Digital Printing of Textiles: A 'How-To' Discussion

In recent years, digital printing has become very attractive as a method for decorating textiles. Because of the efficiencies it brings to the production process, textile inkjet printing not only reduces costs normally incurred with screen printing, but also drastically improves lead times and opens up worlds of design possibilities. There have been many trendsetters who have discovered this process and have applied it to a wide variety of markets. A number of these pioneers have come from the traditional textile printing world to learn digital printing. Others have come from the graphics field and are having to learn some of the techniques and jargon from the traditional textile industry as well. Both may benefit from our discussion of basic techniques and market applications of the finished prints.

Are you ready to digitally scan a customer's exact measurements have her dress style ... material ... pattern ... and colors digitally printed, digitally cut, sewn and ready for pickup within a day? Mass customization is a reality.

Markets for Digitally Printed Textiles

One of the most exciting aspects of digital printing on textiles is the incredibly wide array of markets in which it can be applied. Early on, traditional rotary screen textile printers experimented with applying standard graphic inks to fabric using regular graphic printers in order to develop new patterns without incurring the high costs of rotary screen engraving. They met with some success (much to the chagrin of rotary screen engravers) but they had some limitations. One problem they bumped into was that of metamerism. It is possible to match colors printed by both graphic inks and traditional textile dyes under a particular light source such as daylight, but if they are then viewed under a different light source, they may appear different. The issue of metamerism could only be addressed by using the same types of dyes in both the digitally printed sample and the rotary screen-printed production goods. Thus a few dyestuff companies endeavored to produce digital inks from their textile dyestuffs. You will see the words "inks" and "dyes" used almost interchangeably in the rest of the discussion.

Once digital inks were produced from textile dyestuffs, many textile printers began to see other advantages over graphic inks. The dyestuffs could be "fixed" exactly as they would be if rotary printed. This provided a finished fabric with commercial fastness properties. The digitally-printed goods had excellent resistance to laundering and sunlight, and the colors would not "crock" or rub off onto other fabrics. These advantages led to applications such as printing flags, ban-

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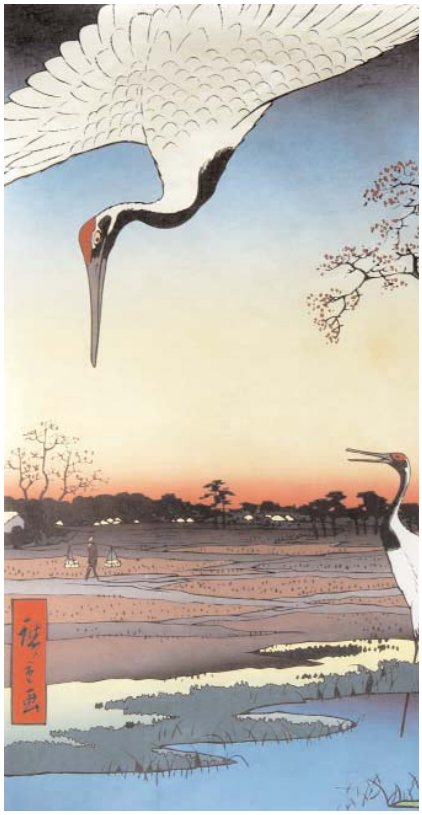

Figure 1: Silk banner digitally printed with fiber reactive inks.

Figure 2: The Steamjet pressurized steamer from Jacquard, for steam-fixation of digitally printed fabrics of all fibers.

Figure 3: Reggiani DReAM printer being used in large-scale flag production in Berlin, Germany.

ners and signs, apparel, home furnishings and quilting fabrics, nonwoven and technical textiles, gaming tables, even leather. All of the materials involved in these markets are now printed on a daily basis by printers around the world. The process is not as complicated as many believe, as long as you follow a few guidelines. Informed selection of fabric, ink and equipment can greatly simplify the process and allow the printer to produce a superior product.

How Do I Select My Ink?

Currently, there are four types of dyestuffs available for commercial use as digital inks. Each type is capable of printing on a particular type (or types) of fiber. They are:

Fiber Reactive Inks – Cotton, linen, silk, rayon and many other plant-derived fibers including jute and hemp can all be printed with fiber-reactive inks. The colors are very bright and the light fastness is appropriate for apparel and home furnishings. Because the dye in the ink chemically reacts with the fiber, it actually becomes part of the fiber, giving excellent wash fastness. Fiber reactive inks require the use of fabric that is pretreated for printing with them. Such fabric is commercially available today from a wide variety of sources. Once printed, the fabric must be steamed and washed, which is much simpler than many printers realize.

Acid Inks – Nylon, silk, wool and leather can all be printed with acid inks. As with fiber reactive inks, acid inks give very bright colors and have overall better light fastness than fiber reactives, making them appropriate for outdoor flags. Acid dyes also react with the fibers giving very good wash fastness. As with reactive inks, the fabric must be pretreated with materials to facilitate their fixation and again, this pretreated fabric is widely available commercially. Also, as with reactives, post-processing of materials printed with acid ink involves steaming and washing the fabric (with the exception of leather).

