

The Impact of Effective Colour Management for Textile Coloration: An Instrumental Way Towards Perfection

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ABSTRACT

The colour produced by the application of either dyes or pigments on textiles must be close matched with reference (standard) provided by buyer. Meeting stringent requirement from Buyer that demands right colour on right time is not a simple task to achieve. The process of colour matching is a lengthy process and needs many trials to get close match. The colour quantification through instruments helps to cut most of the lead time, however, there is a serious need to manage colour during colour approval stage and coloration process. We adopted four different routes for colour approval and compared with the conventional one. The study revealed that out of four instrumental options, the 4th option had shortest route and minimum lead time. We also concluded that by using spectrophotometer, K/S (Colour Strength) and colorimetric values are very good to not only communicate colour numerically but also controlling colour during colour approval process.

Key Words: Colour Management, Colour Measurement, Colour Matching, Colour Approval Process, Textile Dyeing and Printing, Quality Control, Cut Lead Time.

1. INTRODUCTION

In textile manufacturing, the textile coloration has significant role in every aspect of its process carried out on the textile pigments. Textile coloration is the process of dyeing and printing of textiles with colorants that includes both dyes and pigments. The dyeing process applies to colour full batch whereas the printing process applies to localized or specific areas which demonstrates colourful designs and patterns. There are several techniques of dyeing textiles depending upon the type of

textile being dyed and class of dyestuff selected. The dyes are very specific according to fibre composition of which they have certain substantivity, for instance, reactive dyes, vat dyes, sulphur dyes and direct dyes can be applied to cotton fibre; disperse dyes can be applied to polyester and nylon fibre. The pigments, on the other hand, have no substantivity towards fibre and hence applied with binder to fix pigments with the fibre, this allows pigments application for all types of textile fibres [1].

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The dyeing process may be continuous or batchwise or semi-continuous, in any case, the colour management and control plays a vital role to produce dyed goods within specified time [2]. The trials to match colour close to standard are conducted prior to bulk run, this is the stage where the cut lead time approach begins. It would be an ideal if dyer gets close match in one trial but it's not always being the case; normally dyer succeed to match colour within two to three trials but at the price of production loss. As the number of trials increase the machine down time also increases, so it is always been taken at high priority to conduct trials as minimum as possible to match the colour. This is only possible if the colour is measured instrumentally and by correct utilization of tools and technology we have today but new concepts of fashion and trends have significant role in colour matching and colour approval stage. Number of dyeing corrections during dyeing increase dye effluent and affects the fabric quality and colours [3].

The approach of matching colour through use of instruments for instance Spectrophotometer, which has number options available that can be utilized. Spectrophotometer provides numeric values that can be instantly communicated online. This approach greatly contributes to cut lead time reduction; however, overall reduction may be enhanced if the colour approval process is taken into account. This is the area where initially colour is approved before the bulk order can be placed. The colour communication between the dyer and customer can be made effective if once again the instrumentation and latest technology is involved during colour approval stage.

1.1 Objectives of Study

The cut lead time strategies through full utilization of instruments is today's key factor of success, this will not only save time but dyer can fetch many orders by quick response. This paper represents insight into the system of colour matching process during textile coloration and colour approval stage, and outlines the way how instruments utilization can be effective to cut lead time

reduction and colour matching perfection.

2. INSTRUMENTAL COLOUR MEASUREMENT

Colour can be quantified by either colorimeter or spectrophotometer. The difference between the two is that former can measure only colour attributes (hue, chroma, lightness) and the later measures geometrical attributes (haze, specular and diffusive reflections) along with colour attributes. Since the textile surfaces are textured and are not smooth, therefore, need to be measured in spectrophotometer (Fig. 1) [4].

The measured colour of textile given quantified values generated by spectrophotometer on the basis Equation (1):

$$\Delta E(CMC) = \left[\left(\frac{\Delta L}{lS_L} \right)^2 + \left(\frac{\Delta C}{cS_C} \right)^2 + \left(\frac{\Delta H}{S_H} \right)^2 \right]^{1/2} \quad (1)$$

where, ΔE (CMC) is total colour difference with l:c ratio of 2:1, keeping commercial factor 1.2, ΔL is lightness difference, ΔC is saturation or chroma difference, ΔH is hue difference, l is luminosity factor, c is chroma factor, S_L is semi sphere of lightness, S_C is semi sphere of chroma and S_H is semi sphere hue [5].



