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Dear reader,

In a few days, on 19 September 2011, the 43rd Annual Conference of the International Circle will be opened at Norrköping, Sweden. A very warm welcome to all of you who have taken the time to join this event. I am convinced that it will be an excellent convention as were the conferences before. I have seen how much work our Swedish colleagues have invested and how carefully they considered every detail to prepare for a great event.

What you now hold in your hands (or can see on the screen of your computer) are the abstracts of the contributions which have been accepted for presentation at the conference. These papers reflect the whole scope of the International Circle: a thoroughly international attitude, scientific excellence, and excellence in teaching as well. It may seem to be a bit old-fashioned in these days when education is also big business, but Wilhelm von Humboldt's idea of the unity of education and research in an international environment still prevails. And the International Circle stands for this.

Presenting a paper at conference, however, is only part of the process; generally speaking, there is only a slight difference between listening to a speaker and reading an article in a learned journal. The extra benefit of a conference like the IC Annual is the immediate discussion of the presentation. This not only helps to clarify what may have been self-evident to the writer, but not to the reader; it also provides the opportunity to add comments, to contribute own experiences, to point out weaknesses (if there are any) and to further develop the ideas which were presented, in short: to contribute to the advancement of knowledge and to come a bit closer to our common goal, the perfect education for our business.

These discussions may well continue during lunch or over a beer or two in the evening. At the last conference in Moscow, Russia, I awarded – with a smile – the prize for the most-disputed paper to our Swedish colleague, and chairman of this year's conference, Tommie Nyström. This was meant to be a great compliment; his paper perfectly served the purpose meetings take place for.

It must be admitted, however, that conference presentations are important, but that the breaks in between are as well. Talking to each other, starting collaborations, making new friends – all this is an unofficial, but not less important reason to visit our conferences.

I'm looking forward to another fruitful and enjoyable conference of the International Circle.

Wolfgang Faigle

President

Technical papers program: Schedule and contents

Tuesday September 20, 2011

Wednesday September 21, 2011

Typographic and colorimetric properties of non-impact prints on transfer foil

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Abstract

The research focused on the study of typographic and colorimetric properties of prints on transfer foils made with the non-impact printing technology, using two different printers – electrophotography- and inkjet-based, their cartridges and two thermal transfer materials which were transferred onto a cotton fabric. Four-colour prints and typography defined with three different typefaces (one sans-serif, one transitional and one modern) were made. The typefaces were tested in four sizes (6, 8, 10 and 12 pt). The prints were exposed to a different number of washing and drying cycles, the differences in colour and typographic tonal density being measured before and after the cycles. The colour differences of 100% and 50% intensity fields (CMYK100 and CYK50) were measured spectrophotometrically, whereas the difference in typographic tonal density was measured by means of image analysis.

The differences in colour ΔE_{00}, lightness ΔL_{00}, chromaticity ΔC_{00} and hue ΔH_{00} for the substrate and prints (CMYK) after a different number of washes were calculated with the obtained spectrophotometric measurements. The changes in the colour of the substrate alone had to be taken into account as well, as these results demonstrate that the hue of the transferred layer of the transfer foil also influences the indirect transfer printing. While inkjet printers apply a thicker layer of ink, more precise printing of smaller graphic elements is achieved with electrophotography. The most substantial difference in typographic tonal density after a different number of washes was measured at smaller type sizes (6 in 8 pt). Due to its design features, the tested sans-serif typeface displayed higher typographic tonal density than the other two tested typefaces. After a different number of washes, the highest difference in typographic tonal density was measured at the sans-serif typeface.

Introduction

Various technologies and an array of applied materials connected with them substantially influence our everyday lives. One of such fields is the non-impact printing technology, which has become widely spread also due to its quality improvements and the possibility of using different substrates, e.g. paper, plastics, glass or metal. Non-impact printing technologies generally give higher print quality, faster printing speed and are more commonly used in the consumer than in the professional field [1]. The basic advantage lies in the print head which does not come into a direct physical contact with the substrate. Modern digital printing technologies, e.g. piezo inkjet, electrophotography [2], are also used for the information transfer onto textile materials by means of various transfer foils. Nevertheless, the question of the quality and long-term print fastness arises, especially after the washing of textiles.

