# Less Is More In Applying Chemicals to Textiles

## Environmental concerns rejuvenate interest in low wet pickup systems

By Dr. Fred L. Cook,
Director, School of Textile & Fiber Engineering, Ga. Tech and Consulting Editor, Textile World

In the late 1970s, equipment suppliers and the textile wet processing sector made a major effort to reduce water consumption in application of chemicals to yarns, fabrics and carpets. New systems were especially developed to minimize wet pickup (WPU) of fabrics and carpets in chemical applicators of continuous lines.

Liquor ratio (LR: weight of water in a bath compared with weight of goods processed) employed in batch dyeing of yarns and fabrics was steadily lowered by introduction of pressurized equipment with more efficient liquor/goods interaction designed into the units. The major driving force for these innovations (and the inducement to invest the capital required to implement them) was simple: uncontrolled energy costs.

Although cheap compared to other potential organic solvents for applying chemicals to textiles, water requires a comparatively excessive amount of energy to heat up and undergo phase transformations (1,000 Btu to vaporize 1 lb of water). Unfortunately, textiles' wet processing sector has evolved around copious use (or more accurately, misuse) of water in chemical applications.

Indeed, when the textile complex in the Northeastern U.S. began its shift to the Southeast in the late 19th century to get closer to its primary fiber supply (cott and to flee from high taxes and expens labor, it concentrated its new plants alo the fall line and its abundant rivers for t reasons:

(1) to utilize potential energy of t river falls to generate electricity;

(2) to satisfy its insatiable appetite process water.

Although externally-generated electr ty had largely supplanted on-site gene tion by the 1970s. It was not unusual large preparation/dyeing/finishing pla to consume over 2-million gallons of wa daily in its manufacturing operations.

The Arab oil embargo of 1974-75 quic changed the paradigm. The cost of cru oil skyrocketed from $5 per barrel to $ with no return to the pre-embargo lev in sight. "Less is more!" became the ra ing cry in textile wet processing ope tions, as managers saw their already-l profit margins slipping into the red energy costs soared across the boa Less water consumed in applying che cals to products translated into mo energy dollars saved, and hence a retu to profitability.

The state of technology in 1975 consi ed of atmospheric batch machines applying chemicals to yarns and fabr that operated with LR ranging 5-10:1 (ya package and beam dyeing machines, jigs) to 15-20:1 (becks, rotary drums, paddle machines, etc.). Continuous lines invariably used the "slop-pad" method of chemical application, where open-width fabric or carpet was carried through an open bath of liquor via several guide rollers to completely impregnate the structure to saturation. Excess liquor was then squeezed out by pressure rollers.

Depending on the fiber and construction of the textile substrate, retained liquor ranged as high as 500% of the weight of goods (carpets) to 100% (woven polyester). Final removal of residual water was affected by phase transformation, either in curing ovens (e.g., ThermosolR process with cotton/polyester sheeting) or in drying ovens.

Over the next 10 years, machinery vendors responded to their customers' needs with an array of equipment that reduced water volume required to chemically treat textile substrates, both in continuous and batch modes. However, beginning with the election of Ronald Reagan in 1980 and his declaration that the U.S. was not facing an energy crisis, but an energy supply problem, fuel costs became less of an immediate concern for textile producers.

The actual cause, of course, was lessening of tensions with the Arab world, culminating with release of U.S. hostages held by the Iranians on the day President Reagan took office. That development and the subsequent world-wide "oil bubble" that developed by 1982 as the Middle East taps were reopened, sent oil prices plummeting. Textile managers (much to the relief of dyers and finishers) again turned their attentions to more traditional impingers on the bottom line than water and energy, such as labor/fiber costs and level of productivity.

In the past year, with the Clinton Administration occupying Washington, coupled with increasingly-stringent environmental laws and regulations from the Environmental Protection Agency, the textile complex has refocused on the question of water use in application of chemicals to textiles. In addition, although no embargo resulted from the now-allies in the Arab world, Desert Storm re-emphasized the frailty of the U.S. energy supply situation, with over 50% of total U.S. requirements now coming from the Middle East.

