State of Art of Inkjet Textile Printing: Status Report 2012

Hitoshi Ujiie
Philadelphia University
Philadelphia, PA / USA

Abstract
Since the introduction of inkjet textile printing technology in 2003, at ITMA in Birmingham, UK, textile inkjet printing production has changed from inkjet textile sample printing to complete production printing. However, the overall penetration rates for digital inkjet technology in the textile printing sectors are still meager compared with conventional analog printing technologies. Based on empirical research, including international case studies and field trips over the past 10 years, this paper disseminates current utilization of inkjet technologies. Ascertaining user standpoints, mills, printing service operations and designer perspectives will be investigated in relation to commercial applications. Missing links between the manufacturers, engineering concepts, and the end-users demands, will be also be scrutinized.

Introduction
The 1990's were a pivotal period, in which digital printing technology grew in scope, from simply printing with consumer desktops systems, to printing industrial yardage for commercial applications and price points. [1] The year 2003 became a benchmark for the textile printing industry, where production inkjet textile printing was introduced at ITMA (International Textile Machinery Association) in Birmingham, UK. Since then, inkjet textile printing technologies have upgraded their production speeds and assurance of printing capabilities for robust textile production printing.
While these technologies are improving, total utilizations of inkjet printers within the industrial textile sectors of interior and fashion textile printing are meager. (It is close to only 1% out of total conventional textile printing technologies.) [2]
The objective of this paper is to investigate and analyze:
(1) The state of art of the textile industry
(2) The state of art of inkjet printing technology
(3) The various case studies of the printing operations in the Europe and the US
(4) The positive and negative advantages for these models

State of art of the textile printing industry
Textile printing industries are divided into two market segments: industrial textile printing and soft signage printing. The industrial textile printing market produces printed fabrics for apparel, home furnishing, and technical textiles. The Soft signage textile printing market specializes in site-specific environmental graphics and commercial advertisements, which are printed as commercial banners, corporate flags, etc.

In the worldwide market, the printing production of the industrial textile sector has currently reached over 20 billion linear meters per year, and the annual growth rates have continuously gone over 1 percentage due to the acceleration of fashion cycles and continuous growth of the world population. Therefore, the current state of the industrial textile printing industry represents a healthy and demanding environment, and most likely, this growth will continue into the future. [3] [4] At the same time, according to market research reports by I.T. Strategy and Web Consulting in 2005 and 2006, the current market volume of industrial textiles market is twice the amount of soft signage market in terms of end-user expenditures. Nonetheless, current digital inkjet printing technology has utilized only 1 percent for industrial textile printing, and the rest of the textile productions have utilized conventional analog printing technologies.

In contrast, the soft signage printing industry has grown 45 percent in its adaption of digital inkjet printing technology. Some important reasons stem from the following factors: The soft signage industry has developed simultaneously alongside the graphic design industry in utilizing digital design technology. Similar to desktop publishing, the workflow from a computer to a printer is a natural transition. Whereas, the textile design industry has a longer, more complex history. This workflow has been based on conventional spot color systems, which require spot color screen separations and engraving processes, thus it has been more difficult to adapt a digital workflow.

Moreover, the soft signage industry operates with a diverse range of individual job-based projects, which consist of consulting services, designing, printing, finishing and installing the final printed products. Therefore, this industry can generate higher profit margins than the industrial textile printing market, in which the profit depends only on by the volume of printed yardage. [2] [5]

State of art of textile printing technology
The digital printing technologies for textiles have begun to reach their production speed and reliabilities for robust bulk productions. After ITMA 2011 in Barcelona, Spain, the average printing speed ranged from 400 – 600 square meter per hour, which is approximately four

times as fast as the first generation production printers introduced at ITMA 2003 in Birmingham. Among all, La Rio printer manufactured by MS Industry in Italy equips with 119 Kyocera print heads and has extended over the printing speed of 8100 square meter per hour. This is identical to an average printing speed for current rotary screen- printing production. Some of the other printers include:

• Allegra	Kornit	280 sqm/ hour
• Clairis	Zimmer	330 sqm/ hour
• Durst	Durst	600 sqm / hour
• Hongua	Hongua	250 sqm /hour
• La Meccanica	La Meccanica	420 sqm/ hour
• La Rio	MS Industry	8100 sqm/ hour
• Monna Lisa	Robustelli / Epson / Fortex	210 sqm/ hour
• Nassenger Pro 1000	Konica / Minolta	1000 sqm/ hour
• ReNIOR	Reggiani Machine	540 sqm/ hour