In the research, we wanted to establish which modern digital printing technology for printing onto textiles, e.g. by means of a transfer foil used in textile fabrication, enables the best quality and long-term fastness. Moreover, we wanted to find out what typeface in relation to its size contributes to better legibility and its recognition. Several factors need to be taken into consideration, e.g. material composition, printing technology, amount of applied ink (ink layer thickness), and the size of printed graphic and typographic elements, to draw conclusions or even make recommendations.

We focused on three different typefaces and their sizes. The smallest sizes were of uttermost importance, as we wanted to make recommendations on an appropriate use for displaying brand logos printed on textiles through transfer foils, usually placed discretely on a small area of a T-Shirt or other piece of clothes. When a brand name is printed next to a logo, its size is usually smaller, e.g. between 6 and 8 pt. The exact type size depends on the x-height of a typeface – typefaces with larger yet moderate x-heights are generally more legible at smaller sizes [3–5]. In addition, several other typographic characteristics need to be taken into consideration to make the name more legible, i.e. distinctive character features (counter shape), ascenders, descenders, serifs, contrast (stroke width), set width, type size, leading (i.e. space between lines) etc [6].

For the research purpose, we analysed typographic tonal density (or typographic tonality), which refers to the relative blackness or shades of grey of type on a page and plays a significant role in the visualization of information. Typographic tonal density can be expressed as the relative amount of ink per square centimetre, pica or inch [7]. Its variation depends on the changes in various type features [3, 6, 7], e.g. larger counters trap a larger amount of white space in the enclosed spaces of letters, and a thicker stroke width creates more ink per area [7–9]. Typographic tonal density and colorimetric properties, as well as the demand to ensure suitable visibility even after several washes depend on the ink and its layer thickness made with a transfer printing technique [10]. These factors are extremely important and were also evaluated in the research.

Experimental

The research focused on the study of typographic and colorimetric properties of prints on transfer foils made with the non-impact printing (NIP) technology, using two different printers, their cartridges and two thermal transfer foils. The prints were transferred onto a natural material – 100% plain weave (P1/1) cotton. The colorimetric properties of cotton were measured with a spectrophotometer DataColor, Spectra Flash 600 Plus-CT (aperture size 6.6 mm) where the measured whiteness value was 74.48 and the measured hue value was 98.21.

The two printers used in the research were:

- printer P1: HP Indigo S5500; electrophotography with liquid ElectroInk; indirect printing (transfer foil: Forever Digi-Print WT), and
- printer P2: Roland LEC-300; piezo inkjet technology with Roland ECO-UV ink; indirect printing (transfer foil: Poli-flex Printable 4016).

Typography defined with three different typefaces, i.e. one sans-serif (Arial) [11, 12], one transitional (Times) [11, 12] and one modern (Blaznic) [11, 12] typeface, was analysed. The typefaces were tested in four different sizes (i.e. 6, 8, 10 and 12 pt). Furthermore, four-colour prints with 100% (CMYK100) and 50% (CMYK50) intensity fields of dimensions 10 × 10 mm were printed. The test form was designed with the program Adobe InDesign CS5 and was used as a PDF file, which ensured a unified appearance of the form on various computers and operation systems, and in consequence, on the print.

The transfer foils printed with printers were transferred onto textile by means of the heat press PN-45: foil Forever Digi-Print WT at pressure 32 kPa, temperature 168 °C in 20 seconds and foil Poli-flex Printable 4016 at pressure 32 kPa, temperature 175 °C in 15 seconds.

The prints were exposed to a different number of washing and drying cycles, defined in accordance with the standard on textile washing and drying procedures, ISO 6330 [13]. With the washing machine Gorenje WA 1341S (at temperature 40 °C), five washes were performed, whereas for drying, the tumble dryer Mathis HVF 69905 (at temperature 110 °C) was used. Print fastness was measured after each of the five cycles of washing and tumble drying.

