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## **DESIGNING DIGITALLY PRINTED PRODUCTS**

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### **ABSTRACT**

Digital textile printing has been broadly adopted by the soft goods industry as a means of creating proto-types and samples of printed textile products. In contrast, technology development is only beginning to enable this approach for production purposes. While there have been a number of barriers to the implementation of digital production, the process offers tremendous potential in terms of innovative product design. This presentation will highlight opportunities for the creation of unique products and will illustrate the potential for special effect and engineered printing. The presentation will provide examples of creative strategies for print customization and will examine challenges for implementing digital production in real life manufacturing settings.

[TC]<sup>2</sup>'s InkDrop Printing service will be utilized as a point of discussion. This service specializes in the design and production of digitally printed sewn products and serves as a small business incubator that allows artists, designers, and museum retailers to create and produce innovative products with their own imagery resources. The presentation will highlight the design strategies used by the InkDrop team for product development purposes and will outline some of the production challenges that exist within this manufacturing environment. The presentation will also highlight the InkDrop team's exploration of innovative product design in areas including swimwear and home décor.

### **1. INTRODUCTION**

As our industry has adopted a demand driven approach to manufacturing, we have become increasingly reliant on digital processes to provide manufacturing flexibility and supply chain visibility. At the textile production stage, conventional screen print approaches to printing have traditionally served as a bottle neck in the textile supply chain. The creation of screens and the interpretation of artwork via color reduction and separation are time consuming and costly. These steps in the development of printed textiles have made it challenging for product developers to gain an accurate sense of design and color early in the process. In contrast, digital approaches to print development and screen engraving have enhanced the link between design and production and shortened the time frame required for the introduction of new textile prints. The adoption of CAD technology and laser engraving methods has provided an efficient and accurate method for image creation and editing, development of repeats, and color reduction and separation. The advent of digital printing has been a further advantage, enabling product developers and manufacturers to bypass the screen making process for immediate print results on fabric. As a result it is possible to make more educated design and manufacturing decisions earlier in the process.

While digital textile printing has been widely adopted at the sampling and proto-typing stage, it is only beginning to be viewed as an avenue for final production. Even so, digital printing offers tremendous design possibilities and a great deal of manufacturing

flexibility. This paper will describe the link between digital textile printing and opportunities for innovative product design, while highlighting challenges and strategies for the manufacture of digitally printed sewn products.

## **2. THE LINK BETWEEN PROCESS AND INNOVATION**

The process of design is largely driven by inspiration. To onlookers, it might seem that the designer's inspiration appears out of nowhere, as some sort of magical experience. In reality, successful design processes involve a constant search for ideas and a great awareness of environment, process and technology. The link between process and innovation is sort of a 'chicken and egg' scenario. While innovative design ideas can provide the impetus for the development of new manufacturing processes, new approaches to manufacturing can also create an environment that is ripe for innovation in design.

Artists and designers within the textile world have always relied on painting, drawing, and photography as methods of design research and sources for textile design development. Conventional methods of printing have been developed in response to the designer's abilities and have offered a great avenue for the visual expression of color, pattern and texture arising from this design research. From the opposite angle, successful designers have always developed their ideas with process in mind, interpreting and manipulating inspiration and imagery resources so that they fit the parameters for production, yet offer striking pattern, color and/or detail. Roller and screen print techniques partnered with the desire for continuous lengths of colored cloth have helped to create and define print styles in terms of pattern and repeat, fine line detail, and flat or tonal colors. These styles have become innovative design forms in and of themselves.

The introduction of digital inkjet printing has provided an additional layer to this scenario. The ability to bypass the making of screens and utilize a process color approach to printing has removed many of the technical boundaries that designer's face within the conventional print environment. The designer's ability to create full color graphics has certainly been a driver in the development of digital print methods for paper, textiles, and other printable substrates, and in return digital printing has offered the opportunity for a new approach to the development of printed textile products.

## **3. DESIGNING FOR THE DIGITAL PROCESS**

Where digital textile printing is used for production purposes, designer's have a tremendous opportunity to exploit the almost limitless capabilities that digital technology provides in terms of innovative imagery, print engineering, and integration of print design with sewn product design. The tremendous design possibilities paired with manufacturing flexibility make this production method particularly attractive for serving new business models and niche market areas.

