TECHNICAL BULLETIN

Environment +

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TRI 3007

OPEN WIDTH PAD-BATCH DYEING OF COTTON FABRICS

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INTRODUCTION

With increasing worldwide concern about the environment and the need for short lot production with minimum water and energy consumption, the frugal pad-batch dyeing system for cotton fabrics is particularly timely. Cotton fabrics can be dyed efficiently and economically, with reduced energy, water, and chemical consumption, using the pad-batch dye - beam wash-off system. This is a semi-continuous process which involves the padding of reactive dyestuff and auxiliary chemicals onto fabric, batching the padded fabric onto perforated beams to allow time for the dyestuff to react with the cotton, and then washing with minimum quantities of water. This process flow is illustrated in Figure 1.

Pad-batch dyeing has been done for many years, with beam wash-off one alternative for afterwashing the unfixed dye. Since the mid 1970's, Cotton Incorporated has been actively involved in the development of this technology utilizing the installation at the Raleigh Research Center. Since that time, many mills have adopted this system for dyeing knitted and woven fabrics.

ADVANTAGES OF PAD-BATCH DYEING

The pad-batch dyeing system has the following advantages over conventional batch systems such as jets, becks, etc.:

1. Simplicity of dyestuff application.
2. Reduction in water consumption by 50 to 80%.
3. Reduction in energy consumption by up to 60%.
4. Reduction in chemical costs, other than dyestuff, by up to 50%, due to elimination of salt and reduction of alkali requirements.
5. Reduction in labor costs by 40 to 60%.
6. Minimum fabric abrasion.
7. Excellent shade reproducibility from lot to lot.

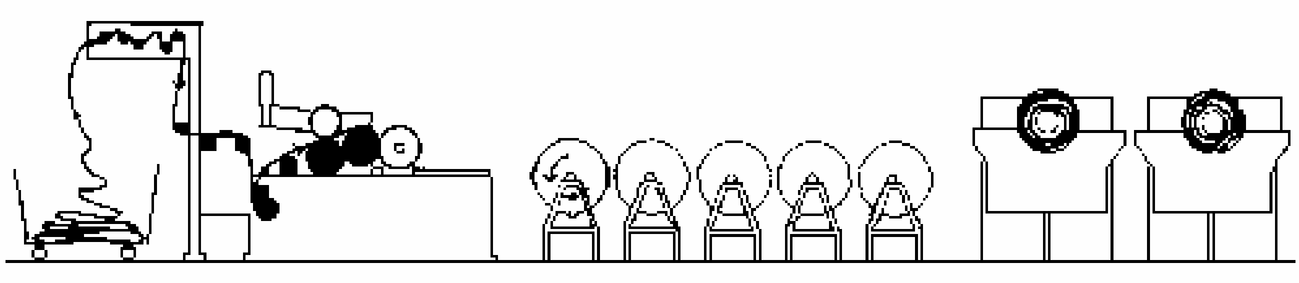

Figure 1.
Pad-Batch - Beam Storage and Wash-Off Unit

EQUIPMENT

For a successful pad-batch dyeing operation, the following equipment is necessary:

1. A good quality dye padder with supporting equipment for batching fabric onto perforated beams.
2. Dye/alkali mixing and metering equipment.
3. Motorized rotating A-frames or storage racks.
4. Beam wash-off stations, wash-off basins or suitable washing equipment.
5. Perforated beams for beam wash-off. Otherwise, non-perforated.
6. Laboratory support.

The padder should have appropriate controls for properly handling the type of fabric to be dyed. For example, to process knits it must have guiding, decurling, and spreading controls in order to maintain the fabric in open width form. This is especially important for single and most warp knit fabrics, which tend to curl under length tension.

Also, the padder should have accurate side-to-side pressure controls, which allow consistent control of the nip. A deflection roll padder is particularly recommended. Another requirement is a small dye trough, preferably 10-gallon (38 liter) capacity or less, to permit good dye liquor turnover in order to minimize dye hydrolysis, which can cause tailing of color throughout the fabric length. Speed controls that synchronize padder and batcher are also necessary.

Stainless steel beams with perforations that allow for about a 4-6 inch (10-15 centimeter) fabric overlap on each side should be used. The motorized A-frames or storage racks must allow slow beam rotation (example: 1-14 RPM) throughout the reactive period.

