The Future of Textile Printing…*Will be Digital*

Brooks G. Tippett
Digital Printing Systems
Orangeburg, New York, USA

Abstract

The world of textile printing is rapidly changing. Customers are demanding a greater variety of color and design. Responding to this demand is a necessity in today's marketplace. Printers are forced to find new and innovative ways to provide printed samples while minimizing cost and waste. Digital printing technology allows customers to streamline the entire design, sampling, and production process.

The majority of all textiles are printed using rotary screen print machines. While this technology offers high speed and inexpensive output, there are many drawbacks. The average order size is rapidly decreasing, and textile companies are printing shorter runs. Rotary screen technology offers obvious benefits during long runs, but does not provide economical short run production. Again, the answer lies in digital printing. Unfortunately, production digital printing of textiles was not a possibility…until now.

When it comes to true inkjet production for textiles, there are not many choices. Most of the current inkjet printers were designed for graphic arts printing, not fabric. Several companies have begun addressing these problems, and the future of digital printing of textiles is beginning to take shape. Targeted to hit the market in 2001 are printers with speeds up to 50 m^2 / hour for direct textile printing and up to 200 m^2 / hour for transfer printing. In addition, most of the machines currently being developed for textiles are based on existing print machines and material handling systems. These printers will be capable of multiple ink chemistries and will print both knitted and woven fabrics.

Digital Technology Has Finally Met the Challenge of True Production Printing….

The Changing World of Textile Printing

The world of textile printing is rapidly changing. For the last ten to fifteen years, textile printers have been talking about decreasing run sizes and fewer repeat orders. One leading cause of this new trend is change in the average consumer. Consumers of printed textiles are demanding a greater variety of color and design. They want fabrics that express their individuality in their homes and in the clothes that they wear. In addition to these demands, the need for quick order turnaround has never been greater. With no promise of a return to the good old days of 20,000-yard average runs and a constant group of loyal customers, printers have been forced to look for other options. Almost all of the traditional textile printers are asking the same question – what is happening and how can we respond to these changes?

The answer is not a simple one, but one popular explanation of this new trend is mass customization. Mass customization is a new theory of production that specializes in short runs (as little as one unit) in which customers dictate exactly what they want. Mass customization involves nearly unlimited design, multiple colorways and is very customer oriented. In order to better understand mass customization, we will look at a few examples of how it is currently being implemented in other industries.

1. **Dell and Gateway:** In the computer industry, Dell and Gateway are pioneers in mass customization. Both companies allow the consumer to "design" a PC or laptop that best meets their needs. The consumer can select from various base models and upgrade the components for improved performance. In some cases, the consumer can purchase optional accessories and change the color of their computer. The end result is a product the customer feels like they have personalized and is very happy with. Both companies have been very successful in their efforts and are perfect examples of mass customization.
2. **Gerber Technology and Digibits Interactive** – Two less familiar entities but better examples of how mass customization will affect our industry. Both of these companies have produced software that allows a designer or buyer to look at different designs on a finished piece of apparel or home furnishing. Viewers can change design colors or put various designs together to see how an outfit will look before producing that outfit. In the very near future, consumers will have similar technology available to them via the Internet and possibly in retail stores. If a consumer likes a dress or piece of apparel but not the design or color, he or she will be able to choose different patterns and colors and have the garment shipped to them.

So how do textile producers offer mass customization? How can the large textile printer offer this option and not completely stray from his existing business? The answer to these questions is a simple one – digital printing. Digital printing is a new technology that offers multiple benefits to the traditional textile producer. Digital printing has a dual

function in printing, acting both as a sampling and production tool. In sampling, digital printing offers immediate results, provides tremendous flexibility in design and coloration and saves time and money. Digital printing as a production tool helps to minimize inventory and provides the option of mass customization. In order to understand why digital printing is such an important new technology in textiles, we will take a brief look at both technologies.

