TEXTILE PRINTING

Textile Printing

1.0 Introduction

The desire of adding color and design to textile materials is almost as old as mankind. Early civilizations used color and design to distinguish themselves and to set themselves apart from others. Textile printing is the most important and versatile of the techniques used to add design, color, and specialty to textile fabrics. It can be thought of as the coloring technique that combines art, engineering, and dyeing technology to produce textile product images that had previously only existed in the imagination of the textile designer. Textile printing can realistically be considered localized continuous dyeing. In ancient times, people sought these designs and images mainly for clothing or apparel, but in today's marketplace, textile printing is important for upholstery, domestics (sheets, towels, draperies), floor coverings, and numerous other uses.

1.1 History of Printing

The exact origin of textile printing is difficult to determine. However, a number of early civilizations developed various techniques for imparting color and design to textile garments. Batik is a modern art form for developing unique dyed patterns on textile fabrics very similar to textile printing. Batik is characterized by unique patterns and color combinations as well as the appearance of fracture lines due to the cracking of the wax during the dyeing process. Batik is derived from the Japanese term, "Ambatik," which means "dabbing," "writing," or "drawing." In Egypt, records from 23-79 AD describe a hot wax technique similar to batik. The early Egyptians also used ink-carved designs on the ends of wooden cylinders to print on fabrics as early as 400 AD. In Europe, the earliest evidence of textile printing is provided by a wooden block discovered in France dated to the end of the 14th century. The family name "Tuchdruckers" or "textile printers" was well known in Germany by 1440. In the United States, woodcut block printing was practiced in Massachusetts, New Jersey, and Pennsylvania by the 1770's. A tremendous breakthrough occurred in 1783 when James Bell, a Scotsman, invented engraved roller printing.

The development of screen-printing began in Japan in the middle of the 17th century. Early development involved the use of design stencils held together by fine silk threads or even human hair. The designs were laid onto textile fabrics and color was applied only to the areas outside of the designs. Since the silk threads were so fine, they were not apparent in the final fabric design. The Japanese technique was taken to France where modern flat screen printing was developed, initially using silk fabric stretched over a wooden frame.

Before the modern methods of textile printing are discussed in detail, some specific information on textile material must be covered. The properties of fibers, yarns, and fabric constructions impact the textile printing processes as well as the characteristics of the final printed fabrics.

2.0 Textile Substrates Used for Printing

2.1 Fibers

Dyes are fiber specific; therefore, dyes are chosen for printing based on the fibers, which compose the textile fabric. For example, a 100% cotton fabric can be printed with reactive dyes, vat dyes, or any dye that works for cotton. Alternately, a cotton/polyester blend requires two dye types combined in the print paste. One type is for the cotton fibers, such as reactive, and one type is for the polyester fibers, such as disperse. Textile pigments may also be used. They are not dyes but colorants and require a binder or glue to fix them to the surface of the textile fibers. Unlike dyes, pigments are not fiber specific; therefore, a 60/40 cotton/polyester blend could be printed with a single pigment. Pigments work equally well on 100% cotton fabrics and various blends.

2.2 Yarns

The type of yarn construction also has an influence on textile printing. Because print color is applied from one side of the fabric, the evenness, brightness, and depth of the color is very sensitive to the hairiness, twist, and luster of the yarns. For instance, the higher the yarn luster, the brighter the printed color. Fiber luster can also influence the appearance of the printed design in much the same way. If yarns are highly twisted, they may not allow print paste to penetrate deeply into the yarn bundle, and this yields poor print colorfastness. Additionally, fine to medium yarns generally are easier to print than large bulky yarns or novelty yarns.

2.3 Fabric Constructions

Fabric construction properties also impact the properties of the final printed fabric as well as the printing process itself. For example, wovens are normally easier to print than knits. The main reason for this statement is because typically woven fabrics are much more dimensionally stable than knits. Fabric distortion or “shift” is a major contributor to out-of-registration prints or misprinting in multicolor textile prints. Because wovens are an interlacing of yarns while knits are interlacing loops of yarn, there is a wide variety of knit fabric structures with varying dimensional stability properties. However, woven fabrics are generally stable.

Also, fabrics with a flat surface print more easily than fabrics with pile surface. A good example of this difference is to compare the typical printing process for sheets with that of bath towels. Sheets are normally printed on flat or rotary screen-printing machines and typically require a single squeegee stroke for the printing process. In contrast, bath towels are usually printed on flat screen printing machines and may require as many as four squeegee strokes to force the print color down into the fabric pile. The extra squeegee strokes severely limit the printing production speed for towel fabric. Any fabric with surface texture will present more printing issues than a comparable flat surface fabric. Additionally, thin or sheer fabric constructions may present printing problems compared to thicker fabric constructions of the same fiber content.

