Continuous Improvement in Yarn Dyeing

Updades on yarn dyeing technology were shared among the 83 participants in the AATCC symposium held at Southern Pines, N. C., in April. The symposium included 11 presentations, problem solving sessions and a discussion session on the challenges of package dyeing microfibers. Developed by AATCC's Committee on Yarn Dyeing Technology, the two-day program offered registrants ample opportunity to confer with speakers and other participants.

Manufacturing improvements

Equipment Modernization

Jerry D. Jackson of International Dyeing Equipment Co. discussed criteria for modernizing or replacing existing equipment. The need for change will normally be dictated by one or more of the following: safety, quality, cycle times and automation.

The decision to modernize or replace equipment, he said, is a matter of economics, improvements in available technology and the potential results from updates.

In package dyeing, flow is the most important parameter affecting the quality of dyed yarn. Jackson noted. Flow rates in gallons per pound per minute should be measured with the dyeing machine fully loaded. For procedures to repeat well from machine to machine, flow rates must be consistent for comparable yarns. If flow is insufficient, unlevel dyeing can result. Increasing the flow can sometimes reduce or eliminate unlevelness. If dyeing results continue to differ between machines, the root of the differences should be determined and corrected to improve the translation between dyeing machines in the plant.

Process engineers and machinery manufacturers continue to look for ways to reduce cycle times in package dyeing. While such mechanical factors as fill and drain times play a large part in determining cycle times, flow rate is the critical factor governing the time it takes to complete a dyeing cycle. A machine with a high flow rate has a shorter cycle time than one with a low flow rate. Utilization of a heat exchanger also can optimize the cycle time. While increasing the capacity of an existing heat exchanger can shorten the cycle, someone with experience should determine the point at which increasing the capacity of the heat exchanger is no longer economically advantageous, Jackson pointed out.

Dyehouses are adopting more and more automation to improve repeatability and reduce labor cost. According to Jackson, most package dyeing equipment now operated manually can be automated relatively economically. Often the change involves no more than the addition of a few valves and some pipe work. Automating draining and filling functions are the best places to start. Jackson pointed out that in dyeing polyester yarns, the process can be shortened if a "hot drop" is used instead of the traditional cooling cycle. Each lot of polyester would have to be done the same way to ensure shade repeatability.

Jackson cited high pressure drying as another way to reduce processing time. Used in combination with removal of water from the airflow and the use of blowers for producing greater differential pressures, some dyehouses have reportedly reduced drying times by 50%.

Laboratory Utilization

Alan D. Correll of National Spinning Co. described how laboratory operations—such as formula development, color physics, dyehouse service support, testing incoming dyes and chemicals, process development and waste treatment plant performance evaluations—play a critical role in the production of yarn dyed products. He offered details on the procedures and equipment used by the laboratory to meet the demands of production.

Formulations are generated using a spectrophotometer with colormatching software and a computer database to compare new formulas with existing recipes. Correll said that dye solution makeup is probably the most critical factor in ensuring that formulas will translate readily from the lab to production. His lab uses The Mini Measure Machine from Benz to assist in the preparation of dye solutions. Use of the machine eliminates the time consuming procedure of weighing exactly 10 grams of dye. The machine also adds the correct amount of water-to-dye weighed in the target weight range of 75 to 105%. The Mini Measure also controls the water temperature in the preparation of stock solutions. A solution makeup procedure can be programmed to include the addition of two auxiliary chemicals and any sequence of water temperatures over a series of steps. A dilute solution is also made up which is passed through a flow-through cell in a Spectronic 1001 spectrophotometer offered by Milton Roy. A diluted solution must have the correct absorbance maximum to a tolerance of ±1.5% and be checked for the correct curve shape to ensure dye purity and the accuracy of the solution prepared.

Yarn samples are prepared using automatic reels which keep the weight tolerance within ±0.4%. Small yarn packages and production size packages can also be dyed in the lab with a similar tolerance for weighing accuracy.

Dye solutions are dispensed in the laboratory using a Kurabo AuKitche volumetric dispensing machine. The machine can prepare dye baths for 16 lab dyeings in about 12 minutes. Most lab dyeings are made on Roaches fluid bed machines. According to Correll, the machine offers very accurate control of dye bath temperature and provides good correlation to production dyeing conditions. Standard washfastness tests are performed in Atlas Launder-Ometers. Overflow and special dyeing temperature work is performed in Ahiba Polymat lab dyeing machines. When scale up of formulas is needed, the lab uses one of its Ahiba Turbocolor 100 machines. The machine can dye both 69 gram packages and 40 gram skeins. Bellini lab package dyeing machines can dye one to seven packages under conditions identical to the company's production machines.

