An initiative to get Optimization in Exhaust dyeing process of Cotton with Reactive dyes

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Basic Understanding – An initiative to get optimization in exhaust dyeing process of cotton with reactive dyes

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ABSTRACT

The purpose of this paper is to review how present market demands can be met with application techniques simultaneously aimed at improving productivity, reduced water consumption and lower effluent loading. Some issues from different stages of the process have investigated for detailed understanding.

Introduction

The demands of leading retailers in the world have undergone significant revision in recent years due to increase in number of fashion trends, range of fabrics, color changes, and environmental pressure. Today's customers are more adventurous more selective and more demanding than ever. They want a wider choice with shop and product designs to match their changing tastes. They want better quality, more information and above all greater value for money. Reduction in order size, repeat orders, lead times and high cost of energy, effluent and labour-alls are increasing production cost and reducing profit margin. The need to improve the productivity in industry is a major and global concern. As a general and maybe provocative statement it can be argued that the dyeing and finishing industry does not have a good reputation for quality and reliability. There is a mentality perhaps based on tradition of that accepts that rework is part of our normal day-to-day practice. We expect things to go wrong, and we adapt correspondingly by being very good at fire-fighting and recovering situations. For our real survival and well-being we need to work better at fault prevention. Dyeing is a complex process and detailed knowledge and understanding about the fibre, dyes, chemicals and their interaction under a system is a possible route to enable RFT in exhaust dyeing system. It is usual to consider and realize all the aspects which are directly and indirectly related with a process to make a satisfactory result but application of the knowledge come from the thinking and continuation of the realization with the adjustment of the result come from day to day experiences under a given environment emerge a system and this optimization is the key to survive in the present competitive world.

Critical Success factors

Several key factors are considered here with a deep attention and different way with a desire of executing the ideas in practical working. Based on which this technology named is water and we all know about the specification of water recommended for use in wet process. We start the

process with the water conform the specification but don't consider the change of water standard throughout the process which initiates difficulties. Upcoming fresh water, substrate with uneven deposition of contaminates liquid chemical & salt are the potential sources which increase the hardness during process. Amount of sequestering agent used to control the hardness coming from these potential sources should be evaluated in respect to alkali and peroxide during pretreatment and soda and salt during dyeing to check whether the amount in recipe able to maintain the hardness limit from the start to the end of the process. Sources and dangers of Bicarbonate are now known by more or less everyone but effective remedy is not practices. Key persons in dyeing should make the peoples understanding about the difficulties arises due to bicarbonate specially that measuring Ph tell us nothing about the bicarbonate content. Many softening process remove cation portion of the salt only leaving anion in water which is difficult to trace. Checking heavy metal content is often denied but takes special care when unexpected fault arise. Arsenic for an example whose contamination is increasing due to collecting water from deep of the earth surface. Major difficulties are the unpredictable content of all contaminations in coming water which vary time to time. Regular checking of some major water requirements should be practices especially for critical shades and anthraquinone dyes.

Chemicals

It is necessary to know what types of chemical are used in dyeing and detailed knowledge about the functions of each chemical. Generally three types of chemicals used namely dyes, electrolyte & dyeing auxiliaries. Dyeing auxiliaries must be

- Fit to do the specific job required
- Not make a problem worse
- Evaluated by performance alongside cost

In most of the cases management purchased the auxiliary considering cost alone without attention its performance and strength. It is usual that chemicals source is changes in factory frequently but are we update ourselves with these changes? Depending on factory management we have to carry out several critical tests to evaluate the chemicals and salt like amount of chemical used & its relation with the performance, strength or active component, hardness, buffering power in dyeing, contaminations, Consistency of supply. Many chemical suppliers offer chemical that shortening the process. We have to consider the effects create by the chemicals in later and the cost required solving the problem if arises, not the fact that it is low price and shortening the process.

Dyes

An out most important matter is to have a brief, clear concept & understanding about the structure of dye and dyeing mechanism of cotton with reactive dye. As compared with other Fibers and other classes of dyes, here the dyeing process requires a considerable number of interventions along with a risk of error. The behavior and characteristics of reactive dye can define by its SERF profile or curves from where it is clear to see two distinct stages. At the beginning of the first phase of the dyeing process, which is called the substantive phase, and

under the influence of the electrolyte present the reactive dye in the form of aggregates exhibit great affinity toward the fibre and by regulating the size of these aggregates and rate of strike it is possible to distribute them evenly over the surface of fibre and then to diffuse and migrate. It should be born in mind that reactive dye

- not be hydrolysed
- not be fixed to the fibre
- able to move within the internal dyebath of the fibre

What we have to do is to prevent the pH from rising to do all and to avoid hydrolysis and premature fixation. Unidentified bicarbonate, improper fibre neutralization and water from liquid chemicals are the potential reasons for hampering this stage on which level shade depend. For second stage Ph and temperature of the bath, reactivity of the dyes addition and force of alkali are some important factors and needs to be readily understood. Dyer should know different properties of dyes like proportion of chromophore and auxochrome, amount of chromophore or dye strength, power of color yielding in fluctuate parameters, moisture content and lot to lot strength variation. Potential reason for unevenness is the careless in measuring and storing dyestuff. Dye absorbs moisture differently in different season which cause variation in its weight and color value. Powder form of dye contaminates the air which result permanent spot on white fabric which store without covering.