The differences in typographic tonal density and colour were measured before and after the cycles. The differences in typographic tonal density of the unwashed and washed samples of typefaces were measured by means of image analysis (ImageJ) [14]. This software gives the opportunity to measure, analyse and provide output values, e.g. area, number of particles and percentage of coverage [15, 16].

The colour differences (CIE L*a*b* parameters) of 100% and 50% intensity fields (CMYK100 and CYK50) were measured with the spectrophotometer DataColor, Spectra Flash 600 Plus-CT (aperture size 6.6 mm) in accordance with the ISO 105-J01 [17] standard using the D65 standard illumination, 10° standard observer and instrument geometry 45/0. The colour difference (ΔE) between the unwashed and washed samples was calculated according to the CIEΔE2000 L*a*b* equation for colour differences [18, 19].

Results and discussion

Typographic properties of prints

The typographic tonal density (TTD) of typefaces, each in different size, was measured before and after each of the five washes. The TTD of tested typefaces according to the used type sizes, printed with different printers is presented in Table 1.

The differences in TTD of prints after the fifth wash are presented in Figure 1. The differences in TTD of printed typefaces in size 6 pt and 8 pt after each wash are presented in Figures 2 and 3. In Figure 4, the average differences in TTD after the first, third and fifth wash are given.

The results show an expectedly higher TTD at the sans-serif typeface (cf. Table 1), due to the differences in the letter stroke width being smaller. The lowest TTD was observed at the transitional typeface Times. Times has its thick stroke thinner than the typeface Blaznic. The best smoothness of letters was printed with printer P1, while the highest values of TTD were given by printer P2, which is a consequence of a thicker ink layer. It is also evident that the smallest values in TTD were given by printer P1.

After a different number of washes, the smallest difference in TTD was observed on the prints printed with printer P1. The most noticeable average difference in TTD occurred at the Arial (sans-serif) typeface (cf. Figure 1).

The obtained results show the biggest differences at the typefaces used in sizes 6 and 8 pt (cf. Figures 2 and 3). TTD at smaller type sizes is usually higher due to a smaller counter size of letters and leading. Furthermore, the differences were more evident after the washing, especially on the prints printed with printer P2. The typefaces with differences in stroke width (i.e. Times and Blaznic) were more influenced by the poor printing quality. At very small type sizes, uppercase letters are more legible than lowercase letters. While comparing the influence of a different number of washes (cf. Figure 4), it can be seen that the differences in TTD on the prints printed with both tested printers (P1 and P2) became similar after the third wash.

Table 1. TTD of tested typefaces printed in different sizes with printer P1 and P2

	TTD (%)							
	P1				P2			
Typeface	**6 pt**	**8 pt**	**10 pt**	**12 pt**	**6 pt**	**8 pt**	**10 pt**	**12 pt**
Times	19.69	18.52	20.40	19.47	39.31	33.74	30.44	28.73
Arial	28.91	26.08	24.63	23.53	42.97	38.24	34.24	32.28
Blaznic	22.22	21.66	21.24	22.85	42.75	37.48	34.95	32.12

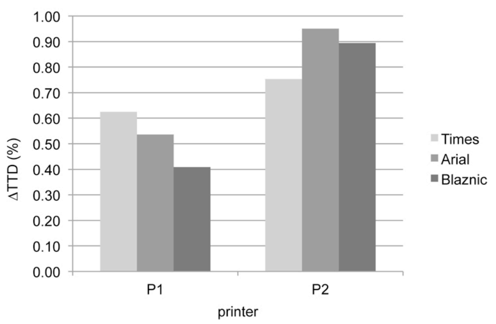


Figure 1. Average difference in TTD of tested typefaces printed with different printers (P1, P2)