### **3.1 Innovative Imagery**

A discussion of the unique design opportunities for digital inkjet printing can begin with an examination of the extensive imaging capabilities this method offers. These capabilities are a direct result of the process color approach to printing. Within the process color environment for inkjet printing, a master set of hues are applied as droplets of color to the surface of the substrate. The specific combination of ink droplets used determines the total color effect in the design. Simplistic inkjet systems use a combination of 4 colors including some version of cyan (turquoise), magenta (red), yellow and black. However, most inkjet systems for textiles use between 6 and 12 colors to obtain a larger printable color gamut. Such expanded color sets may include orange, blue, green, and/or gold yellow and dilutions such as light red, light turquoise and grey. During the printing procedure, a raster image processor or RIP interprets the digital imagery, selecting the droplets of color to be applied for each pixel of data.

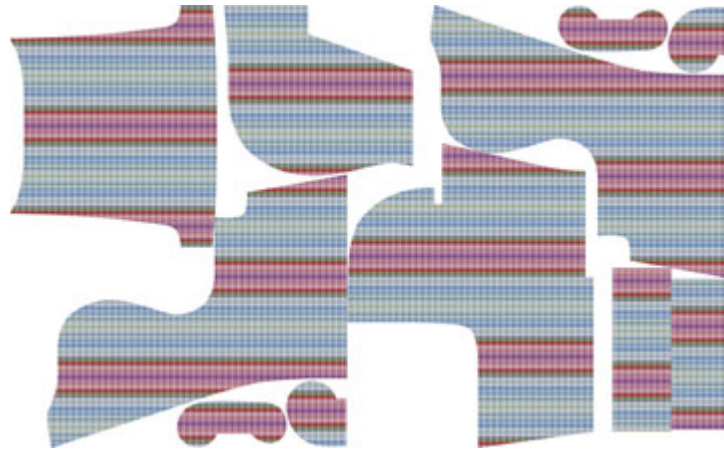
The process color approach to printing is fundamentally different from the spot color approach used for the more conventional flat and rotary screen print methods. In simplistic terms, spot color printing involves the application of a pre-mixed hue. Most commonly, spot colors are applied through a screen that acts as a stencil. Designs for spot color printing are color reduced and separated so that each color in the design corresponds to a screen. The selection of colors and the combination of stencils creates the total color and imagery effect.

What does this mean from a design perspective? While spot color print methods restrict the designer to the use of a finite number of colors resulting in the ‘interpretation’ of original artwork via the color reduction and separation process, process color printing offers accurate reproduction of most imagery and the ability to achieve photo-realistic, painterly and tonal effects that involve the use of many, many colors. Digital print designers are excited by the possibility of being able to accurately render their original design concept and exploit the use of drawing, painting, and multi-media approaches for the creation of designs. They often take the digital process further by integrating and exploiting the use digital tools such as scanning , digital photography and industry specific CAD or off-the-shelf software to capture and render their designs. The result is the creation of very unique printed effects, limited only by the creativity of the designer.

### **3.2 Print Engineering and Integration Of Print With Sewn Product Design**

Digital textile printing also offers unique opportunities for the creation of engineered prints. While engineered printing is not new to printed textiles, this specialized approach is normally encountered in very specific product areas including ladies scarves, men’s ties, and border prints for apparel and home items. Within the digital print world, repeat is no longer a parameter for production, but a design choice. The possibilities for engineered printing are extensive and the designer can now engineer the print for the shape of the product piece rather than for the dimension of the screen. This scenario makes it theoretically possible to design prints that match over fitting and joining seams. In the area of apparel, engineered approaches can be used to create continuous print effects that accent silhouettes and emphasize or minimize areas of the figure. This feature could have a great deal of value in areas such as ladies evening wear and

swimwear, where shape and silhouette are particularly key or in highly decorative product areas such as scarves, ties, purses, and accessory cases. Within the home product segment, it is possible to pre-engineer the print for pattern matching from one piece to the next and to enable placement of key design elements for focal interest (see figure 1.). Digital printing enables the reproduction of large scale imagery and printed panels suitable for engineered drapery, backdrops, or theatrical settings. This feature is already being utilized in the soft signage area. These digitally printed textiles can be combined with digitally printed leather, tiles, and wallpaper for the creation of ‘themed’ or ‘highly designed’ living and working environments where images are integrated from one surface to the next for specific effects.



