# Color Management on Various Types of Textiles in the Context of Fine Art Printing

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## Abstract

This study was carried out in collaboration with the Museum of Textile in Bourgoin Jallieu, France. The objective of this work was to quantify the influence of (i) ink-jet printer calibration and (ii) ink-jet printer profile creation, on the quality of colour reproduction, in the context of fine art printing on textile. An ink-jet printer (Mimaki TX 1600) and various types of textiles with different surface treatments were used. While creating the profile, different input parameters were adjusted: total ink coverage. The performances of the colour profiles (output data) were analysed using colour differences ($\Delta E$), the colour gamut, and some spectral characteristics of the printed colours

## Introduction

The textile industry is endeavouring to develop new technologies. Digital printing is evolving and becoming a way to ennoble textile. Textile ennoblement can apply in various fields such as thick products (carpets), where digital printing was introduced several years ago. Another field concerns industrial products such as non-woven materials or vinyles. Digital printing found a small niche there. As far as flags and banners are concerned, digital printing has reached a rate of penetration of 10%. Finally, digital printing finds application in room textiles such as curtains and clothes. In the latter applications, digital printing may be used for sampling and proofing, but never for production. The rate of penetration is weak (about 0,1%).

The objective of this work was to test some of methods of calibration and characterisation of colours that are traditionally used for papers. Thais enabled us to improve the printing quality of the textiles studied. For our tests we used a Mimaki TX 1600s press. We printed on various textiles: cotton, viscose, twill silk and muslin.

## Background on Textile Printing Using the Ink Jet Process

### Some Background on Ink Jet Technologies

The viscosity of the ink is in the order of 1 mPa.s and its surface tension about 35 mN/m. The volume of the droplets is in the order of 10 pL and their speedin the order of 50 m/s.

The printing presses used for textiles can be classified in three categories. (1) Those which are used for the tests of the designers (design) and for the proofing. The production is then acheived by screen printing. Their speed is of the order of several square metres per hour. (2) Those which are used for quality products, such as the reproduction of art work. These machines have low speeds, but a high resolution and a very wide colorimetric space (up to 12 basic colours). (3) Those which are conceived for productivity. The speed of those exceeds 100 m²/h.

The presses can be characterised by (1) their type of head (Piezo or thermic) and numbers of nozzles. (2) Their print speed (m²/h): between 1 and 50 m²/h (against 900 m²/h or more for rotary screen presses). The most recent presses reach 150 m²/h. (3) Their resolution, expressed in DPI (Dot Per Inch). (4) The number of primary colours used to print: 4, 6, 8, and even 12. More primary coloursenable to increase the colorimetric space (gamut). (5) The printable width: between 1.50 m and 1.60 m (although there are machines which can print up to 5 m). (6) The number of master keys: between 2 and 10. A master key corresponds to the width printed by a carriage if all nozzles work. A master key usually works in the 4 directions.

In practice, compared with printing on paper, printing on textile:

- requires a higher quantity of ink per unit area (20 g/m²). The heads currently used provide approximately the quarter of this value, so that it is necessary to operate in several passes;
- reaches a lower resolution.

A resolution of 300 dpi (even 180 dpi) is sufficient for the digital technologies printing continuous tones on the majority of textiles.

In the near future, the actuators will allow better performances for inks and will accept "metallic" inks or inks with new physiological capabilities, therefore improving comfort and ensuring new functions in communication and clothing. Ink jet printing presents several advantages compared to screen printing, transfer and sublimation:

- reduced time to design and obtain the finished product,
- no colours preparation,
- smoothness of gradation,
- no engraving nor storage of cylinders,
- no problem of reproducibility when sampling,
- reactivity,
- widths exceeding 1 metre can be printed,
- lower printing skills required,
- no pollution,
- flexibility of designs.

However, ink jet printing also shows some disadvantages:
- low printing speed (from 1 to 150 m²/h, depending on the resolution),
- highcost of dyes (from 90 to 230 euro/litre),
- specific treatment of the textiles required (pre-treatment and post treatment),
- matter handling on the press,
- clogging of nozzles,
- shallow penetration in the textile matter (reducing rub resistance),
- need to work in a controlled environment,
- no tanks to hold dyes,
- difficulties to print thick substrates,
- limitation of the colour gamut (CMYK).

