THE USE OF EMBELLISHMENT TECHNIQUES WITH INK JET PRINTED REPEATED DESIGNS

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ABSTRACT

This paper will discuss the use of devore printing as an additional design feature to ink jet printed fabrics. Ink jet printed fabrics are an ideal basis for bespoke fabrics to be generated in small-scale productions. To begin with this paper will discuss the production of ink jet printed fabrics in repeat using textile CAD software. The original design will include all embellishments as part of the original repeat; as an overlay.

Before the application of a devore effect, the ink jet printed fabric will need to be finished conventionally, then the shrinkage which occurs can be taken into consideration and the overlay modified in repeat.

To conclude the paper will discuss the extension of this process into other possible methods of embellishment such as overprinting and resist techniques, which can be used with ink jet printing onto textiles. These techniques will display alternative methods for producing high quality customised fabrics.

1. INTRODUCTION TO INK JET PRINTING

The textile industry today is driven by time, having to meet the constant demands of the customer for new products and the resulting short lead times. The industry needs to be flexible to change, as the customer may want to make style alterations and have shorter print run productions (figure 1). Ink jet printing for textiles is moving the scope of what's possible to manufacture: it can produce photographic imagery and is flexible to changes. Printing can be stopped instantly; alterations made to the design on screen, or alter a design completely in response to customer needs and set off again to print. Ink jet printing is currently restricted from the use in bulk production due to: the speed of printing being too slow, the restricted range of inks. Ink jet is being used for some small production printing but this is still under development.

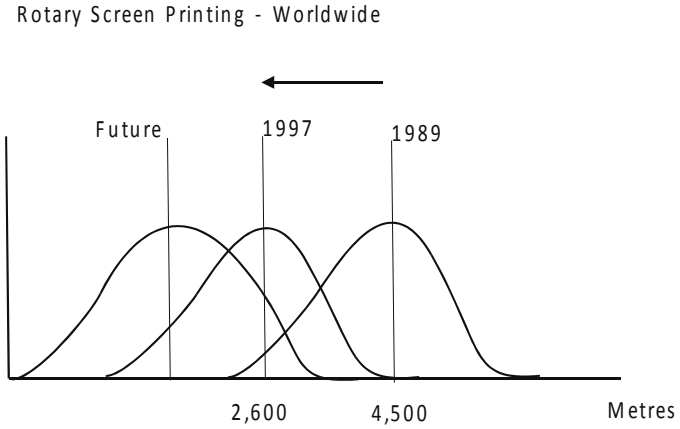

Figure 1: Average Print Run Length (Dupont, 2001)

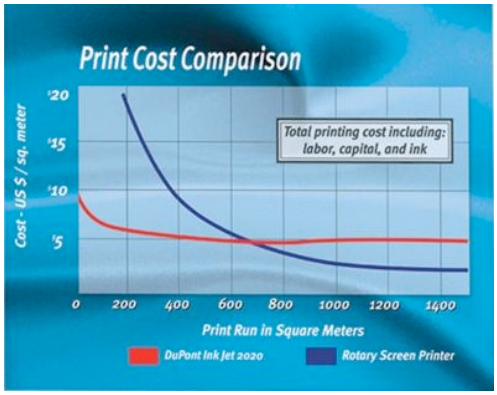

Figure 2 (Dupont, 2003)

Digital printing for textiles has also given the textile designer greater flexibility in the designs that can be produced. With the movement of much of the bulk textile printing industry to the Far East, in order for print companies to survive there is a need to examine printing techniques and the function of the printing processes. There is the need for more original designs and shorter fashion cycles in response to retail demands and seasonal trends. Ink jet printing can cover these needs. (Ervine S, Seimensmeyer K, Seigel B, 2000))

Ink jet printing is ideal for sampling; it can save time and money, as no colour separations need to be done or screens engraved. It can also reduce wastage, as there is no excess fabric or dye used. Ink jet technology prints where needed and on demand. Within 2 years the break even point has been considerably reduced from 1000m to less than 700m (Figure 2).