2.4 Fabric Preparation

The golden rule in the dyeing of textiles is that “a well-prepared fabric is a fabric half-dyed.” This simply indicates the importance good fabric preparation plays in producing high quality final products. For textile printing, especially for cotton fabrics, quality fabric preparation is crucial for quality printing. It has been reported that as many as 60% of textile printing defects can be traced to fabric preparation problems. Often, the company that prints the fabric is not the one that prepares the fabric. When textile goods are prepared for printing, they are normally referred to as PFP goods (prepare for printing). Preparation processes vary widely depending on the fiber content, yarn type, and fabric construction. In the case of cotton, the minimum PFP sequence would include scouring and bleaching. Scouring removes all dirt, oil, and grease from the fabric and is necessary for uniform water absorption and dye penetration. Bleaching destroys all the naturally occurring color in the fabric and is necessary to provide a uniform white fabric base to allow for optimum print color brightness and reproducibility. It is essential after either one of these processes is completed that adequate rinsing be done to wash away the trash that was removed or chemistry that was used. A clean fabric will ensure that the next wet process can be done without interference from unwanted residual components.

For woven fabrics, the size applied to the warp yarns during weaving can interfere with the penetration and fixation of print color. Therefore, desizing – the removal of warp size – becomes an additional necessary preparation process. For very high-quality printed cotton goods, either knits or wovens, mercerization may be an additional preparation process. Mercerization improves the smoothness, dimensional stability, strength, dye uptake, and luster of cotton fabrics. Mercerized cotton prints normally exhibit maximum color brightness and improved colorfastness for a given dye. For extremely hairy or fuzzy yarns or fabrics, singeing or the burning off of the surface, may be an additional step required in the preparation process. Figure 1 illustrates how singeing removes fuzz from the textile surface. Most fabrics used in printing are singed in fabric form.

Regardless of what the preparation sequence for a particular fiber content and fabric construction may be, it is crucial that preparation processing be consistent, uniform, and repeatable. Any variability in the prepared fabric leads directly to poor print quality or printing defects. The importance of high-quality fabric preparation for printing cannot be overstated.

<u>Figure 1- Singed Yarn (Before and After Singeing).</u>

Before **After**

3.0 WET PRINTING TECHNIQUES

The modern textile-printing techniques of flat-bed screen, rotary screen, and engraved copper roller are referred to as wet printing techniques. This is because each technique applies a print paste, which is a thickened dye mixture, to the fabric in the printing process. Before covering the specifics of each printing method, the important processes common to all three techniques will be covered.

For wet printing processes, once the fabric has been prepared and delivered to the printing plant, the basic steps in the printing process are as follows:

1. Preparation of the print paste.
2. Printing the fabric.
3. Drying the printed fabric.
4. Fixation of the printed dye or pigment.
5. Afterwashing.

It should be noted that not all printed fabrics are 'afterwashed'. In applications where pigments are printed on finished fabric, afterwashing of the print is not normally performed.

3.1 Preparation of the Print Paste

The specifics of print paste formulation depend on the fiber content of the fabric, the colorant system used, and to some extent, the type of printing machine employed. However, the typical ingredients found in most paste formulations include the following: dyes or pigments, thickeners, sequestering agents, dispersing or suspending agents (surfactants), water-retaining agents (humectants), defoamers, catalysts, and hand modifiers. In addition to the ingredients, pigments require a binder or resin system to fix the pigment and may include adhesion promoters.

3.2 Dyes for Printing

The most important ingredients of any print paste formulation are the colorants and the thickener system. As mentioned, dyes are fiber specific. The dyes for cellulose fibers – specifically cotton, rayon, and lyocell – that are used for printing are reactives, vats, naphthols, and directs. Reactives dominate the dyes used for printing these fibers, because of their wide shade range, bright colors, good washfastness, and good availability. Vat dyes are also quite popular for textile printing. They usually have very good overall colorfastness properties, but have a limited shade range and are available in mainly deep colors such as violets, blues, and greens. Naphthols or azoic coupling components are unique in that the dye is actually made through a reaction of two separate chemicals inside the fiber. The typical method uses a stabilized naphthol and coupling component print paste mixture printed onto the fabric then exposed to an acid steaming to develop the color. These are known as the rapid fast or rapidogen colors. The use of naphthols is limited due mostly to application complexity. For all of these dye systems for cotton, thorough afterwashing is essential for good crockfastness and washfastness.

3.3 Printing Blends

If the printed fabric is a blend, then a combination of different dye types in the print paste will be necessary. For example, a cotton/polyester blend would require reactive dyes for the cotton and disperse dyes for the polyester. These would also require different color fixation conditions. Therefore, the dominant type of colorant for blended fabrics is pigment systems. Pigments are not dyes, but are colored particles glued to the surface of the fabric. They can color all fibers in the blend the same shade with a single colorant. Once applied, fixation of a pigment color just requires dry heat for a defined amount of time. The colorfastness of pigments directly depends on the binder system employed. Binders are chemicals, which have the ability of forming a three-dimensional film used to hold the pigment particles in place on the surface of a textile substrate. Binders can be water-based (latex) or solvent-based and vary widely in their stiffness. Adhesion promoters (low crock additives) are chemicals added to increase the adhesion of the binder to the fabric. The major drawbacks of pigment prints include poor crockfastness, especially on deep shades, and stiffening of the fabric so that it may feel somewhat boardy. Their wide shade range as well as the flexibility and simplicity of processing make pigments an extremely popular choice for both blended and 100% fiber fabrics.

3.4 Thickener Systems for Printing

The thickener system is the next crucial component of print paste. The purpose of the thickener system is twofold. First, the thickener gives the print paste the proper viscosity or flow characteristics, so the color can be applied uniformly and evenly. In the specific case of screen printing, the thickener which controls print paste viscosity, must become liquid-like as the squeegee pushes the color through the screen. However, once through the screen, the print paste must thicken, or flushing will result.

