4	4
37	3	100	E-Control	150	9	118	105	410	185	32.6	17.4	2.5	4	5	5	3.5	4.5
38	2	150	Curing	130	4.2	118	111	498	226	27	19.2	4	4.5	5	4.5	2.5	3.5
39	1	200	E-Control	140	3.1	130	160	310	130	17.7	11.0	3	3.5	5	3	2.5	3.5
40	2	150	E-Control	150	5	130	140	488	198	31.2	18.4	3.5	4.5	5	3.5	2.5	4.5
41	2	100	E-Control	140	9	130	125	413	212	29.3	18.8	4	4.5	5	4	3	3.5
42	2	100	Curing	130	5.7	110	130	410	217	33.0	19.9	4.5	4.5	5	5	3.5	3.5
43	3	150	E-Control	150	8.9	130	145	457	194	23.3	19.5	3.5	4.5	5	3.5	4	3.5
44	2	100	Curing	140	7	105	130	409	222	33.1	17.9	3	4.5	5	4.5	3.5	3.5
45	1	150	E-Control	130	3.8	130	138	390	175.5	15.3	12.0	3.5	5	5	3	2.5	4
46	3	200	E-Control	130	15	125	105	435	152	22.4	14.3	4	4.5	4.5	3	3.5	3.5
47	3	150	E-Control	140	10.9	125	115	376	225	32.0	18.1	4.5	4.5	5	3.5	4	4
48	3	200	E-Control	140	12.1	130	125	400	152	33.1	15.0	4.5	4	5	3	4	3.5
49	1	200	Curing	150	2.4	130	155	513	228	29.0	23.7	3.5	4.5	5	4	2.5	3.5
50	1	100	Curing	130	2.9	100	105	477	207	33.5	18.4	4.5	4.5	5	4.5	2.5	4
51	3	150	Curing	130	5.2	100	120	502	246	33.2	23.0	3.5	4.5	5	4	3.5	3.5
52	1	100	Curing	140	11	105	125	465	211	32.4	17.4	4	4.5	5	3.5	3.5	3.5
53	1	150	Curing	150	1.8	110	155	443	215	19.9	21.2	3.5	4.5	5	4.5	2.5	3.5
54	3	200	Curing	140	6.9	115	112	403	235	31.5	18.8	3	4.5	5	4	3.5	3.5

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$$\text{Tear Strength Weft} = 16.76 + 0.19A - 0.45B - 0.69C - 0.34D - 0.076AB + 1.08AC - 2.10AD - 1.25BC + 0.54BD + 1.05CD + 0.24A2 + 0.23B2 + 1.00D2 \tag{12}$$

$$\text{Pilling} = 3.72 - 0.026A - 0.041B + 0.11C - 0.14D - 6.197E003AB + 0.089AC + 0.070AD + 0.033BC + 0.21BD + 5.341E-003CD - 0.081A2 - 0.18B2 + 9.829E-004D2 \tag{13}$$

$$\text{Wash Fastness} = 4.47 - 0.011A - 0.078B - 0.030C - 0.13D + 0.044AB + 0.12AC + 0.022AD - 0.045BC - 0.013BD - 0.030CD - 0.013A2 - 0.15B2 - 0.052D2 \tag{14}$$

$$\text{RubbingDry} = 4.96 - 0.021A + 0.020B - 8.714E-003C - 5.898E-003D - 6.065E-003AB - 4.820E-003AC - 0.032AD + 5.303E-003BC + 0.054BD + 7.612E-003CD + 0.019A2 - 0.025B2 - 0.023D2 \tag{15}$$

$$\text{Rubbing Wet} = 3.94 - 0.29A - 0.21B - 0.19C + 0.018D + 0.093AB + 0.15AC - 0.098AD - 0.091BC - 0.22BD + 0.30CD - 0.18A2 - 0.068B2 - 0.015D2 \tag{16}$$