1.1. INK JET TECHNOLOGY

There are two systems of ink jet printing: **Continuous** and **Drop on Demand**.
The continuous method uses a constant stream of ink, which is printed onto a rotating drum with substrate on it; the excess drops of ink pass through the fabric or get pumped into a reservoir and reused. The DOD methods works by squirting tiny drops of ink through the print head nozzles.

There are two types of continuous printing: **Binary Continuous** and **Multilevel Continuous ink jet.** Both methods are known for their high speeds and their reliability. Both have advantages. The multilevel ink jet method has a limitation to the number of inks available, as the ink must have low viscosity, but it has faster printing speeds as it can print over a large area with one print pass. On the other hand, the binary ink jet method is not limited to the number of dyes available and is able to use a wide range of dye chemistries for a variety of substrates. (Cahill V)

Continuous systems have longer print head lives than other ink jet print methods. These printers are generally more expensive, but have higher reliability and are cost effective when producing larger print volumes.

Although continuous ink jet printing is still being developed, the relatively new Drop on Demand printing (D.O.D) is becoming popular. There are two methods of D.O.D technology; Piezo and Thermal.

Piezoelectric ink jet printing was invented in 1972. This method of D.O.D printing works by sending an electric current to piezo crystal at the back of the ink reservoir. The crystal then flexes which creates a drop of ink, which is squirted out of the nozzle and onto the medium. (PC Tech, 2001)

The advantages of the piezo ink jet are that there is more freedom of ink drop size and shape, which can produce higher resolutions prints; it is also quicker than the thermal method as the ink does not need to be cooled and reheated after each rotation. There is a wider variety of inks and dyes available for piezoelectric printing since it can cope with higher viscosities. At present the piezo technology would appear to be the favoured approach for textile applications.

Thermal ink jet printing was developed in 1979 by Canon. (Le Technologies Inc, 1998) The dye inside the print head is heated which creates a pressure and forms a bubble. The build up of pressure pushes the bubble out of the nozzle. The bubble is ejected and bursts onto the substrate as the heating element starts to cool, causing a vacuum, which draws more ink from the reservoir. (PC Tech, 2001)

Ink jet printing produces an image by jetting dots of coloured ink onto a medium. With some ink jet printers having only 4 colours: cyan, magenta, yellow and black (C.M.Y.K), the colour gamut is more limited when compared to conventional printing. The process used to produce the colour spectrum using a small number of colours is called ‘dithering’. Although this process increases the number of achievable colours, it can also decrease the image clarity producing uneven ‘dotty’ colours. (Work RA) Since pale colours were a problem to achieve, printers now have the option to run with half strength inks. Available now on the market there is the option of a 16 headed printer allowing either faster printing times by doubling up the colours, or running to interchangeable dye types through the printer; for example 8 with reactive dyes and 8 holding pigment inks. Certain colours still lie outside the printer’s gamut, so on some printers there is an option of replacing the magenta with say an orange. Increasing the number of dye colours in the ink jet printers will increase the number of achievable colours i.e. stretching to larger colour gamut from CMYK to Pantone.

The resolution of the ink heads is also important. The early machines used a resolution of 300dpi whereas the later versions go to 720dpi or above. The greater the resolution, the slower the print speed, so there is often a judgement to be made on speed or quality of mark.

1.2. DYES

For ink jet printing onto fabric, special dyes/inks have to be used. Also most fabrics used have to be pre-treated in order to accept the dyes. Certain dyes are formulated for the different types of print heads used i.e. thermal and piezo. Also some printers require paper backing on the fabric to soak up any excess dye while other printers tend to have a trough where the surplus dye can be held. Both of these methods stop the dye from smudging over the rest of the fabric.

There are currently four different dye and ink types available for use in ink jet printing: **Reactive**, **Acid**, **Disperse** and **Pigment**. They are each used for specific textile requirements and they enable a wide variety of fabrics to be used.

