Direct dyebath reuse: The future is now!

First mill report: Results from two firms on savings from analysis and direct recycle of dyebath ingredients

Between 1978 and 1980, a team from Ga. Tech's School of Textile Engineering conducted three full plant demonstrations of dyebath reuse technology. It documented that the concept could save about 2¢/lb of dyed goods in energy, water/sewer and chemical savings.

Multiple batches were dyed from the same bath, and shades could be easily switched, as long as they were composed of the same dyes.

Plants participating in the demonstrations have continued to expand and refine the technology. Two firms, Adams-Millis Corp. and E&B Carpets, are realizing substantial savings from vigorously embracing dyebath reuse.

Adams-Millis converts to dyebath reuse

The first demonstration was conducted at Adams-Millis Corp.'s High Point (N.C.) dye plant. One rotary-drum machine was outfitted with a holding tank, and reuse trials on disperse dyeing of nylon got under way.

After reviewing results and benefits, company officials planned expansion of the technology to its Franklinton, N.C., plant.

Wade Johnson, superintendent of seaming and dyeing at Franklinton, says that 95% of the plant's rotary-drum machines are now operating routinely on dyebath reuse. Production is disperse dyeing of nylon pantyhose, with 160-180 lb of goods dyed per batch in 200-gal baths. Problems have been minimal.

"We use the final softener bath from the preceding batch to prerinse incoming goods," explains Johnson. "The practice removes most of the spin finish and knitting oils, while partially replenishing water lost to the dyed goods."

The plant calculates that a dyebath is totally replenished in volume after about seven cycles, based on 15% loss of dyebath to each batch.

"We follow the light-medium-dark, then reverse shade sequence rule," notes Johnson. This minimizes machine cleanup.

The analysis system installed five years ago is still operating smoothly. But Johnson says it needs "better automation." An ideal system would automatically sample a spent dyebath and carry the sample through any required manipulations, such as solvent extraction. The system would then analyze the pertinent dye-containing layer automatically, and print the add-back formula for the subsequent shade. This would eliminate human intervention from the analysis process.

Johnson is reluctant to give exact plant savings, but he confirms that 2¢/lb is a "valid ballpark figure," varying with shade sequencing.

Johnson is emphatic about the value of dyebath reuse: "It was an excellent move by Adams-Millis. Dyebath reuse is the wave of the future, and I believe those who do not incorporate the technology may not have a bright future."

Savings from reuse also entered into capital decisions. "We evaluated replacing our rotary-drum

—*By Dr. Fred L. Cook,*
Associate professor, Textile Engineering, Ga. Tech

Table 1. Batch dyeing systems that are adaptable to dyebath reuse

Product	Fiber	Dye class(es)	Machine	Known plant installations
Knit fabric	Polyester	Disperse	Jet	
	Cotton	Reactive	Beck	
	Poly/cotton	Disperse/reactive	Beck	
Yarn package	Polyester	Disperse	Package	
	Poly/cotton	Disperse/reactive	Package	
Socks	Nylon/spandex	Acid	Paddle	
Pantyhose	Nylon/spandex	Disperse/acid	Rotary drum	X*
Carpet	Nylon	Disperse/acid	Beck	X*
	Polyester	Disperse	Beck	X
Woven fabric	Aramid	Basic	Jet	X*
Skein	Acrylic	Basic	Skein	X

*In-plant demonstrations conducted by Ga. Tech.

Table 2. E & B Carpets' annual savings on five becks

	Volume savings	Cost savings
Dyes, chemicals	—	$43,400
Water/sewer (gal)	6.75-million	3,700
Energy (Btu, millions)	4,231	17,135
Total savings		$64,235

machines with newer, more efficient, low-liquor-ratio machines," notes Johnson. "Considering dyebath on the rotary-drum machines, payout for the new machines became excessively long."