$$\text{Light Fastness} = 3.01 + 0.46A - 0.13B + 0.16C - 1.923E-004D - 0.056AB + 0.069AC - 0.14AD + 0.12BC - 0.023BD + 0.095CD + 0.13A2 + 0.077B2 - 0.12D2 \tag{17}$$

$$\text{Abrasion Resistance} = 3.75 + 0.028A - 0.022B + 0.072C + 0.069D + 4.324E-003AB - 0.021AC + 0.21AD - 0.033BC - 0.042BD - 0.014CD - 0.069A2 + 0.025B2 + 0.13D2 \tag{18}$$

The high values of coefficient of determination indicated that the models adequately explained the combo process. The models were adequate but it would become very cumbersome to determine the optimal value using regression technique. Desirability function was then for response optimization.

IV. MULTI–RESPONSE OPTIMIZATION USING DESIRABILITY FUNCTION

To overcome the problem of conflicting responses of single response optimization, multi-response optimization was used. In multi response optimization, desired wieghtage is given to all responses (equal wieghtage in the present study) and for a combined influence of all responses desirability is determined for varying values of input parameters. Table III shows the range of input parameters and that of responses and the goal and weights assigned to each parameter. The target values assigned were obtained from the experiments performed for the standard two step process of reactive printing and CR finishing (shade depth 1% and concentration of CR 100g/l) as shown in Table IV.

Table III: Range of input parameters and responses.

Constraints Name	Goal	Lower limit	Upper limit	Lower weight	Upper weight	Importance
Chroma (%)	is in range	1	3	1	1	3
Conc. Of CR (g/l)	is in range	100	200	1	1	3
Fixation Mode	is in range	Curing	E-Control	1	1	3
Fixation Temp (˚C)	is in range	130	150	1	1	3
K/S	is target = 5	4.9	5.1	1	1	5
DCRA Warp (˚)	is target =110	105	140	1	1	5
DCRA Weft (˚)	is target = 125	120	168	1	1	5
Tensile Strength Warp (N)	is target = 315	130	530.7	1	1	3
Tensile Strength Weft (N)	minimize	125	246	1	1	3
Tear Strength Warp (N)	minimize	14.8	34.3	1	1	3
Tear Strength Weft (N)	is target = 12	11	23.7	1	1	3
Pilling	is in range	3	4	1	1	3
Wash Fastness	is in range	4	5	1	1	3
Rubbing Dry	is in range	4	5	1	1	3
Rubbing Wet	is in range	4	5	1	1	3
Light Fastness	is in range	3	4	1	1	3
Abrasion Resistance	is in range	3	4	1	1	3

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Table IV: Optimum parameters for Standard Two step Process of Reactive printing and CR Finishing

K/S	DCRA Warp (˚)	DCRA Weft (˚)	Tensile Strength Warp (N)	Tensile Strength Weft (N)	Tear Strength Warp (N)	Tear Strength Weft (N)	Pilling	Wash Fastness	Dry Rubbing	Wet Rubbing	Light Fastness	Abrasion Resistance
4.9	110	125	315.5	120.65	14.345	11.985	3 - 4	4 - 5	4-5	4-5	3 - 4	3 – 4