FIG. 1. SPECTROPHOTOMETER FOR MEASURING COLOURED TEXTILES

The dyer can read the report generated by spectrophotometer and make decision accordingly. The customer standard once is fed and saved in spectrophotometer and all trials are measured against it. The ΔE (CMC) describes how far or close the trial of dyer is close to the standard shade. If the value go beyond the commercial factor 1.2, the spectrophotometer reports as "fail" and dyer is then required to reproduce the colour. The reports are very guiding for dyer in a sense that the second trial cannot go beyond the standard if the report is followed properly. Therefore, it is recommended that each numerical values be given importance and consideration while colour matching.

3. TOOLS AND TECHNOLOGY TODAY

There are number of tools and technology we have today. The light box in which the dyed samples are viewed at certain angle and compared with standard. The inside colour of this box is grey since it reflects light constantly over the visible spectrum (400-700nm); the variety of light sources are installed at the top of the box inside for viewing sample in a desired light. The other instruments include Spectrophotometer; this may be bench top type or portable type, normally, bench top type spectrophotometers have more functionality than that of the portable type, having enough options to control and manage the shade. Sample conditioner is another tool recently been adopted by many industry, the sample are placed inside the conditioner under standard conditions. This helps rapid conditioning of dyed sample and can be measured immediately in spectrophotometer.

Apart from instruments, variety of colour management software available that offered to textile industry. There are many but Datacolor® and X-rite® are among the professional organizations that provide services and software on colour management [6-7].

4. PROBLEM ANALYSIS AND DISCUSSION

The lead time can be cut down at two stages, during colour approval stage i.e. before production and during

coloration stage i.e. during production. It is necessary to review before any strategy adopted towards managing colour effectively.

4.1 Colour Approval Stage

4.1.1 Review of Existing 'Manual' Communication Method

There are still many textile industries, who do not have formalized colour management procedures or instruments systems. Therefore, it is necessary to review and analyze the problem that why not perfection in colour approvals and why delaying?

As case study example, either the physical samples (swatches) or colour pallets (Pantone® etc.) as a standard/control are received at industry via supply chain. The industry than asked by customer to produce Lab-Dips which represents how the sample will look like prior to bulk run with respect to:

- ☐ Colour/shade produced on selected textile substrate
- ☐ Metamerism (if the set is matched in on D65 light source, must also match in other light source such as TL84)
- ☐ Colour fastness properties
- ☐ The cost of dyes
- ☐ The coloration method

To produce lab-dips on the other hand is also a time consuming, because its beginning is based on hit and trial and very mush dependent on colourist experience, who match the colour with given swatch or pallet and producing lab-dips for customer. It's nearly impossible for colourist to produce lab-dip in one attempt and so it requires number of attempts to match as close to standard as possible. One attempt takes around 30-60 minutes depending on the method of coloration chosen. The number of trials may go up to 6 but ideally an experienced colourist match within 3-4 trials, this once again vary depending upon the type

of shade being produced and colourist's expertise. Once the lab-dips are produced, the samples are sent to customer for approval, the physical submission once again a time consuming as well as may open the for confrontation between colourist and customer. Now the starts communicate verbally like the submitted lab-dip is redder than what we provide standard (but how much redder is a question), the sample is also lighter or darker etc.; at this stage colourist try to defend that this should be accepted and submitted lab-dips are under tolerances. When accuracy is everything, then the colour must also be quantified to avoid any technical battle. The tentative time line for this approval process is given in Table 1.

Apart from time consuming, the chances of error is always there. There are equal chances of lab-dip rejection after 4-6 weeks exercise, one can imagine 3-4 weeks should atleast be added when rejection occurs.

The factors causing for errors/mismatch of lab-dip could be many and the majour contributing are listed as:

- ☐ The colourist's experience towards colour matching.
- ☐ Dye selection criteria pertaining to Metamerism.
- ☐ Colour viewing conditions i.e. observer view angle, light source and sample position in the light box.
- ☐ Lab-dip size (may effect if lab-dips is larger than the standard swatch size).