Reactive Dyes: used on cotton and viscose; they can also be used on wool and silk. In the steamer, the dye reacts with the cellulose to form strong vibrant colours. For the chemical reaction to occur an alkali has to be applied as a pre-treatment to the fabric and a post-treatment of heat is needed for fixation. A washing process is then required to remove any excess dye. (Ervine S, Seimensmeyer K, Seigel B, 2000, BASF 2000)
Acid dyes: used on silk and wool, and polyamide fibres. They produce high quality results and cover only a small part of the textile market, but it is still an important area for ink jet printing. The fabrics do need to be pre-treated to enable sharpness of print without bleeding. Steam fixation is needed and also a washing off process to remove any unfixed dye. (Ervine S, Seimensmeyer K, Seigel B, 2000)
Disperse Dyes: used on polyester. These dyes can be printed onto transfer paper and using a heat press, transferred onto fabric, or printed directly onto a pre-treated fabric. Again steam fixation and a wash off process are required, if printed directly onto the fabric. (Ervine S, Seimensmeyer K, Seigel B, 2000, BASF, 2000*)*
Pigment Inks: used on most fibres. These inks are currently used in about 50% of the conventional textile printing industry. No pre-treatment is required to the fabric, and only a short heat post-treatment is needed, for fixation of the inks. The main limitation of using pigment inks is that a binder is required. (Ervine S, Seimensmeyer K, Seigel B, 2000, BASF)

The modern 16-head printers have the option to be run in a variety of ways; either using a large number of dye colours enabling a wider colour gamut, to run 2 print heads of each colour allowing for faster printing speeds, or to separate the print heads for more than one dyestuff. These would be run separately and cut out any complications and time involved with changing the dyestuffs from one to another.

1.3. FABRICS

There are wide ranges of fabrics available with pre-treatment for ink jet printing. The pre-treatment depends on the dye used and the end use of the fabric. Providing that the right equipment is available or for a small charge per metre of fabric, it is now possible to have any fabric custom treated for ink jet printing. This enables the reactive dyes to fix to the fabric and to achieve maximum colour output as possible, and also widens the scope for producing customised fabrics.

The fabrics when used with reactive dyes generally have been very successful, producing strong vibrant colours. Poorer results have been achieved from cotton poplins used from different suppliers. The colour results produced were lacking in vibrancy and some colour areas were proving hard to achieve, whereas the other fabrics tried e.g. cotton satin, gave high quality results in both colour and finish. Some fabrics fed through the printer with greater ease, generally heavier weight fabrics. Also the fabric must be well rolled in order for it to run through the printer evenly. Finer fabrics and those with a satin finish have a greater tendency to slip and move unevenly through the printer. This is where the use of fabric feed roller is beneficial. The choice of fabrics ready pre-treated for the use with ink jet printing is increasing along with the number of suppliers, particularly in the U.K.

2. PRELIMINARY EXPERIMENTS

2.1. PRINT QUALITY AND COLOUR REPRODUCIBILTY

Consistency with colour and print quality is essential to all textile printing, and it is important to keep the consistency throughout the printing process. So when using ink jet technology for sample printing

it is crucial for colour control and reproducibility to be maintained from sampling through to bulk production. Ink jet printing can save time and money in the sampling stages of the designs, but for this there must be consistent strong colour and print results.

From the experiments carried out to date in this research, it has been shown that all fabrics must be tested before use as the colour outcomes may vary with the use of different fabrics. There are several other aspects that must be taken into consideration for reproducible results and these can be controlled within the printing and processing stages; for instance the storage and post-treatment of the fabrics. This research has been studying post-treatment conditions required for ink jet printed fabrics.

2.2. PRE TREATMENT

Most fabrics are pre treated, either by the manufacturer or by the user. The pre treatment recipe for each dye and fabric is available from the dyestuff manufacturer. The fabric needs to be pre treated to allow maximum colour yield, clarity of image and quick drying time. Pre-treatment helps to control the size of the ink drops jetted onto the fabric, ensuring that minimum bleeding occurs. The chemical padding stiffens the fabric enabling the fabric to run smoothly and evenly through the printer. The compatibility of the dyes and fabrics can vary, depending on the printer used. Problems can arise when fabrics have not been treated correctly; when the fabrics are unevenly padded and that are finished with a bowing weft line.

2.3. POST TREATMENT

In this research only reactive dyes have been studied so far, but discussions with users of other dyes indicate that acid dyes have similar, if not worse, problems.

