Influence of Dry-Heat Ageing on Offset and UV Inkjet Prints on Synthetic Paper

Mirica Debeljak, Diana Gregor-Svetec

In the study optical properties of unaged and aged paper substrate i.e. ISO Brightness and Yellowness index and also color differences between unaged and aged UV inkjet and offset prints were studied. A fiber synthetic paper was used as a printing substrate. Prints of solid CMYK color fields were made by presses Oce Arizona 250® GT (UV Curable inks based on pigments) and by KBA Performa 74 (mineral oil-free offset inks). Printed and unprinted synthetic paper was artificially aged in air by dry-heat method at temperature of 105 °C. According to the standard ISO 5630/1 ageing was performed for periods of 1, 2, 3, 6 and 12 days. It was found that dry-heat ageing decreases ISO Brightness and increases Yellowness index on synthetic paper. Significant differences between offset and UV inkjet prints were noticed. UV inkjet prints were more stable than conventional offset print, especially black UV ink print. above.

Introduction

Heat, humidity, light, air pollutants, and mishandling all can shorten the life of a color print. The natural process of deterioration starts as soon as a color image is printed, whether it is produced digitally or conventionally. Heat is one of the most important environmental influences on the stability of color prints. High temperature and humidity adversely affect all color print materials, although not to the same degree. Such elevated conditions cause the colors to deteriorate quite rapidly [1]. The printing inks consist of a complex mixture of different components, which are classified by their function in ink matrix, and the ink composition is significantly dependent on the printing technology [2, 3]. Inkjet inks may be composed of pigments or of dyes. In general, pigmented inks tend to be more stable than dye based inks [1, 4]. Deterioration in quality of an aged paper or prints can manifest itself in the physical mechanical, chemical and optical properties. In regard to the changes of paper over time, the term durability is interesting. The permanence of paper depends on the chemical resistance of its components and on the influence of external factors. Discoloration of a paper may be caused by the formation of chromophores upon ageing as a result of exposure to light and volatile gases. Many volatile compounds as well as alcohols, ketones, aldehydes, carboxylic acids aromatic and aliphatic hydrocarbons and ethers can be released from paper during degradation processes depending upon paper chemical compositions [2, 5]. Color characteristics of inks used on such paper also change in time [6]. Synthetic paper is one of the durable paper and it's defined as a product composed of at least 20% synthetic substances. It can be used in many applications where traditional cotton or pulp based papers will not survive long, for example, where the paper is exposed to the heat, rain and most particularly to UV radiation outdoors [7-8].

In the study, the influence of the dry-heat treatment of conventional and digital prints on their color stability has been studied.

Experiment

Materials

In this study, the conventional and digital printing technique were used. Prints of solid CMYK color fields were made by presses Oce Arizona 250® GT (UV Curable inks based on pigments) and by KBA Performa 74 (mineral oil-free offset inks) on fiber synthetic paper Pretex (G=100 g/m^2). The Pretex is a high-quality, impregnated, and double-side coated special paper made from selected pulp and synthetic fibers (polyamide – PA and polyester - PES) in combination with a special binder system.

Methods

Synthetic paper, UV inkjet and offset prints were aged using standard technique for accelerated ageing: Dry-heat treatment based on standard SIST ISO 5630-1 at temperature of 105 °C for 1, 2, 3, 6 and 12 days.

The optical properties of papers were evaluated based on the ISO Brightness and Yellowness Index YI E313. The measurements were performed in accordance with the standard procedures ISO 2470 (ISO Brightness, R457) by X-Rite spectrophotometer at D65/10°, and in accordance with ASTM Method 313 (YI E313) by spectrophotometer Spectroflash 600 - Datacolor International at D65/10°.

Yellowness index according to the ASTM Method E313 is calculated as follows:

$$YIE313 = \frac{100(C_X X - C_Z Z)}{Y} \qquad (1)$$

where *X, Y, Z* are the CIE trismuilus values, C_X and C_z are coefficients (D65/10°: C_x= 1.3013, C_z = 1.1498) [9].

The colorimetric properties of the CMYK ink were determined using a spectrophotometer, GretagMacbeth Eye-One (D50 standard illumination, 2° standard observer, 45/0 measurement geometry and 4.5 mm measuring aperture). The color differences (ΔE^*_{ab}), which appeared after ageing, were calculated according to Eq. (2):

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad (2)$$

where $\Delta L^* = L^*(0) - L^*(t)$;
$\Delta a^* = a^*(0) - a^*(t)$;
$\Delta b^* = b^*(0) - b^*(t)$ are the differences calculated for unaged (0) prints and the aged prints (t) [10].