The beam wash-off system must have sufficient capacity to supply hot water at 180-190°F (82-88°C), at flow rates up to 50 gallons (190 liters) per minute, for each wash-off station. An in-line indirect steam heat exchanger for incoming water is recommended. Some fabric constructions (e.g., heavy or dense wovens) may be difficult to wash thoroughly on a beam and may require an alternate washing method, such as open width, continuous or jig washing and rinsing.

FABRIC SELECTION

Most 100% cotton and cotton-containing fabrics can be successfully pad-batch dyed; single and double knits, twills, and pile fabrics such as velour, corduroy, and velvet have all been dyed commercially using this method. Possible exceptions may be some fabrics with raised stitches or other novelty designs that may tend to flatten out when padded and batched on a roll.

Beam washing may impose some restrictions. For example, moiré may occur on some woven and warp knit fabrics if they are beam washed, and tightly constructed heavy woven fabrics such as duck cannot be successfully washed on a beam.

FABRIC INSPECTION AND PREPARATION

Prior to preparation, greige goods should be thoroughly inspected. All holes should be sewn closed, or if very large, should be cut out and the pieces sewn together with a butt seamer using monofilament polyester to prevent dye transfer to other areas. The seam must be as flat as possible to avoid forming an impression on the fabric layers during beaming. Careless greige goods inspection, holes, and bad seams will lead to poor quality dyed fabric and excessive seconds.

Fabrics prepared for pad-batch dyeing, whether scoured only or scoured and bleached, should have a residual pH of 7 or slightly less. Also, the fabric should contain no residual alkali, starch, knitting oil, or any other substance that would interfere with fabric absorbency. Both the preparation and the drying should be done uniformly, to ensure rapid and even wetting during dyeing. Overdrying, or drying too quickly at too high a temperature, may decrease dye penetration. Fabric should be cooled before rolling or plaiting. Fabric should again be inspected for holes. It is advantageous to make up dye lots from fabrics which were prepared together to avoid shade variations within the lot. Preliminary trials must be done on the scouring and bleaching equipment to determine whether the equipment can satisfactorily produce a uniformly prepared fabric, free of abrasion marks, for pad-batch dyeing.

Prior to pad-batch dyeing, fabrics prepared in tubular form should be dried open width to avoid edge marks or creases. If fabric is dried on a relaxation dryer, it should be spread properly to avoid folds, which can retain moisture. This will result in uneven dyeing.

Certain fabric styles that will be dyed in dark shades may be dyed in the greige without preparation. However, control of knitting oils, sizes, and other contaminants must be maintained to ensure successful dyeing.

BEAM PREPARATION

Leader cloth or suitable material (i.e. filter paper) should be used for the initial beam wrapping. About 10 yards (9 meters) of leader with a beam perforation overlap of approximately 7-8 inches (18-20 cm.) on each side should be sufficient. Leader cloth can be re-used. After padding, the fabric being dyed should overlap the beam perforations by 3-4 inches (8-10 cm.) on each side. Accurate edge guiding is important to produce a good, even beam.

DYESTUFF AND CHEMICAL SELECTION

For pad-batch dyeing, suitable dyestuffs are reactive dyes with relatively high reactivity. Some examples are dichlorotriazine, monofluorotriazine, dichloroquinoxaline, vinylsulfones and selected bi-reactive dyes. Individual dyestuffs within each group may be selected by consulting information and recommendations provided by dyestuff suppliers.

Auxiliary chemicals commonly used in the pad-batch dye liquor include alkalis, urea, and wetting agents. The type and concentration of alkali should be tailored to the particular reactive dye selected. Urea is sometimes required to improve dyestuff solubility. A wetting agent or surfactant which is low foaming and which provides rapid wetting and penetration of dye into the cotton fiber is added to the dye liquor.

DYEING PROCEDURE

When preparing the pad-batch dye bath, the dyestuff and alkali should first be prepared in separate tanks as separate solutions. Automatic mixing of the dyestuff and alkali solutions are at a ratio of 4 to 1. This mix feeds into a small, 5 gallon (19 liter) holding tank for uniform blending prior to transfer to the pad trough.

The dyestuff solution should be prepared by dissolving the dyestuff completely in water at the temperature recommended by the dyestuff supplier. When required, urea is used to aid dyestuff solubility. The volume is then adjusted to 4/5 of the final volume, wetting agent is added, and the solution is adjusted to the correct volume. The required alkali solution is prepared in a separate tank and the temperature kept close to the padding conditions.

Metering pumps made by several companies (listed under suppliers) have all been found to provide adequate and reproducible mixing of pad-batch dye baths over extended periods of use. Final bath temperature after mixing should be kept between 65 and 85°F (18-30°C) to ensure consistency and reproducibility.