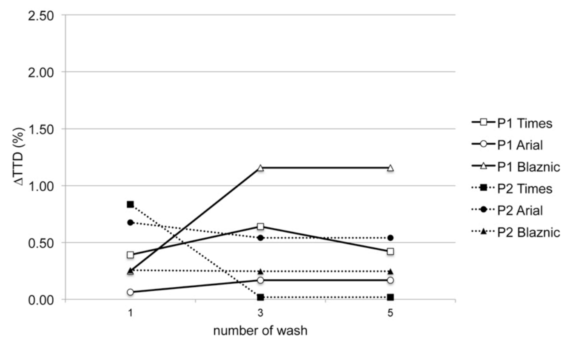


Figure 2. Differences in TTD of printed typefaces in size 6 pt after first, third and fifth wash

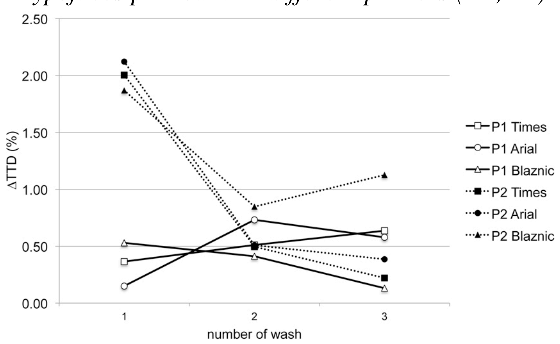


Figure 3. Differences in TTD of printed typefaces in size 8 pt after first, third and fifth wash

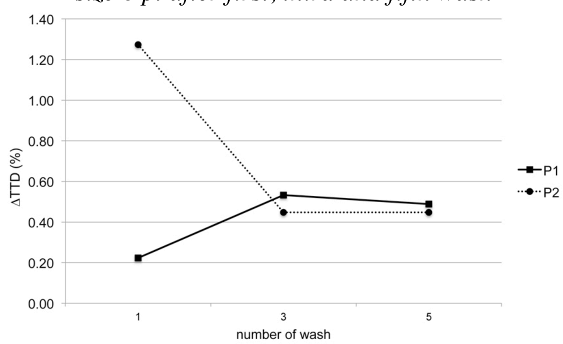


Figure 4. Average differences in TTD of printed typefaces in all sizes after first, third and fifth wash printed with two printers (P1, P2)

Colorimetric properties of prints

An analysis of colorimetric properties of CMYK prints (100% and 50% intensity field) was made. Figure 5 shows the CIE L*a*b* values of spectrophotometric measurements of prints before and after a different number of washes. In Tables 2 and 3, the differences in colour ΔE_{00}, lightness ΔL_{00}, chromaticity ΔC_{00} and hue ΔH_{00} are given for the substrate and prints (CMYK100, CMYK50) after a different number of washes.

The used cotton fabric printed with different NIP technologies using different transfer foils (substrate) showed colour differences, where all the prints became slightly darker after the first wash. After the first wash, the non-printed parts of the substrate also had the highest colour difference (cf. Table 2), which means that indirect transfer foils respond to warm water and extra heating (drying). The agitation in warm water leads to the transfer layer degradation and a better view of the original fabric structure (hue of the substrate becomes grey-bluish). The transfer foil used on printer P2 is much more stable.

Table 2. Colorimetric differences in substrate with corresponding foils after first, third and fifth wash

