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EVALUATION OF TEXTILE PRINTS PRINTED WITH INKJET PRINTER

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Abstract: *In the rapidly evolving textile printing industry, it is critical to understand the impact of substrate properties on print quality. This study objectively compares the print quality and geometric deformations of typographic elements on paper and textile substrates using a large format inkjet printer. We evaluated print non-uniformity and geometric deviations by analysing prints on Microporous Satin Photo Paper and Blackout VI DirectTex textile fabric. Our analysis, conducted using ImageJ software, revealed that the textile substrate had significantly higher NU values and greater variations in both the area and perimeter of the typographic elements compared to the paper substrate. These deviations are attributed to the textured, uneven surface of the textile, the higher thread density and the greater bleeding of the ink, while the smoother paper substrate showed more consistent results. This study highlights the importance of substrate properties in assessing print quality and suggests that future research could focus on optimising materials and printing technologies to improve accuracy on different substrates.*

Key words: inkjet printing, printing on textiles, textile structure properties, quality of prints

1. INTRODUCTION

In modern society, where aesthetics are just as important as the materials used, textile printing has become increasingly popular. It is often used for clothing, home décor, signage and technical textiles. With the rapid growth of the textile printing industry, we now face many challenges. Unlike printing on paper, there are many different variables when printing on textiles, such as the type of fabric, weave or knit structure, thickness and surface finish, all of which have a significant impact on the final print quality.

Advances in digital printing, print head technologies and ink and dye formulations have made digital printing the dominant technique for textile printing. Several manufacturers are introducing new models of inkjet printers that offer higher productivity and faster single-pass printing (Digital Textile Printer, 2024).

Print quality is influenced by numerous factors, such as printheads, inks or dyes, coatings, print settings (speed, resolution, colour management), and the most important factor - the printing materials used. Although the final prints are often compared visually, this method is subjective and is influenced by lighting, room conditions and personal perception. Relying solely on visual judgement can lead to inaccurate conclusions. For this reason, it is important to analyse the print quality objectively. This takes into account various data such as speed, resolution, ink consumption and colour accuracy, which are essential for an accurate comparison. Objective analysis ensures more accurate assessments and helps to determine the best printing device and settings for specific requirements. It is advisable to use standardised test forms or user-created custom forms to systematically evaluate and measure specific attributes or performance criteria (Schilling, 2023).

2. EXPERIMENTAL

In our study, we compared the final prints on paper and textile printing materials to objectively evaluate the differences between the materials and to determine how the basic properties of the textile printing material affect the final prints compared to those on paper.

The paper printing material used was Microporous Satin Photo Paper. This is a one-side coated, semi-gloss paper with a grammage of 195 g/m² (Figure 1) (Papergraphics, 2024).

Blackout VI DirectTex (Pongs, Germany) was chosen as the textile printing material. This is a PVC-free fabric made of 100% polyester (PES) with a grammage of 330g/m². The fabric has a bright white front side and a dark grey back side, which prevents light from shining through (Figure 1) (Pongs technical textiles, 2011).

We analysed the textile substrate in detail and found that it uses multifilament yarns in a woven construction with two weft yarns in a 1:1 sequence, consisting of a reinforced satin with 7 ends on the front and a weft satin with 14 ends on the back. The front side has a thread density of 597 threads per 10 cm in

the warp and 275 threads per 10 cm in the weft, with the warp threads having an average diameter of 170 µm and the weft threads 340 µm.
The higher thread density reduces the open areas and increases the surface density. The floating threads of the satin weave can affect ink bleeding and wicking, which can lead to smudged or blurred prints. The front side has an inkjet coating to smooth the surface and improve print quality (Mendizza, 2024).

Figure 1: Selected printing materials; paper substrate on the left, textile substrate on the right

The imagePROGRAF PRO-4000S is a large-format inkjet printer designed for the poster and signage industry. Both selected printing materials are compatible with this printer. The Fiery XF RIP (raster image processor) was used to calibrate and manage the colours of the printer and the selected printing materials. In order to objectively compare the final prints, we created our own test form with different elements. It included a 100 × 100 mm square with 100% black coverage, lines of different widths and various typographic characters.

3. RESULTS WITH DISCUSSION

3.1 Non-uniformity of prints

Using image analysis, we performed a print non-uniformity (NU) analysis for a 100% coverage black area in the form of a 100 × 100 mm patch. The images were captured with an optical scanner and analysed with ImageJ software. We used a plugin described and developed in the study by Muck and colleagues (Muck, Hladnik, & Stanić, 2009). A higher NU value indicates greater print non-uniformity. The NU value is calculated from the difference between the average pixel intensity above the median (Ux) and the average pixel intensity below the median (Lx). As part of the image analysis, we also created the histograms of the captured images, which show the print non-uniformities of the width of the area in the graph.
Table 1 shows the NU values for the selected materials. The NU value for the digitally designed colour patch is 0, while it is quite high for the textile material (24.2119) and significantly lower for the paper (3.7912). We expected the NU values to be higher for the textile material due to its much rougher surface compared to the glossy coated paper. Figures 2 show the printed patches captured with an optical scanner together with the corresponding histograms. The higher NU value is visible in the scanned images and is also illustrated by the histograms, with the histogram for the textile image covering a larger area than that for the paper.