Disperse Inks – Disperse inks in almost all cases are limited to being used on polyester. The colors can be bright, but in general are not quite as bright as those of the acid and reactive inks. Disperse dyes "sublime," or become a gas when heated to very high temperatures. Once they become gaseous, they are absorbed by the polyester fibers. The dye condenses and becomes physically trapped inside, thus giving very good resistance to laundering. Disperse inks typically fall into two categories: low energy and high energy. Low energy, or "dye sublimation" inks provide good light fastness and resistance to weather. They can be either printed onto paper and subsequently transferred onto polyester, or they can be printed directly onto fabric and then "thermosoled" or heated in an oven or transfer press. High energy disperse dyes provide outstanding light fastness. Their excellent resistance to fading in sunlight make them appropriate for the toughest outdoor applications including lawn furniture and automotive upholstery. They are printed directly onto the fabric that is then cured in an oven or passes through a transfer press for fixation. They cannot be transferred from paper to polyester. Because of the popularity of "dye sub" printing, polyesters for digital printing are probably the most widely available of digital fabrics.

Pigment Inks – At first glance, pigment inks seem to be the best choice for printing textiles. They tend to have excellent light fastness and can be used on all fibers. Fixation is very simple, involving only heat or UV curing. However, pigment inks must contain a resin to glue the pigments onto the fiber. The addition of this resin limits the amount of pigment that can be included in the ink. Therefore, a pigment ink that contains a high level of color typically has less resin, and thus has lower wash fastness. Pigment inks with good wash fastness typically have less color in them. Because many of these resins cure, like glue, when heated, they cannot be used with thermal (bubble jet) printers.

How Do I Select My Fabric?

There are literally thousands of fabrics available for printing and the number of fabric suppliers is rapidly growing. However, for superior print results, it's crucial to find a reliable consistent fabric source that specializes in your desired fabric. It's also important to select the appropriate fabric for your application. For example, flags, banners, signs and outdoor materials typically need to be made of woven synthetic fabric such as nylon or polyester for durability. For apparel and home furnishings, anything goes. Gaming table fabrics were traditionally made from wool, but are now also made from nylon and polyester. Because the good or bad pretreatment of the

fabric can mean either success or failure of the finished product to perform its intended task, it's important to choose a fabric supplier who is technically adept.

Adequate pretreatment of textiles for digital printing is relatively simple, however, many manufacturers have perfected their fabric pretreatments by developing proprietary formulations that improve the performance of their fabric. Such fabric is typically "padded" or impregnated with a solution and subsequently dried in an oven. For basic fabric pretreatment, the elements of this solution can include:

Antimigrants – To prevent migration of ink and prevent "bleeding."

Acids/Alkalis – To support reactions of acid and reactive inks, respectively.

Urea/Glycols – To increase moisture content of the fabric, giving high, even fixation of the inks.

"Effects" Chemicals – Vary widely in purpose. Although there are too many effects to mention here, they can include chemicals to improve the brightness of the prints, water and stain repellants, UV absorbers to improve the fabric's resistance to sunlight, fabric softeners/stiffeners, even antimicrobials to provide resistance to mildew and germs.

The processing of the fabric during pretreatment is also an important factor in producing a superior finished printed fabric. Fabrics must be crease-free and even in width. Some producers provide fabrics that are backed with removable paper to allow companies with graphic printers that have been retrofitted with textile inks to print fabrics. This paper, and the adhesive that holds it to the fabric, must be properly applied so that the paper can be removed easily from the fabric.

Figure 4: Silk banner digitally printed with fiber reactive inks.

What's the Best Digital Printer for Me?

As the number of shops using digital printing has grown over the past few years, the corresponding number of printer models has increased as well. The textile printing capabilities (and prices) of these machines vary widely, but the printers can roughly be grouped into two categories: plotters and industrial printers.

Many textile digital plotters started their lives as paper or vinyl graphic printers. Plotter manufacturers (including Mimaki, Roland, Epson, Encad and a host of others) made simple modifications to the substrate-feeding mechanisms on their machines and met with great success. These modifications included modifying the pinch-rollers that hold the material flat before traveling under the print heads, and removing the vacuum systems that were ineffective in holding down the porous textile material. Over the years, these modifications have advanced to include the mounting of the digital plotter on top of a rubber belt that has been coated with an adhesive. This allows elastic materials pressed onto the belt – such as swimwear fabrics – to be fed through the machine easily and consistently. Plotter speeds vary widely, from three to thirty square yards per hour, depending on the model of the machine and the resolution of the image.

Figure 5: The Rimslow Wash-X designed for digital printers washes and dries fabric continuously from roll to roll.

