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Original Citation

Woodget, Helen L., Macbeth, Penny, Annable, Ray and Pearson, John (2005) The commercial realisation of complex textile craft techniques by CAD and inkjet printing. In: ARCHTEX, September 2005, Krakow, Poland. (Unpublished)

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THE COMMERCIAL REALISATION OF COMPLEX TEXTILE CRAFT TECHNIQUES BY CAD AND INK JET PRINTING

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Abstract

There are many techniques in textile crafts which are virtually impossible to produce commercially, for example hand and computer generated embroidered textiles and hand knotted woven fabrics. With the growing interest in the consumer market in the UK particular for textile craft products, it is becoming increasingly important to develop reproducible techniques to enable these products to be made to a commercially acceptable level.

With the capability of ink jet printing being able to print at high resolution and in almost true colour, it is possible to simulate these techniques on fabric. In doing so, accurate colour representation must be achieved; the method of colour management used will be examined.

This paper will start by discussing textile CAD systems and comparing them to general graphic software. It will describe the steps required to obtain identical images of the textile craft onto a CAD system, with the correct resolution, number of colours and size.

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. 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.

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. (Ervin S, Seimensmeyer K, Seigel B, 2000) [1]

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.

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) [2] 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.

2. PRELIMINARY EXPERIMENTS

2.1. PRINT QUALITY AND COLOUR REPRODUCIBILITY

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.

There are several 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. 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.

In this research only reactive dyes have been studied so far, 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. 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.

The recommended steam temperature from 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) [3,4] 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.

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.

3. EXPERIMENTAL EMBELLISHMENT TECHNIQUES WITH INK JET PRINTING

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) [5]

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.

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.

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.

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.

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.

4. THE PRODUCTION OF COMPLEX TEXTILE CRAFT TECHNIQUES USING CAD AND INK JET TECHNOLOGY

The aim of this research is to achieve an accurate representation of hand-developed craft techniques using CAD software and textile ink jet technology, and to study the problems that may arise with this and to produce high quality printed fabric results. They will need to be commercially viable and in doing so the beginnings of a catalogue will be generated allowing for choice in custom made printed textiles. The process will be documented for future production of simulated craft techniques onto printed fabrics, resulting in the discussion of the use of colour management, CAD software and potential uses.

Research has been done in this area of textiles analysing the reproduction of aesthetic qualities associated with traditional hand surface design techniques of batik and discharge, investigating whether these could be achieved using graphics programs and digital printing technology. (Lawrence, G 2002) [6]

Selections of craft generated techniques were gathered from varying specialist textile craft practitioners of embroidery and weave as a basis for this research. Future work will examine the possibilities of this process being applied to generate high quality simulations of other textile craft techniques. The textile samples of varying sizes (some as little as only 50x80mm) were scanned in at high resolution (400dpi). Scanning in at the higher resolution gives more flexibility for future resizing. All resizing should be considered before colour reduction for the highest quality of image to be achieved.

4.1 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 achievable. 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) [7]

Textile specific software is available to manipulate images, which usually include flat and continuous tone designs; ability of colour separation, a powerful repeat function and 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, 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, with a reliance on the software RIP to do much of the textile work.

In this work, only textile specialist software 'Lectra U4ia' has been used. This software enabled an efficient work process to be developed with all the advantages it has to offer, particularly for printed textiles. Colour reduction can be achieved accurately, image clipboard can be used for building up a large database of craft techniques and the 'repeats' function for the option of one-off craft techniques to be thrown quickly and effectively into repeat.

In connection with the textile specialized software, a colour library was used as the method of colour management in this research. This allowed for the correct colour to be chosen by eye. There is always some noticeable limitation with the printable colour using ink jet technology. This due to the set of dye colours used the printer, which can mean certain colours will lie outside the printers colour gamut. This was an important factor affecting this research.

4.2 Colour Reduction

When producing digital representations of textile craft techniques, the image quality and colour standards must be accurate to the finished sample. High image quality can be obtained through scanning at an appropriate resolution, but colour must be examined in greater depth. When printing the true colour image with no colour alterations made, the printed outcome was unacceptable with harsh and unsubtle colours. This proved the importance of using a method of colour management, in doing so the reduction of colour is critical in this work. The colour reduced file must be perfect to that of the original.

Precise colour reduction can be obtained many ways. This can be done automatically using most general CAD software by specifying the number of colours required to remain in the design (those that are most frequently used). More accurately it can either be achieved by; specifying the actual colours you wish to remain in the design or by using 'palette builder' to select particular colours. For example, choosing a light and a dark tone,

then specifying the additional number of tones between the two colours, and finally allowing the software to automatically fill in these tones. This is then repeated to gather all colours tones required in the design, which can be done by using textile specialized software only.

It was still important to keep large numbers of colours in each image to project a realistic version of the original crafted sample, to an almost photographic quality. Large numbers of colours in designs usually means a great deal of time spent colour matching all colours. This work has looked at ways in which to limit the number of colours that require matching and still achieving excellent colour results.

