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Analysis of the wear of the non-printing elements in offset printing depending on the operating and technological conditions

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Abstract. The purpose of this research is to determine the wear of a printing form in the printing process. Analysis of the wear of the non-printing areas of the offset press depending on the operation is an important factor in the process, especially when printing large circulation series (newspapers, magazines and packaging). Most of the conducted research is in the field of researching the layer, the carrier of the printed elements. This study changes the surface of the non-printing areas, which also have a significant impact on image definition and print quality. To realize the set task of analyzing the non-printed elements, a profilometry method is used in combination with micrographs through a scanning electron microscope SEM for quantitative and qualitative evaluation of the changing characteristics.

EXPERIMENTAL STAGING, METHODS AND MATERIALS USED

The printing forms used in this study are Electa XD thermopositive printing forms with a thickness of 0.3 mm aluminum foil electrochemically roughened and anodized. The production of the printing forms is carried out according to the regulated standard procedures, which guarantees surfaces with controlled roughness. They are produced according to strict, standardized procedures, resulting in surfaces with a controlled, reproducible roughness suitable for the purpose of the study. The molds were made in the Computer to Plate system, and the exposure was made with an IR laser, irradiation of 830 nm wavelength and energy of 125 mJ/cm2. Non-printing elements of the photosensitive layer were removed from the surface of the form by chemical treatment in KODAK 400 xLo developer solution. The machining process was according to the standardized machining procedure at a temperature of 22.3 °C, with a machining speed of 1.2 m/min and a machining time of 15 s. Measurements in this study were made in different circular sample areas (R=1.5 cm) of the non-printable area of the printing form, located along the axis of the printing cylinder in the printing sections and with a center-to-center interval of 20 cm. This is a restriction to avoid possible local printing defects (differences in cylinder pressure, offset blanket defect, etc.). Profilometry measures the reference sample (a printing form not in the printing process) and samples taken after printing runs of 125,000, 180,000 and 300,000 impressions. The printing process was carried out by four-color offset printing on a GOSS M 600 machine with a maximum speed of 45,000 prints per hour, and the color reproduction was realized by subtractive synthesis of the four colors - black, cyan, magenta and yellow. Two of the printing forms, first and last color of the distribution scheme (black and yellow) were included in the measurements to determine the effect of paper dust on the characteristics of the printing form. As part of the paper, the paper dust is transported through the printing press assuming that it desorbs from the paper surface and therefore less of it can come into contact with the printing form in the later stages of the printing process. Since this test is done on non-printable areas, the influence of ink is excluded, as it does not come into direct contact with the aluminum oxide surface. Research in this area shows changes in depth, respectively through focus SEM can provide detailed topographical information about the surface, but cannot provide quantitative information, observation and analysis of printed forms, before and after the run is supplemented by roughness measurement (Landtek SRT-6200) and by SEM, thus combining quantitative typographic information and

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electron microscope micrographs. SEM micrographs of the samples were taken by a FlexSEM 1000 II scanning electron microscope. In order to ensure uniform electrical properties, it is strictly ensured that there is no charging/discharging of aluminum oxide surfaces. Images were taken at a working distance of 15 mm, a spot size of 40 nm and a voltage of 20 kV with a magnification of 2000×. Profilometric parameters were measured with a Landtek SRT-6200 portable surface roughness tester with a 10 µm radius diamond tip. Landtek SRT-6200 has functions to evaluate various roughness parameters: Ra, Rz, Ry,Rq, Rt, Rp, Rmax, Rm, R3z, S, Sm, Sk, tp, as well as hybrid parameters: primary profile (P), roughness profile (R) and tp curve (material ratio Mr), all defined according to the relevant standards.

Ra - average surface roughness

$$R_a = \frac{1}{l}\int_0^l |y(x)|dx \tag{1}$$

Rz_{DIN} – average value of unit roughness depths Zi

$$R_{Zdin} = 1/n\ (Z_1+Z_2+Z_3\ldots\ldots+Z_n) \tag{2}$$

Rv - maximum profile depth (Fig. 1)
Rp - leveling depth, distance between the highest peak and the reference line (Fig. 1)

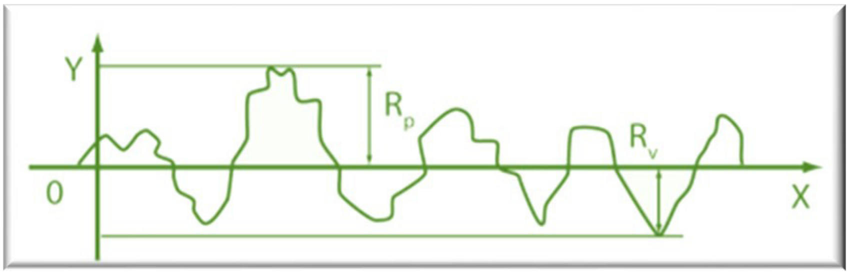

FIGURE 1. Profile of Rp and Rv parameters

Production of aluminum foil suitable for printing forms involves processing by rolling, which results in the characteristic structure of the surface in the direction of rotation. Lines that appear on the surface are undesirable in further aluminum preparation and require treatment to reduce their negative impact on surface roughness. Therefore, the surface roughness measurements of the printing forms are plotted along x and y along the direction of aluminum rolling and perpendicular to the direction of rotation.

