An influence of accelerated ageing on distinctness of image for coated offset prints

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Abstract: *The accelerated ageing is a test method used to simulate the long term effects of heat, oxygen, sunlight, moist etc. over the short period of time. The influences of external parameters are mimicked within the environmental chambers by strictly defined, standard test conditions. Printed products are, as any other material, very susceptible to ageing. This is even more emphasized if they are exposed outdoor. In order to prevent mechanical and chemical damages, products are usually varnished or laminated. In this paper we investigated the influence of accelerated ageing of offset papers coated with different types of coating, with regard to distinctness of image. Since the distinctness of image describes the deviation of the spread of the light reflected at the specular angle, it is a better indicator of a product surface quality than specular gloss. As a samples for this study we used papers printed with conventional and hybrid inks and coated with aqueous and UV coatings. Distinctness of image was assessed for primary process colours before and after ageing, where ageing is performed in accordance to ISO 12040-1997 and ISO 4892-2:2006. From the obtained results it was concluded that the accelerated ageing leads to the increase of surface roughness of coated papers and hence to the decrease of distinctness of image. The same trend is found for each of the primary process colours.*

Keywords: *accelerated ageing, distinctness of image, coating*

Introduction

During artificial or accelerated ageing a material is subjected to extreme conditions in a climate-chamber in order to speed up the natural ageing process. Artificial ageing tests are often used to determine the permanence of paper, i.e. its rate of degradation, as well as to predict the long-term effect of a conservation treatment [1]. There are many methods for accelerated ageing of paper, which differs in exterior factors (temperature and/or relative humidity values) and the presence of other influences (lighting, radiation, presence of gases etc.). Among these methods are several international and national standards (ISO, TAPPI, ASTM, NEN etc.), which describe how the ageing should be performed and also the duration of treatment (expressed in days or hours). There have been many discussions in whether accelerated ageing test methods can give the real insight into paper degradation [2, 3], but what is certain is that these methods are currently the only way to simulate the natural ageing in laboratory conditions [2].

Printing industry has its own benefits from accelerated ageing test methods. By exposing the printed product to certain temperature, moist and other influences, its life cycle and durability can be determined. Many authors gave their contribution to better understanding paper and print degradation by investigating different parameters that can describe prints changes during time. Karlovits and Gregor-Svetec [4], for example, showed that synthetic papers are more durable than cellulose ones (showing better folding endurance and ageing resistance to both dry and moist heat) and also that all ageing processes leaded to increase of paper surface roughness. Havlinova and her coworkers tested the effect of standard moist and dry heat techniques of accelerated ageing on stability of offset inks printed on alkaline offset paper [5]. It

was shown that accelerated ageing leads to significant exponential decrease of relative optical density for magenta and yellow ink layers and that cyan and yellow colours tend to change their appearance most after the treatment (ΔE* values were highest for this colours). Both moist and dry techniques lead to increase of lightness, which was most noticeable for black ink [5]. When it comes to colour fastness, the rate at which an ink fades is driven by many parameters, hence it was stated that „more is known about the mechanisms, the specific chemical processes, involved in photochemically induced fading than is known about the chemistry of yellowing and embrittlement of paper, varnishes and coatings" [6].

Besides colourfastness and durability, other parameters describing the printed product quality can be assessed. Products intended to be used frequently or to be displayed outdoor are usually enhanced by lamination or some sort of coating. In this paper, we were interested in how the accelerated ageing would affect coated prints. Since the process of coating implies application of a thin film of coating material, this film is the most affected by ageing which leads to certain degradation of printed product. In order to describe changes in coatings after ageing, we choose to evaluate distinctness of image (abbreviation: DOI), one of the types of gloss defined by Hunter [7]. DOI defines the deviation of the spread of light reflected at the specular angle and is sensitive to even subtle scattering effects; the more light is being scattered out of the regular direction, the more the initially well defined image is being blurred. Two surfaces may have the same gloss values but differentiate in ability to distort image being reflected. Hence, DOI values would give a better insight in product surface quality than gloss values [8].

Industrial devices for measuring DOI uses the technique in which the sharp edge is projected onto a surface and reflected image is captured using a solid state area or line sensor, e.g. CCD or CMOS [9]. Captured image of reflected edge is further analysed by calculating the Modulation Transfer Function (abbreviation: MTF) – a function that describes a relative contrast at a given spatial frequency. This function describes sharpness of reflected image very well, but in order to correlate with human perception of sharpness, sensitivities of human visual system had to be taken into account. If the human sensitivity is described by visual contrast sensitivity function (abbreviation: CSF), area under the convolution of the CSF and MTF curves when the spatial frequency is plotted on a logarithmic scale is defined as DOI metrics. This value is also known as subjective quality factor (SQF) and is widely used to describe perceived sharpness. Higher the SQF value, higher the perceived sharpness and uniformity of surface gloss. Tse et al. [9] reported high correlation of obtained MTF and SQF values with subjective rankings, where evaluation were performed over 10 ink-jet (unprinted) photo papers. Karlović et al. [10] investigated the usability of this method for evaluating DOI of coated offset prints and also found good correlation with visual rankings, especially for the samples enhanced with glossy coating. Hence, the same method is incorporated in this paper.