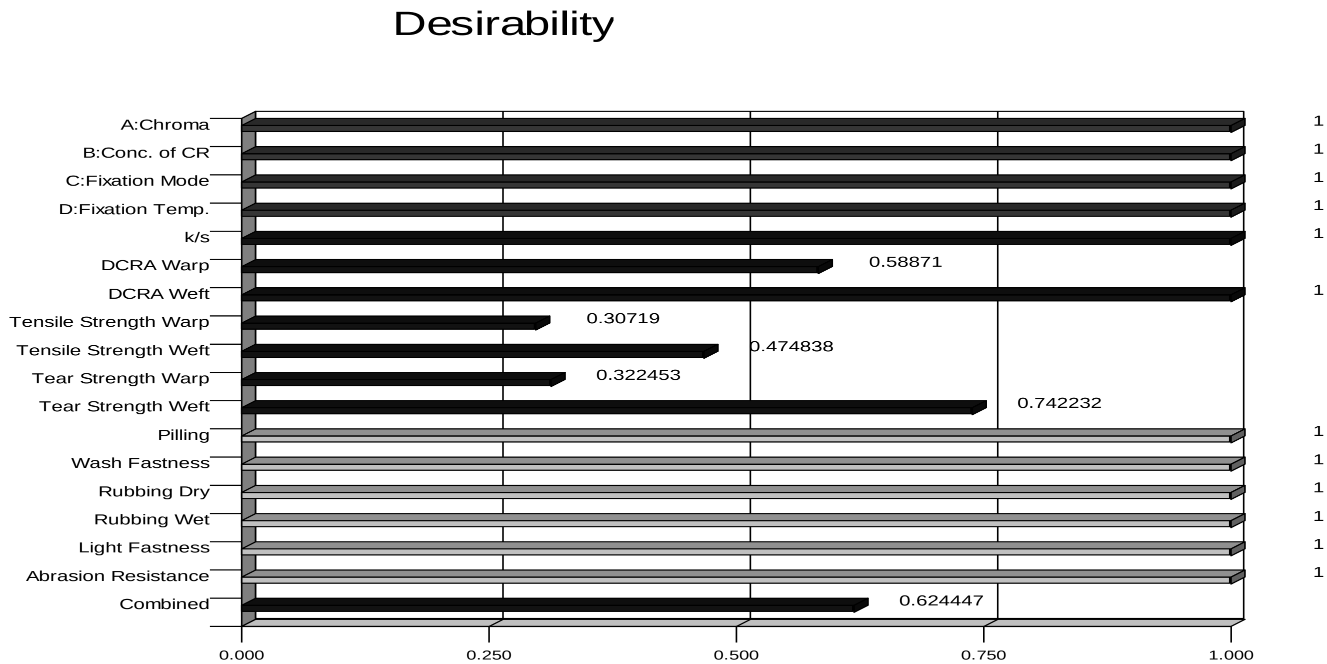

Fig. 1. Individual and Combined desirability Ratings for E Control process at 135°C

Fig. 1 shows the individual and combined desirability curve (all the four responses are given equal weightage). Table V revealed that the overall desirability value is less in the region of Curing and high temperature around 140-150 ˚C, while this is close to 1 in the region of E Control and low fixation temperature around 130-135 ˚C. This is owing to the fact that wet-on-wet fixation of E Control process is based on the temperature of the fabric reached during the fixation process, which depends on the relative humidity inside the hot air/controlled moisture fixation chamber. Therefore, by using steam at130-135ºC in this process, the reactive dye starts its fixation to the cellulose during the prolonged stage at a bulb temperature of 65-70 ºC.

Fig. 2 shows a typical drying curve and the resultant temperature of the goods throughout the E-control fixation process [10]. The goods should spend about 4-5 minutes in the fixation chamber for the drying and fixation process simultaneously as no drying is carried out prior to fixation in this process. Moreover the wet on wet fixation of E Control process gives high values of Tensile and Tear strengths both in warp and weft directions as showing in Table V. Whereas the specifications of K/S, DCRA warp and weft, pilling & abrasion resistance, wash, rub and light fastness are barely satisfied. However, the amount of dye and CR used in the simultaneous fixation will be slightly higher as compared to two-step process of fixation for achieving the same depth of shade and DCRA

