TECHNICAL BULLETIN

COTTON INCORPORATED

6399 Weston Parkway, Cary, North Carolina, 27513 • Telephone (919) 678-2220

ISP 1017

PRINTING OF PIGMENTS AND SPECIAL EFFECTS

This report is sponsored by the Importer Support Program and written to address the technical needs of product sourcers.

INTRODUCTION

Of the print systems used on cotton in the textile industry, pigment printing accounts for as much as seventy percent of the total[1]. This system requires no pre or post treatment other than drying the fabric. The color gamut is wide, and the sharpness of prints is excellent. Pigments do not react with the cotton fiber and must be adhered to the fabric with a film forming binder, which may detract from the hand of the fabric. However, advances in binder systems have made positive contributions to print performance.

Special effects are used in addition to or in combination with pigments to impart a unique look to fabrics. Some of the special effects examined in this bulletin include resist, discharge, and burnout techniques. Alternative pigment types such as thermotropic, phototropic, puff, and plastisol technologies will also be described.

PIGMENT PRINTING

A textile pigment print system includes the following parameters:

- Pigment: A pigment colorant is a colored organic substance that is not readily soluble in most common solvents and imparts coloration to textile substrates only when incorporated with an adequate binder system.

- Binder: A pigment binder is the latex polymer resin that forms a three-dimensional film on the surface of the fiber. This film contains the dispersion of textile pigment and will act to adhere the pigment to the surface of the substrate. The permanence of this film is dependent on the polymer type and the application conditions. Binder chemistry, performance, and application is covered in Technical Bulletin ISP 1008.

- Thickener: The pigment system is composed of the textile pigment dispersed in the polymerizable resin binder, which is further mixed into a synthetic thickener system, comprised of a long chain acrylic acid. The thickener enables the pigmented print paste to stay in place once it is deposited onto the fabric prior to drying. This system is applied to the textile substrate by the following means: rotary screen printing, flatbed screen printing, engraved roller printing, coating, padding, spraying, or immersion.

PREPARATION FOR PRINTING

Many cellulosic textile substrates have been used to produce decorated and colored articles. For minimum results, the following should be a guide.

Preparation includes the following:

- A scour, with detergent and alkali to remove oils and waxes from the fabric and make it absorbent, is required.
- For cotton and cotton blends, an additional bleaching process may be included to further whiten the fabric and remove motes.

[1] Two-phase Printing, Fletcher Stone, 2000, Clemson University /Stork Industries Marketing Statistics – 2004

- In the case of cotton woven fabric, it is advantageous, although not necessary, that the fabric be causticized or mercerized to maximize color value and print appearance as well as to increase fabric luster and sheen. The concentration of sodium hydroxide (NaOH) needed to causticize cotton is 22ºBé. To produce mercerized fabric, the NaOH concentration needs to be increased to 28-32ºBé, and the fabric held under tension during application.
- Woven fabric should also be singed to remove surface fibers.

The dyestuff printer needs a fabric with the following properties:

- Uniform absorbency
- Clean (no lint)
- Uniform base color
- Uniform width
- No creases
- Neutral pH (7.0 - 7.5 is best for all printing)
- Alkalinity ≤ 0.05
- Causticized or mercerized

BASICS OF PIGMENT PRINT PASTE FORMULATION:

The development of a print paste begins with the thickener, which is used to control the viscosity of the paste. For pigments, a synthetic thickener composed of a long chain polyacrylic acid is used. These polymer acids, when neutralized, repulse each other by an electrostatic repulsion to form a 3-dimensional network that thickens the aqueous solution. This increase in viscosity is very useful in acting as an extender or thickener for the pigment colorant. The thickener is an integral part of this print paste, producing a much smoother and more controlled application especially in rotary screen-printing. The relationship between viscosity and printing is important in all types of textile printing applications.

The synthetic thickener imparts a viscosity to an aqueous solution at rest. When stress is applied to this solution, such as when the squeegee forces the print paste through the screen, the viscosity is lowered. When the stress is removed, once the paste is through the screen and on the fabric, the viscosity of the solution returns to the point where it was, at rest, before the stress was applied. This principle is the basis for the rotary and flat screen-printing technique.

Viscosity determines the covering power of a colored fluid. If a fluid flows slowly or not at-all, a large amount of force must be applied to compel the fluid to cover and therefore, color the surface. Fluids that flow readily are thin and may require multiple coats before the substrate is fully covered.

In Figure 1, Fluid 1 has a high viscosity relative to Fluid 2, which has a low viscosity. If these two fluids are put on a plate next to each other and the plate is turned to vertical, Fluid 1 may take 10 minutes to flow one centimeter. Similarly, Fluid 2 flows five centimeters in one minute. This technique provides a way to measure the relative viscosity of the two fluids. The success of the printing system will depend on the balance achieved between these two viscosity platforms.

