The Review of Blind Dyeing- the RFT Technique

•Mohammad Gias uddin

Abstract— Blind dyeing is an exacting service in terms of quality and speedy delivery, supported by advanced coloration technology, with a high level of expertise. The benefits of achieving right-first-time (RFT) production through blind dyeing are documented and include cost savings, increase in productivity with just-in-time (JIT) processing and a quick response (QR) to customer requirements. These benefits would not have been possible without the fulfillment of optimized laboratory requirements and would result in improved, controlled and systematic dye application techniques. A complete change in philosophy and management attitudes is required to the dyeing techniques. Similarity, many technical factors require tight control. In this paper, a review on blind dyeing as well as RFT technique, particularly blind dyeing principle and its concept of success, laboratory requirements for bulk reproduction, main controlling points for blind dyeing, costing and profit is being presented so that industry can get benefit to a considerable extent by adopting this concept.

Keywords: RFT, QR, ΔE, shading, automation, quality, cost, service, management.

1 INTRODUCTION

THE wet processing sector of the textile industry has traditionally suffered from low levels of Right-First-Time (RFT) production. Dye houses today need to recognize the increasing need to adopt a more scientific approach. The pursuit of quality assurance systems and the introduction of total quality management (TQM) can accept no other concept than RFT. Blind dyeing has been viewed as the unattainable goal for colorists in much the same way as like the 'zero defect' concept. But the need for service and quality, while keeping costs down, will only be achieved in this way.

2. PRINCIPLE OF BLIND DYEING

The technique of blind dyeing not only means that no additions are made, but also requires that the shade should not even be checked until the process is complete. There must be confidence in the way the process is set out and controlled, so that an RFT result is the only possibility. The motivation for introducing a blind dyeing operation is three fold: service, cost and quality.

2.1 The service factor [1]

Meeting the customers' requirements is the main thrust of industry today. Fixed delivery dates, fast response, correct specification (shade, handle, finish, etc) are just some of these requirements. These will only be achieved by a carefully planned RFT operation. Due to re-processing the cycle time is increased and thus there is a delay; there is a production loss and also loss of capacity utilization. Blind dyeing lends itself to fixed dyeing times, therefore predetermined machine capacities allow production to be accurately planned and quoted delivery schedules met.

• *Assistant Professor, Department of Textile Engineering, Ahsanullah University of Science & technology, Bangladesh,*
E-mail: giasdtt@gmail.com

2 .2 Cost factor [1]

Profit margin can only be achieved in one of the following three ways:
(a) Increasing the selling price,
(b) Decreasing the cost price, or
(c) Both.
Moreover, failure costs money. It is obvious that a successful blind dyeing process has a cost advantage. Customers are now better informed and aware of their rights to get the best value for their money. This emphasizes the need to reduce costs and ensure timely delivery besides reduce wastes and environmental pollution.

TABLE 1
RELATIVE COST AND PROCESSING TIME OF CORRECTION

Stage	Polyester		Cotton	
	Cost	Time	Cost	Time
Shading	18%	50%	20%	22%
Re-dyeing	80%	135%	100%	200%

So in the area of dyeing, RFT is the only answer to achieve the needs emphasized. Higher the success rate of RFT, greater is the possibility of reducing costs.

2.3 The quality factor [1]

Quality is synonymous with consistency of product. Variable dyeing times and conditions experienced in traditional dye/sample/addition methods introduce variation into the process and subsequently the end result.

ISSN 2229-5518

In exhaust dyeing the surface appearance deteriorates with time. Shading additions are another variable that can have a detrimental effect on continuity. The quality also suffers by re-processing, as the characteristics of the substrate are invariably affected. Blind dyeing will minimize these variables and lead to increased consistency of product.

3. "RIGHT-FIRST-TIME" PRODUCTION

The rate of production of the required shade, at the required levels of fastness, dimensional stability and tensile strength to levels which would satisfy the highest retail specifications of Western Europe and Japan, that is achieved without any further adjustment or re-working in the process. Suppose, a drop in production efficiency of only 10% would mean a "RFT" rate of 90% (extremely creditable) ; but this would obviously mean 10% of the production batches would need some form of repair or shading addition.

70% RFT is not uncommon in a modern dye house. An improvement in RFT level from 70% to 90% would allow for an increased production capacity of 60%.