Second, it holds the color in place so that one color paste can be applied adjacent to another without the color bleeding onto the other. With dyes, the thickener also holds the color in place after drying until the printed fabric goes through the fixation process where the dye is released from the thickener and is diffused into the fiber. Thickeners used with dyes are then washed off the fabric before any chemical or mechanical finishing is performed. However, the thickener applied with a pigment system will remain with the print, as no afterwashing is required. There is a wide range of thickener materials available including alginates, natural vegetable gums, synthetic polymers, or even foams. These materials show sensitivity to factors such as temperature, pH, and salt content.

3.5 Print Paste Auxiliary Chemicals

The following form a group of optional, but often used additives to print paste formulations. Sequestering agents are compounds which complex (bond) with metallic contaminants to prevent interference with the print color or necessary auxiliary chemicals. Calgon® is the most well-known of this type of additive. Surfactants are additives, which allow chemicals of dissimilar nature to mix. They are used in print paste as dispersing agents, suspending agents, and/or wetting agents. Water-retaining agents or humectants are additives, which prevent premature water evaporation or “skim-over” from print paste. Additionally, they often absorb moisture from the air to keep dried print paste from cracking and shedding off the fabric before fixation. Defoamers are materials added to the print paste to eliminate unwanted bubble or foam formation during the mechanical action of the printing process. Unwanted foaming leads to uneven or light print color. Defoaming additives must be rechecked to ensure against adverse effects on final print quality. Hand modifiers, most specifically softeners, are often incorporated with pigment print formulations, because print binders tend to overly stiffen the fabric. While these additives may improve certain aspects of the print, they may also interfere with the binder and should be used with caution.

3.6 Printing the Fabric

There are a number of printing techniques used in the industry. These will be discussed in detail, along with several unique processes, in the next section.

3.7 Drying the Printed Fabric

After printing the fabric, the paste is dried to prevent accidental smearing of the print design and color migration. At this point, depending on the printing plant layout, the printed fabric may immediately go through the fixation process, or it may be held to go to fixation later. The type of colorant and production issues with the printing operation dictates the choice.

3.8 Fixation of the Printed Dye or Pigment

The next step is fixation of the print color. For dyes, fixation normally incorporates an atmospheric steamer with specified moisture content and a nominal temperature of 212°F (100°C). With certain dyes, an auxiliary chemical may be necessary as an extra additive to the print paste. For example, for complete fixation, reactive dyes require additional alkali. In the case of vat dyes, reducing agents are necessary. For pigments on all fibers and disperse dyes for polyester or nylon, only high temperatures are necessary. The fixation equipment used can be a dry heat oven or super-heated steam. The key issue is reaching temperatures of approximately 350°F (177°C) to cure a synthetic pigment binder and as high as 400°F (205°C) for disperse dyes.

3.9 Afterwashing

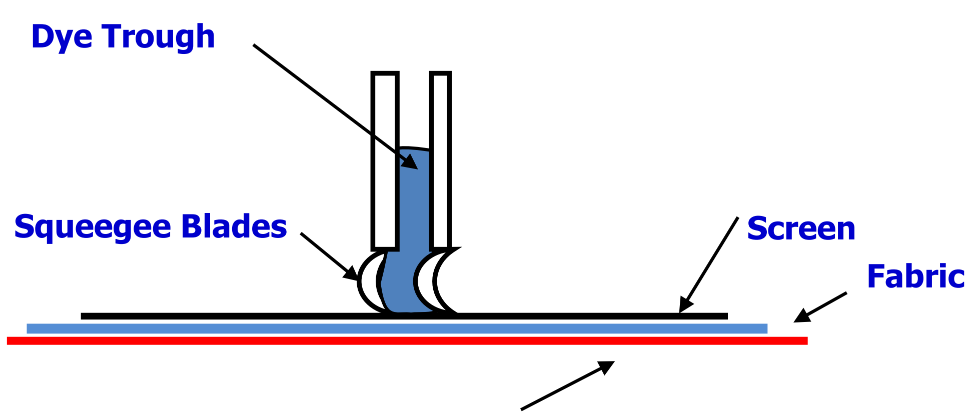
In the case of dye prints, the printed fabric is thoroughly washed then dried after fixation. This step is necessary to remove the thickener, alkali, and other ingredients of the print paste left on the fabric surface after fixation. If not removed, these materials could interfere with subsequent finishing processes. Pigments are often printed on finished fabrics so the afterwashing is not necessary.

4.0 Printing the Fabric

4.1 Flat-Bed Screen Printing

The first of the modern printing methods is flat-bed screen printing. In the textile industry, this process is an automated version of the older hand operated silk screen printing. For garments such as t-shirts, sweatshirts, sweatpants, and caps, the hand-operated process is often used. For each color in the print design, a separate screen must be constructed or engraved. If the design has four colors, then four separate screens must be engraved. The modern flat-bed screen-printing machine consists of an in-feed device, a glue trough, a rotating continuous flat rubber blanket, flat-bed print table harnesses to lift and lower the flat screens, and a double-blade squeegee trough. The in-feed device allows for precise straight feeding of the textile fabric onto the rubber blanket. As the cloth is fed to the machine, it is lightly glued to the blanket to prevent any shifting of fabric or distortion during the printing process. The blanket carries the fabric under the screens, which are in the raised position. Once under the screens, the fabric stops, the screens are lowered, and an automatic squeegee trough moves across each screen, pushing print paste through the design or open areas of the screens. Figure 2 shows the design of a type of squeegee trough. This is also referred to a double blade squeegee.

