Recent advances in wet chemical processing machinery

Sanjay Gupta
Textile Design & Development Department, National Institute of Fashion Technology, Hauz Khas, New Delhi 110 016, India

Advances in textile processing machinery in past few years have been influenced by globalization of textile industry, environment and socio-economic factors, diverse finishing requirements and quality demands. Advances have taken place in process control and automated systems that provide flexibility, versatility and reproducibility. Innovations have been few. Against this backdrop, the various advances in machine design, processes and automation for pretreatment, dyeing, printing and finishing of fabrics have been discussed. It is observed that the advances in process machinery sector meet the requirements of our times, i.e. need for shorter/faster processing and maximum flexibility (quick change and rapid response) as also the demand of reduced water, energy and chemical consumption.

Keywords: Automated systems, Dyeing, Finishing, Pretreatment, Printing, Textile processing machinery

1 Introduction

The paper is in the unenviable position of being written just before ITMA '95 and being read immediately afterwards. The machine suppliers are, however, unlikely to have held back any major innovation for the show from the competitive market conditions existing today.

Since the last ITMA held four years back, many new challenges and changes have emerged that have influenced the direction of development in textile machinery. The major influences have been of globalization of the textile industry, environment factors, energy constraints, diversity and multiplicity of colouration and finishing requirements, quality demands and requirements emanating from a more discerning and selective consumer market.

In the global market, the need to produce world class product quality virtually eliminates any differentiation with regard to the degree of sophistication desired in machinery. For India, to opt for maximum automation may not be justified against low labour costs but, nevertheless, cannot be ignored in terms of the more important ‘automation for quality’ targeted at export markets. Yesterdays’ “we cannot afford to” has to change to present days’ reality of “we cannot afford not to” (refs 3 & 4).

Against this background, global operators at the leading edge of technology must remain adept at selecting and investing in machinery, equipment, process control and automation systems that provide flexibility and versatility in terms of range of fabrics that can be wet processed, and reproducibility to provide uniformity. Top priorities today are economy, ecology, fast response, quality and flexibility.

With these priorities in mind, specific technological advances in machine design, processes and automation are discussed in this paper.

2 Machinery for Chemical Pretreatment

Chemical pretreatment sector is of vital importance to the processing industry because of the increased necessity for greater uniformity and fault-free, right-first-time production in subsequent dyeing, printing and finishing. The general trend towards the increasing use of light-weight fabrics, particularly polyester/cotton blends, which crease more, requires open-width pretreatment using integrated pad-batch or pad-steam process. Use of hydrogen peroxide as a predominant bleaching agent from environmental point of view also supports this process route. Refined versions of high wet pick-up systems (initially displayed at ITMA '91) for single-stage bleaching consume less water, caustic, energy and time, and cause minimum pollution of waste water. A number of such systems, all operating on the basic principle of maximizing the liquor pick-up while impregnating the goods before steaming, are available (Table 1).

Continuous, high-intensity, high-temperature and counter-current flow washing is an essential part of any pretreatment sequence. New open-width washers based on continuous interchange of water around the fibres in the fabric with wash liquors of lower contamination have been developed. These washers
based on spray, multi-nips, vacuum extraction and ultrasonics, e.g. Jat-Vac by Farmer-Norton, Extrac-cta and Impacta by Benninger, and Effecta by Goller, decrease water and steam consumption, give a highly concentrated effluent for recycling and have extremely small space requirement, investment and operating costs9-11.

Machine developments in mercerization include hot impregnation zones, improved designs of clips to minimize clip marks, enhanced fabric stretching systems for chainless mercerizing machines and improvement in recuperation of caustic soda. A development important to India, however, is that of small-size batch mercerisers (Fig. 1). Occupying minimum of space, these ranges are universally applied for the processes of partial mercerizing/caustic treatment, stabilizing and rinsing to smallest of lots9-12.