4.1.2 Best Practice-Effective Colour Management during Colour Approval Stage by Using Instruments

This is the area where retailer are focusing to avoid all visual methods and trying to replace them with the instrumental methods. The inspired colour is set and selected by authority who intends to reproduce onto the textiles. These colours may sometimes be selected from colour pallets or may be provided a numerical value by instruments. There are number of routes available in colour approval stages, as describe [8], Table 2 illustrates such options:

TABLE 1. TENTATIVE TIME-LINE FOR COLOUR APPROVAL STAGE (CONVENTIONAL SYSTEM)

Activity		Tentative Time Frame (Weeks)
Customer	Industry (Colourist)	
Swatch Dispatch	-	1-2
	Swatch received and started producing Lab-Dip; Average number of shade are 4	1-2
	Lab-Dips dispatch	1-2
Decision/Approval Process		1
Total:		4-6

TABLE 2. POSSIBLE ROUTE AND OPTIONS FOR COLOUR APPROVAL INSTRUMENTALLY

Instrumental Option	Possible Route
1	Instrumental evaluation of physical submits; the sample are physically submits to the industry and the dyers then measure in spectrophotometer.
2	Instrumental evaluation of electronic submits in QC programs; in this technology of the designers or colour creator submit electronically the colour values to the dyer. The organization who adopted this technology have been enjoying the massive lead time, cost and quality benefits.
3	Instrumental evaluation of electronic submits using true colour on-screen solution; this is a further enhancement, the true colour can be viewed on the screen at dyers end. This saves lot of time lab dip preparation to check the actual tone of colour.
4	Self approval by the supply base; there are certain industries who are accredited by retailers/ buyers to self approve their own lab-dip and production sample.

The total colour approval process was break-up into four distinctive processes shown in Fig. 2. Each set of four processes conducted in four different options and compared. The description of each option that how instruments utilized were already described in Table 2. Fig. 2 demonstrates a clear picture of cut-lead time that how significantly the instrumental colour approval options are contributing. The Lab dispatch preparation time in option 1 was reduced to 3 days due to the use of spectrophotometer, whilst the dispatch time for swatch and Lab-dips remain unchanged compared to conventional. In option 2, submission of swatch and Lab dips electronically significantly reduce number of days, brought down to 1 day. Instrumental evaluation of electronic submits using true colour on-screen

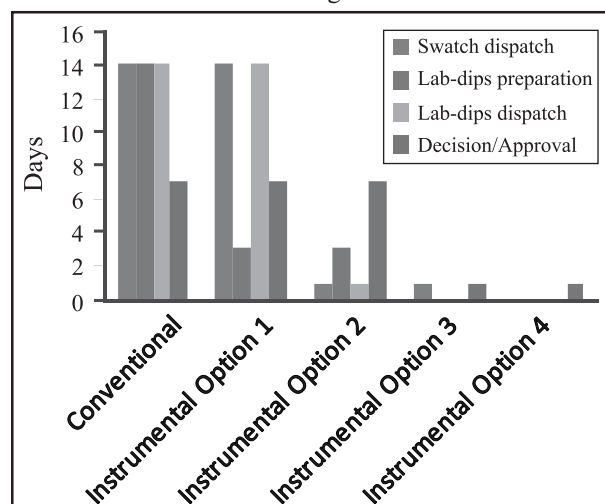


FIG. 2. RELATIVE COMPARISON OF TENTATIVE TIME-LINE AMONG COLOUR APPROVAL STAGE CONVENTIONAL AND VARIOUS INSTRUMENTAL AVAILABLE OPTIONS

required only two days for swatch dispatch and approval (option 3) and lab-dips need not to prepare since colour was approved direct on-screen; the colour information can be observed online or offline, hence no time was required. The option 4 do not require any approval authority since they are accredited by buyers and authorized to approve their samples. Among all options, the options 3 and 4 were quite advantageous with respect to both time saving and accuracy since the human interventions are almost negligible. The instruments involve primarily spectrophotometer and secondary the calibrated monitor. This long term investment can bring about lots of savings in many aspects; the pay back can be expected to be within a year. The colour quantification was only the solution towards this perfection. The colour can now be quantified by describing their values, ΔE , ΔL , ΔC and ΔH already discussed in Section 2 previously. Besides, there are number of other option too that can lead colourist towards more perfection such as Recipe prediction system (Fig. 3) and on screen prediction of Metamerism.