**Figure 1. Portion of engineered print for upholstered chair**

### **3.3 Niche Markets And Products**

As previously noted, digital printing offers tremendous manufacturing flexibility, enabling quick change to color and design and small quantity and/or single item printing. These features are of great benefit to many business settings and open up a wealth of production opportunities for digital textile printing applications. Through the introduction of mass customization and small quantity print strategies, consumers could begin to see a greater variety of prints in the market place and innovative design concepts that are highly customized to the sales setting. It also allows product developers to more effectively serve niche market areas that require only small quantities of printed textile product. Niche markets may also find great benefit in the extensive imaging capabilities that digital printing offers. Note the InkDrop Printing case study at the end of this paper.

## **4. CHALLENGES FOR PRODUCTION**

Successful implementation of digital textile printing involves a systems approach that takes into account the interaction between printer hardware, software, ink, substrate and finishing conditions. These elements must work in conjunction with one another to efficiently produce quality print results. While the benefits of digital textile printing are widely accepted, the implementation of a digital production strategy is not without

challenge. These challenges relate to key areas of consideration including print quality and reliability, accuracy of color reproduction, speed, cost, and integration with cut and sew methods.

#### **4.1 Print Quality And Reliability**

When digital textile printing solutions were first introduced into the marketplace, technology users often noted issues related to print quality and reliability. These flaws could generally be attributed to print head failure and/or fabric feed issues. Although ink chemistry for digital textile printing is largely based on conventional textile chemistry, the colorants for inkjet must be specially formulated for compatibility with the digital printhead and the design of the printer hardware must provide for reliability and continuous maintenance or cleaning. While early digital print systems often experienced nozzle clogging, resulting in striations in the print, more recent technology introductions show tremendous improvements in print reliability. These improvements can be attributed to the design of more robust print heads and refinements to the formulation of inks for textile applications. Early digital print systems were also largely re-engineered paper printers and the introduction of more specialized textile-specific equipment showing refinement of fabric feed strategies has also helped to eliminate issues such as 'head strikes' or substrate 'jamming'. The more production oriented digital print systems available to date typically transport fabric with belt feed systems that allow conveyance and printing of a wide variety of substrates including knits and lightweight fabrics.

#### **4.2 Accuracy Of Color Reproduction**

The ability to accurately reproduce color and detail is a key feature in any printing strategy. While early technology introductions offered a four or six color approach to process printing, currently available systems largely make use of eight or more colors. As previously noted, this larger color set enables a broader printable gamut. The use of dilutions (lighter values of magenta, cyan, and black) and the development of printheads that can deliver variable drop sizes have also enabled smoother tones and a reduction in dithered appearance that can be particularly noticeable in the pastel and neutral ranges. Advancements in ink chemistry and fabric preparation paired with hardware and software development have resulted in the ability to obtain a wide range of hues comparable to the large color space available in the spot color world.

While the ability to accurately render color is very important, the ability to reliably reproduce color time and time again is an essential feature of a production environment. Of course issues of shading are not foreign to the textile coloring arena. As with conventional printing, all of the variables of the digital printing system must be optimized and carefully controlled to enable accurate color reproduction from roll to roll and run to run. Unique challenges exist for early adopters that provide sampling and small scale production as they often have limited control over fabric preparation and finishing. While some small scale print providers may be able to obtain prepared for print (PFP) fabric directly from a mill, most are reliant on service providers for the consistent application of pretreatment chemistry and preparation can be variable. Digital print

providers often use small scale and batch finishing equipment that make it difficult to control the finishing environment with a great deal of accuracy. On the up side, our industry is beginning to see the introduction of small scale finishing equipment that is designed for continuous open width processing, a finishing arrangement that is more appropriate to the production setting.