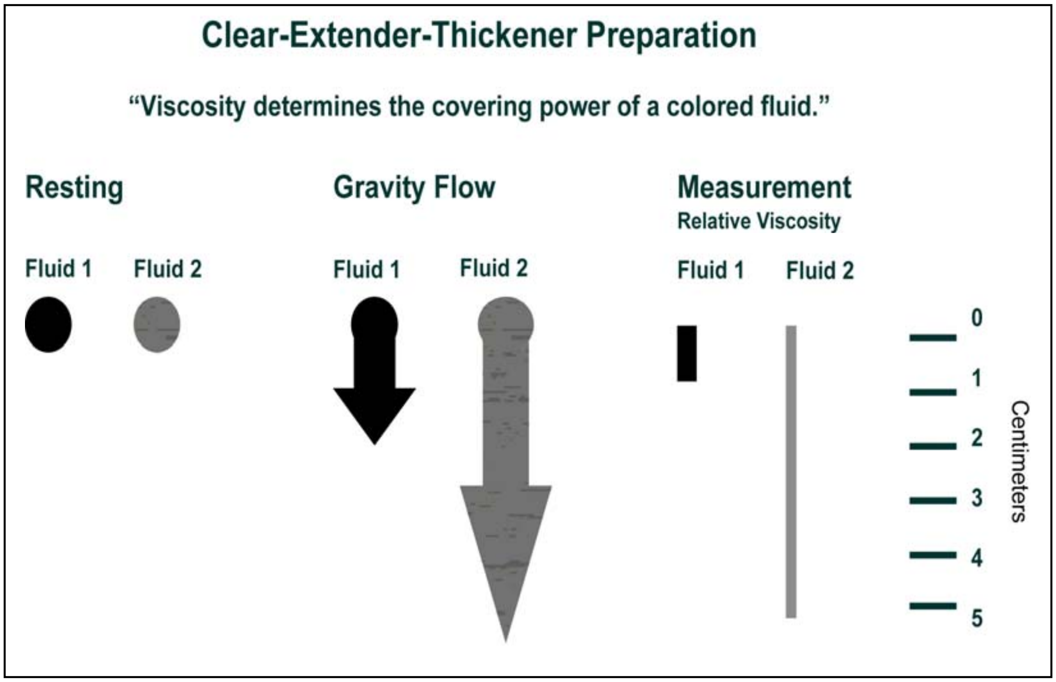

Figure 1. Viscosity and Flow

Thickener or Clear-Extender Preparation

A stock thickener will usually contain water, thickener concentrate, and a low concentration of binder. The stock thickener might also include some of the auxiliaries used in printing. The printer can then take what is needed of the stock thickener and add only pigment to the mix prior to printing. The type of binder is based on the desired properties of the printed fabric. The amount of binder is tied to the amount of pigment in the formula. Binder selection is explained fully in Technical Bulletin ISP 1008. Tables I and II list the stock thickener and print paste ingredients in order of addition. The processing steps are also included into the formulation.

The viscosity of the typical print paste is 17000 – 20000 centipoises (cPs) as measured on the Brookfield® viscometer with spindle number 6 at 20 rpm. Some patterns require a lower viscosity due to shade coverage. Some contours appear fuzzy if the viscosity is too low. Specifying a viscosity on the formula sheet is critical to assured repeatability in pattern production.

When pigments are chemically manufactured, the colorant is pressed in vats and trays to remove water. The resulting product is called pigment press-cake and contains up to 25.0% non-standardized pigment. Pigment colorants are supplied in three general concentration ranges. The least concentrated pigments contain 7.0 – 10.0% pigment. These pigments are inexpensive, and their quality varies (standard strength, hue, and particle size may vary on a wider range than in the other concentrations).

The middle range pigment dispersions contain 10.0-20.0% pigment and have more reliable performance with regards to quality standard variation. Both the lower and mid concentrations are produced directly from colorant press-cake. The third grouping is the concentrated pigments, which contain up to 50.0% pigment and are standardized to a very high quality. Particle size in the least concentrated pigments can vary from 2 to 25 microns. The higher concentration pigments are finished in the 1 to 2 micron range, which produces a more uniform shade and a higher color yield.

After mixing, the paste must be filtered through a vacuum strainer to remove any particles that might cause screen mesh blockage in printing.

