DEVELOPING A CONCEPTUAL FRAMEWORK TO IMPROVE COLOUR SUCCESS RATE OF BULK DYEING WITH NEW COLOURS AT TEEJAY LANKA PLC – A CASE STUDY

L.M.D. Lansakara, M.E.R Perera*

Department of Textile and Apparel Technology, The Open University of Sri Lanka

INTRODUCTION

Dyeing is the second last step in the manufacturing process of fabric materials. Therefore, dyeing of fabric materials should be done with extra attention to get it right by the first attempt. In order to achieve the success in dyeing of fabric materials, different dyeing processes such as lab, intermediate and bulk dyeing are performed. When the right first time (RFT) dyeing concept is practiced, the accurate correlation of intermediate to bulk dyeing is very important. This gets even crucial when dealing with dyeing of fabric materials with new colours. The colour performance of bulk batches and timely delivery of finished fabric materials largely depend on the success of the first batch of bulk dyeing. The consequences of not achieving RFT processing performance in bulk dyeing are severe, and the success depends on the availability of efficient laboratory services and intermediate dyeing facilities. Since intermediate dyeing is relatively inexpensive compared with corrections in bulk dyeing, the use of accurate intermediate dyeing can be considered as a very important processing step (Borse, *et al*., 2016). Teejay Lanka PLC is one of the largest weft knitted fabric manufacturers in Sri Lanka. The success rate of the first batch of bulk dyeing achieving the required colour performance with new colours was 82% when using the dye recipes of intermediate dyeing, though the set target was 90% in the year 2019 (Annual report, 2019).

According to the existing literature, a study has been carried out to identify the associated cost of lab, intermediate and bulk dyeing. It has revealed that the cost of lab dyeing is comparatively less than that of adjustments in bulk dyeing. Since it is important to have compatibility between dye stuffs used in each dyeing stage, testing has been carried out to formulate different dye classes. The study has been further extended to identify the colour behaviour when it comes to changes in liquor ratios and fibre compositions. The study suggests that it is difficult to capture and absorb all the differences between lab and bulk dyeing when it comes to the flow of liquor and movement of the goods due to changes in machine conditions and technology. Therefore, the importance of conducting intermediate dyeing is highlighted (Hildebrand & Hoffmann, 1993). In another study, computer based colour matching mechanisms have been tested to directly obtain the lab to bulk dyeing recipes while omitting the intermediate dyeing process. Due to many variables involved, the accuracy has been a concern affecting the achievement of optimum results (Park, 1991). Moreover, the colour differences of Cashmere yarn dyeing from lab to bulk dyeing have been studied and the optimum parameters was adopted and most primarily influenced parameters have been identified. Once the finest balance of parameters was adopted, the differences in colour have been reduced (Wang's & Wang's, 2012).The main objective of this case study conducted at Teejay Lanka PLC dyeing plant is to develop a conceptual framework to issue optimum dye recipes for new colours from intermediate to bulk dyeing to improve the RFT dyeing performance.

METHODOLOGY

1. A literature survey was carried out to gather information in relation to the topic.

2. A comprehensive data analysis was done by using the historical data during the period from 01.01.2019 to 31.12.2019. Various colour processing routes were analysed and eleven (11) colour processing routes with lower pass percentages were selected for further study.

3. Selected eleven (11) colour processing routes were further observed and analysed from

15.01.2020 to 15.07. 2020 to collect actual data.

4. A conceptual framework was developed and it was tested for accuracy by using six (06) colour processing routes with a minimum of three bulk trails.

RESEARCH DESIGN

The research design has three major parts namely the analysis of the existing process and selection of fabric types, data collection and analysis for the development of the conceptual framework and development of the conceptual framework.

Part A: Analysis of the existing process and selection of fabric types

The total dyeing process of the dye plant was analysed and it was found that three (03) different dyeing processes are practiced. Machines used for lab dyeing are different from the machines used for intermediate dyeing, while three (03) other types of machine groups are used for bulk dyeing. Five (05) different dye programmes are used to obtain the required colours. Out of the large number of fabric types used, three (03) fabric types which are used for a higher number of first bulk dyeing were selected for the study. The study period taken to analyse the existing processes and related techniques was from 01.01.2019 to 31.12.2019. The necessary details are given in the following tables.

Table 1: Different dyeing processes with standard sample sizes:

Dyeing Process	Sample sizes
Lab dyeing	12 g
Intermediate Dyeing	2.5 kg
Bulk Dyeing	200 kg -1200 kg

Table 2: Types of bulk dyeing machines with important attributes:

Machine type	Important attributes
ECO Machines	Nonadjustable water jet, Liquor ratio 1:8/1:10, Charge tank available, Inner drum available
THEN Machines	Adjustable water and air jet, Liquor ratio 1:5/1:6, Charge tank not available, Inner drum available
LR Machines	Adjustable water and air jet, Liquor ratio 1:5/1:6, Charge tank available, Inner drum not available

Table 3: Dye programmes used during the study period:

Number of dye programmes	Specific notation given for dye programmes
05	L01, L05, L07, L08 and L09

Table 4: Types of fabrics used in study:

Fabric Type	Structure	Composition and yarn count of fabrics	Width (cm)	Weight (g/m^2)
A	Single Jersey	95% Cotton of 1/40 Ne and 5% Spandex of 1/22Dtex	172	150
B	Single Jersey	90% Cotton of 1/40 Ne and 10% Spandex of 1/44Dtex	165	160
C	Single Jersey	100% cotton of 1/40 Ne	147	115

The dye plant uses “Munsell colour system” to evaluate the colour behaviour in each dyeing process mentioned above. Spectrophotometer is used to get computerized colour readings with the help of “Data Colour Tool” software. Important parameters of colour such as Lightness (L), Chroma (C) and Hue (H) are determined by using Data Colour Tool software which is based on Munsell colour system.

