Chemical processing on small scale—Entrepreneur’s viewpoint

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The viewpoint of a small-scale entrepreneur for achieving environment-friendly chemical processing of cotton is discussed briefly. It is emphasized that setting up of a laboratory, computer colour matching system, careful study of the literature on products introduced by dyestuff and auxiliary manufacturers and the selective product use help in achieving the right-first-time production, which, in turn, helps in waste minimization and thus in environment protection and value realization. The viewpoint is illustrated with the help of typical practical examples of the use of sequestering agents, non-silicate based peroxide stabilizers, peroxide killer enzyme and effective reactive dye washing after fixation. It is suggested that the investment in research and development would help the small-scale entrepreneurs in achieving the desired goals of environment protection and value realization.

Keywords: Cotton, Ecofriendly chemical processing

In the global market where fashion is changing fast, the chemical processing contributes the major share. Fancy spinning, weaving and designing in textiles does improve the product saleability, but even here the improper wet processing can mar the value appreciation. There is a definite market for textiles which can be marketed as ecofriendly. For such fabrics, the enlightened customer is ready to pay a reasonable higher price. Chemical treatment giving due consideration to ecological problems will also ensure lower air/water pollution and satisfy the requirements of ISO 9000/ISO 14000 which are becoming a pre-requisite for future exports.

Favourable attributes of ecofriendly textile production tentatively include the use of natural fibres; washing and bleaching without chlorine; dyeing and printing involving high fixation, minimum amounts of chemicals and low water consumption; mechanical finishing; ecofriendly packing; and a recyclable or biodegradable final product.

In India, processing of textiles in yarn or fabric form is being done in cottage, small and large organized sectors depending upon the investment capacity of entrepreneurs, the type of fibre and the quantity of goods to be processed to meet the delivery schedules of exports. Every sector has its own advantages and disadvantages and seeing the trends in the global market the people working in different sectors have to secure their place by learning the art of peaceful co-existence. Consumers’ requirements cannot be met satisfactorily if the people from different fields of textile industry think in isolation and are interested in getting the government policies formulated in their favour without considering the overall impact on the industry. Excise policy is one such example where small- and large-scale process houses are getting affected to an extent that existence of small process houses is getting difficult day by day and the large organized sector is forced to indulge in unethical practices. However, leaving synthetic fibres, the natural fibres can be processed successfully in cottage and small-scale industry.

It is essential for every sector in different fields of textile industry to take note of reality and come up with solutions through research, adoption of appropriate technology, dissemination of technical knowledge and necessary mechanization/modernization of process house if it wants to stay in the competitive market. Large units are suffering from overcapacity, high overheads and severe competition from small- and medium-scale processors. On the other hand, insufficient spadework during the conception, planning and execution leads to overall poor performance in small scale. Here, a qualified technologist can play an important role. His/her association with small unit as owner or consultant right from conception to execution can convert poor performance to excellent performance by delivering ecofriendly quality products on continuous basis and improving the financial position of the unit for its sustained growth.

Experience has revealed the following reasons for the overall poor performance of small process units:

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Inadequate inflow of job orders.
Low machinery utilization.
Improper balancing of machinery capacities.
Low labour productivity.
Insufficient provision of infrastructure facilities like water and power.
Inability to cope up with the state-of-the-art knowledge in dyes and chemicals needed to satisfy the requirements of intermediate consumer i.e. an export house engaged in the manufacture of garments, house furnishings and other related products.

Poor inflow of job orders results from either unfavourable location of the unit and/or absence of adequate drive and skill on the part of the authorities of the unit. Low machine utilization follows subsequently. Lack of proper balancing of machinery capacities adversely affects performance of the units. Low labour productivity arises from engagement of labour even when the production requirement is meagre and the concerned supervisors/technicians being not so well skilled to get the best of the labour force.

Uninterrupted power supply is very important in wet processing operations. Sudden stoppage of the machines with yarn or cloth inside the machine may lead to defective products. Attempts to rectify the defects by reprocessing prove costly and may sometimes cause additional defects.

A large quantity of water is used in wet processing of textiles. Quality of water plays a key role in determining the overall performance of the processing unit. Small process houses are aware of it but to a very limited extent. Formation of scales on the inner walls of the boiler increases fuel consumption as follows:

<table>
<thead>
<tr>
<th>Scale thickness, mm</th>
<th>Loss of fuel, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.325</td>
<td>10</td>
</tr>
<tr>
<td>0.625</td>
<td>15</td>
</tr>
<tr>
<td>1.25</td>
<td>50</td>
</tr>
<tr>
<td>2.5</td>
<td>80</td>
</tr>
</tbody>
</table>

The general specifications for dye house water are:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum recommended level/tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hardness</td>
<td>50 ppm</td>
</tr>
<tr>
<td>pH</td>
<td>7.0 ± 0.5</td>
</tr>
<tr>
<td>Copper</td>
<td>0.05mg/L</td>
</tr>
<tr>
<td>Iron</td>
<td>0.05mg/L</td>
</tr>
<tr>
<td>Chloride ions</td>
<td>300mg/L</td>
</tr>
</tbody>
</table>

Natural resources do not meet the above standards. Up to 200ppm hardness, sequestering agents can be used. If water is having more than 200ppm hardness, a water-softening plant of appropriate capacity is needed.