Finally, water supply is rapidly becoming the next U.S. "oil crisis," as the rapid increase of population and other industries in the Southeastern textile states are competing for a finite supply. As one expert noted at a recent textile environmental conference, "We are not creating any new rivers, streams or aquifers, and with ecology concerns, even large lakes are becoming untenable!"

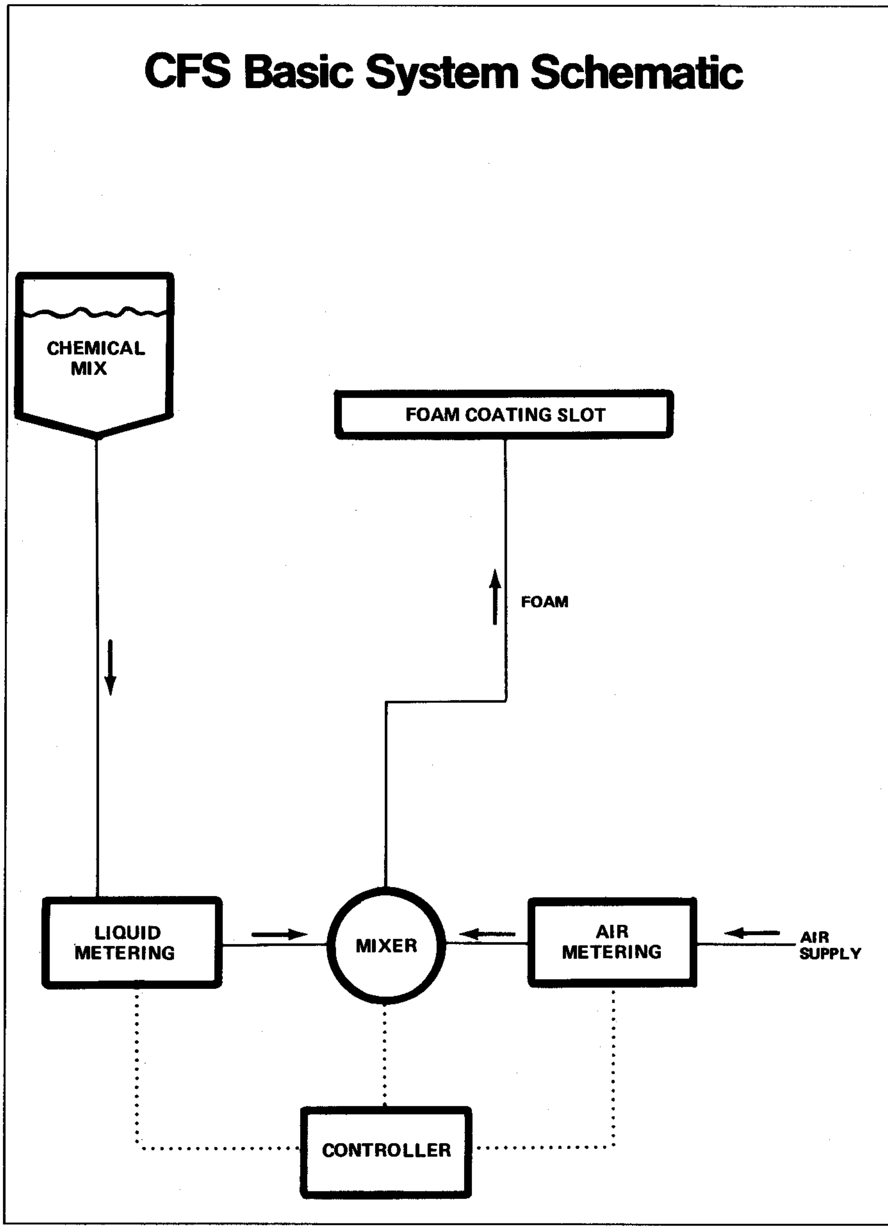


Fig. 1. Gaston County's parabolic applicator system is the heart of its CST unit. The foam applicator has been extensively modified.