Check the following before padding the dye solution onto the fabric.

- Fabric style and accurate weight of dye lot.
- All dispensing lines must be clean.
- Pad trough must be rinsed out well.
- Check function of mixing pump blending ratio of alkali and fiber-reactive dye.
- Check pad pressure side to side and center.
- Check wet pickup.
- Calculate volume of formula based on wet pickup to have sufficient dye liquor for the entire lot.
- Check all functions on operating panel.

Padding should be done at 70 to 100% wet pick-up, and the fabric should then be batched onto a stainless steel perforated beam. Each beam can be loaded up to a total diameter of 56 inches (140 cm.), corresponding to about 1000 to 1500 pounds (450-700 kilograms) of fabric. Once the proper size has been accumulated, the fabric beam should be wrapped in polyethylene film to prevent moisture evaporation, and then sealed air tight with masking tape or by other means. The wrapped beam is then continuously rotated on a motorized A-frame or storage rack to avoid dye build-up at the bottom of the beam. <u>Since the dyeing reaction is dependent upon time and temperature, beams should be stored in a temperature controlled area for the time period recommended by the dyestuff supplier</u>. This procedure assures better reproducibility of colors from dye lot to dye lot.

Typical dye formulations for pad-batch dyeing are as follows:

DYE TANK

x g/l reactive dye
2-6 g/l wetting agent (usually anionic)
0-200 g/l urea (Follow dyestuff supplier recommendation.)

ALKALI TANK

Dye Type	Soda Ash	Caustic (50%)	Salt	Sodium Silicate
Procion MX	5-30 g/l	-	-	42°Be
Remazol	-	10-25 g/L	-	120 g/L
Levafix	-	3-18 g/L	-	25-120 g/L
Cibacron F	-	1.6-16 g/L	-	62-120 g/L
Cibacron C	-	0 -7.6 g/L	-	95 g/L

WASHING PROCEDURE

The perforated beam washing system (see Figure 2) is recommended as a simple and effective way of removing unfixed dyestuff from pad-batch dyed fabric, with minimum water consumption and cost. After the fabric has been batched for the required reaction time, the plastic covering should be removed and the beam installed at the wash-off station. With dichlorotriazine or other similar alkali systems, washing is initiated with cold water until thorough penetration is achieved - usually from 5 to 10 minutes - and then hot water at 190°F (88°C) is used at a rate of 15 to 35 gallons (56 to 132 liters) per minute until no further color can be removed. Then cold water is added to cool the fabric to handling temperature. Other alkali systems containing silicate are washed initially with warm water (110°F or 43°C) until the emerging water is at a pH of 8.5 or lower, and then the hot water washing as described earlier is implemented. This procedure is necessary due to the nature of the alkali, and to prevent hydrolysis of certain sensitive dyes.

Total washing time for beam washing ranges from 30 to 120 minutes, depending upon the type of fabric, the depth of shade, and the nature of the dyestuff. Dyes with high solubility generally tend to require longer washing times.

Washing methods other than beam washing may also be used. These methods include continuous washing, and washing in a jet, jig, beck, or spiral washer.