Table I. Stock Thickener Make-Up

Chemical	**Amount, g/kg**	**Details**
Water	700	Turn mixer on
Ammonia (aqueous)[2]	5	May be added by submerged tubing
Non-ionic surfactant[3]	5	Optional
Binder	30	Mixer baffle plate should be up
Thickener concentrate	30	Add slowly over 2-3 minutes
Softener[4]	15-30	Optional
Bulk with water[5]		Rotate mixer through volume of vessel to obtain an even dispersion of concentrate
Total	1000	

Table II. Print Paste Composition

Chemical	**Amount, g/kg**	**Details**
Stock Thickener	850	
Pigment[6]	X	Add to surface with mixer off
Binder[7]	Y	Add only if pigment exceeds minimum
		Turn on mixer
Auxiliaries[8]	Z	If desired
Bulk with water[9]		Run mixer 3-5 minutes, measure viscosity
Thickener concentrate		If needed for viscosity adjustment
Total	1000	

[2]Ammonia is added to the tank before any other ingredient. Ammonia is useful in pH adjustment, water conditioning, and neutralization. Some printing components are stabilized by ammonia, but this may evaporate during storage. The addition of aqueous ammonia will insure better mixing and running properties. Using a submerged pipe to add the ammonia will prevent large amounts from evaporating into the mix-room environment. Once it is in solution and the other ingredients have been added, the smell is greatly reduced or eliminated.
[3] Non-ionic surfactant aids in screen release and lubrication.
[4] Only add after all thickener concentrate.
[5] Mix 30 – 45 minutes after all ingredients are in tank. Baffle should be above surface of liquid at the beginning of the mixing until the concentrate is all mixed in. Then the routine of moving the mixer in the tank can commence.
[6] If the amount of pigment is small, the rapid movement of the stock paste should cause some of the color to be lost on the side of the vessel.
[7] The amount of binder in stock paste will be sufficient for light shades. Usually medium to heavy shades will require additional binder.
[8] The other auxiliaries are best added with the mixer running.
[9] The mixer should run a minimum of 3 - 5 minutes to thoroughly disperse the pigment and auxiliaries. A small sample should be taken and the viscosity measured on a viscometer. An adjustment can be made to the viscosity at this time.

Auxiliaries used in pigment printing:

- Auxiliary thickener - A solids modifier or other auxiliary thickeners are sometimes added.
- Binder - This could include additional binder to improve fastness or a unique product for special effects.
- Cross-linker - This product is almost always a melamine resin and is incorporated to improve wash fastness.
- Plasticizer - This product is intended to work in the binder polymerization to improve fabric handle. The term 'softener' is often used.
- Lubricant - This product may be a synthetic short-chain polymer, a surfactant with a high molecular weight, a polyglycol or some form of 'oil', and is intended to reduce friction in the printing process (pigment versus screen, etc.).
- Anti-wicking agent - These products help keep the print sharp and minimize print movement across the surface of the fabric.

There are some auxiliaries that are used to try to rectify poor lab practices. These only treat the symptoms and do not fix the cause:

- Antifoam – If the thickener is neutralized properly, it will not create foam.
- Humectants - harm crock and wash fastness and should be replaced by a surfactant with an extremely high ethylene oxide number (See *Lubricant* above…).
- Penetrants - create additional problems of balancing fluidity against viscosity and should be avoided. Absorbency of the fabric is where the focus should be.

SPECIALTY PRINTING PROCEDURES AND PROCESSES

RESIST PRINTING

Resist is the term that describes the *prevention of the dyeing process* by the application of a *physical* or *chemical* substance to the fabric to prevent a dye's access to the fabric. This is done in such a manner so that a pattern is realized after the fabric is dyed.

Resist agents can be waxes, thickeners, surfactants-dispersing agents, organic acids, sulfites, oxidizing agents, or reducing agents. Dyes for resist ground shades are fiber reactive dyes and, to a lesser extent, direct and napthol dyes.

Mechanical Resist Printing

Batik is an example of a mechanical resist. Batik printing starts with the application of a wax, such as melted candle wax, to the fabric in some pattern. As soon as the wax cools, it is almost impervious to water thus setting up a mechanical or physical resist to a dye bath. The fabric is then dyed in a dye bath where only the "unwaxed" areas become colored.

After the dyeing is complete, the fabric is boiled, and the wax is melted and reclaimed. Then the process can be repeated with an additional application of melted wax, producing a second pattern. The dyeing process is repeated with another dye and a second color is imparted to the fabric in a new design. This process, historically performed by hand, can be done over and over resulting in a multicolored work of art that will be difficult to reproduce.

The process has been mechanized by use of specially modified print machines but only as a single color design. There are combination physical and chemical processes, which are capable of multiple color additions. Some of these are described in the literature[10].