Two types of inks meet the needs for textile printing: dye-based inks and pigment-based inks.

Note: pre-treatment and post-processing are necessary, at least in the case of inks containing acidic or dye reactive components. For some dispersed inks and pigment-based inks, post processing can be avoided. Research is also currently carried out in the field of hot-melt inks. This would enable to print on dark substrates (white inks can be designed) and to improve the properties of dye-based inks. such inks are only used with drop on demand technology.

### Classification of Textile Fibres

Fibres may be natural or synthetic. Natural fibres are subdivided into three categories: animal (wool, mohair, alpaca, camel, cashmere...), vegetal (cotton, flax, hemp, raffia...), mineral (asbestos, glass...). Synthetic fibres are subdivided into two categories: artificial fibres (acetate, triacetate, viscose...), and processed petroleum products (polyamide, polyester, polyethylene...).[1-3]

### Textile Dyeing

We find several stages in the dyeing of textile. The first stage is called preparation (it consists of the creation of fibres). The second consists of the creation of the basic textile. The third stage is that of the ennoblement of the textile. The fourth and last stage are that of the clothes industry and the completion.

### Textile Printing

Printing occurs during the textile ennoblement. Ennoblement stands for the various operations of dyeing, printing, finishing, i.e., any treatment which gives to the fabric its aesthetics and requirements.

After printing dyes need to be fixed and fabrics to be washed. In order to fix dyes, saturated vapour, overheated vapour, hot air allowing polymerisation, or alkaline baths may be used. It is then necessary to apply finishes on fabric by chemical or mechanical means. The chemical finishes give the fabric specific properties such as resistance to wrinkling, fire, water, static electricity, etc. The mechanical finishes bring characteristics such as brilliance, flexibility, relief.

## Experimental

### Press

A MIMAKI TX 1600s was used for printing tests. This ink jet printer prints 7 colours and utilises piezoelectric activation nozzles. It can print up to a width of 1600 mm and a length of over 50 m. It is possible to print at different resolutions: 1440 × 720 dpi (dots per inch), 720 × 720 dpi, or 360 × 360 dpi. Printing can be done in 2, 4, 8 or 16 passes.

### Inks and Textiles Used

The substrates tested were cotton, viscose, twill silk and muslin.

For each one of these substrates, the tests were carried out on non-fixed and fixed printed matter. We used inks with reactive dyes.

The fixing was carried out by a company specialised in textile processing.

### Equipments and Software Used

We used a Spectrolino spectrophotometer from GretagMacbeth (D50 and 0/45° geometry), a D19C densitometer and a ProfileMaker software to characterise the printed substrates.

**Calibration** depends on the substrates. We used Jack the RIP as a raster image processor.

First, we printed a CMYK chart. The grey scale in this form had a range of dot area coverage going from 2% to 100%. A medium GCR (Grey Component replacement) was used to generate the black.

We measured the densities and the dot area coverages on the patches. The calibration was carried out with these values.

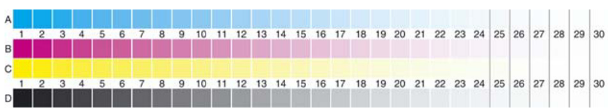


*Figure 1. CMYK chart for the first step of calibration. The dot area increases from 2% to100%.*

### TAC Determination

After having linearised the printer, it was necessary to determine the maximum TAC (total area coverage) accepted by the substrate. This value was determined using the test form TC 3.5. The chart was printed with different TAC going from 280% to 160%. Figure 3 presents the two versions of the printed material. Above 280%, the ink migrates into the adjacent patches.

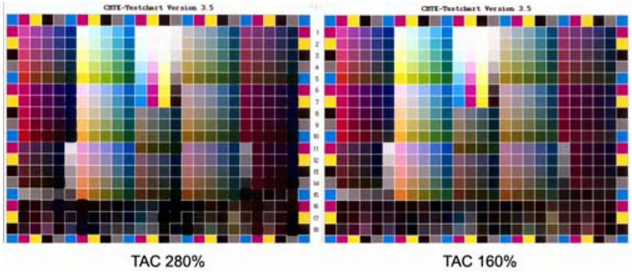


*Figure 2. Two versions of test form TC 3.5 (TAC 280% and 160%)*

### Characterisation

The test form contains an IT8 7/3 chart, two photographs and two grey scales. An ICC profile was carried out with this test form. In order to test the quality of the ICC profiles, another form was printed. It contains patches described in terms of L*a*b* values.

