Comparing the Influence of the Drop Fill and Overflow Rinsing On the Reactive Dyeing Process in a Textile Dye House

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Abstract Drop/fill rinsing method was used for reducing the high water consumption of overflow rinsing process in textile dye house. However, it is not known whether this drop/fill method has adverse effects on the final fabric properties or not. In this study, the effects of using drop/fill method instead of overflow rinsing process on colorimetric and fastness properties of 100% cotton towel fabrics are investigated. It is found that, skipping to the drop fill rinsing method from the over flow rinsing process and obtained fresh water saving has no negative effect on colorimetric and color fastness values of the processed fabric samples and can be used conveniently in the industrial sized production.

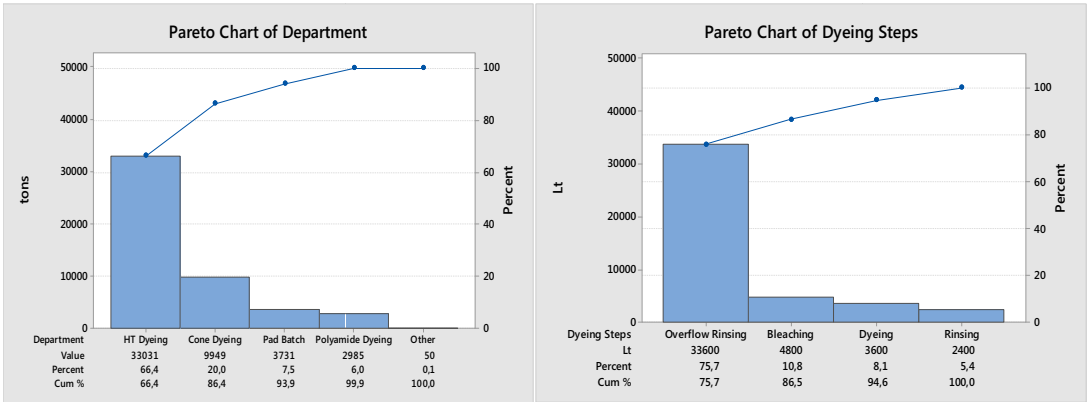
Keywords; **drop/fill rinsing, overflow rinsing, reactive dyeing, water consumption**

I. INTRODUCTION

Fresh water has become one of the most valuable natural source. In the past water resources was abundant and cheap. Therefore, high amount of fresh water consumption and consecutive high amount of textile wastewater discharge were acceptable both by textile companies, municipalities and also governments without any restrictions [1]. Nowadays, water is expensive and the increased costs of clean water and wastewater disposal have increased the social awareness and economic incentives for environmental friendly technologies [1, 2]. Thanks to these environmental friendly applications the natural water resources can be used efficiently [1]. Water management model, an integrated water resource management (IWRM), is offered as a useful tool for complex water research using production systems in industrial companies. The best available techniques (BAT) are introduced to present for a number of industrial processes in order to remove or reduce waste water discharge and emissions.

The textile industry is known as its large amount of water consumption in various processes, especially wet processing. In wet processing, water consumption is extremely high compared to the spinning or weaving processes. According USEPA (United States Environmental Protection Agency), 36,000 litres of water should be consumed for producing 20,000 lb fabric per day during the regular dye house processing. In the textile mills, millions of gallons of wastewater are created [2, 3]. Additionally, percentage of the water consumption of the dyeing process is approximately 16% of the total water consumed during the whole wet processes. In wet processing, water is used primarily for chemical processing and secondly for washing and rinsing [2]. Water conservation or reuse processes are development starts with the determination of how and where the water being used. Furthermore, it would be helpful to develop a diagram of water consumption with specific details such as, quantity and location of water usage, water quality or temperature requirements [2].

In this industrial sized research work, water consumption ratios of each processes were studied to determine water consumption amounts and Pareto analysis were performed. As result of Pareto analysis, data are processed on Minitab and HT fabric rope dyeing and cone dyeing departments were identified as the highest water consuming processes in the dye house.