Rotary Screen Printing vs. Digital Printing

Rotary screen printing is arguably the most popular method of traditional textile printing. On a rotary screen print machine, colors and patterns are applied through nickel screens. Each color in the pattern is applied one at a time, usually from dark to light. Engraved areas allow color to pass through and form one piece of the pattern. The screens are adjusted so that printed areas fit together and form the final pattern.

Rotary screen printing offers many benefits in textile printing. Rotary screen print machines offer high-speed production and economical long runs. The colorants available provide a large color gamut and are relatively inexpensive. Rotary screen machines are typically partnered with dryers and other finishing equipment to provide a continuous and simple procedure - print and dry or print, steam, wash and dry. The resulting print is durable to light or fade, crock (scrub), and wash.

Although rotary screen printing offers many benefits, there are also several important drawbacks to this type of textile printing. One of the biggest drawbacks is machine efficiency (downtime). A pattern setup can take up to one hour, and clean up can take 1 to 2 hours. Due to lengthy pattern changes and printing problems, the typical print machine runs approximately 40 % of the time. Because of this inefficiency, short print runs are not economical. For example, if the setup time and clean up time is a total of one hour, and the print machine operates at an average speed of 30 yards per minute, the printer must print 1800 yards to match printing time with setup time. Unfortunately, print buyers are now asking for one-time runs of 500 yards or less and printers have to refuse the orders. To summarize – printers don't have enough business because they must refuse the small yardage runs that cannot be economically produced.

In addition to the machine efficiency, traditional printing also involves a lengthy and expensive sampling process. The design is converted into screen files and screens are engraved. Once screens are ready, colors are matched and patterns are "struck-off" on the print machine. With an average strike-off time of 5-6 hours and screen engraving turnaround of two to three days, the total time design origination to finished product can be several weeks.

So how does digital printing help to eliminate these problems? One of the biggest benefits digital printing provides is the reduction of downtime. Digital printers do not require a lengthy setup time between patterns and can print continuously 24 hours a day, 7 days a week, 365 days per year. In addition to increased efficiency, digital printing also provides the elimination of screen cost in sampling and short-run production. Printing without screens eliminates the registration problems and most importantly – provides mass customization. Designers can make pattern and color changes immediately and print a sample before engraving screens for the final run. On a digital production machine, the printer can produce as little as one repeat of several patterns using multiple colorways, all in a few minutes.

Based on what we have just discussed, you must be thinking – "digital printing sounds great; what's the problem?" As I mentioned above, digital printing of textiles is very new technology and the available models do have limitations. One of the biggest questions that I receive from textile producers is, "why does it seem that digital printers for textiles are progressing so slowly?" There is no clear answer to this question, but we can look at it from two points of view. First of all, let's look at the problem from a machine manufacturer and integrator's perspective.

Machine integrators in digital printing bring together the collective talents of companies involved with digital printing to offer complete, innovative digital printing solutions. However, when work first began regarding digital textile printing, 99% of all ink jet heads manufactured were targeted toward consumer home/office applications. This means that the print heads were designed to be thrown away and would not survive in a production environment. Additionally, there was not enough incentive for manufacturers to invest in unproven industries, and the customer interest was not there because the right solution did not exist. Further compounding this problem was the lack of proper ink chemistry designed for durability and special coatings or lamination were required to achieve proper print quality. While all of these issues severely limited development of digital printing, arguably the biggest limitation was proper material handling systems. Textile substrates are flexible and porous and traditional digital technology manufacturers and integrators had to learn how to print all over again.