Correll detailed the use of instrumental color measurement to search for existing dye recipes, perform colormatching, refine primary colorant data and develop pass/fail tolerances for batch production. The combination of software and hardware used by National Spinning allows the lab to search 8,000 established formulas to determine if a close match to the proposed formula has already been used in the dyehouse. The software also allows the user to select new combinations of dyes to minimize metamerism and cost. The pass/fail system is based on CMC equations which employ the ratio of 1:4:1. High Tex software allows the lab to refine the tolerances in any area of color space on the computer's video display screen. The procedure allows quick setup of tolerances without having to develop a history of rejected batches.

Correll said that even when good lab formulas are generated the lab must sometimes correct dyeings that are off shade in production. National Spinning allows no adds in the dyehouse. Correll said that allowing personnel to adjust formulas on the production floor generally leads to even bigger errors later, such as when the formula corrections are not documented.
polyster and cotton in a blend fabric in one pass through the range. The polyester fibers are dyed in the first stages of the range by a pad-dry-thermotex process. The cellulosic fibers are dyed in the latter stages of the range using a pad-steam process.

Fabric previously prepared for dyeing enters the dye range from rolls. A scray is used to accumulate fabric entering the range so that the range can continue to run while a new roll of fabric is seen to the end of the strand being run. Uniformity of application of dyes requires that continuous dyeing be done in open width. Typical line speed in a continuous dyeing process is 50 to 150 meters per minute.

Padding is a critical step in continuous dyeing. The disperse dye formulation (and sometimes the dyes for the cellulosic component) is applied in the first padder. The fabric is immersed in the dye formulation usually at room temperature and squeezed to give a uniform add-on of dye formulation across the width and along the length of the fabric. Low temperature in the formulation in the padder minimizes tailing. Higher temperature promotes wetting of the fabric in the short time the fabric dwells in the pad formulation.

The wet fabric leaving the padder enters a dryer to remove moisture and leave the dye uniformly deposited on the fabric. Radiant predrying using infrared energy inhibits migration of the dye. Drying is completed using steam-heated cylinders.

A thermal treatment called thermosteling fixes the disperse dye on the polyester fibers. The thermosteling oven heats the fabric to a temperature of 390-430°C, the exact temperature depending on the particular dyes being applied. The dye sublimes and diffuses into the polyester fibers during the thermosol treatment. The fabric dwells in the thermosteling oven for about one to two minutes.

The cooling cans lower the fabric temperature so that it does not heat the solution in the chemical pad. The chemical padder applies the dyes (and sometimes chemicals) for the cellulosic fibers.

The steamer heats the wet fabric so that the dye can diffuse into the cellulosic fibers. The fabric usually dwells in the steamer for 30-60 seconds.

The washing section of the range is used for rinses, chemical treatments which may be required to complete the dyeing, and washing of the fabric to remove unfixed dyes and auxiliary chemicals used in the dyeing. The dye and chemical formulations used in the padders and washboxes depend on the particular classes of dye being applied.

Continuous Dyeing of Carpet

A continuous dye range for carpet consists of a dye applicator and steamer. The process is designed for application of solid dyes to nylon. Carpet manufacturers are innovative in application of dye to produce special color effects on their product. As a result, many variations of dye applicators exist. A very high liquor ratio is normally required to produce good quality dyeing of carpet. As shown in Fig. 9, a typical application method is to meter the dye solution into the steamer. The stream of dye being metered onto the carpet can be momentarily interrupted to produce patterned effects. Streams of different color dyes can be applied in different patterns to produce special effects.

Loop steamoers are used in continuous carpet dyeing so that the carpet always faces away from the guide rollers. As shown in Fig. 10 this festooning of the fabric prevents compression of the carpet pile by rollers in the steamer.