3.1 ''QR'' and ''RFT'' History [2]

Quick response is an operational philosophy and a set of procedures aimed at maximizing the soft goods pipeline. This means from the fiber supplier over spinning, weaving or knitting, dyeing, finishing, garments manufacturing to retail shops. Manufacturers produce only small quantities of the various dyed goods, but have to be prepared for repeat orders in certain hues without delays that are marked by bar codes previously at the time of selling. This condition necessitates dyes and dyeing processes that are easily repeatable. Roger Milliken first introduced the QR concept, which rapidly found a huge response. The concept of RFT dyeing is necessary for QR processing lines, but it is very welcome also for conventional dyeing. The development of instrumentation colorimetry in the 1990s in both batch and continuous dyeing operations significantly strengthened this concept. QR and RFT are recent economical developments in dyeing technology.

There are two stages of RFT concept in color management:

- Correlation of computer predicted recipe to the target shade in the lab.
- Convert into reality or to get the exact shade at the first attempt right in time.

Again, where there is a close control over the color strength of the dyestuffs and consistent substrate quality dyeability, it is often possible to operate so-called 'blind dyeing' in which the computed dye recipe in the lab is used immediately for bulk dyeing. Where repeat dyeing of same colors are required, it is usually possible to input the reflectance data gained from bulk dyeing in order to refine the database and thereby achieve a greater level of RFT dyeing.

3.2 The reasons for a RFT philosophy [3]

There are probably three areas that need examining if we are to justify the approach of a RFT objective within business. These are:
(a) The market place- its expectations and requirements.
(b) The competition- not local, international.
(c) The 'in-house' benefits of doing this- opportunity and cost savings.

3.3 The requirements for achieving RFT dyeing [3]

The first quality production at the first time is achieved through a combined program of four interdependent key ingredients:
(a) Employee involvement and participation
(b) Attention to detail across the business
(c) Closer relationships with both customers and suppliers
(d) Capital investment.

4. CONCEPT OF SUCCESS IN BLIND DYEING PROCESS

The success in dyeing requires a scientific approach and does not merely depend on skill. By monitoring, manipulating and controlling the various factors and variables that govern the dyeing process, it is possible to produce reproducible results consistently both in laboratory and in bulk. With the advent of plc (programmable logic controllers), instrumentation, automatic dozing and dispensing systems, computer color matching etc., it is possible to precisely control all variables/ factors successfully. Those seeking to adopt blind dyeing must have this foremost on the agenda, for it is the key that will make or break a blind dyeing operation.
Blind dyeing, which means, RFT dyeing will not yield high success rate unless the following variables [4] are controlled precisely:

1. Quality of water
2. Substrate preparation
3. Dyeability of substrate / Selection of dyes
4. Weight of substrate / Weighing of dyes and chemicals
5. Concentration and dispensing methods of dyes and chemicals
6. Standardization of dyes
7. Moisture content of dyes and substrate at the time of weighing
8. Dye bath additives
9. M: L ratio
10. Time/ Temperature/ Temperature ingredients/ pH profiles.
11. Machine characteristics
12. Control of liquor flow/ Substrate circulation
13. Behavior of dyes in combination
14. Accuracy of laboratory dyeing recipe
15. Accuracy of transfer to bulk-scale recipe

ISSN 2229-5518

5. LABORATORY TO BULK REPRODUCTION [5]

The fundamental requirement in a laboratory is to ensure that the reproducibility of shades within the laboratory is consistent. The general practice followed by a number of dye houses for translating laboratory to bulk is to start with a recipe - 10% to 15% lower and add one or more colors after taking out a sample in the bulk to correct the shade. With blind dyeing the laboratory dyeing need to be an exact representation of the standard to reduce the variation in bulk production. The uses of a sample dyeing machine (have the same controls and process conditions as bulk) as an intermediate stage reduce bulk failures due to poor-quality laboratory work.

The many problems for successful conversion of laboratory scale to bulk are caused by wrong recipe choice. Again, the limits of accuracy that must be imposed on the most important variables to obtain reproducibility to a within a ΔE of 1 unit are shown in the Table 2.

TABLE 2
LIMITS OF ACCURACY ON MOST IMPORTANT VARIABLES [4]

Factors	Variation
Moisture Content of dye	3.5%
Moisture Content of Substrate	0.5%
Weighment of substrate	0.5%
Weighment of dyes and chemicals	<0.5%
Dye Standardization	<2.5%
pH of dye-bath	0.35 Units

In other words farther the deviations, greater the variations in reproducibility. Ideally, total color difference, ΔE within 0.5 is necessary for more stringent matching.