Figure 2 – Flat-bed Squeegee Unit.

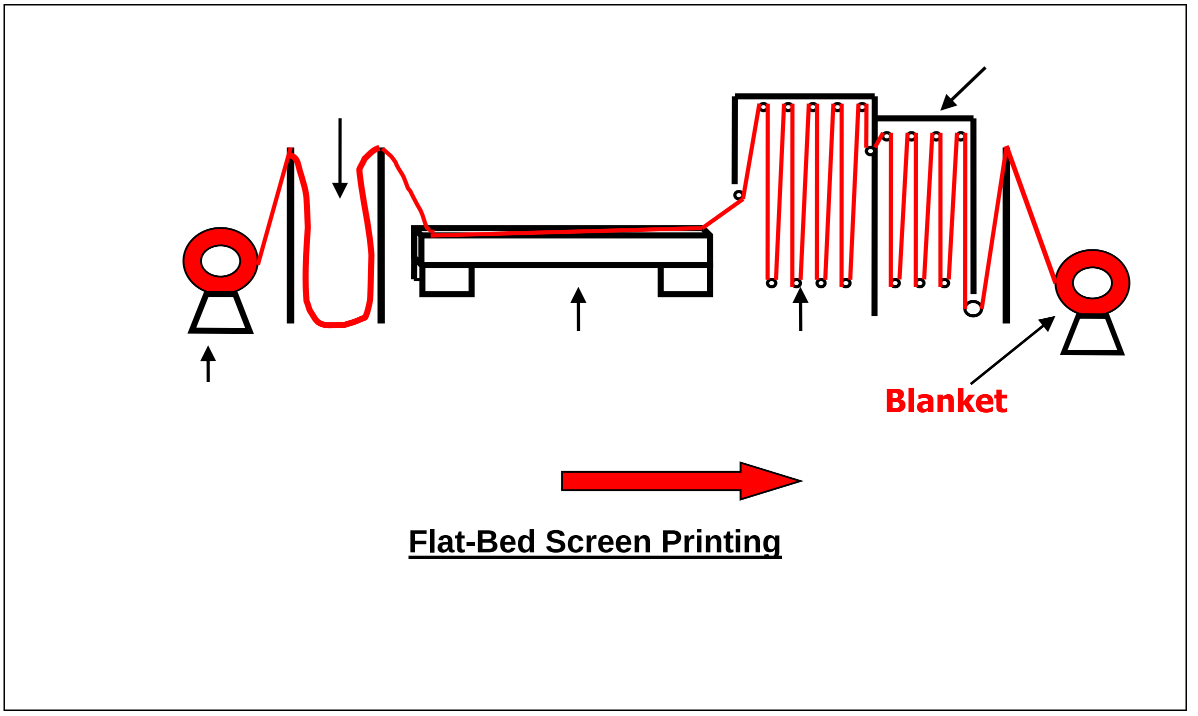


Remember, there is one screen for each color in the pattern. The screens are raised, the blanket precisely moves the fabric to the next color, and the process is repeated. Once each color has been applied, the fabric is removed from the blanket and then processed through the required fixation process. The rubber blanket is continuously washed, dried, and rotated back to the fabric in-feed area. Figure 3 is a photo of a typical production of a flat-bed printing machine. These are large machines requiring large amounts of plant floor space.

Figure 3 – Flat-bed Printing Machine.

The flat-bed screen process is a semi-continuous, start-stop operation. From a productivity standpoint, the process is slow with production speeds in the range of 15-25 yards per minute. Additionally, the method has obvious design limits. The design repeat size is limited to the width and length dimensions of the flat screen. Also, no continuous patterns such as linear stripes are possible with this method. However, this method offers a number of advantages. Very wide machines can be constructed to accommodate fabrics such as sheets, blankets, bedspreads, carpets, or upholstery. Also, this technique allows for multiple passes or strokes of the squeegee so that large amounts of print paste can be applied to penetrate pile fabrics such as blankets or towels. Currently, approximately 15-18% of printed fabric production worldwide is done on flat-bed screen machines. Figure 4 is a schematic of a flat-bed printing line complete with the drying/curing step and fabric take up.

Figure 4 – Flat-bed Printing Line.