2.3.1. Steaming

Reactive dyes require a post-treatment of steaming or heat fixation and a washing process. In this research standard steam conditions have been investigated when using reactive dyes. Dry heat fixation processes such as baking have not yet been investigated in this research, but will be done so that colour comparisons can be made. Steam conditions do appear to have a very strong influence on the ink jet printed outcome. If steam conditions change or do not reach standard settings of temperature and humidity, varying results may occur. In this research so far four steamers have been used, three star steamers (taking loads of about 10m) and one sample steamer (taking roughly A3 sized fabric samples). The star steamers used different steaming methods, direct and indirect steam. The sample steamer is pressurised and uses direct steam.

The recommended steam temperature from Encad and many other manufacturers is 102°C for all fabrics and with variable steam time given: these can range from approximately 7 - 15 minutes for cotton and viscose to 15 – 30 minutes for silks. (BASF, 2000, ENCAD) This research started by looking at steam conditions under which reactive dyes, for ink jet printing, gave best colours and image results. All steam trials were printed on cotton (non-optic) and once a wide gamut of colours was achievable, various other fabric trials were carried out. Tests were carried out using a range of steam times to see the effect of steam time on colour outcome. Shorter steam times produced weaker colours; steaming for 10 minutes produced the optimum colour results. This was consistent with all steamers.

2.3.2. Washing Off

The washing of the fabrics occurs after steaming and it enables any excess dye to be removed together with any auxiliary chemicals used in the pre-treatment of the fabric. It is again a very important factor for reproducible image and colour results. If the washing process was done incorrectly, image clarity may be affected and problems such as back staining or the fading of colours may occur. The general recommendations for the washing off of reactive dyes are 2 cold washes, 1-2 hot washes and a cold water rinse. The wash process now used in this research has reduced the work load and the quantity of machinery involved. An industrial washing machine is used whereby a wash has been set up for ink jet fabrics. It allows the specific temperatures for the various fabrics to be set as required.

3. THE USE OF COLOUR MANAGEMENT AND SOFTWARE WITH INK JET PRINTING

Ink jet printing was developed from wide-bodied paper printers designed for posters and banners. These have long established methods of obtaining full colour reproduction from the secondary colours of CMYK, known as process colours. Textiles have used a spot colour method whereby the actual colour in the form of dyes is used.

With the use of the various dyes there are some limitations to the printable colours that are obtainable. Also the full potential of these colour spaces is not visible until the fixation of the dyes, whereby the colours become a great deal brighter. (Gordon S, 2001)

Textile specific software is available to manipulate images, which usually include flat and continuous tone designs; ability of colour separation and a powerful repeat function. In addition, later versions include colour management.

On the other hand, RIP Software for digital printing of textiles from a graphic package should be able to accept textile industry file formats from CAD design and screen separation programs and accept common graphic file formats. The RIP for both inputs should be able to manage expanded ink sets beyond CMYK, depending upon the printer. Ink control functions manage higher ink densities required for colour saturation of fabric. However, since with digital printing there is no need to colour separate and as the commercial graphic packages become more flexible, there will be a move towards packages such as PhotoShop and CorelDraw and a reliance on the software RIP to do much of the textile work.

There are many commercial textile RIPs available, which use ICC Colour Profiles and have the option of recalibrating the profile. Claims are made for their accuracy but in the author's opinion, there is more work required to prove this.

4. EMBELLISHMENT TECHNIQUES

There are many techniques that can be used with printed fabrics to enhance the design and the fabric's quality and these have been well researched within the traditional printed textiles area. Many techniques can be used to develop the texture, colour and the nature of the fabric using overlays. These techniques can include the use of embroidery, lacquers, Expandex, foils, burnout effects such as devore, discharge printing, and resist methods of printing and dyeing such as using wax and binding techniques.

Previous work has been produced developing effects, combining the use of ink jet technology with traditional surface techniques. This work has concentrated on developing the connection between the two areas and reintroducing craftsmanship to the textile industry. (Hill-Campbell J)

With the use of CAD and CAM within the textile industry, short run printing is continually being developed. Ink jet printing has enabled a reduction in costs and times required to expand this market area. Another advantage of using ink jet printing for short run print lengths is the possibility of generating high quality, innovative, bespoke fabrics at lower prices and at shorter production times. But again for this development in the textile market to occur, certain process and problems have to be overcome. Initially the ink jet printer will need to be set up, assigning the correct pre and post-treatments for the fabrics and the method of colour management to be used. The use of the correct design software is important and particularly the benefits that can be gained with the use of textile specific software as already discuss earlier in this paper.