All of these printers accommodate multiple aqueous print heads for production, with drop on demand piezo technology. Although the ISIS printing system, (which was originally developed by Osiris of the Netherlands) is one of the exception to implement continuous inkjet technology, the current industry standard is a drop on demand peizo technology. [3]

Moreover, the current print heads on the printers listed above, function with dynamic drop volumes between 4 and 36 pico-liter, in contrast to the print heads, which previously utilized only static drop volumes. Therefore, the current printers are more flexible and reliable for printing a wide range of imagery on diverse range of textile substrates. Arising new challenges for proper penetrations of colorants, will be some of the concerns for the industrial textile printing sector in the future.

Case studies for the digital inkjet textile printing operations

From its inception, digital textile printing has been an economically demanding technology, compared to conventional textile printing technologies, due to the high costs of equipment supplies and slower production rates. Therefore, this technology was first adapted to printing operations for high-end luxury textile printing markets, including fashion dress, fashion accessories, and high-end home furnishing. Significantly, northern Italy has been the international capital of luxury textile printing, and the majority of the digital textile printing systems, have been placed in this region. According to field research conducted by the Center of Excellence of Digital Inkjet Printing for Textile at Philadelphia University during past 10 years, conversions from conventional textile printing systems to digital inkjet printing in this region have occurred at a steady rate. Many of these print mills operate full-digital printing production workflows: from digital designing to printing with production digital printers. [6]
Some of the highlights are as following.

- In early 2000, prior to the introduction of production digital textile printing systems, many printing mills in the Como region of Italy, started to utilize multiple units of textile sample printers (Mimaki TX 1 and TX 2) as an industry pioneer. Some of the mills produced as much as 6000 linear meters of inkjet printed textiles, which were continuously printed for 10 days with only 2 sampling printers. However, in 2011, the production digital printers (some are listed above) replaced these sampling printers and produced inkjet textiles in 200 – 400 square meter per hour speed. This new technology trend is evidenced in the majority of printing operations in the Northern Italy today.
- According to Robustelli / Epson /Fortex, a total annual production yardage for all Mona Lisa printing systems sold in each year increased 180 % from 2008 to 2010.
- In 2011, some printing mills declared that production inkjet printers produced more than 5 % of their entire printed fabric collections. (including digital and conventional printing technologies)

Similarly, in the U.S. market since the late 1990's , digital textile printing is now regarded as an upcoming critical printing technology. The majority of the digital imaging and textile printing industries in the U.S. are now proliferating; consequently, many new generations of digital textile printing operations have emerged. For example, some operations have converted from screen engraving businesses, and others have emerged from textile design studios. Many of these new digital printing mills are smaller run operations, and cannot accommodate the complete range of full vertical printing operations, in contrast to conventional textile production printing mills. Notably, they face technical difficulties in controlling pre and post processing, which include: fabric preparations (singeing, scouring and bleaching processes), pretreatments for digital printing, applications of functional finishing, washing and tentering (straightening) processes. Nonetheless, these operations have been developing as driving factors for the inkjet textile printing industry in the U.S.

Rationale

Through analyzing case studies from various digital textile-printing operations, it becomes apparent how these new business models have created a successful niche market. According to Carlo Mantero, of Mantero Seta in Como, their success is based primarily on their the digital textile-printing quality, and secondly on their speed. Moreover, a major aesthetic concern for *Mantero* printed textiles , is that they should not resemble the appearance of so-called "digitally created design ", but should appear "hand made". Significantly, this is one of example where design aesthetics, and crafted control of digital printing technology infuse unique value into a specialized printing system.

The creation of a unique niche market, where innovation and individualized aesthetics create a competitive edge, is the perfect business model for a valued workflow process. As an alternative to the manufacturing process, one of the most significant contributions of this technology is the concept of the *neo cottage industry* workflow. [7] In the traditional textile printing processes, one of the main roles for a textile designer is to create design on paper or on computer screen without producing printed yardage. If the designers themselves decide to produce printed textiles, they would experience complex processes segmented steps including color separation, screen engraving, strike-off, and final productions. Moreover, this conventional textile printing workflow requires minimum production volumes, which becomes an additional financial burden for designers. However, in the *neo cottage industry* workflow, designers will have access to inkjet textile sample printers in their studios, which are as similar to desktop printers in office environments. With this economical sample yardage printing system, designers can design and produce their own final product, within the confines of their design studios, as short run productions. Therefore, individual textile designers can also become small printing mills, manufacturers, and even brand owners. When large volumes are required, designers can outsource the print production, to a larger commission digital textile printing mills. Some textile design studios have already started to demonstrate this workflow, and this model represents a critical niche market for today's competitive textile designers in the global market place.