Table 1—Maximum pick-up systems for single-stage bleaching

<table>
<thead>
<tr>
<th>System</th>
<th>Manufacturer</th>
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<tbody>
<tr>
<td>Super-Sat</td>
<td>Babcock</td>
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<tr>
<td>VAS 200</td>
<td>Farmer-Norton</td>
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<tr>
<td>Flexnip</td>
<td>E. Kusters Maschinenfabrik</td>
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<td>Optimax</td>
<td>Menzel Vertriebs</td>
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<td>Ben Bleach, Impacta</td>
<td>Benninger AG</td>
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<tr>
<td>Reco Vac, Ruco-Yet</td>
<td>Ramisch Kleinwefers</td>
</tr>
<tr>
<td>Dip-Sat</td>
<td>Maschinenfabric Max Goller</td>
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<td>Brubo-Sat</td>
<td>Brugman</td>
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Fig. 2—Schematic diagram of Flexnip applicator

Fig. 1—Schematic diagram of a batch-mercerizer by Farmer-Norton

Flexnip application system by Kuster (Fig. 2), mentioned above, can be effectively used in place of a saturator in a mercerizer, thus bringing down alkali content from 1000-2000 L to just 10 L. It also offers an unmatched flexibility of interchanging mercerizing with causticizing quickly, without any change in setup. Modern open-width washers used here will give highly concentrated washings for easy recuperation of caustic13.
Significant developments have taken place in mercerization machinery for knit goods. Major manufacturers are Dornier, Sperotto Rimer and Brazzoli. Machine offered by Dornier has a patented system of stepless adjustable circular expanders, giving a selvage-mark and crease-free, dimensionally-stable fabric of extremely soft feel

3 Machinery for Dyeing

Developments here have been on several fronts, viz. vacuum application systems for dyeing; high-efficiency padders and other application systems for continuous dyeing; soft flow and air flow machines for dyeing of knits and light-weight fabrics; automatic dye dispensing and colour kitchens; and flexible, automatic yarn dyeing systems.

Dyeing industry today lacks a cost-effective, ecologically sound system for dyeing small lots. Lot size has come down to 200-600 m which is economically unviable on a continuous dye range and for which batch dyeing machines like jigger, winch and jets are to be used. These exhaust machines are prone to batch to batch variations and waste generation. Vacuum dyeing systems like LVLM (low-volume low-moisture) systems by EVAC Corp (Fig. 3) and VAS 200 by Farmer-Norton effectively surmount this problem by giving an even and thorough penetration of dye on a continual basis from a high concentration low-volume dye trough. As against a typical dye-pad bath of about 140-150 L, the capacity of these systems is less than 15 L. Vacuum also removes surplus water, giving a large saving in energy during dyeing.

Though small lots are required for sampling, bulk orders require large yardages to be dyed in a single shade. Continuous dyeing by pad-store or pad-steam method is making a comeback. Primary requirement of such a range is a padding mangle giving a level, even application throughout the length and width of the fabric. Ordinary mangles cannot do this job. Several specialized “Intelligent pad-rolls” are available today like Kusters swimming rolls and Bicoflex padders by Ramisch Kleinwefers. The flex nip applicator described earlier is also eminently suitable for pad-steam dyeing. All these systems have built-in cleaning down facility, minimum waste at the end of production run, and minimum downtime between production runs.

Dyeing of knitted fabrics, microfibre fabrics and fabrics made out of blended and easily creasable material require more gentle handling. In jet dyeing machine, fabric is displaced by the force exerted by a large volume of liquor moving through a venturi, resulting in relatively high fabric speeds and causing certain degree of fabric surface abrasion. In overflow system, fabric is propelled by the overflow liquor only without dynamic pressure, providing more gentle treatment. In the latest generation of soft-flow machines, a part of liquor has been replaced by air, giving a lofter fabric and a highly eco-friendly dyeing. Several Asian, British, Italian, German and American machine makers have come up with different versions based on this aerodynamic principle. Variably adjustable and programmable nozzles are available now (Fig. 4). Polytetrafluoroethylene coating of inner surface is carried out to reduce frictional drag. Liquor ratios used are in the region of 1:4 to 1:6, irrespective of the load.