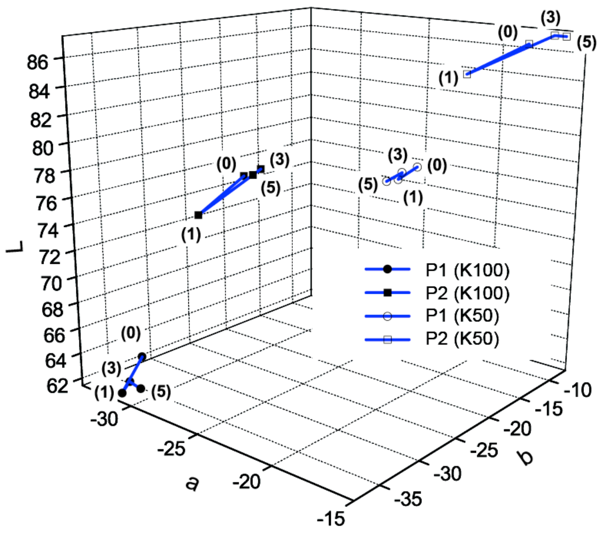
		ΔE_{00}	ΔL_{00}	ΔC_{00}	ΔH_{00}
P1 on substrate	S 0 wash–S 1 wash	2.06	1.25	1.62	0.24
	S 0 wash–S 3 wash	3.40	0.22	1.77	2.90
	S 0 wash–S 5 wash	3.65	1.12	1.42	3.16
P2 on substrate	S 0 wash–S 1 wash	0.55	–0.27	0.30	–0.37
	S 0 wash–S 3 wash	0.79	–0.31	0.63	–0.36
	S 0 wash–S 5 wash	0.74	–0.30	0.65	–0.18

In comparison with other process colours (cf. Table 3 and Figure 5), the prints made with cyan displayed the highest colour differences. The 100% intensity fields made with both NIP technologies changed after the first wash so much that the differences could be seen with a naked eye. After the third wash, the prints stabilized. The 50% intensity fields prints made with printer P2 demonstrated the same behaviour. On the other hand, the 50% intensity fields made with printer P1 worsened after each wash and the colour values were far from those printed on the transfer foil at the beginning. The reason for the changes is the pigment particles based on phthalocyanine in the cyan ink. The phthalocyanine molecules are extremely large, which contributes to poor mutual binding. After the first wash, a relatively large part of pigments was released and lost. The printer P2 ink layer being thicker than the one made with printer P1, the colour differences on the prints made with printer P2 were more substantial. Afterwards, the layer left stabilised and the colour differences were almost not noticeable.

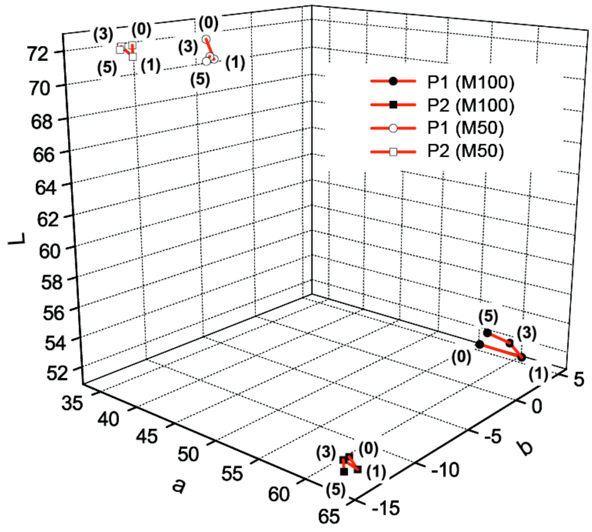
The magenta prints made with printer P1 faced more substantial changes than those made with printer P2. The magenta prints with the 100% intensity field applied with printer P1 hence showed the maximum difference, which diminished after each wash. This was not the case with the 50% intensity field, the colour differences increasing after each wash. At the magenta prints made with printer P2, regardless of whether they were of 100% or 50% intensity fields, very small colour differences appeared. This means that the UV airing contributed to the fixation of magenta pigments (quinacridone) on the substrate.

The yellow colour uses azo pigments as its base. The molecules of azo pigments are of smaller size structure; such prints thus displayed the smallest colour differences. The prints made with printer P1 had much higher colour differences than those made with printer P2.