Secondly, and arguably the most important viewpoint to consider is that of textile printers. Textile manufacturers are historically very conservative and sometimes reluctant to adopt new technologies. In many cases, a textile producer will wait to adopt new technology until someone else buys it first. This reluctance, although justified in some cases, has prevented some developmental efforts in digital textile printing. In defense of textile producers, digital printers offered much slower speeds than traditional printing methods and lowered the available color gamut. The original digital printers provided only CYMK process color, and special pretreatments were required to achieve proper print quality. In addition, many textile customers were required to purchase special fabrics and did not have an option to use their own fabrics. Printers that did allow customers to use their fabrics limited the type of fabrics that could be used. Most printers could not print stretch knits and performance fabrics and fabric capable printers were limited to small rolls of 10 to 15 yards. While some

advancement has been made, the truth remains: **Until now, none of the equipment available was acceptable for production on textiles.**

In order to bridge the gap between textile manufacturers and digital printing integrators, we will take a quick look at ink jet technology in the following section. After reading about the various types of ink jet print heads, hopefully you will understand terms like drop on demand and bubble-jet.

Digital Technology – A Brief Overview

There are two fundamental types of inkjet technology – Drop on Demand and Continuous Ink Jet. Both have benefits and drawbacks, depending on the construction and engineering of the print head. We will briefly look at examples of each type.

Drop on Demand Technology

Drop on Demand ink jet print heads use either Thermal (TIJ) or Piezoelectric (PIJ) technology to place droplets onto the substrate only when they are needed.

Thermal Ink Jet Heads use heat to form a bubble in the ink chamber, forcing droplets of ink out of the nozzle. Up to 85% of all inkjet heads in the ink jet market are thermal, and most use water based inks. Thermal ink jet heads are inexpensive to manufacture, are well suited technology for low-volume printing. They produce high resolution prints by using small drop size, and are capable of up to 1440 dots per inch (DPI). Thermal technology is sometimes referred to as "bubble-jet."

Piezoelectric (Piezo) ink jet print heads use electric charge to warp the interior of an ink chamber, forcing droplets of ink out of the nozzle. Piezo print heads are well suited for high-volume printing, because reliability is built into the design of a print head. Piezo print heads also allow for a wide range of ink formulations, including binder containing pigment inks.

Continuous Ink Jet Technology

Continuous ink jet print (CIJ) heads use a continuous stream of ink droplets that are given a charge. The charged droplets then pass through a deflection area where they are either reclaimed into a "gutter" system or placed onto the substrate. The two main types of CIJ are Binary and Multi-Deflection.

Binary CIJ print heads use a simple gutter and ink reclamation system to control drop placement on the substrate. As ink droplets pass through the charging area in a binary system, they are either deflected into a gutter or allowed to drop onto the substrate. Some ink jet experts claim that binary continuous ink jet is poorly adapted to process colors and that it is expensive to manufacture and maintain.

Multi-Deflection CIJ print heads are the newest form of CIJ technology. A multi-deflection CIJ print head uses the same basic principle as binary CIJ, but with more control. As droplets of ink pass through charging areas in a multi-deflection head, the print system can give varying amounts of charge to the droplet. As droplets then pass through a deflection area, they can be placed on the substrate at a variety of angles. Most multi-deflection CIJ print heads have up to 5 angles of drop travel, excluding the path into a gutter system.

The Role of the Integrator and Choosing the Technology that Works Best for Textiles

Digital Printing Systems is an integrator, a company whose role is to bring together the collective talents of companies involved with digital printing to offer complete, innovative digital printing solutions. When we began searching for technology to build a textile printer, we looked at various advantages and drawbacks to the different ink jet technologies. We are not saying that our choice is the only correct choice, because in ink jet printing, no one machine will meet every printer's needs. However, I will touch on our evaluation of the technologies and our conclusions.