Chemical Resist Printing

A major innovation in resist printing was the development of the "reactive-under-reactive" resist procedure. This means that one reactive dye is used for the ground shade, and another reactive dye is used for the illuminating shade or colorant that is replacing the ground shade. This procedure uses monochlorotriazine (MCT) dyes as the illuminating dye and vinyl sulfone (VS) dyes as the ground shade. The resist is accomplished by the use of a sulfite or bi-sulfite agent that prevents the VS dye from reacting with the cotton, but has little effect on the MCT dye.

This process has multiple application possibilities, but the most widespread use is the print and over-print application. In this process the illuminating colors (MCT dyes) are printed first. The blotch or solid ground shade (VS dyes) is applied immediately over the illuminating colors. The whole process is carried out on the rotary screen print machine in one pass. The result is a faux discharge design. See Tables III, IV, and V for resist stock and print paste formulation.

Table III. Stock Thickening Formula for Reactive/Reactive Resist Printing

Chemical	**Amount, g/kg**	**Details**
Thickener	700	Sodium alginate LV (10% solution)
Sodium bicarbonate[11]	30	Sodium bicarbonate: alkali needed for fixation
Oxidative compound	10	Sodium metabenzinesulfonate
Urea	150	Humectant
Water softener	10	Sodium hexametaphosphate
Water	Bulk	Water to total volume
Total	1000	

Table IV. Print Paste Formula: Illuminating Color – MCT

Chemical	**Amount, g/kg**	**Details**
Fiber reactive dye - MCT	10 – 200	Liquid MCT fiber reactive dyes (selection)
Stock thickening[12]	700	+/- 50 g depending on viscosity requirement
Resist agent	30-40	Sulfite based – aldehyde / bisulfite compound
Water	Bulk	Water to total volume
Total	1000	

Table V. Print Paste Formula: Blotch Color – VS

Chemical	**Amount, g/kg**	**Details**
Fiber reactive dye - VS	50 – 200	Liquid VS fiber reactive dyes (selection)
Stock thickening	700	+/- 50 g depending on viscosity requirement
Water	Bulk	Water to total volume
Total	1000	

[10] Reservedruck-Verfahren (Resist Printing Processes) – W. Kretzschmar.
[11] White resist requires soda ash as alkali for best results.
[12] Viscosity rules are the same as for normal fiber reactive prints. 1500-2500 cps Brookfield Viscometer #6 Spindle @ 20 rpm. Blotch should be 2500-3000 cps Brookfield Viscometer #6 Spindle @ 20 rpm and printed on the surface with little penetration.

Procedure: Reactive/Reactive Resist Printing

1. Print mercerized cotton with white and colored MCT resists.
2. Overprint VS color – full blotch screen wet-on-wet.
3. Dry printed fabric at maximum 250°F (120°C).
4. Steam fabric for 8 minutes with saturated steam at 214°F (102°C).
5. Soap and finish fixed prints as usual.

Table VI. Reactive/Reactive Resist Ground Shade Dye Selection – VS

Vinyl Sulfone Dye[13]	**Color Index**	**Resist**	**Maximum Liquid**	**Best Results**
Br.Yellow 4GL	Y160	Yes	160 g/kg	
Br. Yellow GL	Y37	Yes	160 g/Kg	+
Yellow FG-A	Y42	Yes	240 g/Kg	+
Golden Yellow 3R-A	O16	Yes	200 g/Kg	+
Gold. Yellow RNL	O107	Yes	200 g/kg	
Bril. Scarlet R-3G	-	Yes	160 g/kg	
Bril. Red GG	R 106	Yes	200 g/kg	+
Bril.Red BB	-	Yes	200 g/Kg	
Bril. Red F3B-A	R180	Yes	200 g/Kg	+
Bril. Red 5B-A	R35	Yes	200 g/kg	
Bril. Violet 5R-A	V5	Yes	250 g/Kg	+
Bril.Blue R-A	B19	Yes	240 g/Kg	+
Navy Blue R-GB	-	Yes	240 g/Kg	+
Black BA Liq.50	Blk5	Yes	100 g/Kg	+
Deep Black N 150/Liq.50	mix	Yes	140 g/kg	+