4.2. Colour Management during Coloration Process

4.2.1. Manual Colour Communication Method

Great deal of discussion already discussed in Section 4.1.1, the manual/verbal discussion invites many unseen

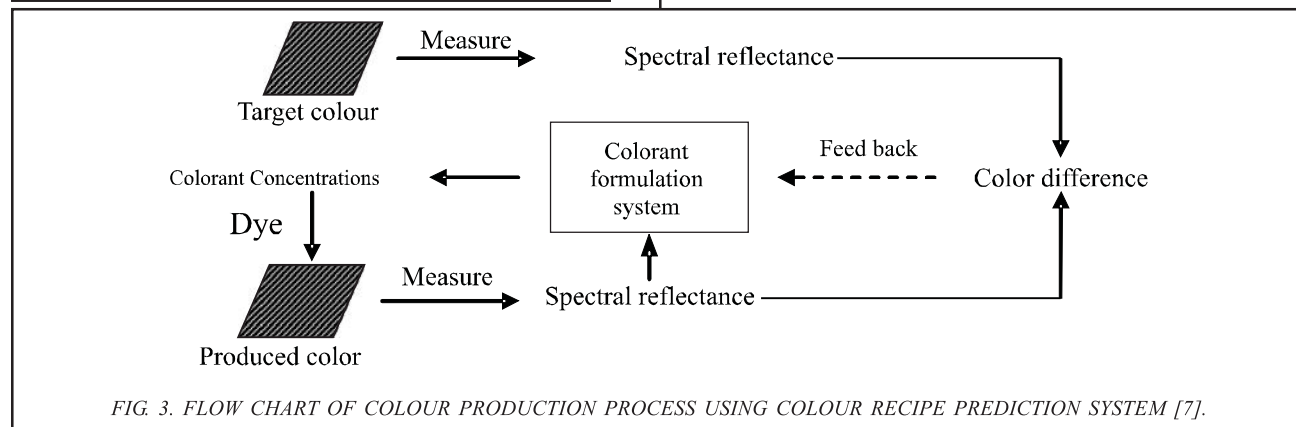


FIG. 3. FLOW CHART OF COLOUR PRODUCTION PROCESS USING COLOUR RECIPE PREDICTION SYSTEM [7].

troubles regarding disagreement of colour approval. However, during the production coloration process when the bulk textile fabric are dyed or printed in the range of 5,000 -100,000 meters long run and the accuracy becomes more important than during colour approval stage. Any rejection at this stage will definitely be tremendous cost has to pay, this disadvantages and may lead to lose customers and wastage time and effort on the other hand. Hence, the margin of errors is too small. Mostly dyers and colourists routinely reprocess to correct the shade, but this correction increase the cost 2.5 times the first time [9]. The RFT (Right First Time) would only be the option to cop all these issues and this possible if the colour communication and its control be done by using colour measuring instruments. Despite the dye recipe of lab-dips saves much of the time and gives idea of what recipe in production be taken, the recipe cannot be reproduced that match the standard. Therefore, 1-2 trial required prior to bulk run. The instrumental involvement reduces this risk as well; there is least chance of a second trial, once again time saving and accuracy in colour production also its implementation will lead to a cleaner environment, and more cost-effective use of starting materials. [10].

4.2.2 Instrumental Colour Communication Method

Simply spectrophotometer is used to determine colour, it generates colour quantified values ΔE , ΔL , ΔC and ΔH . The customer standard is fed in to the spectrophotometer and considered all ΔE , ΔL , ΔC and ΔH at 0.0. The samples are drawn during the production run and measured in spectrophotometer against the standard. The deviated values may be for example:

$$\Delta E = 0.66, \Delta L = 0.45, \Delta C = 0.82 \text{ and } \Delta H = 0.24$$

The spectrophotometer computes by using Equation (1) discussed in Section 2 and provide dyers a valuable guidance whether colour/shade is passed or fail against standard.

Another advantage of using instruments is that the data of each dye can be stored and recipe can be predicted prior to bulk run. The predicted recipe formulation further guide the cost analysis, Metamerism, coloration methodology and the trend of each dye behavior in both reflectance as well as colour strength modes. Fig. 4 shows the reflectance pattern of each dye over the visible spectrum 350-750nm.