6. THE ROLE OF LABORATORY FOR SUCCESSFUL BLIND DYEING

The laboratory is the 'technical service centre' for bulk processing. For blind dyeing operation to be successful, the laboratory has to meet the following requirements:

1. High degree of accuracy in laboratory matching. The laboratory needs to be equipped with automatic dispensing systems. There need to be constant dialogue with the production department for the feed back on bulk reproduction to fine tune the techniques and systems. Process details are to be standardized for both laboratory and bulk.
2. Compatible dyeing methods that can be reproduced in bulk.
3. Choice of dyes that are compatible, give level dyeing and are robust to process condition, that is, the dyes and chemicals should have flexibility and tolerance to accept certain degree of variations in the processing parameters and yet give the desired results, like salt tolerance, pH tolerance, temperature range etc.
4. Highest accuracy of weighing and measuring for both in laboratory and in bulk.
5. Modern laboratory techniques, Computer Color Matching System (CCMS), electronic balances and pipettes.
6. Substrate used for laboratory matching should be of the same source as in bulk.
7. After initial matching trials, the final shade for approval should be carried out on a machine and system that can simulate the exact conditions in the bulk.

7. MAIN CONTROLLING AREAS FOR BLIND DYEING

7.1 Management of substrate - Yarn / Fabric

This is the most difficult area to control, as high degree of discipline is required to source the grey. Cotton being a natural fiber, its characteristics shall vary according to its geographical and morphological factors; also on the grade of cotton. Same kind of mix should be used for entire production of a particular requirement. Here again, management should have a good rapport with the supplier units and prescribe specifications to which the supplies are to be made. Follow exactly the same procedure, taking samples from different parts of the rope in each tube of the machine.

7.2 Management of dyes, chemicals and water

Under no circumstances, can the constituents of the recipe be changed between the laboratory and the bulk. Even the brands used in lab should not be altered. Those colors which are specially engineered to have similar dyeing characteristics for substantivity, exhaustion, reactivity and washing off properties should be used. Specially designed dyeing systems are available to ensure high degree of reliability. Dyes play an important role in cost competitiveness and absolute reproducibility of dyeing. Dyes are the most expensive raw materials of dyeing. Hence, it is important to maintain the main criteria behind dyestuff selection that should be-

(a) High quality of dye standardization i.e. negligible lot-to-lot strength variation in dyestuff supplies. This nullifies the need for the check routine for each lot as well as shade adjustments and ensures high level of reproducibility. The technique of standardization consists of establishing a standard against which assessment is made, assessment of the production batch prior to final standardization and conversion of the batch to saleable material. Dye standardization makes a major contribution to dye selection and the ability to achieve RFT dyeing. The storage conditions of dyes in use must be carefully controlled as the effect of ambient conditions on moisture content can have a significant effect on dye strength.

(b) Choice of medium affinity bi-reactive dyestuffs- Bi-reactive dyestuff gives a high degree of fixation (approximately 80%) as against mono-reactive dyes (approximately 60%). This accompanied with the medium affinity of dyes ensures easy wash off thus, fewer washing baths. This has an impact on the water, time and energy savings in cost effective production. Moreover, the dyes should have a proper combination of reactive groups in the bi-reactive system to achieve ideal and homogeneous application properties.

(c) Good compatibility of dyestuffs- the dyestuffs used in trichromy should be compatible i.e. they should have homogeneous affinity and reactivity. This is essential to ensure reproducible results.

Besides the selection of dyestuffs, the following methods for Purity test of dyestuffs can be routinely carried out in the dye house to ensure the dye quality and thus reproducible dyeing:

(I) Chemical methods
(II) Colorimetric estimation and
(III) Laboratory dyeing trials

Also, chemicals and auxiliaries should be tested for consistent purity and strength. The physical parameters like powder form or liquid form, concentrations etc. should be consistently maintained.

Textile wet processing sector is a major consumer of water and energy. Water should be of consistent quality with only permissible hardness- preferably not more than 5 ppm both for lab and bulk. The hard water with high TDS led to poor performance in processing with inferior quality end product. Hard water does not yield clean dye solution and also affect the performance of various chemicals and auxiliaries employed in processing. In fact this can be understood from the percentage of RFT of the product. Again, ever increasing environmental issues and energy cost are forcing towards RFT approach because when we achieve the target at first time, it reduces the total consumption of water and energy.

7.3 Automation [1]

Modern technology, particularly microprocessors have brought high level of controls to the dyeing process. The process cycles, dozing, MPI- multi product injection systems, Time/ temperature profiles are programmable in modern dye house and there is very little human intervention once the system is set up, thus ensuring reliability and consistency. Due to automation in dispensing and dozing of dyes and chemicals at consistent concentrations, the pH profiles are also possible to be maintained.

7.4 Computer color matching system

The accuracy, predictability and speed of matching have improved considerably by CCMS. With a rationalized range of compatible dyes, the system is very effective. The database should be updated for any changes in the substrate or method of dyeing or dye quality etc. The extent of metamerism needs to be sorted out to avoid controversies later.

