High Performance Piezo Ink Jet Printheads and Production Printing of Textiles

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Abstract

For some time, ink jet technology has been used to digitally print textiles, but with relatively low productivity. Recently, however, systems have been introduced that use piezo based ink jet printheads to digitally print textiles at rates required for practical production volumes. This paper reports the development and application of these new digital textile printers, which move productivity from that suitable for sampling to production speeds running from 600 ft^2/hr. to 3000 ft^2/hr. Characteristics of the printing systems, printheads and inks will be presented. Data for reliability and performance in the field will be presented along with production samples.

Introduction

Most existing digital printers for textiles have evolved from wide format graphics printers. Although the hardware, printheads and even inks are not necessarily ideal for production textile printers, this class of equipment has demonstrated that some of the benefits anticipated for digital printing of textiles are achievable. These systems have helped create entirely new opportunities in a market place long considered staid and inflexible. The equipment has also shown that many advances are required to move from novelty or sample printing to reliable, production printing for textiles. In particular, inks, color control and color management, cost competitiveness and reliability need to be improved.

Recently several machines for the digital printing of textiles have been introduced. These machines address both functional and commercial requirements for production printing of textiles. This paper will discuss several of these machines.

Development of Digital Textile Printers

Ink jet technology is rapidly penetrating markets long served by a wide variety of analog printing technologies as illustrated in Figure 1. This lays the groundwork for the development of production textile printing. Modified wide format machines have demonstrated the importance of printhead, ink and fabric in creating a successful printing system.

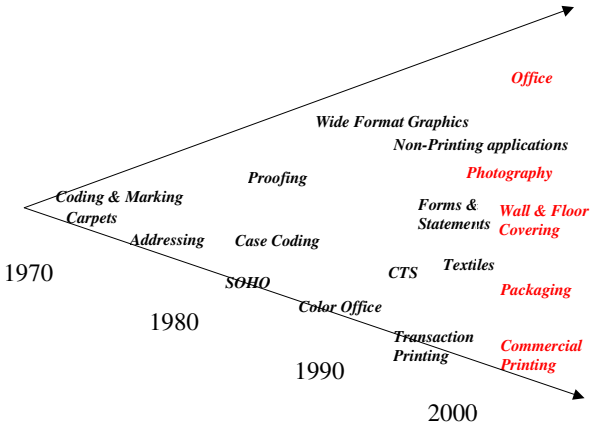

Figure 1. Expanding Ink Jet Market Potential

Ink Jet Printheads

There are advantages and disadvantages for each of the three common types of ink jets: continuous (binary or multi-deflection), piezo-based drop-on-demand and thermal (bubble) drop-on-demand. Tables I, II and III list some of the common attributes of these classes of ink jet technologies.

Table I. Advantages and Disadvantages of Continuous Ink Jets for Textiles

Advantages and Disadvantages of Ink Jets for Textiles	
Continuous Ink Jets	
Operating frequency	60-100 kHz or higher
High velocity	Increased standoff
Long life	Low cost of printing
Volume/Vel/Straightness	Excellent consistency
System complexity	Recirculation, head maintenance
Ink viscosity	1-3 cps limits formulations*. Jemtex is an exception.
Printhead cost	Expensive to manufacture
Equipment design	Heavy, large footprint. Cost of carriage design.
Ink types limited	Pigments difficult for many CIJ systems.

* Performance of Epson piezo fits this category.

Table II. Advantages and Disadvantages of Thermal Ink Jets for Textiles

Advantages and Disadvantages of Ink Jets for Textiles	
Thermal Ink Jet	
Low manufacturing cost	High volume/low cost systems
Proven technology	Reliable in office environment
Mass produced	Easy to integrate/design product
Small drops	High resolution, low speed; multiple passes for coverage
Low maintenance	User replaceable heads
Short head life	<1-10 liters, >cost to print
Ink viscosity	<6 cps, limits formulations
Ink types limited	Only aqueous inks practical

Table III. Advantages and Disadvantages of Piezo-based Ink Jets for Textiles

Advantages and Disadvantages of Ink Jets for Textiles	
Piezo-based Ink Jets	
Cost to manufacture	Lower than CIJ, higher than TIJ
Middle range operating frequency	20-40 kHz
Range of drop sizes	20 to 140 pl
Long life	>100 liters, Trident, Spectra printheads
High viscosity inks	Some >20 cps. May use temperature to decrease viscosity
Low maintenance	Simple purging and wiping systems
Low volume manufacture	Flexible printhead design options
Ink compatibility	Aqueous, solvent, UV curing, oil, glycol, etc.

A wide range of ink formulations has demonstrated reliable operation in piezo-based ink jet printheads. Pigmented ink systems are used in commercial applications such as date coding, addressing, label printing and wide format. The versatility of piezo-based ink jet printheads is further demonstrated by the familiar offerings from Epson for photographic quality printing that rely on both dyes and pigments.

The stiff structure of the jetting body itself permits relatively high ink viscosity as in the case of Spectra's printhead design (illustrated in Figure 2). In this structure all the components are relatively inert materials and ink does not directly contact electrodes. Thus, the printhead can jet a wide variety of textile ink.

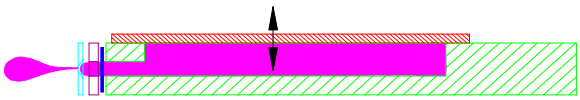

Figure 2. Cross-section of Spectra Jetting Module

Digital Textile Printing Equipment

During 2001 a number of new, innovative digital production printers, targeted for textiles, have been shown publicly. Three of these machines are based on piezo printheads, Virtu™ by Leggett and Platt, the DPS 65 by Digital Printing Systems, and DuPont's Artistri™. Zimmer's Chromotex is the exception, relying on continuous ink jet technology.