(a) (b)

Fig 1. Minitab Pareto analysis results (a) for water consumption ratios of dye house departments,(b) for water consumption ratios of reactive dyeing process

As seen on Figure 1, the highest water consumption ratios of the reactive dyeing process are belongs to rinsing processes, especially overflow rinsing. Similarly, in literature, washing/rinsing processes were known to be responsible for the relatively high water consumptions in the companies [3]. These processes have significant potential for sustainable production. The overflow rinsing is found to be most water consuming processes in the reactive dyeing process. It has reported that avoidance of overflow rinsing, water consumption could be reduced by 25% [2, 3]. It has also reported that instead of overflow rinsing, drop/fill method should be preferred to manage water saving in the reactive dyeing of cotton fabric [2, 4-16].

In this study, the water consumption ratios of a textile dye house are evaluated to reduce water consumption by replacing the overflow rinsing with the the drop/fill method. Drop/fill rinsing method is applied gradually. The effect of drop/fill method utilization on the color and fastness properties of the fabric is also examined to clarify not to cause any deterioration, since it is very important removal of the hydrolyzed dyes completely removed from the fabric surface with the application of intensive rinse and soaping operations. Drop/fill rinsing process was applied in four stages for light shades and five stages in medium and dark shades. At each stage, color and fastness values of samples were examined to explain whether a negative effect on the processed fabric has occurred or not.

II. MATERIALS AND METHODS

100% cotton towels were used in this study. Drop/fill rinsing method is applied gradually. Gradually processes applied in this study are given in Figure 2. In light shades, 3 processes changed, in medium and dark shades 4 processes changed.

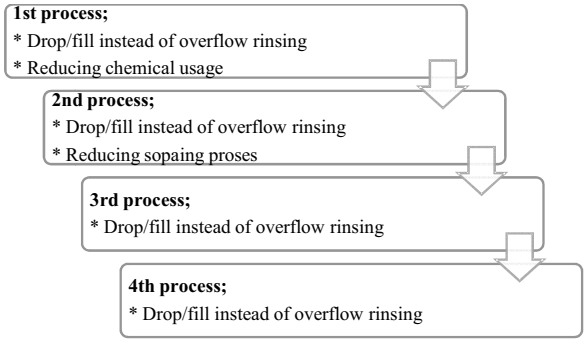


Fig 2. Processes applied to obtain water savings

Fabrics were dyed with 3 different color shades of light, medium, and dark shade. Three reactive dyes with light, medium and dark shades were selected for experiments. The CIE Lab values (*L*, a*, b*, C**, and h^o) *and* ΔE were measured from the reflectance values with using a spectrophotometer under illuminant D65, using 10º Standard observer for each samples. Both dry and wet rub fastness testing were performed according to the ISO

105: X12 protocol and wash-fastness test was carried out according to ISO 105:C06 C1S test standard. Overall fastness properties were evaluated by using ISO grey scales in the light box.

III. RESULTS AND DISCUSSION

A. Colorimetric Properties

It is important to note that reactive dyed samples have the same yarn count and fabric structures. For each dye shades four or five color measurements and washing and rub fastness examinations were done.

The colorimetric data of the samples dyed in light color shades obtained from each process steps are given in Table 1 and Figure 3-5.

TABLE 1
COLORIMETRIC PROPERTIES OF SAMPLES DYED IN LIGHT COLOR SHADES

Samples	L*	a*	b*	C*	h	dE*
11171Dyed fabrics without processes	77,96	7,69	-4,67	9,00	328,73	
11171-After 1st process step	78,42	7,75	-5,04	9,25	326,92	0,603
11171-After 2nd process step	78,46	7,62	-5,18	9,22	325,77	0,725
11171-After 3rd process step	78,33	7,02	-5,02	8,64	324,43	0,843