Table 1: NU values for selected materials

Material	NU value
Digitally designed colour patch	0.0000
Paper	3.7912
Textile	24.2119

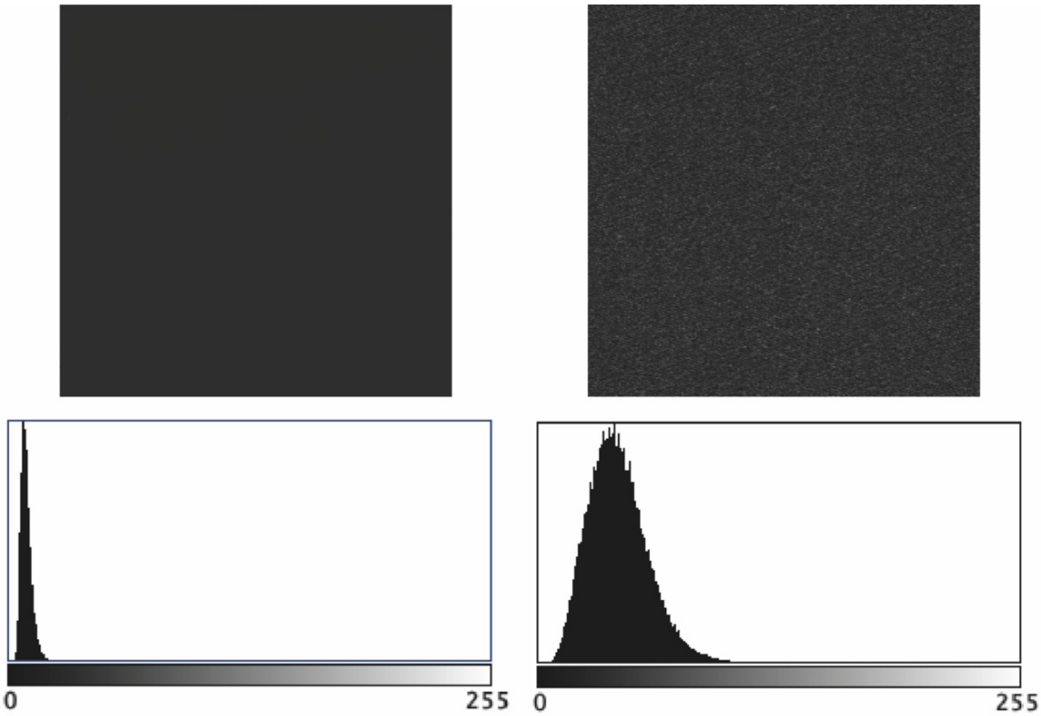


Figure 2: NU for paper substrate on the left and textile substrate on the right, with associated histograms

3.2 Geometric deformations of typographic elements

Using a digital magnification device with the same settings, we photographed the same typographic elements on both substrates in order to analyse the image. The typographic elements were the lowercase letter n in Helvetica font, size 20 pt, and the number 7 in Helvetica font, size 17 pt, both in horizontal and vertical layout and in positive and negative print (Table 2). Using image analysis, we measured the area and circumference of these elements, compared them with the digitally designed ones, and calculated the corresponding deviations (Tables 3–4).

The analysis of the results in Tables 3 and 4 showed significant deviations for both positive and negative print types on the textile substrate. The deviations on the paper substrate were smaller, as expected due to the smoother surface. The areas of the negative prints on both substrates were smaller than those of the digitally designed. The horizontal prints were larger than the vertical prints on both substrates, which we attribute to the warp direction of the fabric and the higher thread density in the textile substrate, as well as the orientation of the fibres in the paper substrate.

The deviation of the in circumference for both typographic elements was higher on the textile substrate, with larger values for the vertical position observed for in both positive and negative print types. The image analysis distinguishes precisely between dark prints and light backgrounds and detects even the smallest changes in the outlines of the elements. The difference was less pronounced on the paper substrate. In the textile substrate, there was a stronger ink spread in the direction of the warp, where the thread density is higher. This was evident when analysing both the lowercase letter n and the number 7.