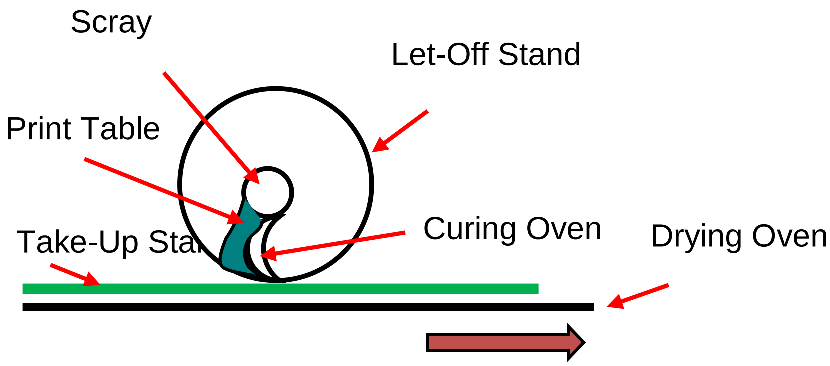


4.2 Rotary Screen Printing

Due to the semi-continuous process, low productivity, and non-continuous patterns of flat-bed screen printing, inventive machine makers developed rotary screen printing. The idea was first proposed in 1947 in Portugal, but the initial commercial machine was first introduced by Stork (Holland) at the ITMA show in Germany in 1963. In concept, the idea is to take a flat screen and simply shape it into a roll by sealing the ends of the flat screen together. The simple modification converts a semi-continuous process to a continuous one. However, initially there were many technical hurdles to overcome before rotary screen machines became practical.

In basic operation, rotary screen and flat screen-printing machines are very similar. Both use the same type of in-feed device, glue trough, rotating blanket (print table), dryer, and fixation equipment. The process involves initially feeding fabric onto the rubber blanket. As the fabric travels under the rotary screens, the screens turn with the fabric. Print paste is continuously fed to the interior of the screen through a color bar or pipe. As the screen rotates, the squeegee device pushes print paste through the design areas of the screen onto the fabric. This is illustrated in Figure 5. As in flat-bed screen printing, only one color can be printed by each screen. After print application, the process is the same as flat screen printing.

Figure 5 – Rotary Screen Printing.



By converting the screen-printing process from semi-continuous to continuous, higher production speeds are obtained. Typical speeds are from 50-120 yards per minute (45-100 meters per minute) for rotary screen printing depending upon design complexity and fabric construction. Initially, no continuous patterns such as stripes were available with this method due to the seams in the rotary screens. However, with the development of seamless screens, continuous patterns such as linear stripes or plaids became possible. Rotary screen machines are more compact than flat screen machines for the same number of colors in the pattern. Therefore, they use less plant floor space. Figure 6 is a photo of a production rotary screen printing machine. Notice the compact nature of how the screens are mounted on the printing table. Also, notice that the squeegees cannot be seen in the photo.

Figure 6 – Rotary Screen Printing Line.

Also, with rotary screens, the size of the design repeat is dependent upon the circumference of the screens. This was initially seen as a disadvantage, because the first rotary screens were small in diameter. However, with today's equipment, screens are available in a range of sizes and are no longer considered design limited. The fact is that today's rotary screen machines are highly productive, allow for the quick changeover of patterns, have few design limitations, and can be used for both continuous and discontinuous patterns. Estimates indicate that this technique controls approximately 65% of the printed fabric market worldwide. The principle disadvantage of rotary screen printing is the high fixed cost of the equipment. The machines are generally not profitable for short yardages of widely varying patterns, because of the clean-up and machine down time when changing patterns. Flat screen printing is much more suitable for high pile fabrics, because only one squeegee pass is available with rotary screen. However, rotary machines are used for carpet and other types of pile fabrics.

4.3 Screen Engraving, Lacquer Method

The process of putting designs to be printed on both rotary and flat screens is known as screen engraving. The most widely used process for screen engraving is known as the lacquer method. The overall process begins with the print design. Once the design is agreed upon, a textile artist separates the design into its individual colors. Each design component of each color is then made into a positive in black opaque ink on clear plastic film; the design is then reproduced color by color.

The flat or rotary screen is evenly coated with a liquid water-soluble photosensitive resin. The screen is dried and stored in the dark. When ready for engraving, the coated screen is then covered in the exact required location with the opaque design positive. High intensity light is then directed onto the screen. Wherever the light hits the screen, it hardens the resin and forms a water insoluble barrier. Where light is prevented from hitting the screen due to the design positive, the resin remains water soluble. After the proper amount of light exposure time, determined by the choice of resin, the screen is washed and dried. The design areas of the screen are opened, and print paste is allowed to flow freely through, but the non-design areas are closed. This method is used for nearly all flat screens.

4.4 Laser Engraving

For rotary screens, the most modern method of screen making is known as laser engraving. Here, the original design is digitized on a CAD (computer-aided design) system. Once again, a skilled textile designer separates each color of the design. At the same time, rotary screens are coated with resin, and the resin is completely hardened. The coated screen is then loaded on a mandrel, which is attached to a laser engraver. The machine engraves the screen using the digitized CAD print design data. Again only one color per screen is possible. The laser vaporizes the resin without damaging the screen material, which is normally nickel mesh for modern rotary screens. Laser engraving has greatly expanded the design possibilities for rotary screen printing. There is also a technique for engraving screens using nickel electroplating technology to form the design on the screen. This technology is known as the Galvano method, but is now seldom used.