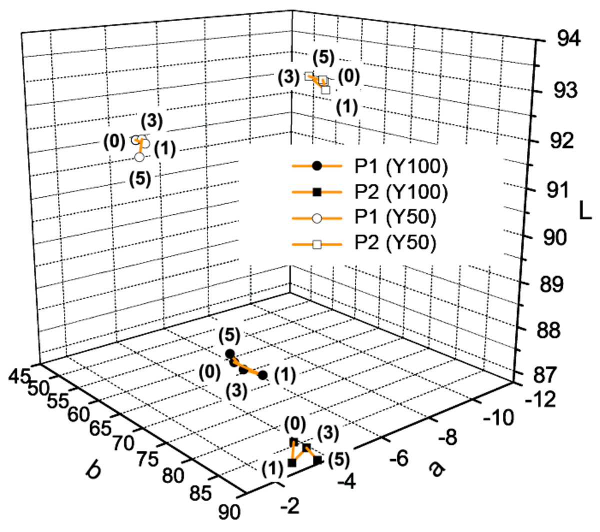
After the first wash, the black prints of 100% intensity fields printed with printer P2 did not change very much colorimetrically, while during further washes, the colour differences became very significant. A possible reason could be found in the fact that the black ink absorbs more UV brightness, which activates a higher number of photoiniciators, creating a more stable top layer. This corresponds to the pigment particles composed of pure carbon, the low molecular structure binding of which is good. Nevertheless, a longer temperature and mechanical exposure degraded such prints, which was demonstrated in significant colour differences. The black prints of both intensities (K100, K50) made with printer P1 were distinguished by smaller colour differences.



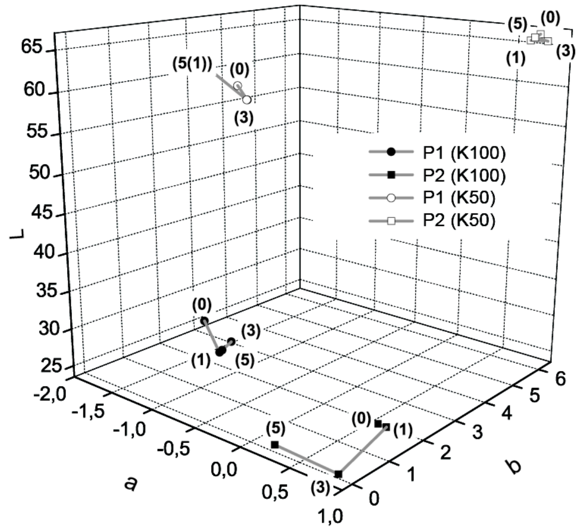
(a)



(b)



(c)



(d)

*Figure 5. CIE L*a*b* values of textile substrate (with used transfer foils) of 100% and 50% intensity field prints (P1, P2) before washing (0) and after different number of washes (1, 3 and 5) for cyan (a), magenta (b), yellow (c) and black (d)*

Table 3. Colorimetric differences in CMYK100 and CMYK50 prints (P1, P2) after first, third and fifth wash