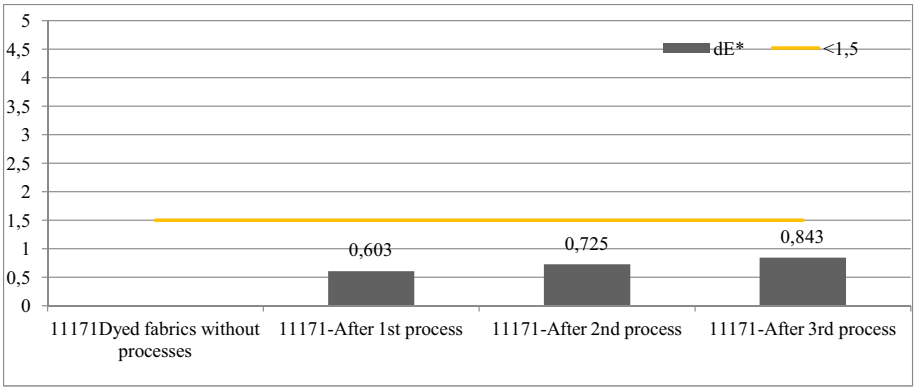


Fig 3. *Color differencs (ΔE)* values of samples

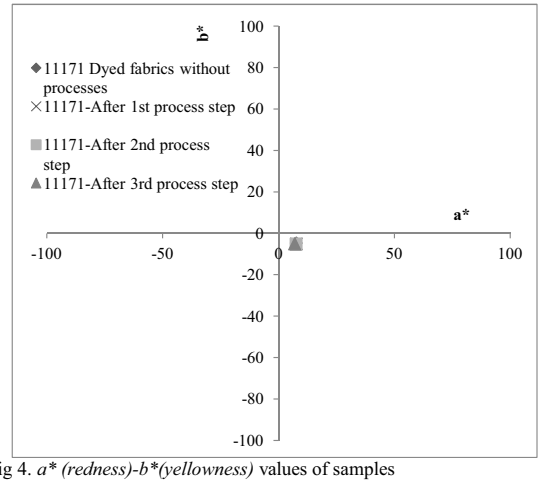


Fig 4. *a* (redness)-b*(yellowness)* values of samples

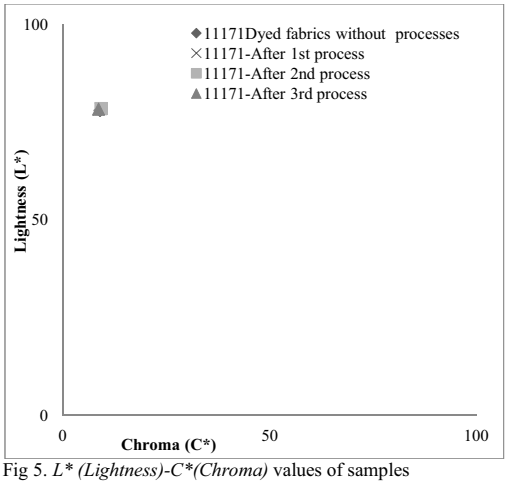


Fig 5. *L* (Lightness)-C*(Chroma)* values of samples

For each stages, the CIE Lab values (*L*, a*, b*, C**, and h^o*) and ΔE* of samples are found to be nearly the same. There have been no significant differences between Lightness (*L*), a*, b**,Chroma *(C*),* and hue angle (h^o) values of the samples.

The colorimetric data of the samples dyed in medium color shades obtained from each process steps are given in Table 2 and Figure 6-8.

TABLE 2
COLORIMETRIC PROPERTIES OF SAMPLES DYED IN MEDIUM COLOR SHADES

Samples	L*	a*	b*	C*	h	dE*
2952 Dyed fabrics without processes	68,68	-18,1	27,08	32,57	123,7	
2952-After 1st process	68,23	-18,1	26,91	32,41	123,9	0,484
2952-After 2nd process	68,43	-18,1	26,69	32,25	124,1	0,458
2952-After 3rd process	68,21	-18,2	27,14	32,14	123,9	0,49
2952-After 4th process	68,28	-18	27,31	32,73	123,4	0,46