Substrate:

It has been known that impurities in cotton are significant and it vary according to region, time, climate, harvesting and use of pesticides, fertilisers and de-foliants. It's a matter of regret that most (if not all) of the preparation processes and recommendations of leading auxiliary suppliers leave prepared cotton containing residual hardness which raise a question- whether cotton is fit for dyeing. If we measure ph of dyebath, fabric surface and internal fibre will get a figure like below.

Surface pH –versus-Internal pH

Parameter	**Batch 1**	**Batch 2**	**Batch 3**	**Batch 4**
pH last rinse liquor	6.60	6.50	6.45	6.70
pH fibre surface	7.80	7.50	7.85	7.80
Internal pH	10.37	10.20	10.30	10.30

The table shows the importance of considering the internal condition of the prepared cotton
For measuring

- residual alkali
- residual hardness
- residual peroxide

Process:

The main work of a dyer is to control the process and he should have a clear understanding that will helps him to achieve process optimization. When selecting a dyeing method for a given set of circumstances (difficulty of shade, difficulty of substrate) the driving force for level dyeing is the performance in production. The performance can be measure by reproducibility between lab to bulk and bulk to bulk, levelness in shade and fastness conformation. So many controlling points are listed and as much as one can understand with application would have been easy to achieve optimization. All variable can be classified under assignable and random variables and we have know which variables are different for lab and bulk dyeing There is a continuous effort to keep all things same for lab and bulk but often ignore the deviation of material being used and deviation in their preparation. We make recipe on the weight of grey fabric in bulk but in lab take weight of prepared material for same shade value. We depend on personal experience for correcting recipe in bulk and not checking the shade adjustment by employing sample dyeing machine for minimising variations due to machine construction in lab and bulk. We are not willing to measure dyes preciously rather depends on workers which is very risky for pale & lighter shades. Sometimes we take broad actions for good result but ignored a simple one. Whatever the process is, good combinations of batching parameters are the key factors for level dyeing. Not only we have to minimise lot mixing but also to distribute the weights of material according to entry path evenly and to synchronizing cycle time, dosing time, run time and temperature gradient. Theoretically for uniform dyeing adsorption, absorption and fixation should be uniform. Scouring-bleaching process determines uniform absorption properties. To get uniform absorption properties if dosing time (DT) of caustic and per-oxide set in such a way that during dosing fabric can complete its full cycles i.e. DT/CT= an integer and run time (RT) also perfect for completion of fabric cycles i.e. RT/CT= a integer. Similarly salt, color and soda dosing and run time ensure uniform impregnation of fabric and hence ensures level adsorption, absorption and fixation. Temperature gradient (TG) in pretreatment and dyeing should also synchronized with cycle and run time. These types of simple precaution often result great improvement in level dyeing. The main object of preparation is to increase absorbency by removing all types of impurities as much as possible with minimum damage of textile and to increase whiteness. We have to realize that whatever the absorbency increasing it must be uniform throughout the substrate and employing new testing method to check as traditional testing can't confirm whether uniform absorbency arises or not. In fact most cases we ignored testing or not any clear concept of achieving uniform absorbency and its necessity. Same thing would be applicable for acquiring permanent whiteness and low degradation of cotton. Improving these two qualities we have to consider internal fibre condition after preparation and fully neutralization. Normally cotton is prone to alkali and long contact during preparation made polymeric deposition which might not clearly be removed in after treatment. We have to remove residual alkali, peroxide and hardness from the core level to achieve level dyeing. Traditional treatment to do all would be sufficient, just an extra care and utilizing sequestering agent in all types of washing might be a solution. We don't use sequestering agent in washing after preparation and dyeing. This should be considered although there is a risk of altering light fastness when sequestering agent used in washing after dyeing for some dyes. Fibre internal condition should consider to avoid the impact of preparation like **QUASI – UNLEVELNESS.** This is not unlevelness in the classical sense of such phenomena as:

- Crease marks
- Rope marks
- "Crows Feet"
- Dye spotting
- Cloudiness
- Abrasion marks.

All those types of unlevel dyeing are noticed at batch inspection stage. “Quasi-Unlevelness” refers to a batch which completely passes QC inspection after dyeing and finishing; but then is returned from garment confection and they are due to Uneven preparation throughout a given batch dye lot.

People:

The importance of all involved in the dyehouse is the understanding of the basic principles involved in reactive dyeing. We have to work with labour and it is our duty to teach them mainly two lessons

- How to do a process in most convenient way
- What negligence can change the complete work to a wrong one?

They should know the importance of accurate weighting of dyes and chemicals and to control the different dyeing parameters. Dyeing personnel should have a clear concept on following.

Basic Principles of Reactive Dyeing.