E & B: reuse on a grand scale

Evans & Black (E & B) Carpets, a subsidiary of Armstrong World Industries, incorporated dyebath reuse in its Dalton, Ga., plant with minimal assistance. Inspired by a seminar on the subject, E & B's plant dyer, chemist and engineering team at E & B began a campaign in 1979 to adapt the concept to disperse dyeing of polyester carpets in jumbo becks (1,800-2,000 lb/batch).

Rejecting holding tanks, E & B connected five becks with a pump manifold system. A small microprocessor unit sequences valves and pumps between any two becks. The dyer controls shade/beck sequencing from panels in the lab.

When the first dyeing is completed and the second beck is empty, the microprocessor activates the proper valves and pumps to transfer the bath.

If scheduling permits, the same shade is dyed each time a dyebath is reused (about 90% of the time). If not, the dyer chooses a light-medium-dark sequence. Each dyebath is used three or four times, depending on shade. Reuse is limited, as dye exhaustion decreases slightly with each use, due to a surfactant used to scour the goods.

A color computer system (IBM) conducts dyebath analysis. In early trials, dyeings consistently showed 90% dye exhaustion, 50% carrier loss and 25-50% loss of leveling agent, depending on shade. Since only six dyes were used for all the polyester shades, experience eventually led to successful add-back.

An evaluation of E & B's five-beck system after a year of reuse operation is detailed in *Table 2* (above). Based on actual savings, a 2-yr simple payback on capital investment was the result. Savings were realized with about 25% of the plant's polyester production being dyed via reuse.

Problems with reuse at E & B have been minimal. Scheduling production so that several loads are dyed the same shade in a sequence is more difficult when business is slow. Minor crocking on dark shades has been linked to reuse.

But savings have more than offset minor problems. The plant has subsequently interconnected six more becks of smaller size in a reuse system. About 45% of the plant's current polyester production goes through the reuse concept, with projected annual savings of almost $115,000. #

Ga. Tech spawned dyebath reuse during the oil embargo

In 1974, the picture for batch dyeing had turned pessimistically bleak, for several reasons:

- Effluent guidelines were becoming increasingly stringent;
- The oil embargo of the previous year had caused concerns about energy supplies and rapidly escalating prices;
- Water supplies had become a variable in some areas, as expanding municipalities and industries placed heavier burdens on delivery systems.

Surveying the situation, Dr. Wayne Tincher and graduate student Gary Mauldin of Ga. Tech's School of Textile Engineering realized that "business as usual" would not suffice, given the realities of the 70s and beyond.

Batch dyeing's most obvious drawback was the "one bath, one batch" practice. After dyeing a single lot of fabric, the bath was routinely dropped to the sewer. In the process, valuable energy, unaffected auxiliary chemicals/dyes and water were lost, while effluent treatment problems were magnified.

Logically, if single dyebaths could be directly reused to dye multiple batches, savings in all aspects of batch dyeing would be substantial.

The key problem was to develop an analytical system that could accurately define the dye concentration left in the bath, and yet be simple enough for plant personnel to operate. Development was aided by early recognition that most auxiliary chemicals are usually present in excess and are not exhausted into the fiber.

Auxiliaries are colorless and thus require sophisticated techniques for accurate analysis. In practice, however, add-back of the auxiliaries proved sufficient, at a level commensurate with the fresh water necessary to return the exhausted bath to original volume.

Tincher and Mauldin demonstrated that simple visible spectrophotometry, using the Lambert-Beer Law as a basis, was adequate to accurately analyze residual dye concentrations in exhausted baths.

Since absorbances at any wavelength of visible light are additive, even mixtures of colorants could be analyzed for their separate components. Differential exhaustion between dyes therefore presented no problem.

For plant application, Dr. Howard Olson interfaced a visible spectrophotometer (Bausch & Lomb) with a desktop computer (Hewlett-Packard 9815A). A custom interface device provided logic-level conversion to provide standard BCD encoding.

After receiving proper input data from the spectrophotometer, the computer printed out reuse formulation for the next shade, including weights of dyes and chemicals to restore the bath to original strength, and the volume of water to be replaced.