Table 2: Images of horizontally and vertically printed positive and negative lowercase letters n in Helvetica font, size 20 pt, and number 7 in Helvetica font, size 17 pt, on paper and textile

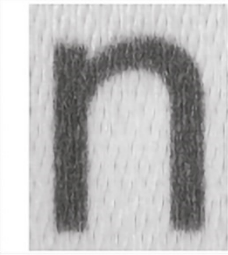
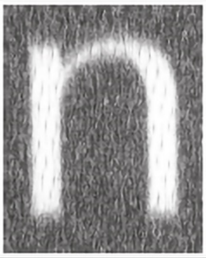
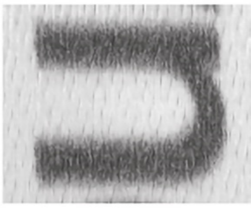
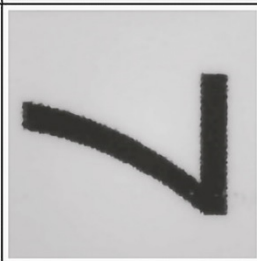
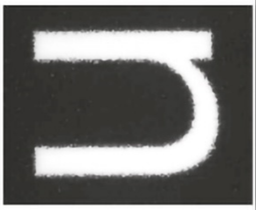
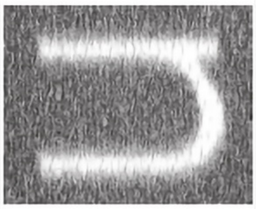
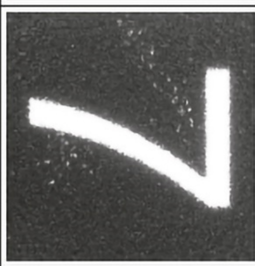
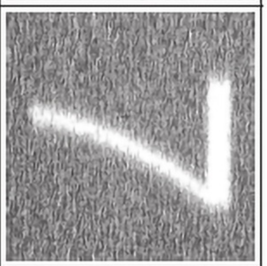
	Printing materials			
	Paper	Textile	Paper	Textile
Digitally defined typographic element	n		7	
Horizontal direction				
				
Vertical direction				
				

Table 3: Digital and measured values of area (A) and circumference (C) of lowercase letter n in Helvetica font, size 20 pt, with corresponding deviations (Δ)

	Layout and type of print	A [mm²]	ΔA [mm²]	C [mm]	ΔC [mm]
Digitally designed typographic element	/	5.47	/	19.70	/
Paper	horizontal, positive	5.73	0.26	23.13	3.43
	horizontal, negativ	4.86	–0.61	25.36	5.66
	vertical, positive	5.80	0.33	26.76	7.06
	vertical, negativ	4.56	–0.91	23.88	4.18
Textile	horizontal, positive	6.44	0.97	33.29	13.59
	horizontal, negativ	4.48	–0.99	37.26	17.56
	vertical, positive	7.74	2.27	52.84	33.14
	vertical, negativ	3.45	–2.02	58.78	39.08

Table 4: Digital and measured values of the area (A) and circumference (C) of the number 7 in Helvetica font, size 17pt, with corresponding deviations (Δ)

	Layout and type of print	A [mm²]	ΔA [mm²]	C [mm]	ΔC [mm]
Digitally designed typographic element	/	3.53	/	15.47	/
Paper	horizontal, positive	3.78	0.25	21.07	5.60
	horizontal, negativ	3.23	–0.30	18.92	3.45
	vertical, positive	3.60	0.07	17.77	2.30
	vertical, negativ	3.19	–0.34	18.06	2.59
Textile	horizontal, positive	4.46	0.93	29.65	14.18
	horizontal, negativ	2.96	–0.57	42.01	26.54
	vertical, positive	3.98	0.45	26.27	10.80
	vertical, negativ	2.54	–0.99	35.64	20.17

4. CONCLUSION

In this study, the print quality and geometric deformations of typographic elements on paper and textile substrates were analysed using a large-format inkjet printer. The aim of the analysis was to objectively evaluate the differences between these materials and to understand how their basic properties influence the final print quality.

Our results show significant differences in print non-uniformity (NU) and geometric deformations between the substrates. The textile substrate had a much higher NU value compared to the paper substrate, reflecting the more uneven surface and greater variability in print quality. This was to be expected due to the textured surface of the textile and the effect of the multifilament yarns, which lead to greater ink bleeding and wicking.

As far as the geometric deformations are concerned, both the area and circumference of the typographic elements were significantly influenced by the type of the substrate. The deviations from the digitally designed typographic elements were more pronounced on the textile substrate, with the horizontal prints showing greater deviations than the vertical ones. This phenomenon is attributed to the higher thread density and warp direction of the textile, which influence ink bleeding and print accuracy. On the other hand, the paper substrate showed more consistent results with less deviation due to its smoother and more even surface.

Overall, the study emphasises the importance of considering the characteristics of the substrate when assessing print quality. While digital magnification devices and objective analysis methods provide valuable insights, the inherent properties of the printing material—such as surface texture and thread density—play a crucial role in determining the final print quality.

Future work could further investigate how different types of materials, coatings and printing technologies could mitigate these issues and improve print accuracy on different substrates.

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