Table VII. Reactive/Reactive Resist Illuminating Dye Selection – MCT

MCT Dye	**Color Index**	**Stable to resist**	**Minimum g/kg**
Yellow 6G	R Yel. 95	Yes	
Yellow H4R	R Yel. 18	Yes	
Golden Yellow E2R / HE4R	R Yel. 84	Yes	
Golden Yellow P2R	R Ora. 12	Yes	
Red B[14]	R Red 24	Yes	10.0
Scarlet RN[14]	R Red 33	Yes	10.0
Red 6B[14]	R Red 218	Yes	10.0
Red 8B[14]	R Red 31	Yes	10.0
Basilen® Bordeaux P2B[14]	R -	Yes	10.0
Cibacron® Violet P2R[14]	R Viol. 2	Yes	10.0
Blue P3R	R Blue 49	Yes	
Turquoise PGR	R Blue 72	Yes	
Turquoise HA	R Blue 71	Yes	
Navy PNR	R -	Yes	
Navy P2R	R -	Yes	
Grey S	R -	Yes	
Black GR	R -	Yes	

[13] All Turquoise Dyes - G 133/ G-A WILL NOT RESIST.

[14] All red MCT dyes are sensitive to sulfite and lose color value. Dye concentration should be maintained above 10.0 g/kg.

Pigment Discharge Printing

Pigment discharge is a technique where a dischargeable dye is removed from a fabric and replaced with a pigment. Pigment discharge printing pastes incorporate a reducing agent that is stable to acid combined with discharge-resistant pigments and binder. Although it is preferred to dry and then steam the fabric after printing to obtain the maximum degree of discharge, a limited amount of discharge can be obtained in gas fired curing ovens.

This process has to some extent enjoyed a revival in the t-shirt printing trade for specialty designs, but it can be applied to roll goods as well. It is a less expensive alternative to vat discharge.[15] The most dependable dischargeable dyeings are produced with VS fiber reactive dyes as described in the *Print Chemistry of Vat Dyes and Vat Discharge Technical Bulletin ISP 1016.* Tables VIII and IX detail the formulation of the discharge stock paste and the discharge print paste.

Table VIII. Discharge Stock Paste

Chemical	**Amount, g/kg**
Pigment binder	30 – 150
Diammonium phosphate[16]	7
Glycerin	20
Urea	100
Thickener e.g. locus bean ether 8%[17]	600
Bulk with water	175 -130
Total	1000

Table IX. Discharge Print Paste

Chemical	**Amount, g/kg**
Pigment Color[18]	20- 60
Stock paste	850-810
Discharge agent[19]	100-130
Bulk with water	30
Total	1000

This discharge formula normally prevents halo formation on the ground. After drying, the prints undergo 6 – 10 minutes treatment with saturated steam at 215ºF (102ºC). The pigments are, when necessary, additionally thermo fixed for five minutes at 302ºF (150^{o}C). If the process is conducted without steaming, the thermo fixation process accomplishes both the discharge and pigment fixation. Typically, this process is, in fact, a modification of the print drying process. After printing, the fabric is dried in a direct gas fired drying oven. Extending the drying time and modulating the temperature will produce the discharge. The dwell time would be 5 – 10 minutes and a maximum temperature of 250ºF (120ºC).

[15] Dillman, G., Hoechst AG/Practical Hints (1982).
[16] Acid donor. A synthetic thickener may be used which would eliminate the need for an acid donor.
[17] Acid stable thickener that can be incorporated directly into the stock paste,
[18] Pigments must be discharge-resistant or the discharge process will decolorize the pigment color.
[19] 1:1 Zinc sulfoxylate formaldehyde.

Plissé Prints

Plissé is the process where a strong alkali is applied to 100% cotton fabric in a pattern. After a reaction time of several minutes, the fabric is washed to remove the alkali. The alkali will cause the fabric to shrink in the printed area. The shrinkage causes puckering in the adjacent non-printed areas. If the print pattern is a parallel stripe, the resulting fabric will have a seersucker appearance. The application can be direct, where the alkali is printed onto the fabric, followed by dwell time on a conveyor belt to allow for reaction (see Table X). Alternatively, the fabric can be printed with a print paste containing a water repellant chemical plus a binder. After curing, the fabric is passed through a strong alkaline bath and then allowed to react before washing. This second method is sometimes referred to a "Fitted Plissé" (see Tables XI and XII). In both cases the washed fabric shows a differential shrinking effect known as plissé.