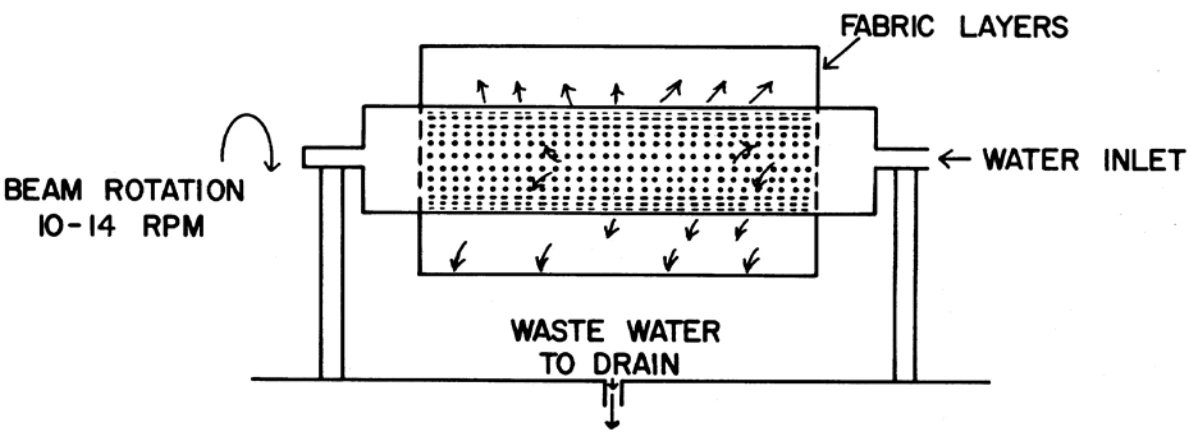

Figure 2.
Perforated Beam Wash-Off Unit

SHADE MATCHING

Shade matching for the pad-batch dye system is one of the easiest of all shade matching procedures. The fabric sample is simply padded through the prepared dye/alkali solution on a laboratory padder, and then placed in plastic and batched for the necessary time, usually 2 to 24 hours. An exception is turquoise shades, which require 20 to 24 hours. Alternatively, if an accelerated method is preferred, samples may be sealed in a zip lock bag after padding (one gallon size works well) and suspended in a hot air oven at 150°F (65°C) for 30 minutes (turquoise shades require longer). The fabric is removed, and then soaped off in a consistent repeatable procedure. Quality and pH of water must have repeatable values from lot to lot.

A microwave oven adjusted to provide approximately 400-500 watts output may be used to further accelerate shade development to just 6-8 minutes. A suitable sturdy plastic container should be used and the sample should not touch the sides of the container in order to avoid blotches caused by condensation.

Important considerations for insuring good laboratory to production shade reproducibility include the following:

1. Same fabric
2. Wet pick-up
3. IMMERSION TIME/SPEED (Example Below)
4. Bath temperature
5. Batching time and temperature
6. Wash-off procedure

SHADE MATCHING LABORATORY VS. PRODUCTION
EXAMPLE:
Production - pad speed at 40 yards/minute - 18" immersion in trough = 0.75 second (volume - 60 liters)
Laboratory Strike-off - pad speed at 10 yards/minute - 4.5" immersion in trough = 0.75 second (volume - 0.5 liter)

Once these factors have been standardized, excellent reproducibility from laboratory to production can be achieved.

STRIPPING OF FIBER REACTIVE DYES

The stripping of fiber reactive dyes can be accomplished by several different methods. Method selection depends on the chemistry of the dyestuff, the degree of stripping desired, and how or if the fabric has been finished. Each dyestuff supplier has recommended procedures that can vary from the use of chlorine containing compounds to caustic and hydrosulfite, to acid treatments, and even bleaching with hydrogen peroxide. For specific recommendations, the dyestuff supplier should be contacted.

FINISHED FABRIC CHARACTERISTICS

Pad-batch dyed fabrics generally have a far smoother, more lustrous, and more uniform appearance than fabric dyed with conventional batch processing. This is in part due to the lower degree of abrasion experienced during dyeing, and fewer opportunities for crease formation. The hand of pad-batch dyed fabrics is also typically judged superior. Knitted fabrics which have been pad-batch dyed generally yield slightly lighter weight and similar shrinkage values when compared to fabrics dyed by other batch methods.

COST COMPARISON

Costs are based on spring 1992 approximate costs for Greenville, SC. Location, usage, and other factors can have a major influence on utility costs.

Water Cost Assumption

Greenville (SC) Water System

$ 1.32/1000 gals. for first 60,000 gals.
$ 0.82/1000 gals. for next 540,000 gals.
$ 0.72/1000 gals. for next 5,400,000 gals.

Assumed an average cost of $0.75/1000 gals.

Sewer Cost Assumption

Western Carolina Regional Sewer Authority, Greenville, SC

$ 1.83/1000 gals.: Commercial Rate, no surcharges

Water & Sewer = $0.75 + $1.83 = $2.58/1000 gals.

Steam Cost Assumptions:

- Assumed natural gas fuel at 35¢/therm = $3.50/million BTU (1 therm = 100,000 BTU)
- Actual gas costs vary with rate classification
- Assumed use of package boiler at 80% efficiency.
- Calculation:
  ($3.50/$10^6$ BTU) (1000 BTU/lb. steam*) ÷ (0.8 boiler efficiency) = $4.38/1000 lbs. steam.

Electric Power Cost Assumptions:

Assumed 5¢/kWh

NOTE: Actual billing rate varies with usage and other factors.

*Rounded Value

Comparison - Reactive Dyeing 100% Cotton (Starting With Prebleached Fabric.)