In January, 2001 DuPont introduced a fully integrated production-capable system at Heimtextil. Figure 3 depicts the Artistri™, which uses eight 256-jet Spectra aqueous compatible piezo printheads to produce 30 m^2/hr. of fabric. The machine has in-line heating for drying and curing prints before they exit the printer. The roll-to-roll fabric handling system enables printing on fabrics (cotton, polyester, cotton/polyester blends, etc.) with no paper backing. It handles fabrics up to 3.2 meters wide with a printable width of 3.05 meters. As can be seen, this is a sizable machine with a footprint of approximately 1.5 meters by 6 meters. DuPont's equipment partner is VUTEk, well known for supplying high-quality, superwide-format industrial printers. DuPont is currently unique in that it is formulating its own textile inks.

Figure 3. Artistri™ by DuPont

Before the introduction of the Artistri™, DuPont was marketing inks designed for sampling and strike-offs on a variety of fabrics. One set of these inks is an aqueous ink based on the same pigments used in conventional textile screen printing and requires drying for only 15-30 minutes at 120-140°C for curing. DuPont also manufactures an acid dye ink set suitable for the Artistri™ and for printing on silk

and nylon. This dye set requires that the fabric be pre- and post-treated similar to the methods used for conventional textile inks.

At DPI 2001 in Atlanta, L&P Digital Technologies, a division of Leggett & Platt, introduced the Virtu™ superwide-format printer that is capable of handling a range of fabrics with or without paper backing. The target application for the Virtu™ is printing mattress cover, a core business of Leggett & Platt. The system will be available for other textile printing applications as well as to wide format service bureaus. The Virtu™ uses two 256-nozzle Spectra piezo printheads for each of four process colors. Productivity is approximately 220 m^2/hr. at 180 dpi and 100 m^2/hr. at 360 dpi. L&P Digital Technologies designed the hardware to function at up to 100 linear meters/hr. to match the speed of mattress and stitching machinery which are the next process steps in the factory workflow. The ink set can print on virtually any textile, but may be most suitable for applications in which a good hand is not critical. Virtu's™ inks are aggressively priced enabling very low cost of ownership. L&P plans to provide other ink sets in the future. There are three models in this line of equipment: 2.3 m wide that handles fabric, vinyl and paper; 2.5 m wide for printing graphics on rigid substrates; and 3.5 m wide for rigid or flexible materials.

The Chromotex digital textile printer sold by Zimmer, located in Austria, uses Jemtex ink jet technology. This is continuous ink jet technology in an array format and the printhead can use relatively high viscosity inks. The machine is 2.2 m wide and dispenses 8 colors from refillable tanks. Dye sets include reactive, disperse and pigmented systems. The color management system can handle both process and spot color. The Jemtex printheads apply approximately 30 g/m^2 of ink at 100% so that there is good penetration of the fabric at resolutions equivalent to 125 mesh screen printing. Throughput is rated at up to 30 m^2/hr. with 4 colors and 15 m^2/hr. for 8 color printing. Again, this is not a small machine with a footprint of 5.5 m by 3.5 m by 1.55m.

The Digital Printing Systems' DPS 65 is based on an ink jet printing system supplied by Aprion. Print speeds at up to 185 m^2/hr. with a web 1.6 meters wide are claimed. Ink sets include pigmented and disperse dyes for six-color process printing. The equipment is designed to handle paper and vinyls.

Results from the Field

Initial textile industry reaction to the new equipment appears to be somewhat mixed. In general, these digital printers address some of the long-standing issues with ink jet based machines. The interfaces are practical and designed for people familiar with the textile industry. The hardware itself is rugged and engineered to handle hundreds of meters of fabric at reasonable production speeds and dryers are available. Ink sets are typically based on colorants already in use in the textile industry so that one would expect the finished textile to meet industry standards for washing, dry cleaning and lightfastness. There is still concern about durability of the ink jet printheads, reliability of the printing system and ink cost. Equipment prices ranging from $325,000 to close to $750,000 mean that many textile printers will be considering investing in this new technology. Today textiles are largely printed with spot colors, not process colors, and it is unclear if process color printing will be accepted by the industry and its customers.

Assuming that 30 g/m^2 are required for complete color saturation and that ink costs $50/liter, then the cost of a square meter of fabric at 100% coverage is $1.50 for the ink alone. Many home furnishing patterns require far less than 100% coverage and thus can capitalize on the inherent efficiency of digital printing. This market may be more attractive initially than textiles for garments.

Conclusion

The introduction of several high productivity digital textile printers means that the promise of digital printing will now be tested in the commercial world. Ink jet technologists and textile screen printers are eager and anxious to learn if digital processes will now begin to affect the ancient industry of textile printing in significant ways.

Biography

Dr. Creagh is currently Business Development Director at Spectra, Inc., Hanover, New Hampshire. Spectra, a MARKEM independent subsidiary, designs, manufactures and markets ink jet printheads and inks for industrial, graphic arts and commercial applications. Linda joined Spectra in 1985 as Director of Ink Development after 10 years in ink jet development with Xerox R&D. Before Xerox, she was involved in liquid display research at Texas Instruments. She has a number of technical publications and more than 15 US and foreign patents in the fields of ink jet technology and liquid crystal displays. Linda has B. S. and M. S. degrees in Chemistry and a Ph. D. in Physical Organic Chemistry from the University of North Texas. Linda has been an active member of IS&T for the past 15 years. She is also a member of the Society for Information Display and American Chemical Society.