DIGITAL INJET TEXTILE PRINTING : STATUS REPORT

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ABSTRACT

Current developments in digital paper printing are being adapted more frequently for the textile market. As digital print technologies improve to offer faster production and larger cost-effective print runs, digital printing will grow to become a technology that provides the majority of the world's printed textiles. This paper includes: (1) state of the arts of digital textile printing technology, (2) impact on workflow, (3) impact on textile design, and (4) into the future.

1. INTRODUCTION

Currently more than 17 billion linear meters of the fabrics are printed for the worldwide marketplace. Year by year, production volume has increased due to the world population growth, faster trend cycles. While more than 50% of worldwide printed textile are produced in Far East, the production of North America and Western Europe are decreasing to be more economically competitive. [1] Current developments in inkjet printing technology offer (1) cost reduction for increasing demands for shorter production runs, (2) rapid market responsiveness on demand for shorter production cycles, and diverse design applications, as well as (3) a new capacity for design creativity. After ITMA in 2003, when several industrial production inkjet printers were introduced into the market place, digital inkjet printing started to become the preferred production technology. Today, it will possibly offer a niche factor to the textile printing industry.

3. STATE OF ARTS OF TECHNOLOGY

2.1 Overview

Inkjet printing technology was first commercially utilized in the carpet printing industry in 70's. During 80's and 90's, this technology had been implemented for strike-off (sampling) usage with printers mostly adopted from paper printing plotters. Consequently, in the 90's, some of the mills started to produce short run inkjet printing textiles with the adoption printers. Today, more than 700 units of Mimaki TX1 and TX2, which are the most popular adoption printers, are distributed worldwide for both short run production and strike-off. Since the year 2000, and after the introduction of the ITMA 2003, a new benchmark for the industry standard was created. Since then, many printing machine manufacturers have introduced production digital inkjet printers such as Mimaki (TX3), Dupont / Vutech /Ichinose (Artistri 3210/2020), Robustelli (Monna Lisa), Konica / Minolta (Nassenger V), Reggiani / Ciba/ Scitex Vision (DReAM), d.gen, Honghua, etc.

Printer Types		Installed Units
Short Run / Sampling Printers		
Mimaki	TX1 and TX2	700+ units
Production Printers		
Dupont:	Artistri 2020	100+ units
Robustelli:	Monna Lisa	48+ units
Konica / Minolta:	Nassenger V	40+ units
Reggiani / Ciba / Scitex Vision:	DReAM	30+ units

Table 1: Printer distribution (The Center for Excellence of Digital Inkjet printing of Textiles, May 2006) [2]

Table 1 indicates the numbers of printers distributed by manufactures, and the current popularity of this technology.

2.2 Current Trends

Unlike the 90's, when engineering was focused on the ability to consistently eject proper colorants onto the appropriate textile substrates, current engineering development focuses on the improvements and refinements of these printing technologies. Refinement of printing technologies can include: maintaining printing assurance, upgrading printing speeds, and the ability to print on wider ranges of novelty fabrics. Some of the printers on the current market are developed based on these engineering concepts, and are characterized by automatic printing without man-power to maintain the printing assurance and productivity. One of these upcoming printers will promise to upgrade a printing speed from a current average speed of 2- 150 square meter to over 1000 square meter per hour, which will be, at least, compatible to the speed of automatic flat-bed screen printing. In the initial stage of this printing technology, printing textile substrates are rather limited to flat and thin textile construction. This is also true of paper substrates such as; cotton sheeting and plain silk fabrics. Because of the popularity of inkjet printing, manufactures are increasingly interested in digitally printing onto novelty textiles, which can be light weight, sheer, stretch knit, thick and textured, or even pre-colored textile substrates. Thus, for stretch and sheer textiles, the majority of current production inkjet printers are equipped with an adhesive belt to feed textile substrate securely. This same mechanism exists for automatic, flat-bed and rotary screen printing feeding handling systems. In addition, these printers facilitate adjustable print head heights to accommodate a variety of thicknesses of the printed cloth. In terms of colorations, especially in the flat-bed inkjet garment printing segment (T-shirts printing), inkjet printing on pre-colored garments has become yet another technology challenge. Emerging developments of white pigment and discharge printing systems have become very critical.