Long Chain Dye Range

Warp yarns are often dyed with indigo and sulfur dyes using a long chain dye range. The process is used where the warp will be one color and the filling another color, as in denim fabrics. A schematic diagram of the process is shown in Fig. 11. Ball warps (sometimes called "logs" because of their cylindrical shape) are prepared as supply packages for the long chain dye range. A ball warp is a warp in which several hundred warp yarns are condensed into a rope and wound as a single strand into a ball (log). The yarn from each ball warp constitutes a continuous rope (chain). A long chain dye range accommodates multiple ropes or chains side-by-side so that thousands of yarns are being dyed simultaneously. After exiting the long chain dye range, each rope is taken up in a separate container. After dyeing, each individual warp is wound onto a warper beam (section beam) and becomes a supply package for the slasher.

Long chain dye ranges usually have a wet-out box to wet and partially scour the yarn before it enters the dye application section of the range. The range contains a series of dye boxes which are designed to apply indigo. Indigo has low affinity for cellulose and must be applied in several stages called dips. Each stage consists of immersing the yarn in a solution of the reduced indigo, squeezing to remove excess solution, and skying to allow air to oxidize the dye and make it insoluble. The shade gets progressively darker at each dip. The dye boxes are large and a circulation system involving all of the boxes is used to keep the indigo solution mixed well and prevent tailing of the shade.

A sulfur dye can be applied either before the indigo, giving a sulfur bottom, or after the indigo to give a sulfur top. The use of a sulfur dye reduces the amount of the more expensive indigo needed to produce the shade and may also modify the fastness properties as required for a particular use of the fabric.

References


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Problems With Static?

The Fabric-To-Metal Cling Test Apparatus is used in AATCC Test Method 115 to evaluate the electrostatic clinging properties of fabrics. The complete test unit is available from AATCC and includes: Metal Test Plate, Grounding Plate, Wood Rubbing Block, Urethane Foam Pad. Complete set: $111.00 Order No. 8354
The two-day symposium on yarn dyeing featured 11 guest speakers, problem solving sessions and an update on package dyeing microfibers. The program was one of a continuing series of professional development courses offered by AATCC.

The use of color physics and available computer software assist the lab in determining a one-shot correction formula to put the batch on shade. In selected cases, the lab can use color physics to develop a formula without performing laboratory dyeings.

Testing incoming dyes and chemicals is another important support function of the lab. National Spinning’s lab uses a Perkin-Elmer Lambda 6 ultraviolet-visible spectrophotometer to measure replicate samples of diluted dyes. Basic, acid and direct dyes are processed by diluting each weighed dye sample individually in deionized water measured in a flow-through cell with a one millimeter path length. Due to the difficulty in dissolving disperse dyes, they are prepared using 0.01 to 0.02 grams of dye per liter in 50% acetone/50% water solutions made from one gram per liter dispersions. Samples of disperse dye solutions are measured with a flow-through cell using a one centimeter path length. According to Correll, reactive dyes do not lend themselves to the UV-visible method. They must be dyed and visually compared.

Another dye house support function performed by the lab is the calculation of retarder to use when dyeing acrylic to ensure that the dye rate is slowed appropriately without blocking dyesites.

Several parameters of incoming auxiliary chemicals are tested including percent solids, pH, viscosity and chemical consistency. Titrations are performed on commodity chemicals to determine their strength consistency.

The laboratory can also develop and evaluate dyeing procedures with the aid of the spectrophotometer, a flow-through cell and an Ahiba Colormat CM3000 lab dyeing machine. The ability to measure the changing dye concentration as alkali or salt are added to the bath offer the ability to determine when process parameters are most critical and develop robust production processes.

The laboratory also provides support to assess the performance of the wastewater treatment plant. The conditions of National Spinning’s self-monitoring permit require that certain tests be performed to ensure that waste treatment was performed correctly. Selected tests must be performed by outside firms due to the high cost of test equipment and the need for more immediate results to satisfy the reporting rules.

Improving Lab Dyeings

Vincent W. Bannigan Jr. of Crompton & Knowles offered several methods for improving the accuracy of laboratory dyeings. He said that first, the person evaluating the dyeing must answer the question, does the dyeing meet the specifications? Dyeing specifications can include shade, uniformity, cost, colorfastness, physical properties and whether the process was timely—and most importantly—that the results are reproducible. He advocates the use of a checklist to help determine the root of a problem with a production dyeing. The checklist includes categories which he defines as the components of a dyeing. The categories are the vehicle (generally water), substrate, substrate components (intentional and unintentional contaminants), dyes, dyebath additives, exhausting chemicals, dyeing machinery, instrumentation and human resources.