4.2.1. Colour Reduction Method 1 – Most Common

This method works by selecting the number of colours that you wish to remain in the design/image as described earlier. It is very quick to complete and sometimes achieves promising results, however from experience this is rare. In these experiments the images were reduced in colour to the maximum allowance in a reduced colour window (255). If at this stage the image was an accurate representation to the original, colour matching would be considered to ensure the required printed colour outcome. However, it was not feasible to colour match 255 colours. Therefore, the colour palette was re-organised to show the colours ranging from the most to the least frequently used, which allowed for the most commonly used colours (over 1%) to be easily identified. However, it quickly became apparent that colour matching at the above 1% threshold would not achieve the desired standard, as many key colours would not be matched. Therefore logic would suggest lowering the threshold, ultimately increasing the number of colours required for matching, moving ever closer to the infeasible number of 255.

4.2.2. Colour Reduction Method 3 – Individual Colour Selection

This method was not used in this research due to it being very time consuming when selecting large quantities of colours.

4.2.3. Colour Reduction Method 3 - Tones

Using 'Palette Builder' (Lectra U4ia) as described early as 'tones', can be found in textile specialist software. This proved to be the most successful process for colour reduction. It requires only 2 colours to be selected at any one time (typically a light and dark tone of the same colour). The software then builds up the palette based on the optional number of tones selected between the 2 tones/colours chosen initially. This method is time efficient and flexible as only a small number of colours need to be selected, each with a wide range of tones, and groups of colours can be added and deleted as necessary. With careful selection, an accurate representation can be achieved easily.

Two experiments in colour matching were undertaken. They examined ways in which to achieve the best colour results possible and considered the time involved.

In experiment one only the initial two tones/colours in each group were colour matched, which resulted in a smaller proportion of colours needing to be matched. For example, out of 125 colours only 50 colours were matched.

In the 2nd experiment the reduced palette was re-organised into a range of the most to least frequently used colours (an automatic function available with textile specialist software). This made it clearly visible for matching all colours used over 1%.

4.2.4. Printed Results

The strongest results achieved were those colour matched using method 3 and in accordance to the method described in experiment 1. By matching the initial two tones/colours in each group, a wider range of colours were matched.

For example, if the most frequently used colours in a textile craft sample are the pale cream and grey tones with the occasional red, yellow, and blue, matching all colours used over 1%, would not reach enough of the latter colours. This suggests that more colours would need to be matched, thus extending the amount of time required or leaving unexpected colour results after printing.

Achieving excellent colour outcome in this work is essential to enable an accurate representation of that of the original. Colour matching is essential for this to occur, however, some colours are still unachievable. In this research a Mimaki TX2 has been used. Eight reactive dye colours are used; Cyan, magenta, yellow, black, grey, light magenta, blue and golden yellow. However, even with this number of dyes available some colours are still unobtainable. A possibility of improving the colour outcome would be to change the dye colours as necessary.

Image quality is also essential to achieving strong printed results. The printer was set to print at a resolution of 720 dpi, this allowed for high quality prints to be produced.

The printed results are very strong in this research. They show an accurate representation of a variety of textile craft techniques. Once each sample is recorded in a digital format and the above work has been applied, the crafted samples become very flexible as to their future uses. They can be custom made and commercially viable in small scale production using ink jet technology. For example, some images lend themselves to be thrown into a repeat, which gives the customer the option of the amount of printed fabric they require. Using CAD software small areas can be simply extracted out of the original sample and dropped onto plain background or even accurately positioned onto another design. The colours are inter-changeable to customer needs and alternative colour-ways are easily done. Examples of these can be seen below.

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, allowing more printed samples to be produced for the customer, providing 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.

As shown in the initial experiments, custom made bespoke fabrics can be produced utilising CAD, Ink jet technology and traditional screen print techniques. However, this is only the beginning to how these techniques can be combined together. The advantages of linking CAD and ink jet technology, and what they have to offer in developing custom-made fabrics, are just beginning to be explored. With the appropriate design skills, the relevant textile specialist software and experience of CAD/CAM these can be combined creatively and push the boundaries of textile sampling and custom-made fabrics. They can also be used as a high quality production method of hand-developed creative textile craft samples.

Most hand-developed textile craft techniques are very time consuming to make and are often 'one-off' pieces. This work is not trying to distract from the value of 'one-off' textile crafted samples, but to further develop and expand some of these qualities commercially.

Today there is a new era emerging and it is called Mass Customisation. Mass Customisation takes the best of the craft era, when customers had products built to their specifications but only the elite could afford them, with the best of the mass production era, when everybody could get the same product because it was affordable. (Fralix, M 2001) [8]

There are many advantages of using CAD and ink jet printing for the development of complex textile craft techniques. The scale of the original textile sample can vary; small samples can be used with flexibility for future re-scaling. This means there is less time involved with the original development of the textile sample. Once the method of production is set up each sample can be easily and quickly produced to a high standard. Once the samples are in a digital format they are flexible to changes, such as scale, re-colouring and repeats. The printed results are excellent using ink jet technology, with an almost photographic outcome. Digital printing is the most suitable method of production for this work due to its high quality, flexibility and its low cost for small scale productions.

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