4. IMPACT ON WORKFLOW

3.1 Digital Strike-off Workflow

Conventional textile printing workflows typically consist of design creation and acquisition, color separations, screen making (engraving), strike-offs, and production. The entire process from design approval to productions takes as long as 6 – 18 weeks. [3] Depending on modifications and readjustments of engravings and strike-off processes, it often takes several months to be approved for production. However, in the digital printing environment, a whole new workflow, from designing to strike-offs, to production is performed inside a faster, more efficient digital paradigm. The strike-off processes can be demonstrated through digital inkjet printers, without the need for screens and engraving processes. The production time is shortened compared to conventional methods, and this workflow enables faster response from market demands. Today, a majority of digital inkjet printers are used for this strike-off purpose, and this digital strike-off workflow becomes an important model in the textile printing industry.

3.2 Full Digital Printing Workflow

Conventional textile printing processes are suited for the typical volume printing market, and it would be difficult to create effective workflows for an on-demand short run production market. The exception exists in Italy, where there are successfully operating digital inkjet printers for on-demand short run production, which range in production volumes from 600 to 1000 linear meters. For these current mills, fast digital printing speeds have become their specialty niche in the textile printing markets. In general, approximately 50% of their textile designs, which are in the strike-off stage, go into final production. [4] From a production perspective, they have successfully integrated a full digital printing workflow, which eliminates engraving processes and enables them to save on: sampling costs (test printing), physical screens, and inventory space.

3.3 Alternative Manufacturing

Since the mid 90's in the U.S., when market research firms stated their focus on "Generation Y" as the next biggest consumer group, a new personalized mass-customized product began to develop. [5] "Generation Y" was characterized by a reaffirmation of individuality. Thus, in various stages of digital inkjet printing in the 90's, alternative-manufacturing options began to develop to this new target group. A wide variety of designs for personalization, and mass-customization developed crucial attributes of full digital printing workflows. These alternative-manufacturing workflows required new thinking and business plans, which are different from the traditional textile printing industry. Consequently, especially in the US, conceptual development adapted to non-traditional textile printing companies such as: athletic goods, shoes, bags etc. Concurrently, many new small digital printing operations to offered personalized printing to the consumers with large format sampling printers.

5. IMPACT ON DESIGN

Printing Mechanics vs. Design Styles

Historically, mechanical restraints of textile printing have influenced the developing styles of printed textile design. In block printing, for example, each block representing color separations mainly consists of flat silhouette shapes. A three dimensional effect of the motifs is obtained by printing several layers of flat separated shapes. So-called "traditional floral design" printed by rotary screen printers today still retains the same look as the historical block printed designs. Similarly, engraved copper plate and roller printing in 17th century contributed to "toile" styles, in which tonal effects are created by crosshatched engraved lines and dots to create the conversational sceneries. Digital inkjet printing will function in the same way, and unlike former mechanical restraints, it will generate a totally new textile design style aesthetic. [6] This new design aesthetic can be categorized in (1) a millions of colors, (2) diminutive designs, (3) digital effects, and (4) engineered designs. These new styles, which can not be achieved easily in any other conventional printing technologies will stimulate the design creativity and eventually, become the competitive niche factors. [7]

A Millions of Colors

Conventional textile printing is based on multiple spot color formulated separately to each existing color on the screen separation prior to printing. In comparison, digital inkjet printing does not require screen separations. It is based on a pre-set process color of CMYK, and the combinations of the CMYK process colorants assigned to each pixel color of the digital design data. The textile designs, created in CAD software, have a possibility for creating millions of colors in 24-bit RGB colors space. Successful color-managed inkjet printers have the ability to translate millions of colors from a 24-bit RGB color space onto the final CMYK output space of the textile substrate. Although design files in 24-bit RGB color space retain a far bigger color

gamut than a traditional printers color gamut, current developments of inkjet textile colorants have increased the color gamut even further. Further developments of the CMYK color gamut, have been altered by adding so-called *hifi* colors of orange, blue and green. Designing without limiting the number of colors, opens enormous creative possibilities. There are many new design experimentations inputting photographic images through scanners and cameras, and printing digitally onto various textile substrates.
Many of the "newer" and more innovative looking textiles have been introduced in exclusive high-end fashion printing markets.

Diminutive Designs

Printing continuous tones is one of the most challenging tasks in the conventional textile printing. The printing parameters of the continuous tones attribute to the consistency and fineness of each raster dots under the proper printing rheology. Today, in the separation film stage prior to printing, 50 micron of the dots in diameter is considered to be the finest. However, in digital printing, the printing resolution can be as fine 720 dpi and it is equivalent to 35 microns. With the consistent depositions of these fine dots, controlled by the dithering algorism of software, digital inkjet printing technology can produce smooth tonal effects and fine lines effortlessly on textile substrates.