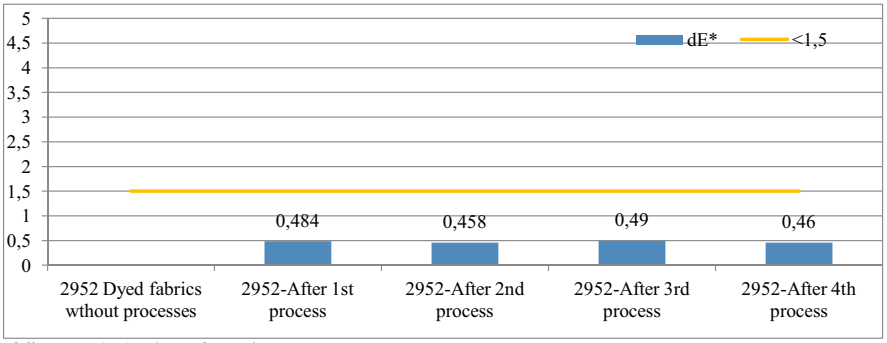


Fig 6. *Color differences (ΔE)* values of samples

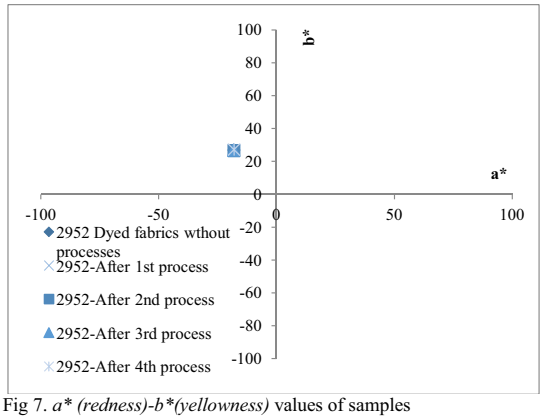


Fig 7. *a* (redness)-b*(yellowness)* values of samples

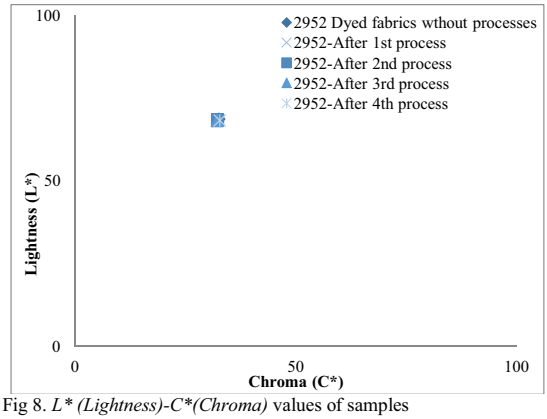


Fig 8. *L* (Lightness)-C*(Chroma)* values of samples

For each stages, the CIE Lab values (*L*, a*, b*, C*,* and h^o*) and ΔE* of samples are found to be nearly the same. There have been no significant differences between colorimetric values of the samples.

TABLE 3
COLORIMETRIC PROPERTIES OF SAMPLES DYED IN DARK COLOR SHADES

Samples	L*	a*	b*	C*	h	dE*
1946 Dyed fabrics before processes	37,4	50,46	12,72	52,04	14,15	
1946-After 1st process	37,4	50,46	12,73	52,04	14,15	0,011
1946-After 2nd process	37,58	50,73	12,97	52,37	14,34	0,414
1946-After 3rd process	37,66	50,08	12,67	51,66	14,2	0,46
1946-After 4th process	38,22	50,68	12,58	52,22	13,94	0,858