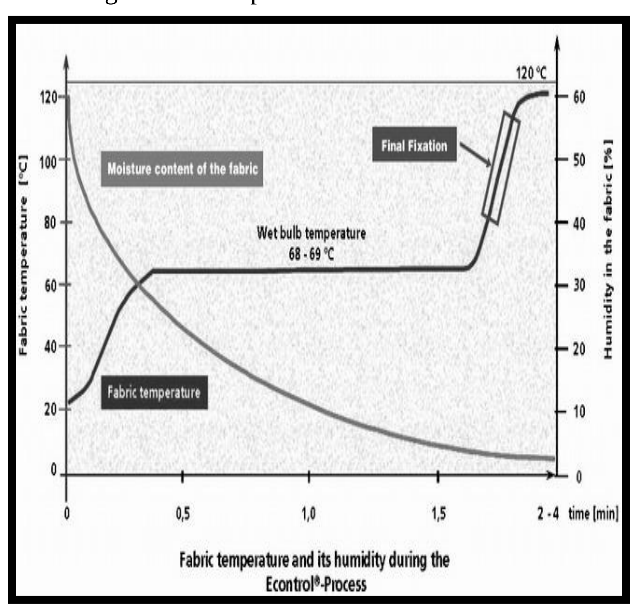

Fig. 2: Fabric Temperature and its humidity during the E Control Process

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The adequate parameters to maximize the overall desirability involve the following specifications:

- Chroma = 1.8 gm
- Concentration of CR = 159 g/l
- Fixation Mode = E Control
- Fixation Temperature = 135˚C

The following step consists of setting the optimal input variable levels that have maximized the overall desirabilities. That is, the optimum parameters would be set as mentioned in Table III. In this case the single step process of fixation of reactive dye and CR finishing showed similar results as a two step process. These results are evaluated giving high importance to response of k/s, DCRA warp and DCRA weft, but in actual practice in industries, depending upon the specific requirements of product and limitations of process, importance can be changed and the overall desirability and associated optimal levels can be determined. Some parameters having certain constraints can also be added. Table V shows the values of 27 levels of input parameters that will give acceptable overall desirability along with the values of responses.