This research has been concentrating on setting up a strict process to be followed for the creation of embellished ink jet printed fabrics. The designs used are generated in repeat at a traditional design size used in industry of 64cm or a division of this. Although a specific repeat size is unnecessary for the use of ink jet printing, this allows the option of later generating the design using traditional printing methods. Also repeated designs gives more scope to the amount of printed fabric by increasing and decreasing the number of repeats using the CAD software or the Textile RIP.

Again, although reducing the number of colours per design is unnecessary for ink jet printing, working in reduced colour enables the colours to be matched prior to printing, thus cutting out any colour trials

that would usually need to be done. With the use of accurate colour reduction using the CAD software, excellent results can be achieved, still obtaining 3 dimensional and photographic qualities.

To be able to prepare all equipment and information ready for applying the embellishment technique to the ink jet printed fabric, the overlay is calculated as part of the original CAD design. From either, a single colour separation or a design motif in the original design, an overlay can be extracted. This can later be used for developing a screen or can be fed into the relevant software. For instance a single colour separation can be used to generate a screen ready for a print overlay or transferred into an embroidery package ready for production. For this to occur certain requirements must be applied, such as the separation must be cleaned making sure there are no stray pixels and that the edges are smooth. Lines may also be required to be of a certain thickness for a print or embroidered area to be noticeable or feasibly produced.

The fabric shrinkage will need to be taken into consideration to enable accurate registration between the printed fabrics and the embellishment overlay. This measurement will need to be taken after the printed fabric has been post-treated. A study has been done in this research to gain the shrinkage information on three fabrics at present: white cotton, silk/viscose velvet, and silk/viscose satin. Previous tests had been done to gather information on whether the wash method and temperature had any effect on the amount of shrinkage to the fabric, and no difference was seen.

From the information gathered, the necessary alterations to the CAD design and overlay were able to be made prior to printing, so that the result after the embellishments are applied is a 32 x 32 cm design. This information will need to be gathered for any fabric used for printing and embellishment.

When using a printed embellishment overlay, the ink jet printed fabric will need to be pinned down on a backing cloth on the print table. This ensures that the fabric is kept taut and is square. Again this is essential for accurate registration. Techniques such as devore, pigment ink, lacquer and more have been tested and have produced some very promising outcomes with good registration. Some of the best results were gained from the use of devore on the silk/viscose velvet and satin fabrics.

Figure 4: Silk viscose satin with devore embellishment *(18)*

Figure 5: Silk viscose velvet with devore embellishment *(19)*

After the devore technique has been applied to these fabrics very little colour can be seen left on the silk mesh as the ink is unable to penetrate all the pile when ink jet printed. To enable a colour to be applied to these areas, a reactive dye paste was used on the reverse of the fabric. The colour was originally matched to the CAD design and a recipe was developed using the Datacolor recipe prediction system. The dye paste was pulled through a blank screen cutting out any registration problems that may occur again. An 11% increase in viscosity to the dye paste was required to ensure that the dye would not bleed and affect the other colours in the design.

Figure 6: Silk viscose satin with devore and reactive print on reverse of fabric *(20)*

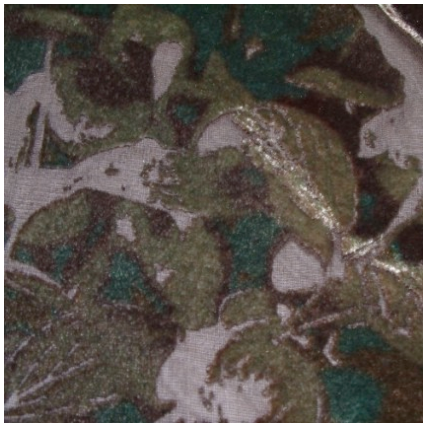

Figure 7: Silk viscose velvet with devore and reactive print on reverse of fabric *(21)*