The critical aspects of water quality include hardness, pH, suspended solids, organic matter and chlorine. Knowing both the quantitative and qualitative characteristics of the water used in a dyeing is important for shade repeatability.

Substrate consistency is also a factor of concern. The source of natural or synthetic fibers may create variations that require formula adjustment. The blend ratio, count and texturing history will also have an influence on dyeing results.

Substrate additives can also confound the dyeing process. Bannigan said that dyers often make assumptions on additives that are quite erroneous. The preparation process can leave behind residues such as bleach which can change the expected result. Bannigan considers the put-up method (whether the yarn is wound on dye tubes or springs) as a substrate additive because it can create variations in yarn density and moisture content which can affect shade repeatability.

Dye selection plays an important role in the quality of laboratory dyeings and their correlation to production. The dyer must consider whether the generic type and class within the selected type are the most appropriate for the goods to be dyed. While no one disputes the importance of characterizing dye properties—such as solubility and compatibility—using different sources (sample versus drum) can negate all the testing done by the lab. Use of a representative sample of what is currently used in production helps ensure shade repeatability. Differences in storage conditions and preparation methods must also be considered when comparing the results of laboratory and production dyeings.

Bannigan suggests that incoming...
checks of dyebath and finishing auxiliaries are as important as checking the characteristics of incoming dyes. The stability and source of what is used in the laboratory and production should be the same.

Machinery considerations include whether the volume, flow and geometry of lab dyeing equipment are the same as the conditions used in production. Temperature control is important not only at the dwell stages of the process but also throughout the rate of rise and rate of cooling. Control of the rate used to perform the wash step can also improve shade repeatability.

Bannigan said that such instrumentation as graviometric weighing devices have helped the accuracy of lab dyeings, but he cautioned that they can create another source of error in production. Production quantities of chemicals are often measured volumetrically while gravimetric methods are used in the lab. Moisture content differences between products stored in the lab and in the production area can also create errors in the amount of product dispensed in the lab and production. Bannigan commented that while the latest in computer technology linked to dyeing machinery has helped improve accuracy, personnel can often put too much trust in the correctness of the conditions reported by the equipment. The accuracy of dyeing conditions must be verified on a regular basis.

Even with the most advanced instrumental controls, the importance of the human factor has not decreased, Bannigan noted. Cost cutting pressures have removed personnel from the laboratory, the dyehouse, and from maintenance and quality control areas to the point that many departments cannot function efficiently.

Communication skills are an important component of the human factor in terms of understanding the specifications of the dyeing and determining whether the end result is satisfactory. Bannigan cited the CMC method for determining the acceptability of shades as a great improvement in color communication. On the topic of visual assessment of shade, as well as with other topics on improving dyeing accuracy, he provided references for additional reading.

Fiber Blending Effects
Hassan M. Behery of Clemson University's School of Textiles discussed the influence of fiber source and blending on the uniformity of dyeing. He compared fiber blending to fiber mixing by pointing out that blending is based on exact measurement of all fiber properties and correct proportioning whereas mixing is more or less a haphazard operation. Behery offered four objectives of blending:

- Improve the overall uniformity of the products at the different processes.
- Achieve the desired properties in the final product especially when blending two different types of fibers (e.g., cotton/polyester).
- Obtain particular color effects which are difficult to obtain by conventional dyeing techniques.
- Achieve the necessary cost savings in raw materials and minimize labor cost.

According to Behery, new technology in cotton yarn formation has reduced the number of processing steps and increased the importance of good blending. Faster machines generally require a better raw material input. Dyeing will readily show the nonuniformity in fiber distribution, but unfortunately the problem shows up too late to take corrective action.

Behery noted the group that fiber manufacturing process parameters such as cooling tower conditions, air pressure, temperature, winding tension and speed have a direct effect on the fiber dyeability. He said that the identification of different merges of man-made fibers is a strong indication of the different fiber properties of the merges and care should be taken not to mix merges in the same dyeing load. Yarn spinners must make provisions to properly segregate not only fiber types but also variations in properties within a fiber type, such as high elongation, high tenacity and low pilling polyesters. A slight mistake in mixing at the spinning mill can be a disaster in the dyehouse. Behery stressed the importance of asking for information about yarn because it will have a direct impact on dyeability. He said that often what you do not know about the yarn will indeed hurt the quality of the dyed result!