4.5 Screen Printing Defects

In the case of screen printing, some general print defects should be mentioned. They are as follows:

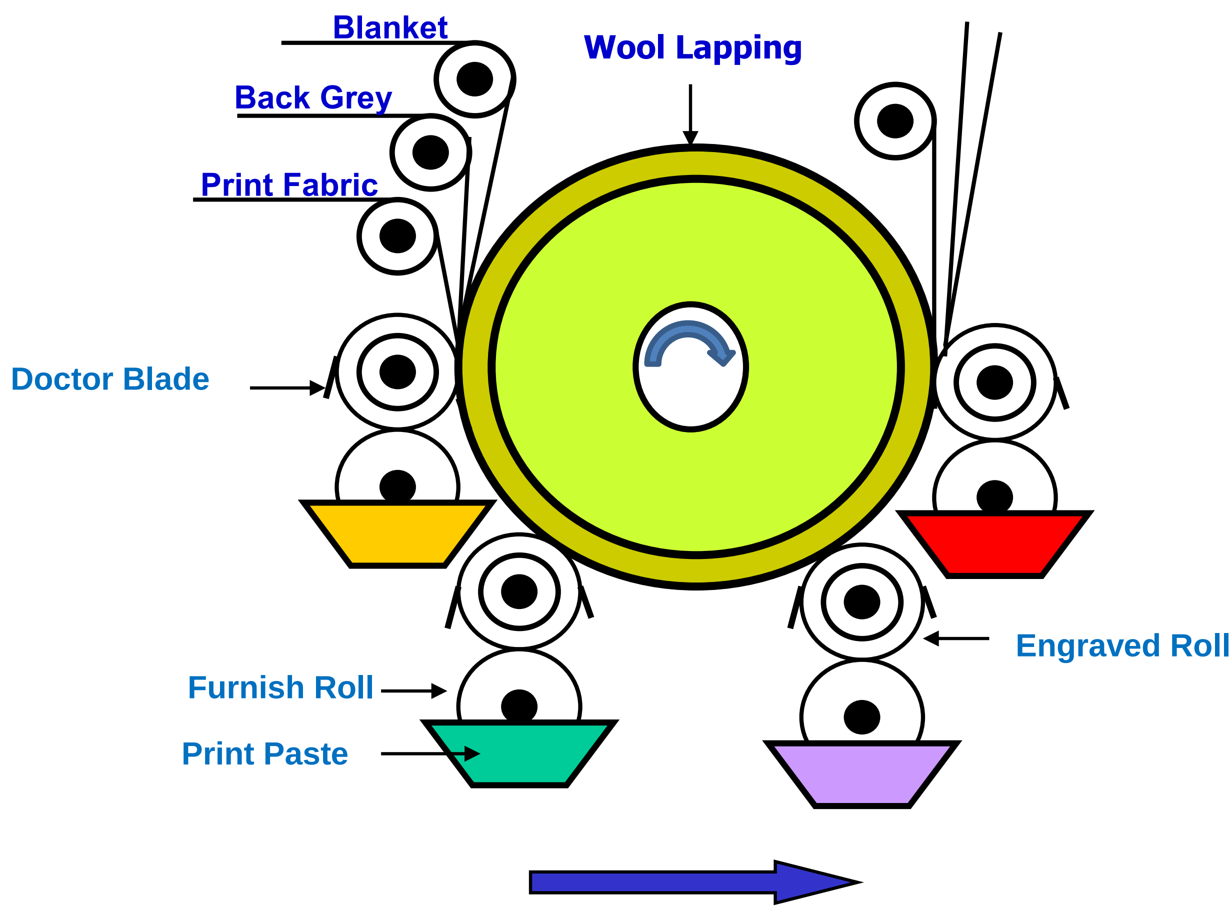
- Out of registration – pattern out of fit.
- Glue streaks – from the rubber blanket.
- Color smear.
- Color out – from a lack of print paste.
- Creased fabric.
- Pinholes in any screen.
- Damage to the screen leading to misprints.
- Lint on the fabric causes pick-off.

Remember, with print designs, color application must be correct the first time, because printing defects cannot be repaired. There have been many new and exciting improvements in screen printing in recent years, especially in the case of rotary screen machines. The use of microprocessor control systems have allowed for printing that is more accurate, has reduced print defects, and allows for increased productivity. New techniques for recovery and reuse of unused print paste have reduced dye and chemical costs and the pollution load on waste treatment systems. Overall, these improvements have produced machines capable of better quality printing at higher productivity with few defects and reduced environmental impact.

4.6 Engraved Roller Printing

Engraved roller printing is a modern continuous printing technique developed in the late 19th and early 20th centuries. Until the development of rotary screen printing, it was the only continuous technique. In this method, a heavy copper cylinder (roller) is engraved with the print design by carving the design into the copper. Copper is soft, so once the design is engraved, the roller is electroplated with chrome for durability. The print design development and color separation are identical to that used for screen printing. Once each roller (one roller per color) is engraved, it is loaded on the printing machine. This machine has a main cylinder that is fitted with a large gear. This gear fits into and drives each print roller. Each roller is fed print paste by a furnish roller rotating in a color box full of print paste. The main cylinder gear drives all of these parts. As print paste is applied to the print roller, a stationary doctor blade scrapes away all the surface print paste leaving only that which is embedded in the design etchings. Fabric is fed to the machine, backed by a greige fabric to absorb print paste flow through, and backed by a cushioning print blanket. The backing greige is often discarded, but the print blanket is washed, dried, and reused. Printing occurs as the fabric swipes print paste from the print roller as it passes through the pinch point between the roller and the main cylinder. This is illustrated in the schematic shown in Figure 7. The high fixed cost of copper rollers, expense of engraving process, and possible distortion of fabric during printing have led to its reduced use, now being less than 5% of the worldwide textile printing market. The fine design detail possible with this technique has always been its main advantage.