A natural shakeout has occurred in the innovative systems introduced in the late 1970s and early 1980s to reduce water consumption in chemical applications to textiles. Some technologies lost due to technical flaws; some to adverse capital and/or maintenance cost factors; and others to a combination of these factors.

Batch dyeing/finishing equipment has reached a plateau stage and the perceived limits of liquor ratio, running in a touted 2:1-4:1 range for yarn/beam dyeing equipment, and in the 4:1-8:1 range for jet, jig and other fabric and carpet dyeing machines. The status of several of

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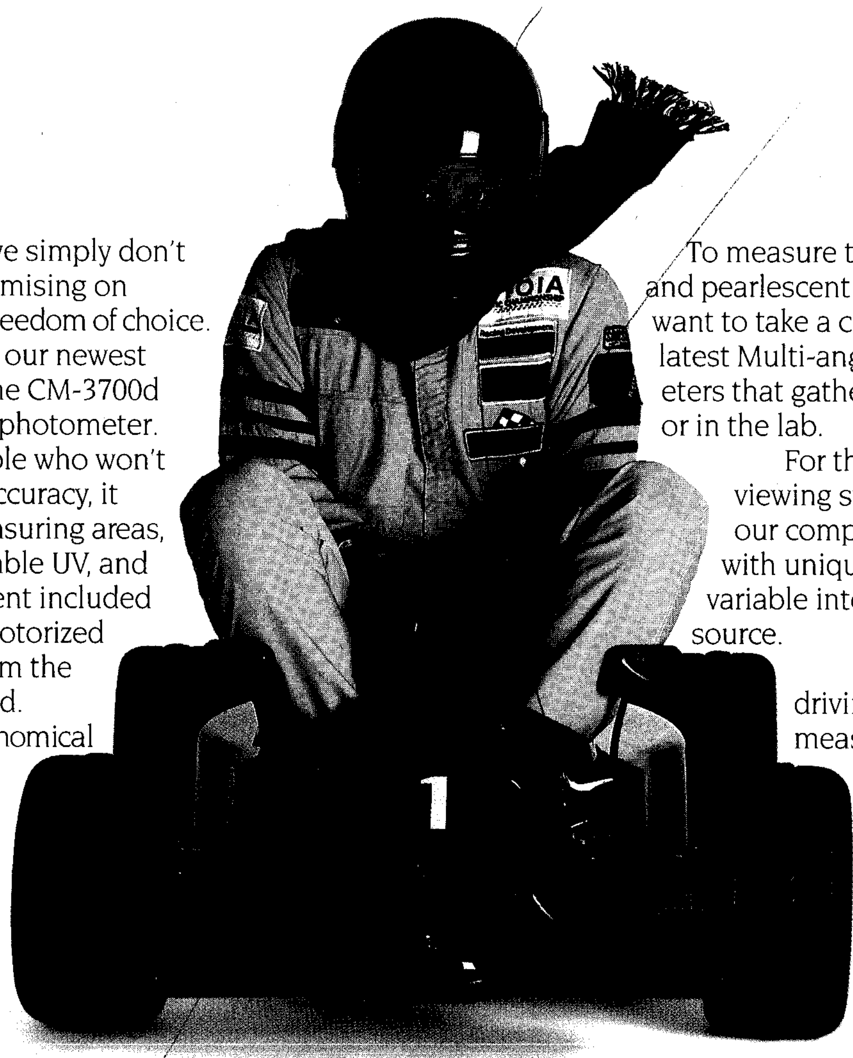

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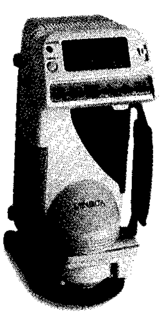