Table X. Print Paste – Direct Plissé Print

Chemical	Amount, g/kg	Details
Thickener	35	Starch ether
Sodium hydroxide, 50%	800	Alkali (50ºBè - 106º Tw)
Wetting agent	2	Anionic wetting agent
Water	Bulk	Water to total volume
Total	1000	

Table XI. Print Paste – Fitted Plissé

Chemical	Amount, g/kg	Details
Thickener	35	Polyacrylate
Wax emulsion	100	Water repellant
Fluoro-chemical	10	Water repellant
Binder	200	Styrene acrylate
Cross linking agent	5	
Water	Bulk	Water to total volume
Total	1000	

Table XII. Padding – For Fitted Plissé

Chemical	Amount, g/kg	Details
Water	198	
Sodium Hydroxide, 50%	800	Add sodium hydroxide to water
Wetting agent	2	
Total	1000	

Burn Out Prints

Cotton and other cellulosic fibers are destroyed by strong mineral acids or their acid salts. This procedure is sometimes referred to as "Burn Out". A cotton / polyester blended fabric can be printed with a print paste containing the burn out chemicals, and after fixation, the cotton portion is destroyed and only the polyester remains. This allows a patterned lacey design to be imparted to the fabric. It also is possible to incorporate a disperse dye in the burn out paste and dye the polyester during the burn out phase. This process is very corrosive and requires special screens and special care in handling. Table XIII contains the "Burn Out" print paste formula.

Table XIII. Burn Out Print Paste Formula

Chemical	Amount, g/kg	Details
Thickener	48	Guar gum
Ethanol	50	
Emulsifying agent	20	
Humectant	100	Glycerin
Anionic Wetter	20	
Aluminum Sulfate	85	Creates mineral acid
Water	Bulk	Water to total volume
Total	1000	

Garment Printing

Garment printing, also called Unit Printing, is typically performed by small operations and done in batch-on-demand form. Although many items of clothing and other unit items are printed, the most recognizable is the t-shirt.

Some of the other items commonly printed by this process are caps, sweat shirts, and towels. Printing is typically done on carousel unit printing machines. This process can be manual or automated to the point where only attendants are needed to add and remove the items being printed. These machines are available with four to as many as twenty printing stations. Computer process control can accommodate differences in each screen of a particular pattern and control external drying ovens and other systems incorporated in the process. See Figure 2.

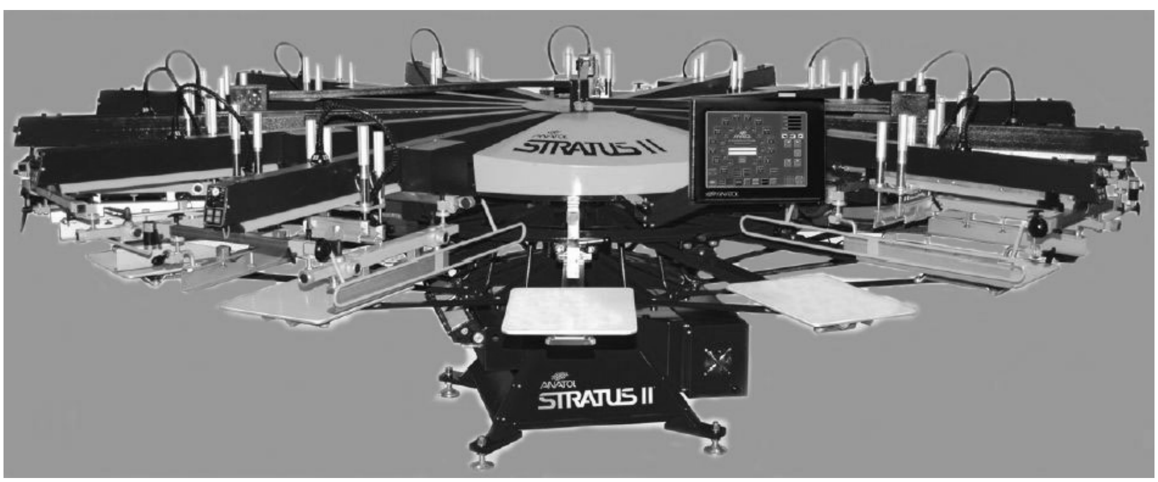

Figure 2. Carousel Unit Printing Machine Photo courtesy of Anatol Equipment Mfg. Co

SPECIALTY PIGMENTS AND OTHER COLORANTS

Puff Prints

Sculptured designs can be added to the fabric by the print application of a compound known as a Puff Print Extender. This compound swells when heated to create a three dimensional effect on the fabric. When applied in a discontinuous pattern, this product can create a puckered effect on the fabric as it dries and contracts during the curing phase. The puff paste can be colored with pigments and can be used to create faux embroidery looks. The products available are intended to be used "as is" no formulation or dilution necessary.

Plastisol Prints

Plastisol inks are made up of polyvinyl chloride resin, plasticizers, and pigments.[20] According to Rutland Industries, this balanced system of solids to liquids is a finished product ready to print. Additives such as dye migration blockers, fillers, puff, and stabilizers can be incorporated into the formula depending on the final product requirements.[21] These products are sold ready to use in screen-printing for all types of unit printing applications. The most common form of unit printing is garment printing.