Processing of small lots with high quality standards can be taken as challenge and opportunity by the technologist of small process house. He should design the process house and its process technology to enable the company to work profitably for its chosen market segment to fulfill their requirements at sampling, production and finishing stages.

Having decided the market segment for which the process house has to work, the cost of project should be worked out carefully. In the prevailing environment with debt/equity ratio of two, the suggestive investment in plant and machinery is around 65% of total project cost (excluding land and building). Process charges should be such that the gross profit on sales comes out around 33% to run the process house smoothly. To achieve this profitability, it is necessary to have target of producing goods right-first-time. Optimization of the existing process is no longer sufficient to meet the ecofriendly requirements. We need new products, new procedures and new techniques to serve the competitive global market.

Among different fibres, the cotton will remain the dominant in the textile field. The discussion in the following paragraphs is mostly related to cellulosic fibres.

Various problems observed and heard from processors and exporters are as follows:

- Harsh feel, particularly in heavier fabrics like twills and canvas.
- Cluster of pinholes.
- Poor absorbency before dyeing.
- Loss in depth and dulling of shade.
- Unlevel dyeing, dark selvedges.
- Poor fastness to washing and rubbing.
- Hairiness/pilling.
- Staining on white fabric during hydro-extraction of goods.
- Side to side shade variation during drying.
- Reproducibility of shades.
- Yellowing of white fabric on storage.

The reasons for occurrence of above-mentioned faults are as follows:

Among the inorganic impurities (0.7 - 1.6 %) present in cotton, the presence of phosphorus in the form of organic and inorganic compounds is of
importance to the scouring process prior to dyeing. The phosphorus compounds are soluble in hot water but become insoluble in the presence of alkaline earth metals. The use of hard water, therefore, can precipitate alkaline earth metal phosphates on the fibre instead of eliminating them. Use of silicate-based stabilizer in hydrogen peroxide bleaching causes silicate deposits. Silicate-based stabilizers are active in the presence of magnesium ions only. In the absence of magnesium ions, silicate-based stabilizers are activators and decompose hydrogen peroxide at faster rate than desired. Alkaline earth phosphates and silicate deposits give harsh feel and poor absorbency to the fabric. Small amounts of calcium and magnesium affect migration and diffusion properties of reactive dyes, causing restraining or even precipitation which results in reduced yields, unlevelness, poor reproducibility and reduced fastness. Traces of heavy metals, copper and iron can influence the shade of certain dyes. It is better to have soft water in bleaching/dyeing rather than using additional auxiliaries to offset the effect of hard water. Use of excess chemicals adversely affects the working of effluent treatment plant. If soft water is not available, the use of proper sequestering agents to offset the effect of hard water. Residual peroxide ( > 5 ppm) and high hardness in dye bath lead to loss in depth and dulling of shades. Along with improper pretreatment of fabric before dyeing, the variations in pH and temperature of dye bath lead to unlevel dyeing and center to selvedge variation during dye fixation phase. Hairiness/pilling on the fabric surface giving unsightly look can be because of the lower quality of yarns used in weaving. But it has been observed that sometimes even the good quality combed yarn gives hairiness on the fabric surface. The reason lies in the uncontrolled bleaching operation following mercerization. Experience shows that mercerization being one of the most important processes in chemical processing of cotton, if not done with care, leads to more problems in subsequent processing, specially in case of reactive dyes. Improved mercerizing effects have shown a good possibility of using less dyes for a given shade and thus leading to reduced consumption of dyestuffs and lesser quantity of hydrolyzed dye in the bath. However, to get good dyeing results, uniform mercerization of fabric must be ensured.

For ecofriendly processing of textiles, right-first-time production is desired as it will consume less resources like power, fuel and water. To achieve this, it is necessary to choose dyes capable of delivering right-first-time performance. Study of literature on the new products developed by various companies in textile dyes and chemicals field is very helpful in selecting the appropriate product and designing the process to meet the customer’s requirements successfully.

Many of the problems arising in wet-processing of textile materials are caused by polyvalent cations present in the treatment liquors, such as ions of alkaline earth (Ca**, Mg**) and heavy metals (Fe**, Cu**, Mn**, Co**, Ni**, Zn**). Demineralization with sequestering agent is suggested. If the product is compatible with amylase enzymes, desizing and demineralization can be carried out simultaneously.

After the preparation processes, cold rinsing can cause redeposition of non-emulsified oils and waxes, resulting in a subsequent unlevel dyeing. Therefore, hot water rinsing at 70-90°C after preparation is strongly recommended. Similarly, there are major benefits from hot rinsing after dyeing. At elevated temperatures, the interstices of the cellulose remain open allowing rapid diffusion out of hydrolyzed dye into the rinse liquor. The stability of the bifunctional dye-fibre covalent bond is perfectly suited to hot rinsing in the presence of alkali.