## Results and Discussion

### Calibration

Without correction, the tone value increase reaches 50%. Therefore, there is nearly no difference on the printed material between a 50% and a 100% (solid) patch. In other words, all details in the shadow tones are lost.

Calibrating the printer is often aimed at obtaining a linear relationship between the digital reference dot area input for each channel CMYK and an output value which can be a variation in colour (delta E) or a luminance (L) or a density or a dot area coverage. This calibration tends to minimize the tone value increase for each primary colour.

Figure 3 represents the dot areas and the densities before and after calibration. We linearised the relation between the theoretical and printed dot areas. The resulting densities are presented on the right side of figure 3.

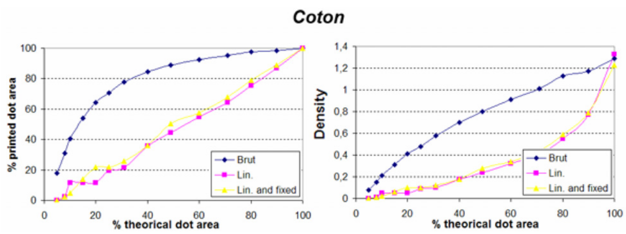


*Figure 3. Variations of the dot areas and densities before and after calibration.*

### TAC Values Obtained

**Table 3. TAC for the Different Substrate**

| Textile | TAC |
|---|---|
| Cotton | 250% |
| Viscose | 240% |
| Twill silk | 180% |
| Muslin | 150% |

The more opaque the material is, the higher the TAC, resulting in an improved colour gamut.

**Table 4. Different Settings Used to Test Each Type of Textile**

| | Linearisation | Chracterisation (ICC) | Ink fixed |
|---|---|---|---|
| A | No | No | No |
| B | No | Yes | No |
| C | Yes | Yes | No |
| D | Yes | Yes | Yes |

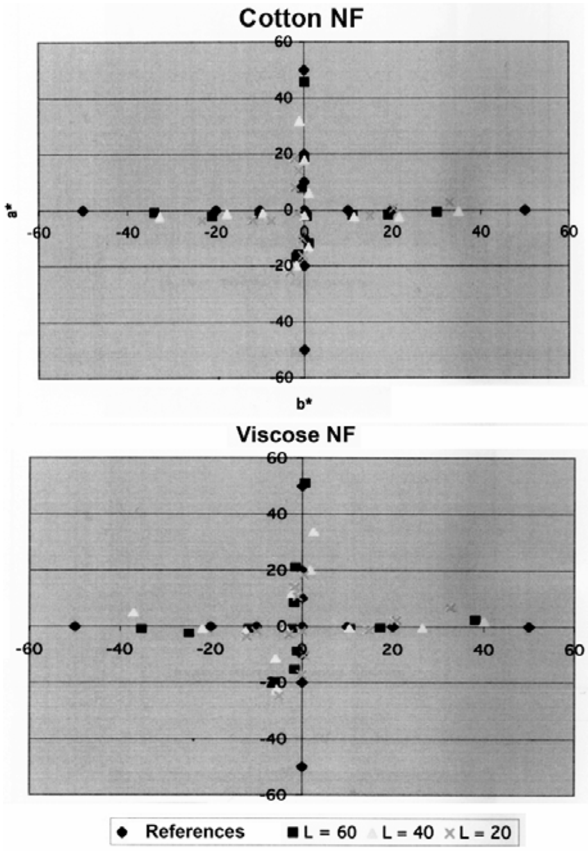


*Figure 4. L*a*b* values for two textiles*

### Printing Tests on Cotton

*Figure 5. Visual results, on the left a face before calibration, on the right after calibration*

On the left of figure 5, we can see the colorimetric deviation in case A. The photograph of the face appears too red and the details in the shadow areas are lost. After calibration, the result looks better but the face still does not contain enough colours and contrast (case B).