Fig. 5 shows K/S values of each dye concentration over visible spectrum form 350-750nm. Each dye can be managed and control instrumentally by using both reflectance data and K/S values. More recently, measurement of metamerism in half tone is now possible [11].

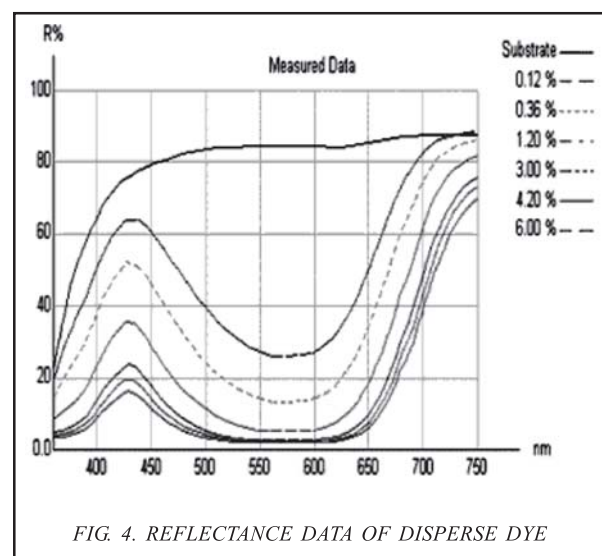


FIG. 4. REFLECTANCE DATA OF DISPERSE DYE

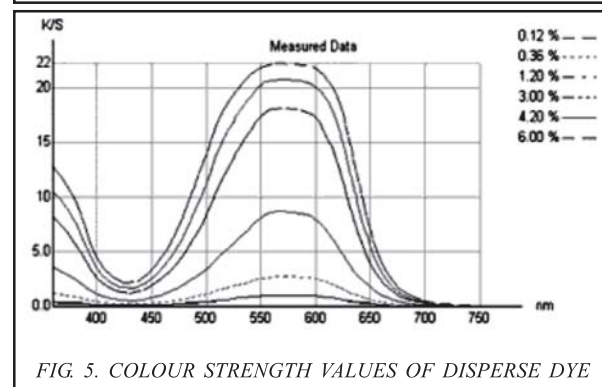


FIG. 5. COLOUR STRENGTH VALUES OF DISPERSE DYE

Managing colour during coloration process can save lot of time. Dyers sometime careless to follow colour matching instrumentally and feel botheration to use technology as a result they attempt and believe their experience and guess that may result into a perfect match or go beyond the limit. The dyer should adhere himself to the following important points to avoid any discrepancy while colour matching and can save colour matching time:

- (i) Proper record in spectrophotometer.
- (ii) Must follow same spectrophotometer parameter as set when standard was measured and saved.
- (iii) Proper conditioning prior to reading in spectrophotometer.
- (iv) Check setting parameter of spectrophotometer.
- (v) Learn to master in reading spectrophotometer.
- (vi) Educated guess based on report for further dye additions to the dye bath if needed.
- (vii) Keep record of history of all dye addition.
- (viii) Keep all trial in consistency order and number properly.
- (ix) Keep the commercial factor as lower as possible to keep room for improvement in further processing stages, the commercial factor may be set between 0.8 and 1.0.
- (x) It is also advised to target ΔC and ΔH for more perfection.

5. CONCLUSION

The use of spectrophotometer and colour software can significantly reduce the lead time and brings accuracy and perfection at both level colour approval stage and during coloration process. Study revealed that the self approval by the supply base (option 4) is the highly

significant among all other options? in terms of lead time reduction. The instrumental colour communication can quantify the colour and provide a numerical values, the ΔE total colour difference should not exceed commercial factor 1. The K/S values on the other hand, illustrates true picture of colour strength in the numeric form within the visible spectrum range 300-700nm. The manual that is conventional method of communicating colour is still widely being used by several industries in spite of many disadvantages. Effective Colour Management for Textile Coloration, at present, can only be done if the dyer/ colorists and retailer ideally accept the technological change and adopt them in their respective areas. The barrier to this may be due to the lack of vision, reluctant to invest and lack of understanding the lengthy colour theories. To survive in this fast pace market, the dyer/colourist can effectively manage the colour by using instrumental ways and techniques.

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