Resist techniques have also been experimented with when using ink jet printing. First a pigment print has been used to resist the reactive dyes used with ink jet printing and this had little effect, the results showing only over print effect with no resisting occurring. Experiments in developing the resist paste were then carried out. Rather than using a general pigment paste, discharge paste was used, as this can cope better with the use of acids. In this case a tartaric acid was added to the paste. The acid affects the alkali (sodium carbonate) used in the pre-treatment of the fabric for the reactive dyes, causing the reactive dyes once printed not to fix to the fabric leaving the resist print. Also in one experiment a reactive resist agent was used, to the same 8 % quantity as the acid. This did not make any difference to the resist print. Pigment inks were used to colour the resist paste.

The process started with the resist paste being printed onto the pre-treated fabric. Once dry, the paste was heat fixed. The fabric was then fed through the ink jet printer and post-treated with a steam fixation and wash process as usual. Varying heat temperatures and times were experimented with for the fixation of the resist print paste. The original temperature tried was 150° for 5 minutes; this was according to the fixation of the pigment inks. Although there was excellent fixation of the resist paste, the heat process appeared to have an effect on the colour outcome of the ink jet printed design, causing patchy faded areas and less vibrant colours in general.

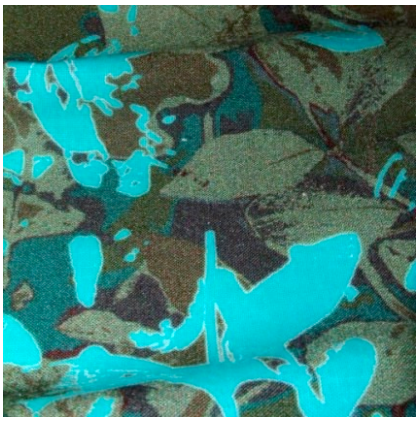

Figure 8: Resist printing *(22)*

Later trials were done at lower temperatures for longer times. This resulted in accurate colour outcome for the ink jet printed areas, but the resist paste colour was not fixed sufficiently. The most effective outcome came from baking the fabric at the higher temperature of 150° for only 2 minutes. This allowed the resist print paste to be fixed properly without damaging the pre-treatment to the fabric for the ink jet print.

Once these processes from design through to finished product are complete, this printing process can be applied, adapted and enhanced to develop a collection of unique embellished fabrics. Effects such as the use of various fabrics and more than one overlay can be applied and there is a possibility of combining various embellishment techniques. Advancing the colour of the devored fabrics on the

reverse has introduced the possibility of generating fabrics with design qualities on both sides of the fabrics. The registration can be matched by reversing the overlay.

By applying these additional features to the ink jet printed designs, the printed textiles market has the opportunity to develop the area of customisation. The customer will be able to choose from a variety of techniques and overlays, which will be constantly increasing in number, to generate their desired effect. The outcome will be of high quality, bespoke fabrics.

5. CONCLUSION

Wide format ink jet printing for textiles will have major effects on the modern textile designer. Ink jet printing reduces the time and costs involved with sampling, meaning more printed samples can be produced for the customer allowing a wider choice in designs and colours to be achieved. From a creative perspective, ink jet printing can give more freedom when designing, allowing more colours per design and also highly detailed, photographic imagery to be used. This area of design was previously very limited when screen-printing.

Although ink jet printing has its own limitations when compared to rotary screen-printing for production purposes, constant developments are being made in fabric pre-treatment, dyestuffs and ink jet technology. It is critical that all print procedures involved with ink jet printing are followed strictly in the running of the printer (environment/conditions) including the pre and post treatments of the fabrics, ensuring that all times and temperatures used are accurate. This is important to enable consistent print quality and colour reproducibility. Tests prior to printing, such as alignment of print heads, priming of colours and colour standard trials can help to ensure reproducible outcomes. The use of colour libraries and colour management systems will also contribute to achieving the consistent results needed.

The blend of embellishment techniques with ink jet printing is unlimited, allowing desired effects to be achieved at lower prices, shortened production times and with minimal wastage. The procedures must be set up prior to producing these fabrics. Once these are in place the creativity can truly begin in embellishing and enhancing the fabrics. These will then lead on to developing the small print production market and allow for individual custom made printed fabrics.

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