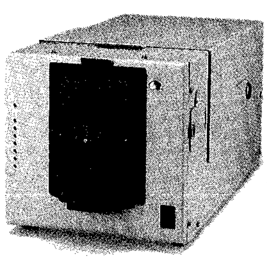

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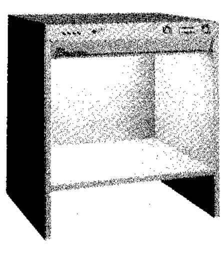

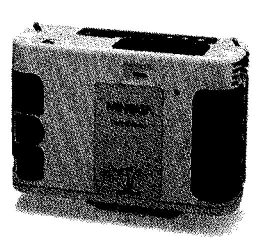

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the more prominent low WPU technologies for continuous application of chemicals to textiles is thus reviewed in this article.

## Gaston Co. Foam System Durable, Consistent

Continuous foam application technology to textiles from a pressure plenum was developed in the 1970s by Union Carbide Corp. The principle objective was to develop finite control over chemical application, using uniform quantities and controlled penetration.

Foam as a medium extends the surface area of the chemical system to more closely match the surface area of the fibers, yarns and/or substrates, leading to tremendous reductions in required liquor (WPUs of 8-80% on weight of substrate). Reduced water uptake results in commensurate reductions in energy requirements for evaporation, elimination of cross-sectional chemical non-uniformities due to product migration and, in many cases, increased production speeds because of decreased required oven dwell times. The technology of applying foams under pressure has several key characteristics:

- High chemical concentrations in the liquor.
- Minimum thickener needs.
- Precise, controlled air feed rates.
- Controlled, uniform, repeatable foam half-life, bubble size and density.
- Wide range of foam densities.
- Uniform foam age from generation to application.
- Fast foam break upon substrate contact.
- Fast wetting/penetration rates into substrate.
- System speeds of 30-300 mpm.

However, one foam system and its vendor has proven equal to the task over the years: the Chemical Foam System, or CST, of the Environmental Systems Div. of Gaston Co. Dyeing Machine Co. Previously called the Foam Finishing Technology (FFT) system, over 90 of the Gaston Co. chemical foam application units are operating worldwide, applying a wide variety of chemicals, binders, dyes, finishes, etc.

About three years ago, Gaston County undertook a complete, ground-up reevaluation of its FFT technology. The result was a new parabolic applicator system that forms the heart of the modern CST unit, with the foam distribution chamber dramatically modified from previous FFT units (Fig. 1).

The parabolic applicator provides a more consistent dwell time for foam in the applicator and a more uniform distribution through the delivery slot across the width of the substrate. This results in improved side-to-side and end-to-end liquor and chemical uniformity. Programmable logic controllers (PLCs) have also been incorporated in the CST, easing operations. Ranges can now be altered, new programs entered and application codes modified easier than on the older FFT units. With its new applicator nozzle design, the CST allows higher production speeds (greater than 150 mpm). The exit component of the nozzle was modified to allow higher throughputs, with speeds of more than 300 mpm recently achieved on smooth surface substrates.

From an environmental viewpoint, CST offers two possible approaches to eliminate effluent from the chemical application process. One is to take the proper strength of generated foam when in "standby" or at initial startup to pass it through a foam separator unit (Fig. 2). The unit removes air from the foam and returns the chemical concentrate for regeneration.

The second means to accomplish zero discharge is to capture all flush water from the units and collect it in a remote tank. This diluted solution of unknown strength can be returned to the compounder for evaluation, used for subsequent shipments or properly disposed. Collection troughs and a bypass flush system have also been incorporated into the CST unit.