Behery pointed out that there are two basic approaches to fiber blending—intimate blending and draw frame blending. Intimate blending is practiced in the U.S., draw frame blending more in other countries. The earlier in the process that blending begins, the more uniform the final product will be. When practiced with proper control, intimate blending offers the best opportunity for uniformity and less chance of dyed yarn defects. Draw frame blending offers the advantage of better control of the percentage of the constituent fibers along the yarn length by delivering slivers of selected fiber types to the draw frame in a known ratio. Behery said that the initial amount of cotton may be adjusted upwards to account for the dirt and trash which will be removed in later processing.

Possible causes of dye defects from irregularities in blending can be evaluated by looking at longitudinal sections and cross-sections. Yarn migration can cause dyeing problems when blended fiber types have different dyeabilities. Behery commented that current interest in use of polyester microfibers as the outer portion of the yarn is technically unsound. He said that studies on yarn migration lead him to believe that staple microfibers will migrate to the center of the yarn where the aesthetic qualities will not be realized.

Behery described two types of blending faults which can sometimes be detected by dyeability differences. Systematic faults have a particular magnitude and sign (+ or -). They appear in the same manner with all measurements and in dyeing are seen at regular intervals. Random faults vary in magnitude and sign and are different with every measurement. Systematic errors are less critical because they usually do not cause faults in fabric, provided the yarn packages are processed batchwise.

Yarn Preparation Methods
S. Michael Leamon of Hoechst Celanese discussed the importance of properly preparing yarn prior to dyeing. The critical first step in improving quality and reducing seconds in yarn dyeing is to remove the natural or added impurities on the yarn. Due to the breadth of the topic, he limited discussion of procedures to the preparation of cotton, polyester/cotton, polyester and rayon yarns.

Since yarn preparation is a batch question, it presents some of the same disadvantages as fabric preparation but offers some advantages due to the nature of handling yarn packages instead of a fabric. The advantages to processing yarn packages over fabrics include:

- No warp sizes to remove.
- No slashing waxes or binders to remove.
- Impurities are not heat set by singeing.
- No knitting oils to remove.
- No wet winding emulsions to remove.
- Reduced inconsistencies due to wet-on-dry applications.
- No constant monitoring of chemical concentrations by titrations.

The disadvantages of preparing yarn packages include:

- Packages act as natural filters to catch impurities.
- Channeling exists because of differences in package densities.
- Yarn shrinkage causes flow compaction and flow problems.
- No countercflow action of water to yarn due to stationary packages. This makes washing more difficult.
- Results are not known until the end of the cycle. No visible inspection possible.

The quantity and type of impurities to be removed will dictate the preparation
methods used. Natural cotton can contain as much as 10% by weight of natural impurities and an additional 0.3% from added impurities. Color on cotton represents a trace amount of the total impurities. Synthetic fibers usually have between 0.50 to 1% impurities. All preparation procedures require adequate hot water washes (between 160 and 180°F) to remove impurities as well as any residual preparation chemicals. Leamon offered two comments about the relationship between preparation and dying:

- Between 50 and 60% of all dyeing problems are a result of improper preparation.
- A well prepared yarn (or fabric) is half dyed!

The biggest misconception in any preparation step containing cotton is that if the cotton is well bleached and white, then it is well prepared. Leamon commented that too much time is spent removing pigmentation by bleaching when the remaining impurities are the major cause of faulty dyeings. If goods will be dyed in dark or medium shades, bleaching becomes unnecessary. According to Leamon, a caustic scouring procedure will produce good quality dyeings. The benefits of using the procedure he offered are:

- Build heavier shades.
- Eliminate oxidative damage.
- Minimize insoluble hydroxides.
- No residual peroxide.

Cotton to be dyed in pastel or bright shades will require pre-bleaching to remove pigmentation and mutes. Leamon suggested use of a hydrogen peroxide and caustic soda stepwise procedure that not only offers good color removal but also as removes yarn impurities and chemical residues from cotton and cotton/polyester yarns. He said that many pre-bleaching procedures contain too little caustic soda to remove the impurities and too much hydrogen peroxide for the amount of color present. The excess hydrogen peroxide adds work to the washing step.

Leamon pointed out that all synthetic yarns require preparation to ensure uniformity in dyeing. Fewer impurities are present and the procedures are generally not as long or severe. Care must be taken to note the heat sensitivities of particular additives on synthetic yarns to ensure adequate removal and to prevent redissolution in the preparation bath.