We first looked at thermal print heads due to their availability and low cost. After an in-depth evaluation, we rejected thermal heads due to their short life span. A thermal print head is basically a throw away head and is not suited for the high-speed production environment. In addition, heating elements inside a thermal head severely restrict the use of binder containing pigment inks – a necessity to achieve print fastness. Piezo print heads were also evaluated and showed great promise. Piezo print heads have a much longer life span and allow for binder containing inks. However, in order to achieve good print quality, piezo print heads must be approximately 1 millimeter from the substrate surface. While this is okay for paper and vinyl substrates, the lint and thickness of textile substrates can cause nozzle clogging and head failure at that distance. In addition, the drop on demand properties of a piezo head cause some nozzle clogging when using pigment inks. The next print head to be evaluated was the binary CIJ print head. CIJ technology was very promising due to reduced clogging and drop speed, but binary CIJ print heads tend to be unreliable and expensive to maintain. CIJ technology does offer a significant nozzle distance from the substrate, but binary CIJ printers need an excessive number of printheads to cover fabric with ink drops. Binary CIJ was rejected due to its unreliable nature and cost. The final print head evaluated was a multi-deflection CIJ head. As with binary CIJ heads, multi-deflection heads provided faster drop velocity and a larger distance from the substrate. Contrary to binary CIJ heads, JEMTEX multi-deflection print heads offer reliability and more fabric coverage with fewer heads. JEMTEX multi-deflection print heads are 100 % stainless steel with replaceable alumina* nozzles and a large drop size. The combination of larger drop size and drop velocity provided fabric saturation, a vital key to producing uniform flat colors and preventing side-to-side shading problems. Because color is an important factor in textiles, we chose JEMTEX multi-deflection CIJ print heads for our textile printers.

A benefits summary of JEMTEX multi-deflection ink jet print heads:

1. **Designed for High Reliability and Long Lifetime**
   a. 100 % stainless steel print heads and alumina* nozzles
   b. Cover more pixels with less heads – reliable
   c. Inexpensive to manufacture and maintain
   d. Replaceable nozzles – easy to unscrew and clean if necessary
   ** Alumina is a special metal alloy that is extremely chemical resistant*

2. **Designed for High Throughput**
   a. Tested up to 200 m2/hr
   b. Well suited for textile printing and high speed applications

3. **Highly Modular and Interchangeable**
   a. Integration with a higher number of colors is much easier

4. **Allows for Flexible chemistry**
   a. High Viscosity inks – small dot expansion with strong colors
   b. Dye and Pigment Based Inks – Larger Drop size makes it possible to use Binder/Pigment Inks as well as Disperse and Acid Dye Inks (Not easily accomplished with DOD)
   c. Higher Drop Frequency – Fabric Penetration and Throughput

5. **Substrate Clearance**
   a. Allows Digital Printing on Thicker Fabrics
   b. Clogging is minimized

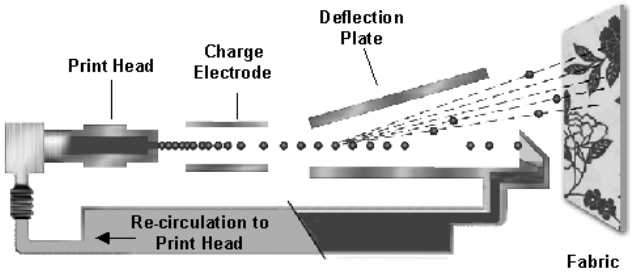

Figure 1. Multi-Deflection Continuous Inkjet Printing

Meeting the Needs of the Textile Industry

Based on a comparison of traditional printing and digital printing listed above, it is clear that only a printer designed for textiles will be successful. Printers currently being used for textiles were originally graphics printers and did not address all of the needs of the industry. In addition, width and speed limitations of available models did not provide adequate throughput needed at the end of an eight-hour day.

Figure 2. The Jemtex Family of Multi-Deflection Continuous Ink Jet Print Heads

Several companies have begun addressing these problems, and the future of digital printing of textiles is beginning to take shape. Targeted to hit the market in 2001 are printers with speeds up to 50 m^2 / hour for direct textile printing and up to 200 m^2 / hour for transfer printing. In addition, most of the machines currently being developed for textiles are based on existing print machines and material handling systems. These printers will be capable of multiple ink chemistries and will print both knitted and woven fabrics.