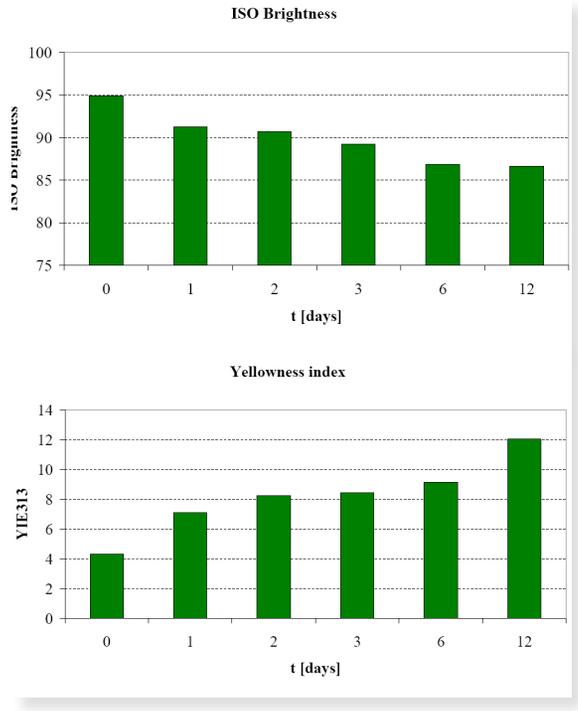

Figure 1

Results and Discussion

Influence of dry-heat treatment on optical properties of synthetic paper

In our investigation, the dry-heat (105° C) accelerated ageing was applied in order to determine the durability of fiber synthetic paper. The optical stability of paper (i.e. ISO Brightness and Yellowness index) during accelerated ageing was followed. Figure 1 summarizes these results.

As seen from Figures 1, the influence of dry-heat treatment on synthetic paper has shown logarithmic decrease of ISO Brightness. Values of ISO Brightness dropped after 12 days of dry-heat ageing from 95.0 to 86.7. The unaged paper's Yellowness index was YI E313=4.3. After 12 days of dry-heat ageing, the yellowness index potential increase to value of YIE313=12.1. Paper yellowing is a natural process of paper ageing, which is caused by sunlight, moisture, and air. The whole complex of these factors and their impact on paper is called photochemical ageing [11]. The loss of brightness (paper yellowing) during the ageing procedure is attributed to the presence of the chromophores formed by the degradation of paper components (cellulose, hemicellulose, lignin) [12].

Influence of dry-heat treatment on offset and UV inkjet prints

Ultraviolet curing inks have a different structure than conventional offset printing inks. They are made up of monomers, prepolymers/oligomers, pigments/colorants, additives and photoinitiators/synergists [13]. One of the advantages of UV curing method compared to traditional drying technique is high durability due to the superior weather resistance of the UV cured ink print [14].