In marketing the CST unit, Gaston County is currently concentrating on areas that don't lend themselves easily to vacuum extraction techniques, e.g., thick substrates and nonwovens. Upholstery fabrics, which run at slower speeds and typically incorporate thick, dense constructions, invite CST foam application on the continuous unit between frames. CST replaces traditional spray applicators, and with the low WPU, offers for the first time the ability to simultaneously apply a latex backcoat to the substrate. CST is also ideal for uniformly applying low add-on, expensive chemical finishes to lightweight nonwoven fabrics, such as fluoropolymers, silicones and wetting agents. Because of the requirement of absolute uniformity of application in continuous dyeing of solid shade, CFS is mainly used in the U.S. for application of finishes rather than colorants.

## Curved Blade Applicator Offers Films for Foams

Capitalizing on an initial discovery by then-WestPoint Pepperell Co., West Point Foundry & Machinery Co. markets the Curved Blade Applicator (CBA) system. Another chemically-driven system, CBA utilizes a unique film transfer system instead of the foam collapse route.

A roller is contacted with a trough of liquor containing the desired application chemicals and selected surfactants that will give the desired film properties on the roller, as well as on subsequent contact with the fabric. A thin film of liquor is applied to the roll as it contacts the liquid surface. The roll then rotates to a point where it contacts the moving fabric under a fixed pressure. Acting as a curved blade, it brings the film to the interface. The film immediately collapses upon contact with the fabric, and the fluid penetrates into the substrate.

Chemistry required to generate film with the desired properties is not as complex or difficult to control as that incorporated in foam application, and thus is an advantage for the CBA unit. The main concern is generating and maintaining desired viscosity range for various finish formulations. Two-sided application of finishes, water repellent on one side and softener on the other, is made possible by the unit's low WPU, utilizing a double blade modification of the base CBA system. Again, because of lack of absolute uniformity control at such low WPUs, the system is not being used in the U.S. for continuous dyeing.