### **4.3 Speed and Cost**

From a production perspective, the digital print process has often been described as a slow, costly procedure. While this statement is generally true, technology development is currently enabling print rates that surpass 30 yards per hour. The growth of technology adoption and the application of digital printing for more production oriented purposes are also having a moderating effect on the cost of consumables. While today's digital solutions are not yet comparable to the screen print approach in terms of production speed and cost, it can be argued that the tremendous flexibility and imaging capabilities digital printing offers can offset the limitations in specific market and product areas. Many industry leaders argue that the potential for short runs and customized product outweigh cost issues for some business areas and limitations in speed can be overcome through printer redundancy i.e. having multiple printers to meet production needs, much like a weaving environment.

### **4.4 Integration With Cut/Sew**

The integration of digital printing with cut and sew operations poses an interesting challenge to our industry. While, currently available automated single-ply cutting systems can easily manage printed goods that are imaged with repeating patterns, the ability to cut engineered designs is more complicated. In an ideal situation, the cutter would be provided a printed marker where the design exists only within the boundaries of the sewn product piece. Although it is possible to prepare digital prints in 'marker' format, the wet post processing of fabric causes dimensional change, having an impact on our ability to accurately cut the print. Current advancements in camera technology and automated piece recognition could eliminate this barrier. Developments in alternative forms of ink chemistry that eliminate the need for wet post-processing (e.g. pigments or nano technologies) could also aid the development of continuous or integrated printing and cutting. The further integration of digital printing with short cycle or agile manufacturing methods will enable print providers and their customers to take full advantage of a print-on-demand scenario.

## **5.0 CASE STUDY: INKDROP PRINTING**

InkDrop Printing (formerly The InkDrop Boutique), exists within the [TC]<sup>2</sup> technology demonstration center and serves as an investigation of the application of digital printing within a real life manufacturing setting. The research undertaken by the InkDrop team focuses on the development of strategies for sampling, print customization and short-run production. At the same time [TC]<sup>2</sup> is providing a setting for their members and industry visitors to learn more about the digital process and it's potential use. From a business

standpoint, the InkDrop service specializes in the small scale production of digitally printed sewn product, providing output to artists, designers, and museum retailers. These customers typically utilize the service as a low cost means of turning their imagery assets into finished textile products. Their customer base is largely made up of individuals or cultural institutions with great design ideas or imagery assets that are not able to commit to the long runs required by screen printing. They are also interested in utilizing the unique imaging capabilities the digital method offers. In this way, the InkDrop service exists as a business incubator, enabling their customers to enter the market place with minimal investment in product development and inventory.

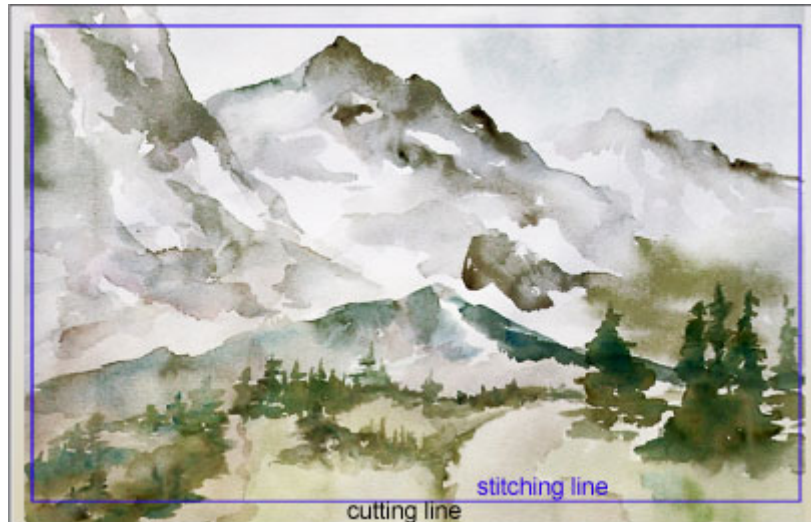
With respect to production capabilities, InkDrop currently provides reactive and acid dye printing and stocks a selection of fabrics suited to these dye chemistries. Their most recent technology installation is a Sapphire II printer (see figure 2.) with belt fabric feed system that has been provided by Stork Digital for demonstration purposes. They also utilize older generation equipment including two ColorSpan Fabrijet printers and a Mimaki TX1600s machine. All finishing is completed in batch form with a Jacquard Steamjet that is housed in the warehouse area of the building, along with a home washer and dryer. As an additional development they are currently investigating the acquisition of continuous, open-width steaming equipment that will enable greater control over the finishing process. The InkDrop staff further enables the production effort by providing expertise in textile print design, color management, sewn product development and manufacturing. The process is also supported by a small team of sewing specialists and equipment for cutting, sewing and pressing.