Digital Effects

Image editing software also contributes new styles in textile design. Input images can be manipulated with a variety of digital effects by filtering and distorting tools the software. Some of the image, manipulated with these tools sometimes resemble to an obvious prefabricated "digitally distorted and filtered" look. This could be considered controversial to the authenticity of the originality of the design, if the result becomes too generic to digitally distorted and filtered look in the software. However, use of digital effects of the software can be a great creative tool for novel textile designs.

Engineered Designs

In conventional textile printing processes, the size of the design has been dictated by the physical dimensions of the screens and rollers. Therefore, textile designs for continuous yardage productions need to be created in a specific step and repeat format. Depending on variations of the screens and rollers at the printing mills, the range of the repeat unit size is rather limited. Conversely, in digital inkjet printing, printing processes do not require any image-transferring devices of screens and rollers. There are no physical limitations of the repeat units for the continuous printing, and it can be as large as several meters that a computer can handle. Therefore, in the digital printing design workflow, the aesthetic judgments become far more critical factors to define the repeat sizes and the visual appearance of the designs in relation to the specific applications and functions become a key attribute for the creative design process. Moreover, designs for digital inkjet printing can be visualized in a format of contained design rather than one of continuous yardage. Designs can be engineered to the size specific areas of a full garment, a specific entire wall space, etc. The ability for the engineered designs also contributes to the process of personalized and mass-customized product developments.

5. INTO THE FUTURE

Digital inkjet printing has become one of the important textile production printing technologies and it has been influencing new workflows, business plans and creative processes. Nonetheless, there are many improvements that need to be addressed including (1) limited color gamut, (2) ink penetration (3) applications for specialty printing, and (4) universal colorants for inkjet printing.

5.1 Limited Color Gamut

As forward mentioned, color gamut of process colors even with *hifi* color sets are still smaller than spot color applications of conventional textile printing. To solve the problems textile ink manufactures and formulators are introducing more colors to the *hifi* color sets. At the same time, some of the printer manufactures are starting to implement different print head technology. In the current market, the mainstream of the production inkjet textile printers is based on drop on demand piezo print head technology. However, some of the upcoming printers are engineered for continuous inkjet print head technology and the print heads are compatible for conventional textile colorants instead of specially formulated textile inks. Therefore, this printer will have an ability to jet any colors with spot color process as well as process color applications.

5.2 Ink Penetration

Digital inkjet printing is a non-impact printing technology, and textile inks are ejected from the print heads to strike to the substrates without any mechanical contacts. Therefore, ejected droplets tend to stay on the top of the substrate's surface without enough penetrations the cloth. At the same time, ejected droplets should not wick out. Therefore, pre-treatment of the textile substrates are necessary process and the treatments should have proper chemistry to enhance image property (less wicking), proper ink penetrations and fixing inks (fixing agents). Although there are many researches conducted to offer novel pre-treatments, more researches and developments are necessary, especially, for the printed fabrics requires proper penetrations of the colorants such as a scarf, certain dress fabrics, etc.

5.3 Specialty Printing

Today, inkjet textile printing is still in the direct printing stage. The textile inks are directly colored on to the white print cloth. Specialty printing technologies in conventional textile printing such as devore, plisse, discharge (with illuminating colors), and so on, should be addressed for digital inkjet printing. Currently, in the t-shirt printing segments of inkjet textile printing, discharge solutions based on reduction chemistry and titanium oxide pigment white have been developed for printing pre-colored t-shirts. Nonetheless, the reliability of the process and stability of chemistry need to be further developed.

5.4 Universal Colorants

The concept of universal colorants in digital printing refers to of one set of inks to color any substrates including metals, vinyl, woods, textiles, etc. This research is considered as the holy grail of digital printing, and we have not found the proper solution yet. Although textile pigment inks can be one of the solutions (several textile pigment inks are available on the market for printing on almost any fiber), these inks need to have a much higher optical density and wider color gamut to be used as a universal set of colorants. Aside from these textile pigments, there are other innovative approaches for this application, which could incorporate a synthesis of new class of dye ink [9], chemical switch with micro / nano encapsulations, new reaction chemistry including UV curing, etc.

6. SUMMARY

Since the rotary screen printing machine was introduced in a middle of 1960's, there has not been any new developments in textile printing technology up to now. From the year 2000 onward, the new millennium should prove to be a pivotal time for the textile printing industry and digital inkjet printing technologies to redefine a new workflow and textile design paradigm.

7. REFERENCES

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