Figure 7 – Engraved Roller Printing.

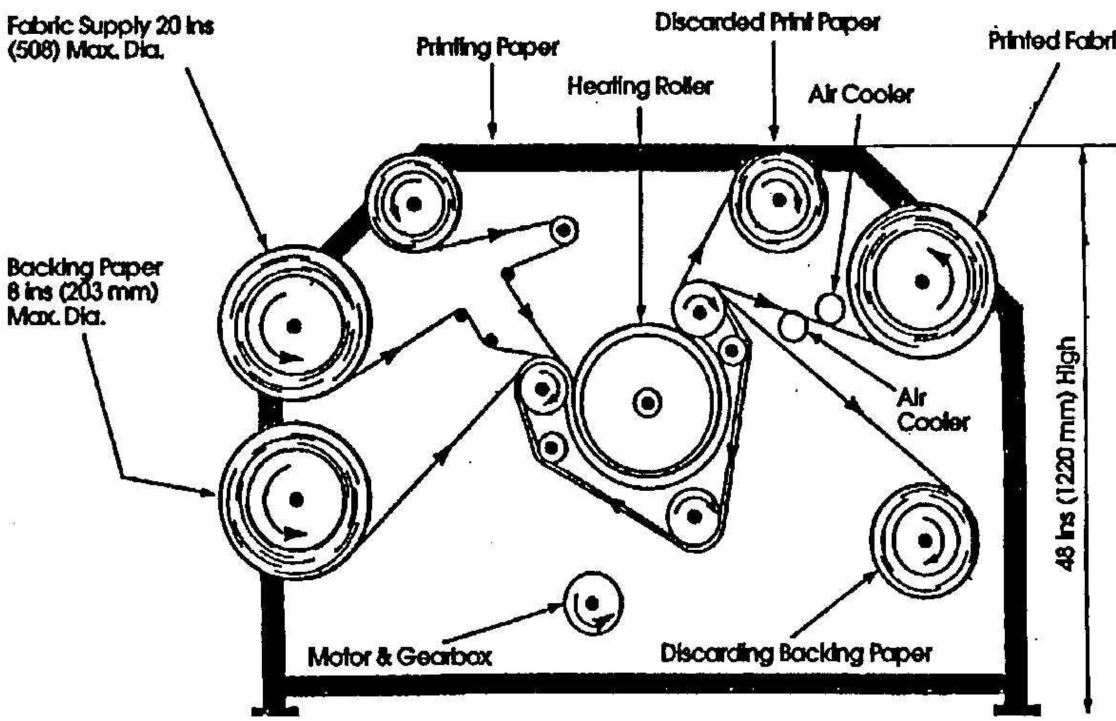


4.7 Heat Transfer Printing

Heat transfer printing is a technique where paper is printed, followed by the transfer of the design from the paper onto the textile fabric. For cotton, the only widely used commercial process involves printing release paper with pigments.

The design on the paper is placed onto the fabric, heated so that the pigment binder softens, releases from the paper, and adheres to the fabric. This release temperature is usually around 400°F (205°C). Figure 8 shows a schematic of a heat transfer printing calendar. This machine is used for printing rolls of fabric. From the schematic, the print paper is held in contact to the print fabric as they travel around a heated cylinder. The heating time varies, but is long enough for the color to transfer to the fabric. Backing paper is used behind the print cloth to capture any color which might come through the fabric. This is discarded after printing.

Figure 8 – Heat Transfer Printing on Continuous Fabric.



In general, fabrics printed using this technique must be treated with caution when being ironed or exposed to excessive heat. Also, these fabrics will exhibit all the other characteristics of pigment prints both good and bad. As a point of information, there have been a number of attempts to heat transfer reactive dyes employing a combination of wet/dry processing. None of these attempts has been a widespread commercial success.

4.8 Digital **Ink-Jet Printing**

The newest printing method for textiles is digital ink-jet printing. From a technical standpoint, this process is identical to the ink-jet printer used with nearly every desktop computer. However, for fabrics, these machines are 60-84 inches wide. Digital printing offers tremendous design capabilities. Designs of photographic image quality are possible with this technique. Of course, the method uses a CAD system with digitized image data. It presents the opportunity to change from one design to another immediately without any printed fabric waste. This method has been used in conjunction with body-scan data to produce printed fabrics that are custom fitted for the individual. It has also been used to rapidly produce trial prints for sale or evaluation. Many individuals foresee this method as a technique for the future. There are technological shortcomings associated with this method. The current top printing speeds range from 30-150 yards per hour for flat fabrics compared with a rotary screen machine output of 50-120 yards per minute. The limiting factor on printing speed is the technology of the printing heads. Reports indicate that these production speeds will not increase unless there is a breakthrough in the mechanics of the printing heads. Other printer hardware limitations include cost of the printer heads, ink-jet nozzle clogging, ink recycle, reuse systems, and machine width limitations. Figure 9 is a photo of a typical traversing print head digital ink jet printer. Higher speed digital printers, those with speeds over 60 yards per hour, use up to 4-printing heads that print simultaneously.

Figure 9 – Digital Ink Jet Printer.