Rayon and cotton differ in physical properties such that the same preparation procedure cannot be used for both yarns. Rayon has fewer impurities, exhibits less wet strength and higher shrinkage, and has a lower degree of polymerization and a higher moisture regain than cotton. According to Leamon, the caustic scouring procedure he detailed builds heavier shades while protecting yarn strength.

Polyester spun yarn requires a pre-bleach to remove fiber finishes and manufacture impurities. Leamon also described a short procedure designed to remove any residual metallic ions that remain on the yarn.

Improving Dye Cycles

Michael V. Carter of Macfield offered several practical suggestions for improving package dyeing cycles when using disperse dyes on polyester. He said that whenever an investigation of methods to shorten dye cycles is undertaken, four parameters should be considered: machinery, dyes, chemicals and procedure. He cautioned that finding the best and fastest way to dye a yarn requires a tremendous amount of research and development. It is imperative that the lab equipment correlates to production equipment when testing any new product or theory to shorten a dye cycle.

Equipment parameters which can be adjusted to improve dye cycles include increasing the bath flow and addition of an automatic chemical metering system. One way to increase flow is to increase the diameter of the impeller, provided the machine has a centrifugal pump. Carter said that a larger motor may need to be added due to the extra strain put on the machine's existing motor. The extra cost may make the change uneconomical.

Automatic chemical metering offers faster cycles by dispensing products from bulk storage at the precise time required by the dyeing procedure. It has the added advantage of reducing labor in the dye room, eliminating human error in auxiliary and eliminating the problem of disposing or returning empty chemical drums. Carter reported that Macfield uses 200-gallon to 600-gallon mini-bulk containers for less commonly used chemicals and 600-gallon mini-bulk containers for less commonly used products.

To shorten the cycle dye can be selected that have faster rates of exhaustion. Carter suggested that disperse dyes with exhaustion curves that flatten shortly after high temperature is reached are preferred over dyes that exhaust slowly. Dyes that exhaust slowly not only require a longer dying time but also can cause shade variability if the cycle time is varied by as little as five to ten minutes.

Dye properties such as barré coverage, dispersion, lightfastness, washfastness, crockfastness, sublimation, dye build, money value and other tests that are end-use specific should be tested to determine if the dyeing cycle can be shortened without adversely affecting required properties. If a particular dye is sensitive to change in a critical area—such as washfastness—perhaps a suitable substitution can be made. Carter recommended keeping a library of dye properties for reference when making substitutions.

A good chemical system is very dependent on the type of equipment used in package dyeing. Carter warned that just because an auxiliary works well in another dyehouse does not mean that it will work in yours. He encouraged in-house experimentation with a variety of available products to see what works best.

While modification to the dye procedure may be the first thing that comes to mind when attempting to improve a dye cycle, Carter said that it is important to remember that machinery, dyes and chemicals will be the limiting factors in successful shortening of dye cycles. For example, starting a procedure at a higher temperature may seem like an easy way to shorten a dye cycle but if the dyes and chemicals selected are fast strikers, the success of this procedure may be greatly reduced. Another option is to increase the rate of rise to high temperatures. Dye and chemical selections are again limiting factors. Additional capacity may need to
Yarn Dyeing

be added to the heat exchanger if existing equipment is not capable of more rapid heating.

Hot dropping the bath at the end of a high temperature cycle can reduce the time spent cooling the dyebath before discharging it. Equipment is a limiting factor if piping must be installed to execute the procedure. Installing piping may make the change cost prohibitive.

The final suggestion for a process change to improve a dye cycle is to put hold times (do not continue to ramp) at critical dye uptake temperatures. This change will slow the strike rate of the dyes when they have a tendency to go into the fiber too fast. Although this change will lengthen the cycle time, it can improve the levelness of the dying thereby reducing the need for reworks. Addition of a retarding agent may be necessary to slow the strike rate further.

Reducing Adds and Reworks

Chester P. Turner of Ciba-Geigy discussed how proper attention to three key elements of the yarn dyehouse—quality control, tools and people—help reduce adds and avoid reworks.

Inputs to the yarn dyeing process include packages, dyes and chemicals, procedures and preventative maintenance. Quality control involves checking whether raw materials meet specifications as well as whether procedures are up to date and equipment is maintained. Packages must be inspected for consistent quality winding. The importance of checking incoming shipments of dyes and chemicals is directly related to the rigidity of performance expected from the dyeing operation. Turner said that the tighter the shade tolerances the more important checking incoming dye shipments becomes.