Technology of dyeing polyester in supercritical carbon dioxide under pressure, first demonstrated in ITMA '91, is quite well developed now. Larger machines will no doubt be shown during ITMA '95 (ref. 4).

With the current interest in quick response and right-first-time dyeing, practice of blind dyeing using standardized dyeing cycles and automated dye dispensing and colour kitchen equipment is on the increase. Lower-cost systems with greater flexibility, versatility and ability to network with laboratory dyeing systems are now available. These are complemented by on-line colour measurement and control systems, hand-held spectrophotometers for quality control and colour matching softwares. Data colour, Hunterlab and Macbeth are the pioneers in this field.

Yarn package dyeing machines have undergone a total technology upgradation in last few years. Emphasis now is on flexible load capacity, versatility and automation/robotics options. Many machine makers like Gaston County, Longclose, Fong, Bellini and OBEM will be coming up with innovations covering the above-mentioned aspects. OBEM' s horizontal multiple-tube API/O dyeing systems, for example.
has ability to handle lot sizes ranging from 20 kg to
3000 kg per batch with almost constant liquor ratios,
independent of batch size. Cubotex of Italy has come
up with a multi-purpose cabinet machine with a speci­
cal pump that gives a range of capacity and head re­
quired to dye yarn in hank, bobbin or cake form. Most
machines have PLC (programmable logic controll­
ers) to monitor and control process variables and ro­
botic options to load and unload the machines.

4 Machinery for Printing

The technological advancements in the field of printing have been dramatic, particularly where
India is concerned. The process of printing, consist­
ing of design development, colour separation, tracing produc­tion, screen engraving, sampling, paste prepar­
ation and finally printing, may take anywhere be­
tween 6-18 weeks and large investments are made even
before the customer makes a decision regarding his
selection. With modern technology, this time frame
has been reduced to less than a week. At this point, I
would like to stress that the modern technology does
not replace the original designer who would continue
to give the initial creative input.

CAD application starts with at least one overall
coloured design which is scanned into the computer
and can then be modified and coloured. Various col­
our combinations are tried, stored and a hard copy
taken out on paper or fabric. Inkjet printers available
now-a-days can print directly on fabric using reactive
dyes. In fact, there are special steamers for fixation
of such prints. Selection of design by customer can
hence be made at this stage by simply looking at the
printed sample or at the hard copy. Major saving in
time is, however, made in the pre-print stage where
the colour separation of selected design is carried out
by the computer and the screens directly engraved. Laser engraving systems by Stork and Zed for lacquer rotary screens and flat screens by companies such as Macchine e Sistemi are commonly available.24 These systems can prepare screens for several designs in one day. Chapter systems where, instead of engravers, plotters are used to prepare tracing are commonly available even in India.

Among the printing machines, the share of flat screen has remained more or less static, with rotary screen printing replacing roller printing in most cases. 61% of the total meterage is printed using rotary printing, 19% by flat screen printing and only 14% by roller printing machines. In the last two years, rotary printing machines have been modified to make them more versatile (coping with small lots), economical and ecofriendly. Modifications include providing a ring motor for individual control on every single screen and synchronization between printing blanket and screen in terms of speed and repeat adjustment. Machine downtime is reduced from 60 to 12 min. Design setting is now a matter of few minutes and the repeat errors, even at high printing speeds, are negligible. In fact, a new design can be set on the machine even when it is busy printing another. The paste content in screen, squeeze, pump and printing is recoverable, reducing system waste from 4.5 kg to 700 g per screen. Even the clearing of squeeze etc can be carried out on-line. Using this machine, it is possible to print non-stop any number of designs on any length of the fabric. For such an operation, however, it must be dye dispensing and paste preparing system.

Considerable improvements in adjustment and changeover functions of flat-bed screen printing units have also been made to get faster production speeds. These machines are now capable of giving over 20 m/min production rate of high definition, level and deeper colour prints. There is a provision of heating the blanket up to 50°C, continuous gluing and cleaning of conveyor belt and tension-free transport of fabric.

Print washers have also been modified to give high energy and washing efficiency and reduced water consumption in open width. Most of these paste use a combination of spray and vacuum attachments.