Plastisol inks are thixotropic. That means the mixture is high in viscosity when at rest and is low in viscosity when shear or movement is applied. Shear or movement of the plastisol against the surface of the container or screen can generate heat. During mixing or printing as friction heat builds, the viscosity decreases. As temperature decreases, viscosity then increases.

T-shirt printing is most often done in a non-textile facility. Plastisol inks can be loaded with "block-out" fillers which allow the printing of designs, on dark dyed t-shirts, which are visible and completely cover the dark background. The resulting prints sometimes show an increase in stiff handle due to these additives.

Water-based pigment inks have been developed which yield a more acceptable handle. Screen drying of these water-based products present a problem of running properties similar to normal textile printing. However, the clean up of screens and equipment is done with soap and water and does not require the use of solvents which makes these products more environment-friendly.

For a plastisol ink to fully cure, the water in the garment must first be dried off, then the resin in the ink swells to react with the plasticizer to form a film. Table XIV details some of the variables which can impact curing of plastisol inks.

Table XIV. Variables in Curing Plastisol Inks.[20]

Variable	**Description**
Fiber type	Some fibers hold more water than others (cotton vs. nylon)
Fabric color	Dark garments heat faster than light colored garments
Garment weight	Heavier garments take longer to heat to temperature
Fabric construction	Fabrics with greater surface area will take a long time to heat
Ink thickness	Thicker prints will take longer to heat than soft-hand prints
Ink type	Specialty inks may take longer to heat then conventional inks
Room temperature and humidity	Ambient conditions may impact dryer efficiency

[20]Union Ink Company, 1997
[21] Rutland Plastics Technologies, Pineville, NC

Phototropic Colors
Phototropic colors are pigments with an ability to change or shift their chromophore and become visible when exposed to ultraviolet light. An example of this technology is the pair of sunglasses that automatically darken when exposed to the sun's UV light rays. These pigments have been used, in lower concentrations, in prints on textile fabrics. These colorants are expensive and have poor light fastness. Normal indoor exposure will destroy the color in several weeks. Outdoor exposure will destroy the color in less than ten hours. These products are applied as pigments.

Theromotropic Colors
Thermotropic or thermochromic colorants have the ability to become colorless upon exposure to heat. This reaction is wholly reversible, and the color returns upon removal of the heat source. These pigments can be blended to react under a range of temperatures. They can also be blended with conventional pigments so that a change in shade develops under the exposure to heat. Some commercial success has been achieved with garments that change shade as the wearer exercises and the body temperature increases. These colors may be applied by printing, pad dyeing, and garment exhaust dyeing as pigments. Thermotropic colors are more stable than the phototropic colors but still have poor lightfastness. These colorants are more expensive than conventional pigments, and their color strength is one tenth as strong.

Metallic Pigments
Metallic pigments such as pigment gold and pigment silver are used in decoration on apparel fabric achieving a faux metallic lame'. Traditionally these products were dispersions of very fine grinds of bronze (gold) and aluminum (silver) combined with a melamine resin to offer maximum binding power. The print paste was basically a pigment dispersion, and these earliest prints had very poor wash fastness. In addition, the handle was very stiff and some of the metallic particles would flake off in normal use. Today these products are more consumer friendly in that their binder system imparts a better hand, and the metallic particles have been coated with an epoxy to prevent tarnishing and to increase fastness.

Presently many "metallic" pigments contain no metal. These are compounded with normal textile pigments in a pearlescent dispersion or the actual pigments are made from chopped polyester film.

Sparkle or Glitter Prints
Glitter prints are made with special pastes incorporating flakes that are polyester chips; these can be dyed for color or plated for a metallic appearance. They are available in several sizes ranging from 50 microns to 1.6 mm. The base is a modified curable optically clear product with very low viscosity. Sparkle print is a special condition produced when an undyed glitter flake produces a sparkle or shimmer effect. This is accomplished by using these flakes in combination with special binders that refract light in this manner. Normal pigments can be incorporated into the glitter base for special effects.

Since the particle size of a glitter flake is so large, relative to a standard pigment particle, special screens with a large mesh must be used to apply them to the fabric (40 – 60 mesh maximum).

Fluorescent Pigments

Fluorescent colorants are called light emitting colorants. These products absorb ultra violet (UV) and visible light and emit the light in different wavelengths, which makes them appear to glow. These are sometimes referred to as “hot” pigments. These colors can be printed alongside normal pigments, but it is not recommended that the fluorescent color be shaded with the normal pigment as the brightness may be lost and the resulting shade may be very dull.