Quality control also applies to the preparation process since it has a direct impact on the levelness of dyeing. Specific knowledge about types of waxes or lubricants applied during manufacturing helps in planning their removal. Turner said that it is good to know the melting point of a wax so it can be matched with a surfactant with the sufficient cloud point to ensure removal. He shared an unfortunate experience with participants where a dyer was told that everything put on the yarn was water soluble. What the spinner forgot to tell the dyer was that the wax was only soluble at temperatures of 140°F or above. The wax redeposited on the yarn at temperatures below 140°F.

Turner said that control of procedure

Correcting Faulty Dyings

Gary L. Champion of J&C Dyeing said that all dyehouses sooner or later are confronted with reworks. He offered a protocol to determine why the faulty dying occurred, how to repair it and how to prevent it from occurring again. Dyeing problems include dye spots, migration, uneven dying, staining, shading, off shade, poor union on blends, poor hand and poor fastness. He reviewed probable causes for each problem but said that, in general, 90% of them result from the following:

- Machine malfunction
- Formulation error (lab and dyeing)
- Substrate
- Windsing
- Operator error
- Chemical or dye problem
- Water (metals and chlorine content)
- Drying

Champion said that his company dyes as many as 169 different yarns from 23 different suppliers. Current market demands have the mill running 70 to 80% of its production in 100% cotton. He offered three repair procedures for dyings on cotton yarn.

Repairing an unlevel fiber reactive dying is almost impossible. Champion said that identification of the following conditions may allow stripping to be avoided:

- Lot may not have been cleaned up well before finishes (fixative and softeners) were applied.
- Fixatives and softeners were applied unlevel.

To check whether stripping can be avoided, he recommended that fixatives and softeners be removed to see if the dyeing appears level. The test should first be run on a small sample in a beaker. If results from the beaker look good, a package should be run in a lab machine before moving on to production equipment. From the sampling procedures the decision can be made whether a rework or top up procedure is required. If removal of finishes does not yield the needed results, packages are stripped and redyed.

Of great concern in the stripping of cotton yarns is the probable loss of tensile strength. The redyeing can also result in unlevelness, and at this point there is generally not a second chance to repair the problem. Champion offered two procedures for stripping reactive dyes and noted that some reactive dyes require the addition of hypochlorite bleach.

Repairs on sulfur dyings on cotton require more caution than dyings with other groups of yarn because of the greater loss of tensile strength seen with stripping.
Champion offered two procedures for repairing sulfur dyeings based on the severity of unlevelness.

Knowledge of the which class (A, B, or C) of direct dyes is applied to an unlevel dye lot is essential for determining the repair procedure. Champion reported that class A or B dyes can be leveled but class C dyes must usually be stripped before re-dyeing. If a dyeing has been aftertreated or fixed, the finishes must also be removed before re-dyeing. While some fixes can be broken with common salt or hydrochloric acid, Champion recommended first following the removal procedure given by the manufacturer of the fix. He offered a leveling and a stripping procedure for direct dyes. Yellow direct dyeings can be difficult to strip and can be removed by a sodium chlorite method.

All the stripping and re-dyeing procedures have the drawback of weakening cellulosic fibers. Champion recommended that all goods be checked for strength differences before shipping.

Environmental Concerns

Textile Industry Activity

Don A. Alexander of the Institute of Textile Technology cited the recent twentieth anniversary observance of Earth Day as a demonstration of increased public concern about such issues as ozone depletion, global warming, deforestation and acid rain. He reminded the group that negative press from one incident can overshadow all the positive accomplishments a mill has had.

ITT recently held a workshop on environmental problems which was attended by 15 of the school’s member companies. The 44 delegates represented a cross-section of responsibilities including those in charge of environmental programs, technical managers, production management and corporate vice-presidents. Approximately 60% of the workshop time was devoted to group discussion to list, classify and prioritize the obstacles to complying with environmental regulations in the textile industry.

The group decided that it is impossible to separate concerns by greige or wet processing. The top ten obstacles to environmental compliance, the group decided were education, support, regulations, disposal, attitude, responsibility, suppliers, public relations, technology and control.

Half the group’s discussion time was devoted to education and support. Lack of education was the single biggest concern. The group agreed that information on current regulations and how to comply with them should be disseminated to everyone from top management to line operators. Alexander noted that the group also cited the need to let contractors, suppliers, local citizens and government agencies know what a mill is doing to improve its level of environmental compliance.