Not much advancement has taken place in the area of steamer designs, though a flash steam ager by Arioli promises fixation of reactive prints on cotton without area. Fabric is transported through the steamer in small loops. The system allows a treatment time of 60-120 s at a speed of 30-50 m/min and temperature of 120°C (refs 7 & 25). In addition, the machine may be used as a conventional steam ager for fixation in saturated and superheated steam and for polymerization of pigment prints with hot air.

Mechanical moisture applicators, such as WEKO rotor damping system and Farmer-Norton spinning disk system, have also been available for sometime for conditioning the fabric and for partial replacement of urea in reactive printed fabrics by spraying water on them just before steaming.

5 Machinery for Finishing

Mechanical finishing, owing to being environmentally most preferred, is coming back in a big way. Old concepts are being modified and modernized using PLCs, microprocessors, servo motors, individual drivers and the like.

Control and monitoring of running fabric, web straightening, uncurling, opening, detwisting or even simple guiding of fabric are now carried out by some very innovative equipment developed by Bianco, Mahlo, Erhardt, Leimer and Tandematic, etc (ref. 7).

Process control and automation are at an advanced level on the new range of stenters by Babcock, Brueckner and Monforts. Maintenance-free chains, automatic control of fabric width, overfeed temperature, moisture and dwell time with high energy efficiency and reduced exhaust pollution are some of the features. Many other new drying machines, like shrink dryers and tumble dryers, are designed to be multi-functional machines. Shrink dryer by Krantz not only dries, but also controls shrinkage, develops volume and improves feel in its tumbling zone. Fabric is fed at low tension onto a screen belt with an adjustable high overfeed of up to 200%. Drying is carried out continuously by hot air in either of two modes—rebound jet or permeation drying (Fig. 5). This semi-dry, pre-heated fabric is then dynamically moved by a special circulating-air control system. The speed of this tumbler process is adjustable according to the finish desired.

Softset tumbler by Henrikson, on the other hand, uses the same principle as the jet dyeing machine, only with hot air instead of water to transport the fabric. Air velocity, adjustable from 0 to 2000 m/min. allows processing of small amount of delicate fabrics to even large amount of heavy fabrics. The machine not only dries the fabric and reduces the residual shrinkage to less than 5% but also gives a very soft handle, breaks pigment prints, imparts finish to velvet, artificial leather and fur. The softset dryer is available in both continuous and batch models. Another mechanical machine re-developed for softening uses breaking rolls. Other surface effects like sueding (Fig. 6), peach skin, sand wash, fading, raising, cutting, pressing, compressive shrinkage (sanforizing), compacting of weft knit fabrics and calendering are all popular today. New machines for all these finishes are being
offered by many machine makers. Farmer-Norton, for example, is offering a two-bowl calender to produce a wide variation of finishes (from glazed to dull) with different degrees of softness and stiffness. One of the bowls is high-temperature steel and the other a polyamide sleeved roll. Individual drives allow finishes which were earlier possible only on friction calender.

Dry treatment of wool using corona discharge or plasma pretreatment machinery for producing machine-washable or superwash finishes is fast replacing wet chlorination techniques because of environmental advantage.

For the few chemical finishes which need to be applied, there are low add-on applicators like Recovac by Ramisch and high add-on applicators like Flexnip.
by Kuster. Drying, particularly at yarn stage, is effectively carried out using radio frequency (RF) dryer as it ensures drying at lowest possible temperature. For fabric, UV and IR superheaters are available for flash drying and subsequent curing.

6 Conclusion
The advances in the wet processing machinery sector meet the requirements of our times, i.e., need for the shorter faster processes and treatment cycles and maximum flexibility (quick change, rapid response) as also the demand for a substantial reduction in the consumption of water, energy and chemicals.

The machinery industry is ready. Question is—Are we?

References
5 Gaurajan M L, Private communication.
10 Product brochure, Bemingers India.
11 Product brochure, Max Goller.
12 Product brochure, Menzel Vertbebs.
13 Product brochure, Edward Kusters.