**Figure 2. Sapphire II printer**

From a product development standpoint, InkDrop offers a range of standardized products that can be customized with digital imagery their customers provide. To assist the process, the InkDrop staff has created a range of product templates for items including scarves, purses, totes, cushions, and other accessory pieces (see figure 3.). These products have been designed to feature the printed imagery and provide quality materials and construction methods for higher end markets. As digital printing remains a relatively expensive print strategy, many of the products combine printed imagery with stock

fabrics and trim as a means of controlling the overall cost structure (see figure 4.). They work closely with their customers to assist them with product design and provide graphic and product development services as the specific situation requires. The staff uses Adobe® Photoshop® as their main product development tool and while some customers provide digital imagery that is ready to print, many require assistance with design layout and imagery formatting.



**Figure 3. Product template for professional tote bag**



**Figure 4. Professional tote bag with reinforced bottom and leather straps**

Once the digital artwork is prepared, it is possible to move forward with the printing process. As an initial step, many customers select to obtain a ‘first print sample’ in order to get a sense of color and print quality. This sample can take the form of a printed swatch or a completed final product. From the sample, the customer may approve the move to production printing. Alternatively, a customer may also determine the need for additional image editing and/or color proofing. Although InkDrop uses color profiling

strategies to optimize color and obtain accurate print results, these profiles do not generally eliminate the need for color adjustment where a high degree of color accuracy is required. If color proofing becomes necessary, a graphics specialist will adjust the digital file and the manufacturing team will print small scale swatches of the image for color approval. A proofing fee is charged for this service and customers are typically provided several versions of the color adjusted image that they can select from. This strategy helps to minimize the 'back and forth' that can be typical of color proofing processes.

Once color approval has been obtained, most customers place orders of between 6 and 100 pieces and the InkDrop team strives to provide replenishment of that product on demand. Minimum orders are determined by the number of product pieces that fit across the width of the cloth. For example, 12 by 60 inch oblong scarves print in multiples of three. Within this minimum order it is possible to obtain three different print designs. Most customers take advantage of this flexibility so that they can obtain a variety of product with minimal investment. Many also re-purpose their artwork for multiple product types and obtain a selection of items for their selling environment.

The InkDrop service also provides printing for mass customization scenarios and can customize the manufacturing process to enable order submission and production schedules for a weekly order process. They currently provide service to one customer that sells wristlets, purses, totes and cushions that are printed with digital photos the end consumer provides. Within this mass customization setting the first print must be the right print and the greatest challenge to effective implementation of this particular scenario relates to the variability in image quality that exists from consumer supplied graphics. With this in mind, they have worked closely with the customer to develop design templates that are easily customizable and they have developed a checklist for image preparation that helps to identify problem images so that they can execute some color adjustment prior to printing if needed.

In addition to their standard product offering, the InkDrop design team is also working on design concepts related to the customization of ladies swimwear and high end home furnishing products. With respect to swimwear, the design team is developing engineered prints that can be selected and colored to accent and/or minimize key figure areas. In the area of home furnishings, they are focusing on the development of silk products related to drapery, top-of-the-bed, and decorative upholstery (see figure 5.).



**Figure 5. Bedroom layout**

## **6.0 CONSLUSION**

While the implementation of digital printing is not without challenge, the manufacturing flexibility and ability to create unique and customizable product are extensive. Technology development and education will help to drive adoption and as an industry we are just beginning to see the application of this process for production purposes. Just as new technology can drive innovation in product design, designers can support technology adoption through the development of innovative design concepts that take full advantage of all that technology has to offer.

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