Conclusion

ITMA 2011 has revealed assurance of industrial textile printing production in terms of speed and reliability; however, as forward mentioned, this digital inkjet textile technology is utilized only for a small percentage of total textile printing production. However, in comparison with ITMA 2007 at Munich, Germany, current technological improvements are enormous, the industry still requires technical improvements including:

- Penetration of colorants to the textile substrates
- Color gamut
- Development of universal ink for all textile substrates
- Specialty printing (for devore, plisse, discharge printing etc.)
- More speed of printing production

Never the less, the real problem of low utilization does not relate to digital inkjet technology itself, but to the overall structure of the digital inkjet textile printing industry as a whole. Specifically, problematic issues arise from the gap in the workflow and supply chain from the industry among end users, equipment manufactures, suppliers and system integrators. For example, in the U.S., there are vast numbers of individual textile art and craft practitioners along with independent textile designers, who are interested in digital inkjet textile printing technology. However, there is a very little access to digital inkjet printing, because of lack of technical information and economical printing systems. It is critical for equipment manufactures, suppliers and system integrators to understand the diversity of end users and their needs. Instead of focusing only on high-speed volume textile production markets, the industry needs to consider all segments of the end users.

In conclusion, new innovative working systems and aesthetic understanding of textile printing technologies need to be redefined and pushed further. In general, the term "textile printing" refers to the visualization of imagery on a textile substrate, by means of printing technology. The classic historic definition of "printing" has been characterized by the interaction of colorants to various substrates.

For example, in a successful digital printing environment, rapid alteration of colorants can occur by switching the ink cartridges to change the coloration chemistry, and thus, accommodate flexible colorations on a wide range of substrates. Within this definition, "printing" becomes a universal application, and is not limited by any traditional boundary of any concentrated discipline. Going forward into the 21st. century, this rapid alteration of a broad range of surfaces will be expanded to include multiple aesthetic outcomes. *Surface Imaging* is the next wave of broad innovation in the field of digital inkjet printing technology. It does not adhere to the existing traditional fields; including graphic, textile, packaging, etc. *Surface Imaging* visualizes imagery on diverse porous and non-porous substrates, with digital printing technologies. It is foreseeable, that in the near future, the definition of digital inkjet textile printing might be upgraded to *Surface Imaging*, which will provide more aesthetic possibilities and innovative opportunities.

References

[1] Pond S (2000), Inkjet Technology, Carlsbad California US, Torrey Pines Research.

[2] Ujiie H (2010), 'Inkjet Textile Printing Status Report 2010' Presented at the Digital Inkjet Textile Seminar, Hangzhou China. Available from: http://www.hitoshiujiie.com/inkjetTechLibraryResearch.html/Honghua2010.pdf

[3] Osiris (2008), 'Is digital production a reality? "ISIS" The velvet revolution in textile printing', AATCC/TC² Symposium, Durham North Carolina.

[4] Stork (2002), Developments in the textile printing industry 2002, Boxmear Netherlands, Stork Textile Printing Group.

[5] Ujiie H (2012), 'Fabric finishing: printing textiles', in Sinclair R, Textiles and Fashion: Materials, Design and Technology, Cambridge UK, Woodhead Publishing.

[6] Ujiie H (2006), 'Design and workflow in digital inkjet printing', Ujiie H, Digital Printing of Textile, Cambridge UK, Woodhead Publishing.

[7] Ujiie H, (2005), 'Innovative Product Development in Digital Fabric Printing', Presented at the Digital Textile 2005, Berlin, Germany.

Author Biography

Hitoshi Ujiie received his B.F.A. degree in Fabric Design from Kyoto Seika University in 1985 and his M.F.A. in Textile Design from the University of Georgia in 1988. Presently he serves a director if the Center for Excellence for Digital Inkjet Printing for Textiles at Philadelphia University. He specializes entire segment of the printing system including design, engineering and business. As a specialist, he has offered his consulting services to many imaging and companies.