Item	Beck	Beck Cost Factor, $	Pad-Batch	Pad-Batch Cost Factor, $
Batch Size	1000 lbs.	---	1000 lbs.	---
Liquor Ratio	15/1	---	1/1	---
Water Consumption	18,889 gals.	$ 48.73 (1)	4980 gals.	$ 12.85 (1)
Steam Consumption	13,430 lbs.	$ 58.82 (2)	4350 lbs.	$ 19.05 (2)
Electrical Consumption	60 kWh	$ 3.00 (3)	< 30 kWh	$ 1.50 (3)
Salt	1000 lbs.	$ 40.00 (4)	0	0
Total Excluding Dyestuff & Labor	---	$150.55	---	$ 33.40

SAVINGS: $150.55 - $33.40 = $117.15

1. Based on water & sewer cost of $2.58/1000 gals.
2. Based on steam cost $4.38/1000 lbs. of steam. Pad-batch includes extra drying.
3. Based on electric power cost of 5.0¢/kWh.
4. Based on sodium chloride at 4¢/lb.

MACHINERY SUPPLIERS

<u>Pad-Batch Dye - beam wash-off equipment is supplied by</u>:

Beautech Ltd.
PO Box 4476
Rock Hill, South Carolina 29732
Tel: 803/366-1782
Fax: 803/366-8855

Burlington Textile Machinery Corporation
2215 Airpark Drive, PO Box 782
Burlington, North Carolina 27216
Tel: 336/229-6441
Fax: 336/229-1139

Kleinewefers Textile Machinery Corporation
Greenville Machinery Plant
P.O. Box 12269
Greenville, South Carolina 29216
Tel: 864/879-3011
Fax: 864/879-2727

Ramisch Kleinewefers GmbH
PO Box 2350
D-4150 Krefeld, Germany
Tel: 02151/893-0
Fax: 02151/893-275
(Represented in U.S. by **Kleinewefers Textile Machinery Corporation –** see address above)

Edward Kusters Machinenfabrik
Postfach 1750
Gladbacher Strasse 457
415 Krefeld, Germany
Tel: 02151/8260
Fax: 02151/826206

Represented in U.S. by:
Zima Corporation
PO Box 6010
Spartanburg, South Carolina 29304
Tel: 803/576-5810
Fax: 803/591-1985

Morrison Textile Machinery Co.
6044 Lancaster Highway, PO Box 1
Fort Lawn, S C29714-0001
Tel: 803/872-4401
Fax: 803/872-4443

DYESTUFF AND CHEMICAL SUPPLIERS:

BASF Corporation (Procion and Basilen M Dyes)
4330 Chesapeake Drive
Charlotte, North Carolina 28270
Tel: 800/628-5890
Fax: 704/393-3649
www.basf.com

Ciba Specialty Chemicals Corp. (Cibacron F and C Dyes)
4050 Premier Drive
High Point, North Carolina 27104
Tel: 336/801-2500
Fax: 336/801-2707
www.cibasc-colors.com

Clariant Corporation (Drimarene Dyes)
4000 Monroe Road
Charlotte, North Carolina 28205
Tel: 704/331-7138
Fax: 704/331-7112
www.clariant.com

Crompton & Knowles Corporation (Intracron Dyes)
Dyes and Chemicals Division
P.O. Box 33188
3001 N. Graham Street
Charlotte, North Carolina 28233-3188
Tel: 704/372-5890
Fax: 704/332-8785

DyStar L.P. (Levafix and Remazol Dyes)
9844-A Southern Pine Blvd.
Charlotte, North Carolina 28273
Tel: 704/561-3000
Fax: 704/561-3008
www.dystar.com

Rite Industries, Inc. (Rite Reactive)
1124 Elon Place
High Point, North Carolina 27260
Tel: 800/582-6481
Fax: 336/884-8785

COMPONENT SUPPLIERS

Beautech Ltd. (Beautech Ltd. Pump System)
P.O. Box 4476
Rock Hill, South Carolina 29732
Tel: 803/366-1782
Fax: 803/366-8855

Graco Incorporated (Graco Pump)
P.O. Box 1441
Minneapolis, Minnesota 55440
Tel: 612/623-6000
Fax: 612/623-6893

Pulsa Feeder (Pulsa Feeder Pump)
2883 Brighton Henrietta Townline Road
Rochester, New York 14623
Tel: 716/292-8000

Prominent Fluid Controls, Inc.
136 Industry Drive
Pittsburgh, Pennsylvania 15275
412/787-2484

RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.

- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.

- Computerized fiber management techniques result from in-depth fiber processing research.

- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.

- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.

- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.

- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

For further information contact:

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