7.5 Computer-integrated control

The controls necessary not only involve the machine running conditions, but also the availability of information in relation to:

- Raw material traceability
- Piece identification
- Batch information
- Process specifications
- Management information
- Recipe control

7.6 Administration

The production planning and control should monitor and maintain records of material movement in the process house right from the grey receipt. They should be in close coordination with the various departments and supply information on source fabric/ yarn, batch size, process specifications, management information etc.

8. ANALYSIS OF TRUE COST OF OF RFT, SHADING AND RE-DYEING BATCHES [6]

The dyeing and finishing of a cellulose textile with reactive dyes consists of preparation, colouration, washing off, after treatment and finishing.

Let us consider the colouration stage (dyeing) only. Every batch that meets requirements "Right First Time" would cost 100 units if blind dyed, or 03 units after shade sampling.

Let, the total cost that breakdown into the individual contributions for 1 batch of coloured cellulose (dyed with reactive dyes) amounts to 100 units.

In our country generally the total cost would be made up as shown in Table 3 and Figure 1.

TABLE 3
TYPICAL TOTAL COST OF A "BLIND DYED" BATCH

Cost element	Relative contribution
Dyes and Chemicals (D+C)	25%
Labour (L)	20%
Energy (EN)	10%
Water + Effluent (W+E)	10%
Depreciation and Overheads (D+O) Finance (Cost of money and influence of inflation)	35%

D + C	L	EN	W+E	D + O	RFT
25	20	10	10	35	100

Fig. 1. Cost of RFT batch of coloured cellulose (Blind dyed).

Blind dyeing is the exception rather than the rule, and it is more usual to take samples (S), assess the shade against a shade standard. This of course costs time and money; and let, shade sampling will provide a 3% contribution.

D + C	L	EN	W+E	D + O	S	RFT
25	20	10	10	35	3	103

Fig. 2. Batch which passes after first sample.

A small shading addition provides a relative contribution of 30 units; and a large shading addition 70 units. These units include additional dyes and chemicals charge, additional utilities charge etc, required for shading.

D + C	L	EN	W+E	D + O	S	Add	Total 133
25	20	10	10	35	3	30	

Fig. 3. Effect on cost of small shade add.

D + C	L	EN	W+E	D + O	S	Add	Total 173
25	20	10	10	35	3	70	

Fig. 4. Effect on cost of large shade add.

D + C	L	EN	W+E	D + O	S	Add	Total
25	20	10	10	35	3	30	206+
D + C	L	EN	W+E	D + O	S	Add	
25	20	10	10	35	3	70	

Fig. 5. Total cost of an unlevel dyeing (Strip & re-dye)

So any deviation of shade reproducibility from "Right First Time" is obviously expensive. The risk of an unlevel dyeing, and therefore cost of stripping and re-dyeing (206+ units) increases markedly with every shading addition.

9. MAJOR BENIFITS OF RFT-BLIND DYEING [1]

- Cost saving
- Improved planning
- Enhanced quality
- Increased productivity
- Customer satisfaction
- Reduced effluent load

Subtle benefits include the development of a logical problem-solving approach and also a move towards less 'chaotic' production.

10. CONCLUSION

RFT approach has become the need of the present day. The RFT- blind dyeing is possible with the availability of modern technology. Also the success rate in this system contributes vitally to the three important requirements for survival in the global textile market in the changed environment of free competition i.e. 1) quality with better features, 2) competitive price and 3) just in time delivery. To survive, we need to provide customer satisfaction and I believe that the implementation of blind dyeing through sound management will help bring about the success required for this purpose.

REFERENCES

[1] Finnie, G.M. Blind dyeing- theory in practice. J.S.D.C., May/June 1991, Volume 107, p. 197-200.

[2] Colour Chemistry. Heinrich Zollinger, Third, Revised edition, New York, 1987 p. 380

[3] Farrington, D. W. Right-first-time- an approach to meeting the demands of today's customers, J.S.D.C., September 1989, Volume 105, p. 301-303.

[4] Park, J; Shore, J. Significance of dye research and development for practical dyers, Coloration Technology, August 2007, Volume 123, Number 4, p. 209-216.R. Nicole, "The Last Word on Decision Theory," *J. Computer Vision*, submitted for publication. (Pending publication)

[5] Park, J; Shore, J. Significance of dye research and development for practical dyers, Coloration Technology, August 2007, Volume 123, Number 4, p. 209-216.

[6] Gupta S. "India Told to Aim Higher": International Dyer: Sept 2004, Part III- Improving Productivity in the Exhaust Dyeing of Cellulosic Substrates.