Part B: Data collection and analysis for the development of conceptual framework

Thirty - seven (37) colour processing routes (combinations of fabric types, machine groups and dye programmes) were studied and analysed to identify the possible correlation between the material type, machine group and dye programme against the colour performance. Eleven (11) colour processing routes with lower pass percentages were selected for further study. Table 5 shows the details of the selected colour processing routes with lower pass percentages.

Table 5: Summary of selected colour processing routes for further study

Material Type	Machine group	Dye Programme	Number of 1st bulks performed	Number of 1st bulks passed	Pass % of 1st bulks
A	ECO	L 07	8	5	63%
	LR	L 05	3	2	67%
	THEN	L 07	6	4	67%
B	ECO	L 07	1	0	0%
	LR	L 05	3	1	33%
	THEN	L 01	2	1	50%
		L 07	2	0	0%
C	ECO	L 01	10	7	70%
		L 08	4	2	50%
		L 09	3	2	67%
	THEN	L 01	7	5	71%

Colour readings were obtained from both intermediate and bulk dyeing for the selected eleven (11) colour processing routes. As per the general practice of the dyeing plant at least three (03) 1st bulk trails are required to obtain accurate results. This concept was used to develop the conceptual framework. Table 6 shows the details of the collected data.

Table 6: Summary of the 1st bulk trials of eleven colour processing routes

Material Type	Machine group	Dye Programme	Number of 1st bulk trials	Eligibility for Conceptual framework
A	ECO	L 07	04	Yes
	LR	L 05	00	No
	THEN	L 07	02	No
B	ECO	L 07	03	Yes
	LR	L 05	03	Yes
	THEN	L 01	03	Yes
		L 07	02	No
C	ECO	L 01	08	Yes
		L 08	01	No
		L 09	01	No
	THEN	L 01	08	Yes

Part C: Development of the conceptual framework

Six (06) colour processing routes were eligible for the development of the conceptual framework. The colour readings were obtained by using the Munsell colour system for intermediate and bulk dyeing. The average variances were calculated for Lightness (L), Chroma (C) and Hue (H) as given in the Table 7.

Table 7: Summary of the average variances of selected colour processing routes

Material Type	Machine group	Dye programme	DL	DC	DH
Type A	ECO	L 07	-0.58	-0.17	-0.38
Type B	ECO	L 07	0.21	-0.10	-0.98
	LR	L 05	0.27	0.10	-0.59
	THEN	L 01	0.28	0.20	0.30
Type C	ECO	L 01	-	-0.10	-0.16
	THEN	L 01	-0.17	0.31	-0.53

RESULTS AND DISCUSSION

By using the average variances for each colour component, a conceptual framework for the selected colour processing routes was developed. As per Table 7, the colour deviates from intermediate to bulk dyeing by an average variance. Therefore, to meet the required colour standard for the bulk dyeing, it is recommended to adjust the dye recipes of intermediate dyeing by using the average variance values of each colour component. For example, in the colour processing route A-ECO-L07, the level of lightness (L) has deviated by a minus DL value of 0.58. This means that the level of darkness issued from intermediate dyeing comes out 0.58 darker in the bulk dyeing. Therefore, to meet the required colour level, the bulk dyeing recipe for colour processing route A-ECO-L07 should be issued 0.58 lighter than the recipe used for intermediate dyeing of the same colour processing route. The same concept can be extended to adjust deviations in other colour processing routes as well.

In order to examine the accuracy of the developed conceptual framework, trials were carried out for the selected six (06) colour processing routes from 01.08.2020 to 31.12.2020. It was possible to perform three 1st bulk trials only for the colour processing routes A-ECO-L07 and C-ECO-L01 due to the lack of bulk production in the dye plant under the Covid 19 pandemic situation. Therefore, those two colour processing routes were compared as shown in Table 8 and it shows that there is an improvement in the pass percentage of first bulks.

Table 8: Comparison of pass percentages before and after applying the conceptual framework

Material type	Machine group	Dye programme	Pass % of 1st bulks before applying the conceptual framework	Pass % of 1st bulks after applying the conceptual framework
A	ECO	L 07	63%	88%
C	ECO	L 01	70%	86%

CONCLUSION

This study was carried out to develop a conceptual framework to determine optimum dye recipes for new colours from intermediate to bulk dyeing to improve the RFT dyeing performance at Teejay Lanka PLC. It was possible to perform a minimum of three 1st bulk trials only for colour processing routes A-ECO-L07 and C-ECO-L01 during the period of validation of the developed conceptual framework. As per the results, both colour processing routes have shown a significant improvement. It was further noticed that ECO machines with L07 dye programme and THEN machines with L01 dye programme exhibit a clear draw-back when it comes to colour deviations from intermediate to bulk dyeing. Therefore, further testing should be carried out on the respective dye programmes as well as on the overall framework capturing other related dyeing variables such as liquor ratio and pH controls. The framework can be further improved by increasing the number of trials. Higher the number of trials captured, the more accurate the framework will be. Generally, colourists adjust the dye recipes to meet the level that the colour is required to be with their years of experience. The developed framework not only provide a guideline for colourists for new colours but also for repeat colours for re-dyeing. Once the intermediate to bulk dyeing framework is fully established, a similar kind of framework for lab to bulk dyeing, which will be beneficial for the dye plant to minimise the overall cost of dyeing process can be developed.

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