Subject	Issues
The Reactive dye molecule	Molecular Engineering. How the molecule is built. Which part of the molecule influences which dyestuff property?
The Dye – Fibre covalent bond	How it is formed. What determines its inherent strength? How different reactive systems form bonds of different strengths. Which fastness properties are determined by the stability of the dye-fibre bond? Which dye-fibre bonds are stable to modern per-oxy containing washing detergents?
Reactive Dye systems	How do they compare for strengths and weaknesses?
Migration	How is it determined by dyestuff properties? How can it be measured? What is the difference between “Migration Potential” and “Migration in Practice”? How can “Migration in Practice be

	optimized?
Compatibility	What determines the compatibility of a dyestuff recipe? And what is the impact on "Right First Time" production of compatibility?
Shade Robustness to Process Variables	What do the dyestuff suppliers tell us? Is there anything the dyestuff suppliers are NOT telling us?
The "SERF" profile	What is it? Why is it important? What can it tell us about a Reactive dyeing system, and its suitability for exhaust dyeing?

Equipment:

Different machinery and equipments are largely affect the dyeing process and most of cases we don't have any clear idea about the functionality of machinery or we don't have any desire. One or two key persons may have detail idea but they don't willing to share. As much as we develop automation in processing, high will be the beneficial. Regular maintenance, checking and housekeeping are the requirements for getting better result from automation. Besides we should try to know the facts that a machinery supplier never told us but it affects the process. One of such parameter is the Machine Volume and Liquor Ratio. The volume of an exhaust dyeing machine is a vitally important parameter of any exhaust dyeing process in relation to

- Batch to Batch reproducibility in production (bulk – bulk).
  Shade reproducibility from Laboratory to production (lab – bulk)

The machine has a calibrated levelling device (usually at the side of the machine). Known volumes of water are pumped through a measuring meter (Electro Magnetic Flow meter) which tells us exactly how much water has been delivered to the machine. Each water fill level registers on the levelling device, and is therefore calibrated against the known delivered volume. In this sense, the machine volume before addition of substrate is known, and known quite precisely. What is not quite so certain is the "Working Volume" of the machine in the presence of an absorbent substrate. Cellulose, and especially knitted cotton, absorbs water. Therefore, the **working volume** cannot possibly be equal to the **calibrated volume**. Furthermore, the amount of water absorbed (and therefore the difference between working and calibrated volumes) is extremely difficult to predict. The difference between "True" and "Calibrated" volumes will depend on:

- the nature of the substrate
  - knitted versus woven
  - cotton versus viscose or mercerised cotton or Lycra blend
  - the type of knitting (interlock, rib, jersey etc)
- the source of the cotton

- the type of preparation (scour, full bleach, half bleach)
- the uniformity of preparation (rope to rope, package to package, hank to hank)
- the consistency of preparation (batch to batch).

The difference between working (true volume) and calibrated volume (on which weights of chemicals will be calculated) is therefore largely an unknown. Chemical amount will be vary (overfill/under fill) which make environment where RFT is difficult. Variation in salt & soda with addition of bicarbonate may create buffer system which increase hydrolysis and shade loss. Variation in stem pressure due to gauge, amount of water mixed with dyes and alkali for dilution, regulating temperature and utilizing heat are also discussing topics for machine and equipments.

Management Preference

By visiting so many dyehouses, it has been possible to distinguish two extremely distinct types of management:

1. "Fire Fighting".

   Accept "Wrong First Time" production is going to happen.
   Build an allowance into the cost structure.
   Seek and appoint Staff who is skilled at shade correction.

2. "Fire Prevention".

   Accept that "Right First Time" is possible.
   Train staff in the basic understandings.
   Set up management of Lab-Bulk interface and Productivity monitoring.

The major fact is, we know everything and have a desire to implementation but there is no way but to absorb ourselves by the system of tradition. We all consider instant profit without giving attention to future. We accept chemicals that shortening the process but don't look the complication it made afterwards which ultimately reduce the profit due to reworking.

Colour and Colour measurement:

Concept about colour and the method of creating different colour on fabric by the dyes combinations and interaction between dyes and light must readily understand by the people engage in shade matching. Dye molecule can affect light in all wave length but specifically in one wavelength and thus dye is the molecule which is capable of absorbing selective wave length. We produce colour by deducting selective wave length light that falls on the fabric and remaining lights of incident combining cotton own colour are reaching to our eyes whose mixed appearance will be the colour of the fabric. We should learn this mechanism in details and also the trichromatic combination and compatibility of dye. It is known that all three coloured dyes are not penetrating the fabric in same way. Some needs temperature and some need auxiliary. Fabric absorption of different dyes can be idealized from their exhaustion and fixation curve but it is unpredictable to know desorption of colours. When we strip colours from the fabric, all dyes are not strip in same way which makes the matching difficult. It will be safe to lowering the amount of dyes in

the recipe getting from spectrophotomer. If we examine shade by instrumentally then their recommendation of examine must strictly followed. Spetrophotometer is a huge potential instrument but it is not utilized due to unknowing. Lab activities must be strong to set up blind dyeing concept and colour concept needs to be studied.

Conclusion

The driving force must come from the top. All team members should be aware of their contribution to the total effort. No Productivity Improvement programme will ever work without Teamwork. As long as we are with a system, we must be in a system.

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