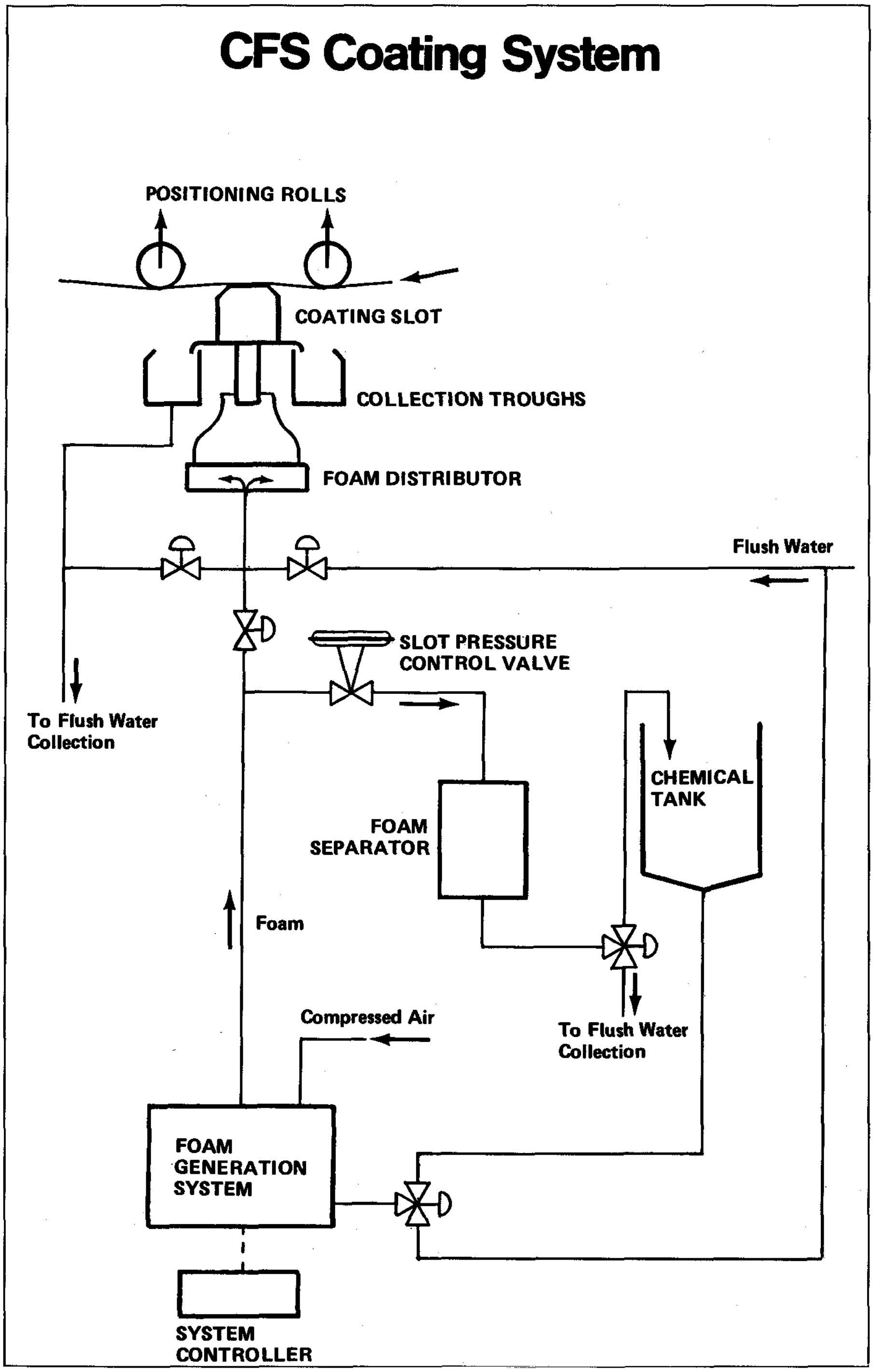


Fig. 2. CST offers two approaches to effluent elimination. Here, proper foam strength passes through a separator unit that removes air prior to chemical regeneration.

West Point is aggressively marketing the CBA unit and is considering replacing the original control system with a closed loop feedback system of some configuration.

## Vacuum Extraction Allows Complete Fabric Impregnation

The low WPU system that has gained wide acceptance in the large volume, commodity textile markets is the vacuum extraction/concentrate reisolation system from EVAC Corp., a subsidiary of Kuesters Co. (U.S. rep: Zima Corp.) EVAC systems allow the manufacturer to fully impregnate the textile with liquor, while providing the mechanism to capture and reuse liquor extracted from the system. Full impregnation avoids problems with applicator systems such as foam- or film-based units by supplying enough liquor to the substrate to achieve uniform through-structure penetration. In addition, the "security zone" of dyers and finishers is satisfied, as the application mode is basically the same slop-pad operation they've used throughout their careers.

The EVAC vacuum system removes the bulk of the entrained liquor, and a unique centrifugal force-based separation unit isolates fine microdroplets of liquor from the air stream. Although some attention has to be paid to concentration of certain chemicals left in the recovered liquor due to true exhaustion into the fiber diameter, e.g., dyes, most of the collected liquor is directly reused. The only effluent from the system is the chemically-bound water of the substrate emitting as steam from oven stacks.

Hundreds of EVAC installations are in place worldwide, with application of finishes to commodity fabrics and pigment dyeing being two major success stories. EVAC is continually expanding applicability of the technology, with several offshore installations using the unit to dye solid shades continuously. This application in the U.S. is expected to follow with renewed ecological and energy concerns.

## Carpets Still Wed to High Pickups

The carpet wet processing sector, with its unique opportunities of density and thickness of substrate, eventually abandoned the concept of low WPU dyeing due to severe side-to-side and end-to-end shade uniformity problems. Since the mid-1980s, Kuesters Fluidyer slot applicator/bladder pressure technology has been the continuous carpet dyeing technology of choice, running in the 350-400% WPU application range. Recently, the offshoot Kuester's Fluicon finishing technology, which incorporates foam in a similar type application to apply stain repellents, stain blockers, softeners, etc., to floorcoverings, has experienced major growth in the carpet sector to replace less efficient spray and batch applications. ❑

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