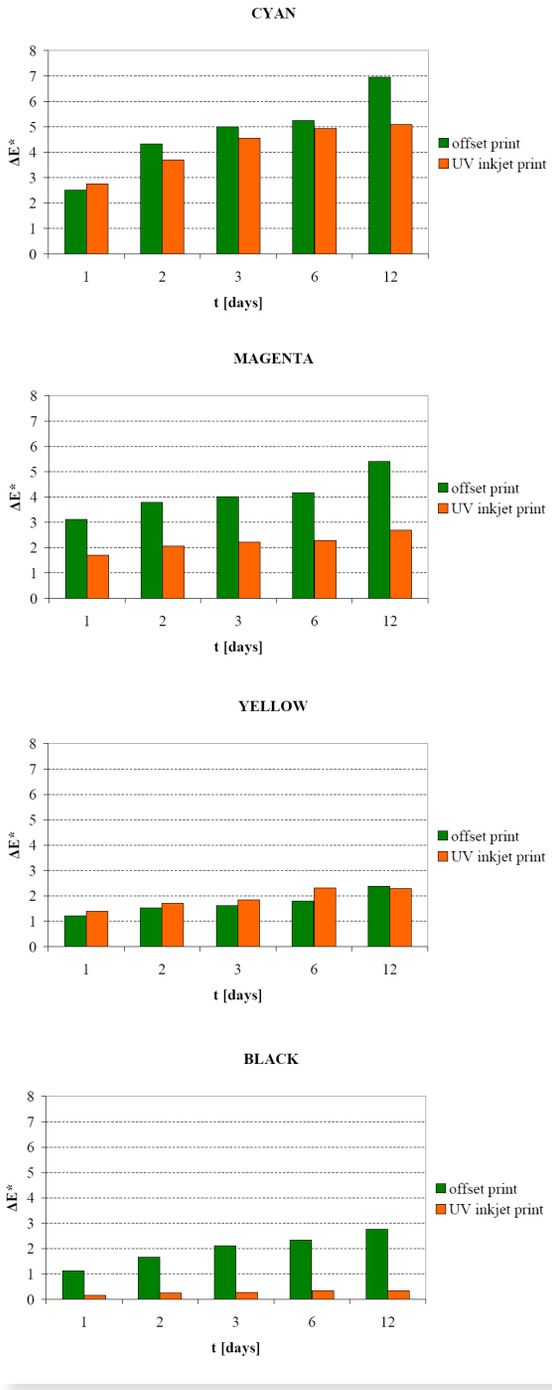

Figure 2

Figure 2 shows the influence of dry-heat ageing on stability of offset and UV inkjet prints.

The dry-heat ageing procedure is very powerful and fast. Three days under these conditions correspond to 25 years of natural paper ageing [3]. Significant differences between offset and UV inkjet prints were noticed using the dry-heat ageing as we can see in Figure 2. It's evident that on average the highest color differences (ΔE^*_{ab}) obtained offset prints at all ink colors, except at yellow ink. On average, cyan ink printed by both techniques, i.e. offset and UV inkjet, obtained the highest color differences. Especially high was at cyan offset print. It started with the ΔE^*_{ab}= 2.52 in the case of 1 day of ageing, futhermore ΔE^*_{ab}= 4.34 (2 days), ΔE^*_{ab}= 5.00 (3 days), ΔE^*_{ab}= 5.24 (6 days) and ended with ΔE^*_{ab}= 6.95 (12 days). The results correspond to massive deviation and significant change in color. Only in the case of 1 day ageing, the cyan UV inkjet print obtained higher values. Magenta print (Figure 2/b) was slightly more stable as cyan print, especially printed by UV inkjet press. The color difference exhibited only ΔE^*_{ab}= 2.68 after 12 days of ageing. On the other hand the total color difference of cyan offset print was ΔE^*_{ab}= 5.40, which corresponds to the noticeable change in color. The results obtained for yellow print show (Figure 2/c), that the print was very stable at both printing techniques. It was interesting, that slightly higher color difference was obtained using UV inkjet press. Nevertheless, the values after 12 days of ageing was only ΔE^*_{ab}= 2.36 for yellow offset print and ΔE^*_{ab}= 2.29 for yellow UV inkjet print. Black UV inkjet print was the most stable, color difference was only ΔE^*_{ab}= 0.27, which corresponds to the negligible change in color.

Conclusion

In this study the influence of dry-heat ageing on optical properties of synthetic paper and on colorimetric properties of offset and UV inkjet prints were investigated. The results have shown, that high temperature at 105 °C decreases paper's ISO Brightness, paper become more yellowish. Significant differences between offset and UV inkjet prints were noticed. It was established that UV inkjet prints were more stable than conventional offset prints, especially black UV ink print. The highest color differences between unaged and aged prints were obtained at cyan offset print.

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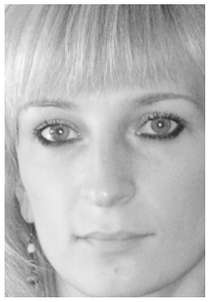

Mirica Debeljak

University of Ljubljana
Faculty of Natural Sciences and Engineering,
Snežniška 5,
SI-1000 Ljubljana,
Slovenia

mirica.debeljak@ntf.uni-lj.si

Phone:
00386-1-200-32-66

Diana Gregor-Svetec

University of Ljubljana
Faculty of Natural Sciences and Engineering,
Snežniška 5,
SI-1000 Ljubljana,
Slovenia

diana.gregor@ntf.uni-lj.si

Phone:
00386-1-200-32-72