The following printing test (C) shows a better rendering: contrasts and neutral greys are satisfactory.

The last printing test (D) provides satisfactory contrasts and more vivid colours than in case C, although a slight deviation toward the red can be observed. Moreover, the print quality is lower than in case C. The fixing process appears to have a large variability. Because of this, the ICC profile cannot improve the rendering as well as when the ink is not fixed. However, the result is of course, more satisfactory than when printing is carried out with or without linearization (cases A and B). One must understand that fixing colours is a necessary step in textile printing, because it prevents dyes from being washed away during textile cleaning. We reach here a limitation in improving colour rendering when printing textiles. This phenomenon will also prove to be true when printing viscose, twill silk and muslin.

*Figure 6. Visual results, on the left a face after calibration and characterization – application of an ICC profile, on the right after fixation*

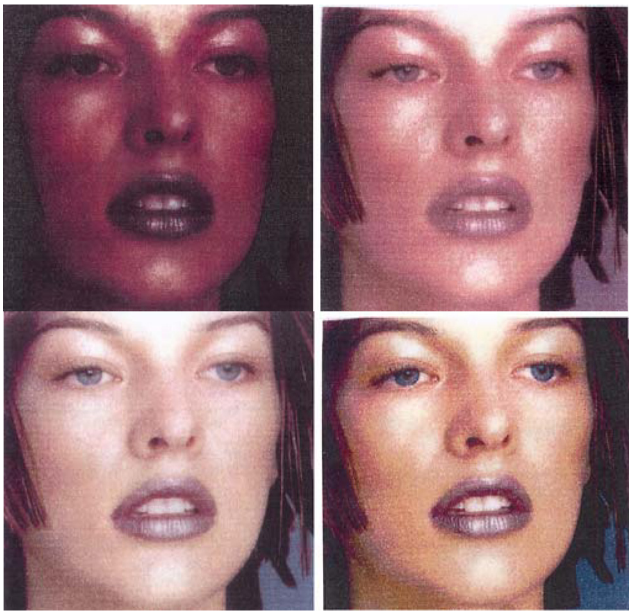

*Figure 7. Visual result on the viscose*

**Printing Tests on Viscose**

The first printing test (A) shows a colorimetric deviation. The latter is larger than in the case of cotton. The linearisation (B) enables to limit this colorimetric deviation, but the reddish appearance remains. Test C improves the rendering, although greys are still reddish. In test D, a yellowish tint can be observed on the face. Moreover, the printing quality is poorer, as observed in the case of Cotton.

**Printing Tests on Twill Silk**

Linearisation (B) again improves colours and grey scales. In case C the original colours are matched. Again case D shows more reddish and vivid colours than in case C.

**Printing Tests on Muslin**

Because of the thinness of muslin, results are mediocre due to a high transparency. Indeed, the spectrophotometer analyses colours as “too clear”, resulting in corrections which are too dark and saturated. Therefore a manual profile needs to be designed in order to compensate for this phenomenon.

## Conclusion and Perspectives

If linearising and using ICC profiles definitely improves colour rendering when printing cotton or viscose, the variability of the fixing stage proved to be a limitation of the process, because it cannot be corrected.

One solution to this will be development of ink jet inks which don’t need to be fixed after printing.

As far as TAC is concerned, thin materials cannot bear high TAC values and thus have limited colour gamuts.

In this study, we linearised using the dot area coverage as input and output. It would be interesting to carry out a similar study using luminance (L) as input and output during linearization, because it better reflects the sensitivity of the human eye.

Another perspective would be to try to create ICC profiles using spectrometers with sphere geometries, because the latter are more spread in the textile industry. Typically, ICC profiles are generated using spectrometers with a 0/45° geometry.

## References


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## Biography

**Lionel Chagas** graduated from the French Engineering School of Papermaking and Printing in 1989 and received his Ph. D. at the National Polytechnique Institute of Grenoble in 1997. Since then he has been working in the French Engineering School of Papermaking and Printing as a teacher and searcher. His work is focused on prepress and particularly on color management.