The workshop participants emphasized the need for a company to have a corporate environmental policy and the financial resources to make the policy effective.

Compliance Audits

J. H. Coley of Du Pont spoke of the importance of conducting environmental compliance audits to gather information needed to start, improve or maintain environmental compliance programs. Since the term audit generally has a negative connotation, he redefined it as follows: An audit is a systematic, comprehensive evaluation of conformance with specific, agreed upon standards.

An environmental audit must be systematic in its structure and planning, and must be comprehensive in its coverage. All the parts of an operation should be held up against the regulations, not just those where there is a suspicion of problems. The evaluation is not just a list but an examination of how the requirements are interpreted and applied. Three common causes of failure to meet the standards are:

- Standards are not known or understood.
- Approach to standard is flawed or incomplete.
- Execution of approach is flawed.

Of course, a plant may choose not to perform an environmental audit, but the consequences of not knowing where problems exist can be devastating. Coley added that if you are not prepared to act on the findings of an audit, no purpose is served doing one. However, the reasons for performing and acting upon an audit outweigh the costs of avoiding one. Reasons to audit include:

- Smarter regulators and enforcers.
- Increased enforcement efforts.

Topics of the Yarn Dyeing Problem Solving Sessions

A popular feature of the symposium was the small group problem solving sessions. Each group was assigned a topic of universal interest to the package dyeing industry and was given two hours to identify the important issues about the topic and techniques for solving related problems. Each group presented analysis of their discussion on the second day of the symposium. Vince Bannigan, one of the symposium speakers, referenced the summaries of last year’s problem solving sessions as an invaluable resource to package dyers. Perhaps the summaries of the following topics will be equally, if not more valuable.

- Standard operating procedures (SOP) for shade repeatability.
- How to improve package leveling.
- SOP’s and parameters for checking dyes and chemicals.
- Statistical process control.
- Optimum liquor circulation for different substrates and dye classes.
- Stripping dyed yarns.
- Water quality and usage.
- Proper extracting/drying of cotton, rayon and acrylic.
- Microprocessor/dyeing machine automation.
- What information is needed in a package dyer’s handbook?
Biological nutrients have become an increasing problem to dyeing operations since more water bodies in the Southeast U.S. are dammed. Algae, a secondary pollutant, grows readily where water is stagnant and sun shines on it. Use of ammonia, a common ingredient in dyeing buffer systems, will have to be eliminated because of the change in the biological nutrients present in today’s water supply. Every part of ammonia put into the sewage consumes four and a half parts of oxygen. Lower phosphate content detergents have helped improve water but total dissolved solids (TDS) from detergents and other sources have also become a concern. Industrial wastes in the water source have raised the TDS from 150 ppm to 250 ppm. Neutralization with caustic soda may seem like a cost effective method but adds to TDS problems.

Another important environmental issue to the textile industry is sludge toxicity standards. Barnhart referenced a recent ATMI study which showed that textile sludges are not toxic by the Toxicity Characteristic Leachate Procedure (TCLP). He said that the textile industry does not have the resources to adequately address what is coming its way in environmental enforcement. He encouraged dyers to work more closely with dye and chemical suppliers to develop alternative methods which will decrease waste emissions. The methods will rely on product substitution and process simplification.

Barnhart concluded by pointing out that the 1970s was the decade of discovery, the 1980s the era of growth and structure of the EPA and other regulatory agencies and the 1990s will be the era of enforcement of environmental laws.

Technology Committee
Wilton C. Finch of Dohmen U.S.A. served as chairman of the symposium and of the steering committee that developed the program. Finch is also chairman of the AATCC Yarn Dyeing Technology Committee which meets three times a year. Steering committee members who also served as session moderators were David Vlaservich of the Institute of Textile Technology, William E. Singleton of J&C Dyeing and Frank D. Little of Ciba-Geigy. Don A. Alexander of the Institute of Textile Technology and Bill N. Chackal of Carisbrook Yarns were also members of the steering committee.

Additional Reading
For those who were unable to attend the symposium and are interested in the complete text of the papers presented and the summaries of the problem solving sessions, copies of the proceedings are available at $51 ($28 to AATCC members) from the AATCC, P. O. Box 12215, Research Triangle Park, N. C. 27709-2215; telephone 919-549-8141; fax 919-549-8933.