		ΔE_{00}	ΔL_{00}	ΔC_{00}	ΔH_{00}		ΔE_{00}	ΔL_{00}	ΔC_{00}	ΔH_{00}
C 0 wash–C 1 wash	**P1 (C100)**	2.11	1.85	−0.62	−0.81	**P1 (C50)**	0.99	0.52	−0.63	−0.56
C 0 wash–C 3 wash		1.39	1.00	−0.45	−0.86		1.20	0.04	−0.64	−1.01
C 0 wash–C 5 wash		1.71	1.15	−0.29	−1.23		1.63	0.47	−1.08	−1.13
C 0 wash–C 1 wash	**P2 (C100)**	3.20	1.81	−1.22	−2.35	**P2 (C50)**	2.94	1.42	−1.92	−1.72
C 0 wash–C 3 wash		0.98	−0.68	0.43	−0.55		1.06	−0.50	0.89	−0.31
C 0 wash–C 5 wash		1.01	−0.40	0.22	−0.90		1.48	−0.49	1.32	−0.48
M 0 wash–M 1 wash	**P1 (M100)**	2.29	1.68	−0.53	−1.46	**P1 (M50)**	1.10	0.88	−0.66	0.09
M 0 wash–M 3 wash		1.48	0.69	−0.24	−1.29		1.17	0.66	−0.87	0.41
M 0 wash–M 5 wash		0.84	−0.13	0.19	−0.81		1.44	0.84	−0.99	0.63
M 0 wash–M 1 wash	**P2 (M100)**	0.56	0.50	−0.24	−0.05	**P2 (M50)**	0.63	0.39	−0.48	0.13
M 0 wash–M 3 wash		0.18	0.07	0.01	0.16		0.38	0.02	0.05	0.38
M 0 wash–M 5 wash		0.57	0.49	−0.14	0.26		0.50	0.11	−0.14	0.47
Y 0 wash–Y 1 wash	**P1 (Y100)**	1.10	−0.03	−1.10	0.10	**P1 (Y50)**	0.34	0.04	−0.33	−0.07
Y 0 wash–Y 3 wash		0.59	−0.02	−0.57	0.15		0.23	−0.02	−0.23	−0.05
Y 0 wash–Y 5 wash		0.15	−0.12	−0.01	0.09		0.31	0.23	−0.21	0.02
Y 0 wash–Y 1 wash	**P2 (Y100)**	0.41	0.15	−0.30	0.23	**P2 (Y50)**	0.33	0.13	−0.26	0.15
Y 0 wash–Y 3 wash		0.32	0.03	−0.32	−0.04		0.56	−0.04	0.55	−0.09
Y 0 wash–Y 5 wash		0.57	0.17	−0.54	−0.11		0.30	0.05	0.19	−0.23
K 0 wash–K 1 wash	**P1 (K100)**	1.54	1.39	0.65	−0.10	**P1 (K50)**	1.05	1.00	0.32	0.12
K 0 wash–K 3 wash		0.86	0.63	0.56	0.19		0.92	0.29	0.87	0.10
K 0 wash–K 5 wash		1.45	1.33	0.59	−0.01		1.80	−1.66	−0.54	−0.43
K 0 wash–K 1 wash	**P2 (K100)**	0.56	0.53	−0.12	−0.11	**P2 (K50)**	0.51	0.44	0.26	0.05
K 0 wash–K 3 wash		2.81	2.65	0.36	0.88		0.54	0.50	0.10	0.19
K 0 wash–K 5 wash		2.55	2.17	1.22	0.55		0.42	−0.01	0.37	0.20

Conclusions

Print fastness is influenced by the application of ink and the type of the non-impact printing technology. The application of thicker ink layer is more suitable for printing onto larger surfaces and provides better fastness. On the other hand, this is not appropriate when details or elements in smaller sizes are being printed, e.g. letters in smaller sizes. Electrophotography enables precise printing of smaller graphic elements, e.g. thin strokes and serifs at smaller sizes of letters. The biggest difference in the fastness of prints after a different number of washes was measured at smaller type sizes (6 and 8 pt). Despite the most substantial difference in typographic tonal density being measured at the sans-serif typeface, this did not affect its legibility, as the typographic tonal density is higher at this typeface due to its design features than at other typefaces with different stroke widths. The use of sans-serif typefaces and uppercase letters instead of lowercase letters is recommended for smaller type sizes.

In general, the UV drying inkjet ink is more stable during the substrate changes; furthermore, smaller colour differences can be measured. While larger molecular parts of pigments (cyan) easily separated from the substrate, smaller molecular parts of pigments (yellow) remained almost unchanged.

To achieve suitable visibility of smaller graphic elements, e.g. of letters printed with the non-impact printing technology, special attention has to be paid to the choice of typographic characteristics of typefaces and their sizes, with regard to the used type of printer.

A further research needs to be performed to analyse a more substantial degradation of the printed layer, subsequently leading to a more suitable method for a long-term use of textile products.

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Author biography

Blaž Rat was born on 6 September 1982. After he finished Gymnasium Velenje in 2002, he enrolled at the Faculty of Natural Sciences and Engineering, Department of Textiles, University of Ljubljana, study programme Graphic Arts Technology. He graduated in 2007 and employed himself the same year as an early stage researcher. He entered the postgraduate or doctoral study programme, respectively, where he has been conducting research in the field of communication, graphic and interactive technology. He devotes special attention to typography.