Table V**:** Input Parameters for high value of desirability

S.No.	Chroma (%)	Conc. of CR (g/l)	Fixation Mode	Fixation Temp (˚c)	K/S	DCRA Warp (˚)	DCRA Weft (˚)	Tensile Strength Warp (N)	Tensile Strength Weft (N)	Tear Strength Warp (N)	Tear Strength Weft (N)	Pilling	Wash fastness	Dry Rub	Wet Rub	Light Fastness	Abrasion Resistance	Desirability
1	1.8	159.8	E Control	134.8	5	122.3	125.0	464.4	188.5	28.0	15.0	3.8	4.4	4.9	4.2	3.0	3.7	0.62
2	1.8	159.3	E Control	134.7	5	122.2	125.2	464.3	188.6	28.0	15.0	3.8	4.4	4.9	4.2	3.0	3.7	0.62
3	1.8	159.3	E Control	134.6	5	122.3	125.4	464.3	188.7	28.0	15.0	3.8	4.4	4.9	4.2	3.0	3.7	0.62
4	1.8	161.6	E Control	134.9	5	122.7	125.0	464.9	188.4	28.0	14.9	3.8	4.4	4.9	4.2	3.0	3.7	0.62
5	1.7	156.6	E Control	134.1	5	122.1	126.94	463.6	189.4	27.9	15.2	3.9	4.4	4.9	4.2	3.0	3.6	0.62
6	1.8	165.0	E Control	135.0	5	123.5	125.0	465.6	188.0	27.9	14.8	3.8	4.3	4.9	4.1	3.0	3.7	0.61
7	1.7	156.9	E Control	133.8	5	122.3	127.7	463.7	189.7	27.8	15.2	3.9	4.4	4.9	4.2	3.0	3.6	0.61
8	1.8	166.6	E Control	135.1	5	123.9	125.0	465.9	187.8	27.9	14.8	3.8	4.3	4.9	4.1	3.0	3.8	0.61
9	1.7	154.7	E Control	133.6	5	122.1	128.4	463.2	190.0	27.7	15.3	3.9	4.4	4.9	4.2	3.0	3.6	0.61
10	1.8	167.2	E Control	135.2	5	124.2	125.0	466.1	187.6	27.8	14.8	3.7	4.3	4.9	4.1	3.0	3.8	0.61
11	1.9	171.2	E Control	135.5	5	125.3	125.0	466.3	186.8	27.7	14.6	3.7	4.3	4.9	4.0	3.0	3.8	0.60
12	1.7	174.6	E Control	135.8	5	126.4	125.0	466.2	186.1	27.5	14.5	3.7	4.2	4.9	4.0	3.0	3.9	0.60
13	1.6	151.4	E Control	132.3	5	122.6	133.0	462.6	192.2	27.1	15.6	3.9	4.4	4.9	4.1	3.0	3.6	0.60
14	1.7	176.0	E Control	135.1	5	127.3	127.3	464.7	186.9	27.3	14.6	3.6	4.2	4.9	4.0	3.0	3.9	0.59
15	1.3	109.3	E Control	148.1	5	126.7	145.6	457.0	211.0	27.4	18.6	3.5	4.2	4.7	4.4	3.0	3.8	0.47
16	1.2	108.6	E Control	148	5	126.9	145.5	455.9	210.9	27.4	18.6	3.5	4.2	4.7	4.4	3.0	3.8	0.47
17	1.3	110.6	E Control	148.3	5	126.2	145.8	459.0	211.2	27.5	18.7	3.5	4.2	4.7	4.3	3.0	3.8	0.47
18	1.3	111.5	E Control	148.4	5	126.0	146.0	460.3	211.3	27.6	18.7	3.5	4.2	4.8	4.3	3.0	3.8	0.47
19	1.2	106.7	E Control	147.7	5	127.6	145.4	453.2	211.0	27.4	18.7	3.5	4.1	4.7	4.4	3.0	3.8	0.47
20	1.2	105.9	E Control	147.6	5	127.9	145.4	452.3	211.1	27.3	18.7	3.6	4.1	4.7	4.4	3.0	3.8	0.47
21	1.3	113.4	E Control	148.7	5	125.4	146.5	463.3	211.8	27.8	18.8	3.5	4.3	4.8	4.3	3.0	3.8	0.47
22	1.3	114.1	E Control	148.8	5	125.2	146.8	464.4	212.0	27.8	18.8	3.5	4.3	4.8	4.3	3.0	3.8	0.47
23	1.2	105.4	E Control	147.6	5	128.0	145.4	451.7	211.2	27.3	18.7	3.6	4.1	4.7	4.4	3.0	3.8	0.47
24	1.2	103.5	E Control	147.4	5	128.6	145.6	449.7	211.7	27.4	18.8	3.6	4.0	4.8	4.4	3.0	3.8	0.46
25	1.7	108.4	Curing	131.4	5	110.0	120.6	418.1	214.7	31.4	19.0	4.0	4.5	4.9	4.8	3.0	3.5	0.39
26	1.7	108.7	Curing	131.3	5	110.2	120.5	418.6	214.7	31.3	19.0	4.0	4.5	4.9	4.8	3.0	3.5	0.39
27	1.7	148.9	E Control	132.9	5	121.7	129.8	462.3	191.6	27.6	15.7	4.0	4.4	4.9	4.2	3.0	3.6	0.36

II. CONCLUSION

This paper optimizes process parameters for simultaneous fixation of reactive printing and crease resistant finish fabric using the overall desirability function. In order to aid in multicriterion optimization, a model was developed to compare the combo process and the standard two step process for reactive printing and crease resistance finishing. Table V lists twenty-seven different desirable ranges of input parameters and responses which give overall acceptable value of desirability. As clear from the Table V, E control process at 135˚C is enviable for getting high values of desirability and consequently a good substitute of the two step process. Furthermore, in this model we can vary the objectives, the tolerance intervals and the corresponding weights of the responses as required by the customer.

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