Because of the obvious economic advantages of digital printing over traditional printing, there is now a strong demand for sophisticated machines with very high production capabilities and very robust performance. Thus, a few traditional textile screen-printing equipment manufacturers (such as Reggiani Macchine of Italy) have begun to develop machine designs based on the tried-and-true industrial screen printers of the past. These large machines are capable of producing up to 185 square yards of high-resolution printed fabric per hour. By retaining the basic workings of the machine and replacing the screens with a large number of robust print heads, they have produced equipment capable of running 24 hours a day, 7 days a week with little or no downtime. Although the machines are expensive to produce, the variable cost

Figure 6: The DReAM industrial digital textile printer from Reggiani, capable of printing 86 inch-wide fabrics at 185 square yards per hour (1650 square feet/hour) at 600 dpi resolution.

Figure 7: The Mimaki TX2-1600 digital textile printer.

Figure 8: Xorella MINICONTEXXOR® for Fabric Steaming and Conditioning. For the use of all thermal treatments of fabrics of all substrates, both manmade and natural fibers within the saturated steam range between 50° - 150°C, for processes of print dye fixation. Handles fabrics up to 84 inches in width.

savings to the print shop with enough throughput can be enormous. Many machine owners are currently producing over 300,000 linear yards of 60-85"wide goods per year with their machines.

What Other Equipment Will I Need?

The equipment you will need for pre- and post-treatment depends largely on fabric and ink type, and on the scale of production you anticipate. If printing pigment inks, no pretreatment may be necessary and inexpensive textile curing ovens can be used for post-treatment. A transfer press may be all that is necessary for subliming disperse dyes, whether for paper-transfer or direct-printed polyester. For acid and reactive inks, a steamer and washer will be necessary to fix the dyes and subsequently wash off any excess dye. Some examples of this pre and post-treatment equipment are shown in Figures 2, 5 and 8 (pages 42 and 43).

How Do I Process My Printed Fabric?

Once you have digitally printed fabric, you must perform some process to fix the ink. What process this is depends on the type of ink you use. Post-treatments by ink type are:

Pigment – Pigments are the simplest to process and involve only curing in an oven. Typically, ink manufacturers recommend a cure at 325-350° F for 30-90 seconds. Some print shops use their transfer presses to accomplish this task.

Disperse – For disperse-transfer or dye sublimation, paper is printed and subsequently transferred in a press to polyester at 380-410° F for 30-90 seconds. For direct-printed disperse inks, the fabric is cured or thermosoled at 380-410° F and, depending on the fabric, is subsequently washed and dried to remove excess unfixed dye.

Reactive – Reactive-printed fabrics are steamed to fix the dyes. In non-pressurized or "atmospheric" steamers where the material is not rolled up, the fabric is steamed for 8-10 minutes at 212-214°F. The time required for reactive dye fixation in pressurized steamers varies from manufacturer to manufacturer but is typically in the 20-30 minute range. Once reactive dyes have been steamed, the fabric must be washed. Because of the amount of unfixed color that is removed in the washing process, it's generally recommend that reactive prints be washed in two or more cycles, starting with a cold rinse and followed by progressively hotter washes. By doing the washing in steps, a limited amount of unfixed color is removed in each cycle, thus reducing the chance of "backstaining" the fabric with loose dye. In some washing units, there are multiple washing troughs, allowing multiple cycles to be performed in one pass through the unit. Drying the fabric can be performed with many types of machinery, from dedicated textile drying units to transfer presses. Many print shops use residential tumble dryers.

Acid – As with reactive dyes, acid dyes are steamed in the fixation step. The temperatures are the same but the times are roughly doubled, to about 20 minutes in atmospheric steamers (40 minutes for heavy materials and green/turquoise shades) and about 40–60 minutes in pressurized steamers. The washing procedure for acid dye-printed fabrics is essentially identical to reactive-printed fabrics, starting with cold rinsing followed by successively hotter washes.

The Future of Digital Textile Printing

There has been and will be much speculation as to where new applications of digital printing will be found in the future. In one scenario, a customer walks into a clothing boutique one afternoon to buy a new spring dress. The customer dons a form-fitting bathing suit and steps into a booth where her exact measurements are taken by a digital scanner. She then selects the style of the dress she prefers, then her favorite material, then the pattern, even the colors of the individual flowers in the pattern. Within 24 hours the fabric has been digitally printed and digitally cut and sewn and the dress is ready for pickup the next day in exactly her size, favorite pattern, and favorite colors. This concept of "mass customization" is already a reality presented by TC^2, a not-for-profit organization based in Cary, North Carolina involved in promoting the advancement of technology in the sewn goods industry. Artists and designers are now working on designs at home or in branch offices. Their finished designs are downloaded directly to digital print machines in print shops or even in their customers' offices. Custom digitally printed silk ties are now being offered for prices that the average consumer can afford. Low cost digital T-shirt printers are now available that can print custom designs quickly and efficiently.

The applications for digital fabric printing are endless. With the low cost, fast turnaround and unlimited flexibility, it has begun to take over large portions of the print-for pay market and with advancements in software, hardware, and chemical technology being made every day, the old way of printing may be going the way of the dinosaur….