Method

Samples used in this study were printed with conventional and hybrid inks and coated with UV and aqueous coatings (glossy and matte). Test image contained of four solid colour squares (primary process colours were used), dimensions of 10x10 cm. Printing were performed following the ISO 12647-2:2004 on KBA Rapida 105. As a substrate we used glossy 130g/m^2 paper (defined as Type 1 in ISO 12647-2:2004). Both sets of printing inks were from Sun Chemical – conventional from World Series (complying with the ISO 2846-1:2006) and hybrid from HyBrite series. After printing, the conventional ink prints were coated with aqueous glossy Prestofix Hochglanzlack H6055/55 and aqueous matte coating Prestofix Mattlack H260/55 in two quantities regulated with two anilox rollers (60 l/cm and 90 l/cm). The quantities were calculated through the weight measurement of the 10x10 cm samples taken on 6 positions on the sheets and were defined in g/m^2, which is standard industry specification for calculating coating transfer and coverage. The hybrid ink prints were also coated using the two anilox rollers with

and UV glossy coating VP 10532 from VEGRA and was dryed by the UV lamps installed on the machine (using the factory settings).

Overall we obtained 8 types of samples, which differ in ink and coating types. Their characteristics were evaluated for all four process colours. The list of the samples are given in Table 1. In order to simplify the notation, samples are marked with letters (Table 1).

Table 1: Samples labels and characteristics

Sample label	Inks	Coating type
A	Conventional inks	No coating
B	Conventional inks	Aqueous glossy coating, 60 l/cm
C	Conventional inks	Aqueous glossy coating, 90 l/cm
D	Conventional inks	Aqueous matte coating, 60 l/cm
E	Conventional inks	Aqueous matte coating, 90 l/cm
F	Hybrid inks	No coating
G	Hybrid inks	UV glossy coating, 60 l/cm
H	Hybrid inks	UV glossy coating, 90 l/cm

After printing and drying each of the samples were characterized by measuring DOI and surface roughness. Surface roughness was measured with a portable roughness tester TR200 (Cut-off length: 0.8 mm, Evaluation length: 4 mm, Filter: Gauss), while DOI measurement was performed in the same manner as described in [10]. As a parameter of importance for DOI measurement we chose to evaluate subjective quality factor (SQF), since it incorporates the sensitivity of human visual system into its calculations. SQF was calculated with Imatest 3.8 Master software. In order to simulate ageing Atlas SUNTEST XLS+ chamber was used, where accelerated ageing was performed according to ISO 12040-1997 and ISO 4892-2:2006. All the samples were aged for 5 days, after which we evaluated changes in surface roughness and DOI. Results and discussion are given as follows.

Results and discussion

Figure 1 shows change in surface roughness after 5 days of accelerated ageing. Arithmetical mean roughness parameter (Ra) was taken into account for this measurement. It can be seen that the roughness increases with ageing for almost all the samples, which is consistent with [4]. The only exception is sample with conventional inks and glossy coating (labelled C), where the roughness was slightly reduced.

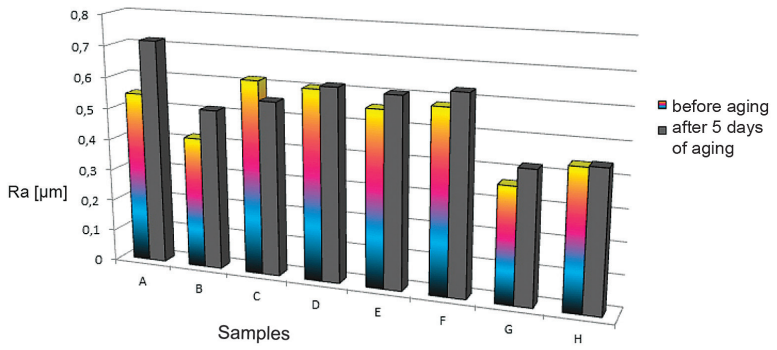

Figure 1: Changes in surface roughness with accelerated ageing

Figure 2 and Figure 3 show changes in distinctness of image for all the samples after 5 days of accelerated ageing. DOI is expressed in SQF values, where viewing distance was set to 15 cm. Changes are shown for all the process colours.