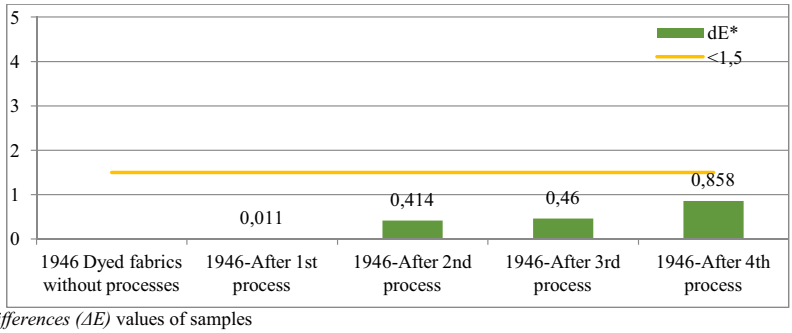


Fig 9. *Color differences (ΔE)* values of samples

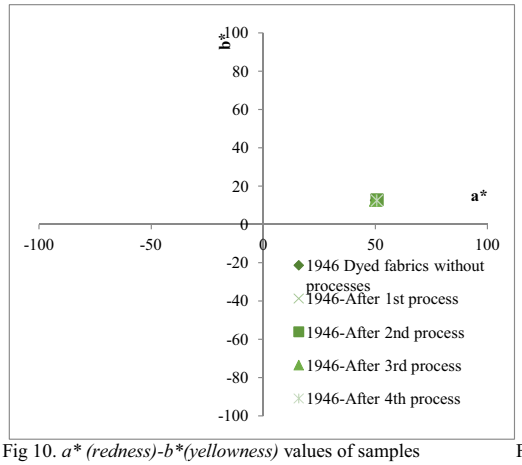


Fig 10. *a* (redness)-b*(yellowness)* values of samples

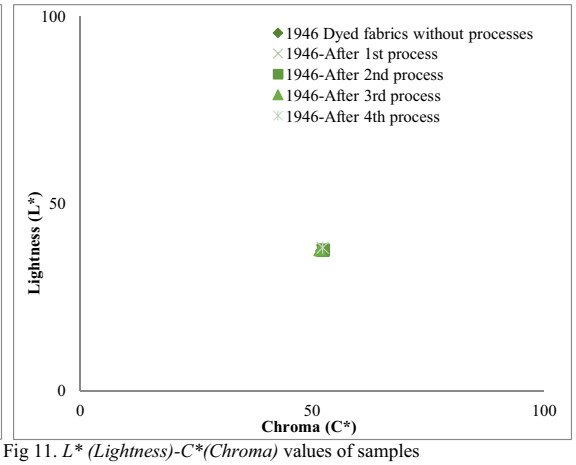


Fig 11. *L* (Lightness)-C*(Chroma)* values of samples

For each stages, the CIE Lab values (*L*, a*, b*, C*,* and h^o*) and* ΔE of samples are found to be nearly the same. There have been no significant differences between colorimetric values of the samples.

In this case, it can be stated that use of drop/fill rinsing method instead of overflow rinsing method have no negative effect on color properties of fabrics and the water consumption reduction method can be used in the dyeing process conveniently.

B. Wash and Rub Fastness

The rub and wash fastness values of samples were given on Table 4.

TABLE 4
RUB AND WASH FASTNESS PROPERTIES OF SAMPLES

	Rub Fastness						Wash fastness	
Samples	**Wet**	**Dry**	**WO**	**PC**	**PES**	**PA6.6**	**CO**	**AC**
11171Dyed fabrics without processes	5	5	5	5	5	5	5	5
11171-After 1st process step	5	5	5	5	5	5	5	5
11171-After 2nd process step	5	5	5	5	5	5	5	5
11171-After 3rd process step	5	5	5	5	5	5	5	5
2952 Dyed fabrics without processes	4/5	5	5	5	5	5	4/5	5
2952-After 1st process	4/5	5	5	5	5	5	4/5	5
2952-After 2nd process	4/5	5	5	5	5	5	4/5	5
2952-After 3rd process	4/5	5	5	5	5	5	4/5	5
2952-After 4th process	4/5	5	5	5	5	5	4/5	5
1946 Dyed fabrics before processes	3/4	4/5	5	4/5	5	5	4	5
1946-After 1st process	3/4	4/5	5	4/5	5	5	4	5
1946-After 2nd process	3/4	4/5	5	4/5	5	5	4	5
1946-After 3rd process	3/4	4/5	5	4/5	5	5	4	5
1946-After 4th process	3/4	4/5	5	4/5	5	5	4	5

All dyed samples in each stages exhibited moderate to good rub and wash fastness values according to 5 grey scale ratings. There were no differences between the fastness values of samples in each step. It can be stated that use of drop/fill rinsing method instead of overflow rinsing method have no negative effects on washing and rubbing fastness values of fabrics and the water saving approach can be used conveniently.

IV. CONCLUSION

Drop/fill rinsing method was used for reducing the water consumption in textile dye house. In one textile dye house, %61,8 reduction in water consumption and %20,4 reduction in process time were achieved by using drop/fill rinsing method instead of overflow rinsing. However, it is not known whether this drop/fill method has adverse effects on fabric or not. In this study, the effects of using drop/fill method instead of overflow rinsing, on colorimetric and fastness properties of fabrics were investigated. The colorimetric and fastness properties of samples exhibited almost the same values. Therefore, it is shown that this water consumption reduction method has no negative effect on colorimetric and color fastness values of the fabric samples and can be used conveniently in the dye house.

ACKNOWLEDGMENT

This research was supported by the Ozanteks Textile R&D center and related equity project number is 17S02.

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