Originally, these colors were based strictly on fluorescent basic and acid dyes that could be coagulated with various resins. The water fastness was very poor. Now the manufacture includes a micro-coating process that has increased the efficiency of these products.

There are five to six basic fluorescent pigments, and these can be mixed with each other to produce as many as ten specialty fluorescent colorants. Fastness to washing and dry cleaning is fair to good. Fastness to light is usually poor.

Block-out Prints

Block-out is a term used to describe the over-printing of a pigment print on a dark dyed fabric that results in an easily seen colored print. Normally, the pigment would be over-come by the dye shade and would not be visible. The block-out paste imparts a white background to the pigment and prevents the dyed shade from interfering or “blocks out the dyed shade.” The paste is based on a pigment white modified with special clay to provide much better covering power to the white base. The base can be used to produce a white or colored fabric with normal pigments for a colored pattern.

Pearlescent Pigments

Pearlescent print pastes are utilized to give a luster or a shiny appearance to the print. Both pearl and mother-of-pearl can be used to affect the result. A synthetic powder made from polyester has been used to compound the pearlescent paste. The particle size is again, as with the glitter paste, relatively large (25 – 50 μ), and screen mesh selection to accommodate these particles must be taken into consideration.

TROUBLESHOOTING

If manufacturer’s instructions say “print direct from the drum”, can the product be altered? Manufacturers typically instruct printers to use specialty products as they are compounded. If the printer desires a lower or higher viscosity or some other modification, it is usually best to make a small trial to determine the limits of alteration that the products will tolerate. Check with the product supplier and refer to the technical data sheets to determine what additives are compatible with their print system.

What causes print screens to clog? Many specialty prints contain components with non-uniform particle size. Screen clogging occurs anytime the components in the print paste build-up and blocks the openings in the screen. Utilization of the proper screen mesh will help prevent this occurrence. Other factors that can contribute to screen clogs are:

- The pH of most print pastes should be maintained on the slightly alkaline side (8.0-8.5). If the pH falls below 7.0, the paste viscosity will drop dramatically causing an agglomeration of the thickener. The print binder may also start to polymerize as the pH drops.
- Colorant dispersion problems, which usually begin with specks forming in the print design, can also block the screen. It is always recommended that the print paste be strained before it is put in the screen.
- Undissolved or poorly dispersed thickener concentrate may eventually lead to blocked screens. This problem does not immediately show itself, since it is only after time that the thickener swells so that the agglomerations become too large to pass through the screen.
- Lint on the surface of a fabric can stick to the screen and block openings in the mesh.

<u>What are the elements that adversely impact print appearance?</u>

- Improper print paste viscosity
- Improperly prepared fabric
- Fabric with non-uniform absorbency
- Fabric with contaminants such as salt or oil
- Inadequate lint removal from fabric
- Improper screen mesh selection
- Poor print registration
- Contaminated color

Problems most often encountered in pigment printing are summarized in Table XV. The frequency of the defects is noted in the Percentage column. The subsequent columns indicate what factors can contribute to a particular defect. This table illustrates how important well-prepared fabric is to the production of first quality fabric.

Table XV. Printing Defects

Defect	Percentage	Color	Machine	Screen	Fabric
Machine Stops	40%	X	X	X	X
Out of Fit (Registration)	25%		X	X	X
Clogged Screen Mesh	9%	X		X	X
Color Smears / Mark-off	8%	X	X		X
Color Flushing	7%	X			X
Cloth	6%		X		X
Contaminated Color	5%			X	X
Statistical summary [22]	100%				

[22] The "Opportunities" Of Rotary Screen Printing - Alan W. Hewett, ABCO Textile Chemicals

Importer Support Program

The Cotton Board and Cotton Incorporated are funded by U.S. upland cotton growers and importers of cotton and cotton products (this includes raw cotton, piece goods, and finished apparel). A percentage of the importer funds are devoted for importer specific programs organized under the Importer Support Program. Examples of projects funded from this fund include training schools, educational programs, focus groups, economic meetings, and research initiatives.

Selected technical issues have been identified by importer members as relevant to their business. This report is a condensed, less technical report of those issues intended to provide the reader with basic, yet useful information on the topic.

For more information contact:

COTTON INCORPORATED
WORLD HEADQUARTERS
6399 WESTON PARKWAY
CARY, NC 27513
PHONE: 919-678-2220
FAX: 919-678-2230

COTTON INCORPORATED
CONSUMER MARKETING HEADQUARTERS
488 MADISON AVENUE
NEW YORK, NY 10022-5702
PHONE: 212-413-8300
FAX: 212-413-8377

Visit our website at: www.cottoninc.com

COTTON INCORPORATED