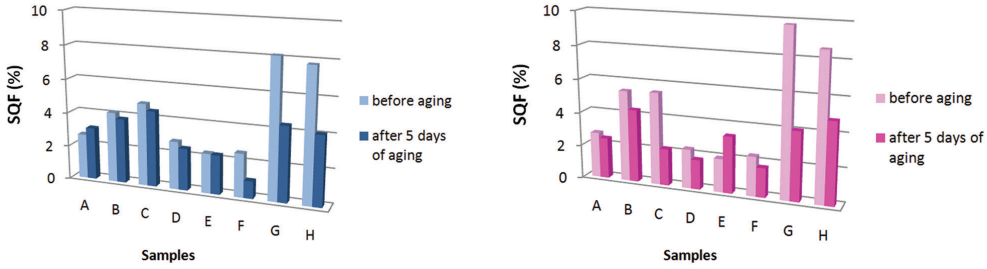

Figure 2: Changes in SQF (%) with accelerated ageing for (a) cyan, (b) magenta print

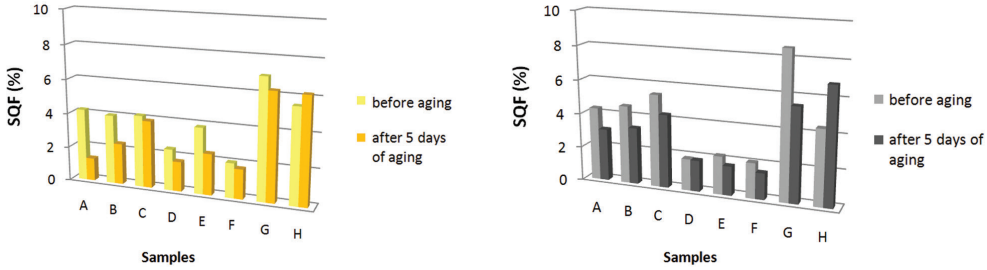

Figure 3: Changes in SQF (%) with accelerated ageing for (a) yellow, (b) black print

From the Figures 2 and 3 it can be concluded that the accelerated ageing decreases the subjective perception of distinctness of image. Small SQF values, which indicate poor quality, were even smaller after the ageing. This trend applies to all process colours. The only exceptions were sample without coating for cyan, matte coated sample for magenta and UV glossy coated samples with small amount of coating for black and yellow. In these cases accelerated ageing improved the subjective quality. The biggest change in SQF value was noticed for prints with hybrid inks and UV coatings (especially cyan and magenta), meaning that these prints were the most affected by ageing. Prints coated with aqueous matte coating were the least affected overall.

It can also be seen that the samples coated with UV coating acquire highest values of SQF, meaning that the perceived gloss and its uniformity is highest for these samples. Matte coating tend to reduce DOI of uncoated samples in each case, while glossy increase it to a greater or lesser extent. If we observe SQF values for all the process colours, worst quality is noticed for yellow. This is somewhat expected due to the fact that yellow ink has the lowest density and image projected on a print of such a light colour should be less sharp then the image projected on a print of the other inks.

Since the accelerated ageing increased the surface roughness and decreased the SQF value for almost all the samples, a coefficient of determination was calculated between these two parameters. For process colours it was shown that there were a moderate determination for cyan, magenta and black (R^2=0.42, 0.58 and 0.59, respectively) and very good determination for yellow colour (R^2=0.8). If all the samples were taken into account, it can be said that subjective perception of distinctness of image can be efficiently predicted if surface roughness is known (R^2=0.75, as shown on Figure 4), and vice-versa.

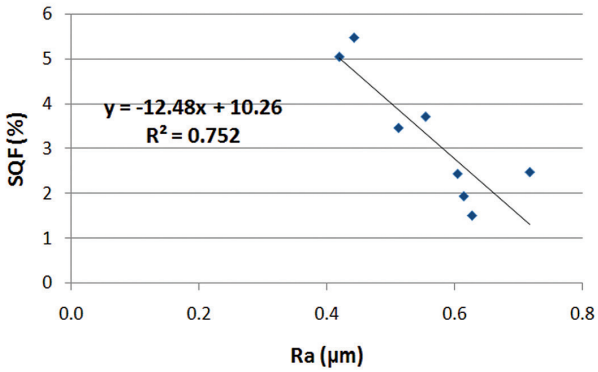

Figure 4: Coefficient of determination between SQF and surface roughness for all samples

Conclusion

In this paper influence of accelerated ageing on distinctness of image, one of the quality parameters describing uniformity of surface gloss, was evaluated for coated offset prints. As a DOI parameter, subjective quality factor was used. Hence the results of this study can be interpreted in the sense of human perception of the assessed surfaces. Different coatings and inks were used and evaluation was conducted for all the process colours. Surface roughness of the samples was also measured, both before and after ageing, in order to characterize the changes in coating film topography.

According to the results, the accelerated ageing had an influence on both surface roughness and distinctness of image for all the samples observed in this study. Surface roughness increased, while DOI decreased, meaning that the surface of prints had changed during this process. If the printed product is intended to last without degradation, coating will most certainly protect it, but the choice of coating material is not the trivial task. In this paper it was shown that the least affected by ageing were matte coated prints, while the biggest change was noticed for UV glossy coated prints. Hence, if the intent is to obtain product which will maintain its original appearance after a long period of time, we suggest that UV gloss coatings should be avoided.

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