In addition to these hurdles, there are color depth and colorfastness issues with many of the dye systems currently available. Generally, the fabric to be printed must be pretreated with a material such as sodium alginate and alkali, so the printed dye will not bleed and smear before fixation. Ink-jet pigment inks have been developed, but from a commercial viewpoint, ink viscosity, pigment colorant particle size, and print durability are limiting factors.

Regardless of the technical limitations, digital ink-jet printing is a viable commercial alternative technique for small runs (50 yards and under) of highly styled premium fabrics as are used in scarves and ties. Currently, numerous organizations are researching ways to overcome the problems of ink-jet printing of textile fabrics.

5.0 Special Printing Techniques

5.1 Resist Printing

In addition to normal printing techniques, there are special techniques available to the printer to produce unique effects on fabric. The first of these is resist printing. In this method, the fabric is first printed in a design with a chemical that resists dye. The fabric is then dyed. The resist will leave the fabric white or some other color in the print areas. One of the advantages of this method is that dyes with very high colorfastness can be used. For cotton, resist printing can be performed with reactive, vat, or naphthol dyes. This method is very similar to the ancient method of batik.

5.2 Discharge Printing

A second unique process is known as discharge printing. In this method, the fabric is dyed to the required ground color. Next, the fabric is printed with a chemical that selectively destroys the dye. This leaves a white ‘discharge’ design in the ground color. As an alternative along with the discharging agent, a dye, which is unaffected by the discharge agent, is printed onto the fabric. This yields special color effects of a colored discharge design surrounded by a stable ground color. Using this method, it is possible to surround delicate colors and intricate patterns with deep ground colors. Both discharge and resist printing have higher production costs than normal printing techniques. However, designs not easily achieved with other methods are produced this way. In the case of discharge printing, care must be taken to choose dyes that can be selectively destroyed without extraordinary means and without damaging the textile fabric. Discharge printing is routinely performed on cotton fabrics.

5.3 Flock Printing

A third unique printing technique is known as flock printing. Here an adhesive is printed in a design on the fabric. Next, the fabric is covered with cut fiber known as flock. The fiber is then embedded in the adhesive by one of various techniques such as compressed air, the shaking process, or the electrostatic process. Once the fiber is embedded in the resin, the resin is cured to firmly fix the fiber. This technique produces a three-dimensional pile surface effect in a specific design on the fabric.

5.4 Puff Printing

Puff printing is another unique technique where a three dimensional design can be obtained on the surface of the fabric. In this technique one or more of the parts of the design are printed with a compound (usually a urethane) that swells when heated. This is usually done with pigment prints and it is the heat of curing that swells the compound. This can also be used to create a puckered effect on the fabric.

5.5 Burn out Prints

Burn out printing is the method used to create a sheer pattern or random look. In the standard process, a fabric made from a yarn blend of cotton yarns and filament polyester yarns or core spun yarns cotton-filament polyester strong, is printed with mineral acid in the print paste. This is heated so that the acid attacks and destroys the cotton leaving the polyester. This results in a sheer pattern on the fabric. Pigments or disperse dyes can be included in the print paste to color the polyester which is left behind.

5.6 Foil Prints

Foil can be applied to the surface of the fabric in a design or pattern. In one method, foil is precut into patterns and backed with an adhesive. The foil design is transferred to the fabric and simultaneously heated to cure the adhesive. This is a type of heat transfer printing.

In an alternative method, an adhesive pigment is printed on the fabric. A thin foil sheet is placed in contact with the adhesive and heated to cure the adhesive. The foil film is removed leaving a foil design wherever the film was in contact with the adhesive.

5.7 Specialty Pigment Prints

There are a number of specialty items that are printed using pigment binder systems. In most cases, the specialty materials are just one part of the overall design. The rest of the design is printed with standard pigments. These specialty materials include glitter, metal flake, finely ground plastic chips, ground mother of pearl, and sugar. These are all granular materials and must be ground very fine in order to pass through the mesh of the print screens.

5.8 Specialty Dye Prints

There are a number of dyes with unique color characteristics that are popular today. In some cases the materials are printed as dyes. In other cases they are printed like a pigment using a binder system.

Fluorescent colorant prints have the ability to absorb invisible UV energy and re-emit this as visible light. This makes these prints extremely bright.

Phototropic colorant prints have the ability to change color when they are exposed to UV energy, especially sunlight. In some of these designs, the print appears to be only black and white in the closet. But when it is worn outside, it turns into an array of colors.

Thermotropic colorant prints are sensitive to heat. This is, they change color when they reach a certain specific temperature but change back to their original color at room temperature. Many of these materials have a color change temperature of around 98ºF, which can make for some interesting color effects when worn as a garment.

Phosphorescent colorant prints have the ability to glow in the dark. These colorants absorb light energy, especially sunlight, and then slowly release this energy over time. This effect is most dramatic when a garment or item is in the sunlight during the day, and then is worn in the dark at night. As commercial products, these are only used as pigments.

6.0 Summary of Textile Printing

The desire to use textile fabrics as a carrier of designs for decoration or identification has existed for many centuries. The development of modern equipment and colorant technology has enabled textile manufacturers to be able to reproduce highly colored textile designs with excellent colorfastness. This can be performed on a wide variety of fibers and fabric constructions, employing cost effective processes. However, as good as textile-printing technology is today, the processes are continuing to improve. New technologies and new developments in existing methods promise to continue the expansion of the capabilities of textile printing well into the future.

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