In peroxide bleaching, the selection of non-silicate based stabilizer is important. Organic stabilizers, on which interest is currently focussed, are Mg compounds of polycarboxylates. Several combinations of sequestering agents are offered in the market as substitutes for silicates. It should however always be taken into account that, in most cases, the Mg ion forms an essential component of peroxide stabilizing systems and that the added sequestering agent will not unduly bind the Mg ion present in the liquor. SIFA of SANDOZ and Lufibrol KE (BASF) are the products which encounter the problems of metal ions in peroxide bleaching. Peroxide killer can be used to destroy the residual hydrogen peroxide completely before the dyeing operation.

The conventional techniques of neutralizing hydrogen peroxide are based on intensive and repeated washing treatments, which consume enormous quantities of water, and use of reducing agents such as hydrosulphite, thiosulphate or other polluting sulphur compounds. Excess oxidizing or
Reducing agents remain and both endanger the dyes. Moreover, there is an excessive load of salt in the waste water. Use of enzymatic peroxide killer is an ecological choice for safe and rapid removal of residual hydrogen peroxide.

Among all the dye classes for cellulose, the reactive dyes are the most suitable choice in terms of fastness and reproducibility. However for pastel shades, vat dyes can be used because of better light fastness as compared to reactive dyes. The performance of a reactive dye is defined by the “reactive dye compatibility matrix” (RCM). The critical measures of performance are substantivity (S), migration index (MI), level dyeing factor (LDF) which is a measure of the impact of the migration and secondary exhaustion on the level dyeing performance, and the time taken to achieve half of the final fixation value (T50)—an index of the reactivity of the dye.

Right-first-time production will be maximized if above fundamental measures of performance within the RCM are set at a substantivity of 70-80%, MI larger than 90%, LDF larger than 70% and minimum T50 of 10 min.

Traces of Ca, Mg, Cu, Fe, Al, etc. can be responsible for faulty dyeing. But care should be taken in using a sequestering agent. With some metallised dyes, care must be exercised if a sequestering agent is added to suppress the unwanted ions. EDTA may be sufficiently powerful to remove the metals from the metallised dye itself and hence should not be used. Dekol FB-SN (BASF) has a moderate chelating effect on metal ions and is an effective dispersant for the calcium carbonate formed in the dye bath. However, the chelating effect of Dekol FB-SN is not high enough to remove the metal ions from metal complex dyes and consequently, it does not impair the shade and fastness properties of dyeing obtained with reactive and direct metal complex dyes.

To ensure level dyeing, auxiliaries such as Drimagen ER (Sandoz) or Depsodye LD-VRD (ICI) can be employed in the dye bath as these products effectively control the rate of rise of pH during alkali addition phase of dyeing cycle.

The degree of fixation directly influences the water and energy consumption of the washing-off process. The larger the amount of unfixed dye remaining, the longer the washing-off period will be. Care should be taken while making additions to match the shade. Rate of hydrolysis of reactive dye increases with the temperature and alkali contents of the dye bath. It is better to set up small laboratory and computer color matching system while designing the process house to achieve right-first-time dyeing.

By using appropriate products like Hoequest SA (Colourchem) having marked dispersing, sequestering and diffusing properties, the removal of unfixed hydrolyzed dye from fabric is facilitated. In case of reactive printed goods, the material should be loaded in the cold bath containing Hoequest SA. It does not allow staining of unprinted portions.

Because of the lack of knowledge of textile auxiliaries available in the market, the technicians use dye fixing agents to fix the hydrolyzed dye for reducing the process time. This in fact is a wrong practice and it leads to staining at exporters end when finished goods are washed and hydro-extracted. A qualified technologist understanding the chemistry of the process can easily reach to an acceptable solution and satisfy his customer.

Good house keeping involving safer handling and minimization of waste will add to the production of ecofriendly goods. Reactive dyes posses good storage stability. It is recommended that containers should always be closed tightly and stored in cool and dry conditions. Hot humid conditions promote deterioration of reactive dyes.

Reactive dyes should be handled with care to eliminate the generation of dye dust. Weighing and dissolving areas should be suitably vented to minimize exposure of operatives. Accurate weighing of dyestuff is an essential requirement for shade reproducibility. Dyes should be weighed within a tolerance of ±0.2%.

The quality of electrolyte has a large influence on the yields obtained from reactive dyes on cellulose. The quality of commercially available common salt and Glauber's salt can vary enormously in terms of pH, alkaline earth metals content (hardness) and moisture content. If appropriate corrective actions are not taken, the potential savings in cost of salt will be more than offset by the very high cost of reprocessing.

If production is optimized towards the existing environmental requirements that have been approved by different social and pressure groups, and if we are able to make the new attributes plausible to the average consumer, then there is a reasonable chance of achieving realistic prices. These should allow the responsible entrepreneur to invest in research for further improvement.