Probably the most asked question regarding digital printing of textiles is "when will these gadgets be as fast as my rotary screen printer?" Well, lets look at the actual speed of Rotary Screen printing vs. Digital Printing today:

Rotary Screen
- Average Pattern Speed of 30 yards / min
- Average of 40 % Efficiency or 60 % Downtime
- Net Speed = 30 yd / min * 40 % = 12 yd / min

Production Digital Technology
- Available in Speeds of 50 – 200 m2 / hour
- At a width of 65 inches, Speed is equivalent to approximately 1 – 2 linear yards / min

Current Speed Comparison
Rotary vs. Digital
12 yards / min *vs.* **1 – 2 yards / min**

When you analyze this speed comparison, notice that the gap continues to narrow! In addition, the elimination of pattern setup with screens and the ability of production ink jet printers to produce short-run yardage must be considered in the comparison of the two printing methods.

The "Other" Side of Digital Textile Printing

While the traditional textile manufacturers are slowly coming around and accepting digital printing technology, perhaps the fastest growing group of textile printers have no experience with traditional printing at all. This group of entrepreneurs consists of advertising groups, design companies, and even producers of complementary furnishings from adjacent industries. Many of these companies have begun experimenting with digital textile printing with great success. While their knowledge of textiles may be limited, their presence in the market cannot be underestimated. Through the use of the Internet and also retail organizations, several companies plan to offer custom fabrics for home furnishings, apparel, and just about any other fabric application you can imagine. One of the most impressive ideas I have seen offers the ability to design and coordinate a complete room – carpets, bedding, drapery, wallcoverings, and even furniture; all with patterns and colors chosen by the end user. Another group plans to offer customized apparel that can be design and colored by the user and even viewed for fit through special 3-D body animation software. The customer can input body measurements or have a body scan performed to generate a computer simulation of their figure. Special software then takes garment design data and simulates a virtual dressing room experience. Most of these businesses are in the early stages of development, but they will most likely be a strong force in textile markets by 2002.

Why is the Future Digital, and How Can My Company Utilize Digital Printing?

As mentioned earlier, digital printers play a dual role in textile printing and offer many advantages over existing technology.

In sampling, digital printers can shorten the time from design origination to production, reduce and / or eliminate traditional strike-offs, and get multiple colorway samples to the customer before your competitors.

As a production tool, digital printers provide Just In Time (JIT) manufacturing and allow textile producers to print only the number of yards that have been sold. A prime example of JIT manufacturing, digital production offers inventory reduction and better control. If a textile producer receives a small repeat order and they have no stock, or if they receive a large order and are a roll short – the order can be filled with digitally printed fabric. In addition to inventory control, production digital printing allows textile manufacturers to complement their current product line with creative digitally printed products. A textile manufacturer can offer unique products that were previously too costly and possibly create new markets. Arguably the most important benefit of production digital printing is capacity to accept short print runs and one-time orders. With run size decreasing and repeat orders becoming a rarity, textile printers must adapt in order to remain competitive.

Conclusion

The future of textile printing will be digital, though no one can predict when we will see it unfold. The bottom line is simple – printers are being developed that meet the needs of both traditional textile printers and entrepreneurs. For a traditional printer, digital printing saves time and money and will allow them to remain competitive in a changing world of textile printing. For an entrepreneur, digital printing offers all of the benefits described above; but most importantly, the freedom of unlimited design and a true vehicle for creative ideas.

Biography

Brooks G. Tippett is the Textile Product Manager for Digital Printing Systems. He is responsible for the design and integration of new textile inkjet solutions as well as the worldwide sales and marketing of all DPS machinery and ink for textile applications. Prior to working at DPS, Brooks held the position of Technical Manager for Excel Products in Los Angeles, California and Plant Chemist for the sheet printing operation of Fieldcrest Cannon in Kannapolis, NC. Brooks has focused the majority of his career on digital printing of textiles and has consulted for machinery manufacturers to promote research and development into this market. Brooks holds a B.S. degree in Textile Chemistry from Clemson University.