RESULTS, SEM ANALYSIS

SEM micrographs were taken to obtain visual indications of the surface structure of the printed form. SEM micrograph presented in Fig. 2, shows the structure of an aluminum oxide surface of the reference print mold sample. The surface of the sample from an unused printing form is characterized by high narrow peaks and deep and narrow pores. The surface of the anodized alumina layer is uneven, the size and depth of the pores vary, which is believed to be a consequence of electrochemical graining and anodizing in the manufacturing process. But on the other hand, this surface structure improves the adsorption of the wetting solution in the printing process and gives the printing form better mechanical properties. Some flat visible spots are the result of processing in an alkaline solution, which has been found in other studies on the composition of the formed precipitates in the form of metasilicates in the development process.

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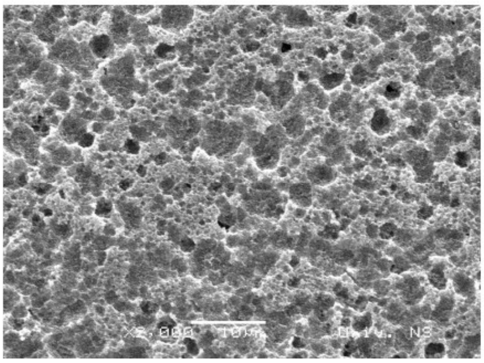
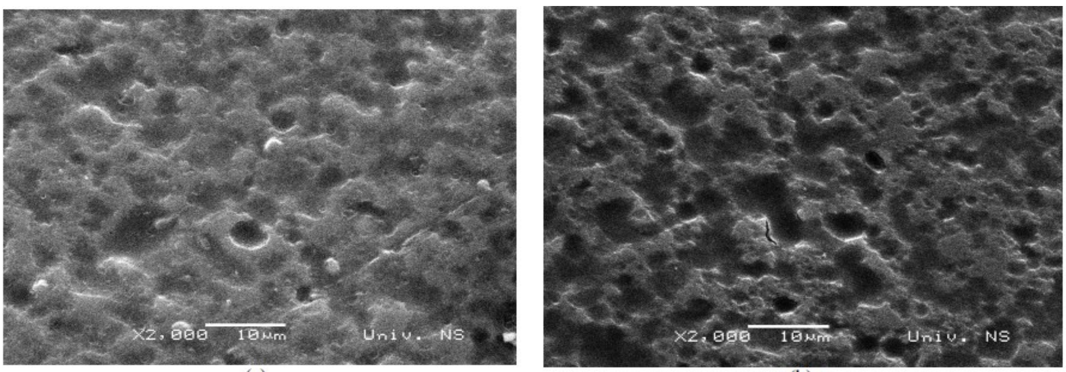


FIGURE 2. SEM micrograph of a reference mold sample before printing

It is clearly seen that the print surface, the format used in the print, is different from the reference sample. The surface of the used forms is characterized by a "more pronounced" structure. The valleys of the printing forms for both colors, black and yellow are filled with paper powder elements. The peaks visible in Fig. 2, are flattened by the printing process, resulting in a smoother surface. Comparing Fig. 3a and 3b, it can be seen that the printing form for yellow color remains coarser than the printing form for black color, which means the influence of the printing sequence, black is the first color printed and yellow is the last, that is, the amount of paper dust reduced by transporting the paper through the printing press. In fig. 4 are samples of printing forms after 300,000 printing strokes. The deformations of the surface of the printing form are even more visible compared to fig. 3a and 3b. The printed forms for both colors have similar surface structure (Figs. 30a and 30b). During the printing process, the printing form is in contact with ink and water rollers as well as the rubber offset canvas. In all these contacts there is friction, which causes wear of the material (aluminum oxide), taking into account the microgeometry of the elements in contact with the form, ink and water deposit rollers and offset blanket. Comparing Fig. 3a and 3b with fig. 4a and 4b, respectively, it can be seen that the surface changes are smaller compared to the changes between an unused printing form and that after 125,000 impressions. This behavior is a consequence of wear but at a higher resistance (resistance) of the aluminum oxide after the highest peaks have been removed.



(a) (b)

FIGURE 3. SEM micrograph of printed forms after 125 thousand hits a) black color and b) yellow color

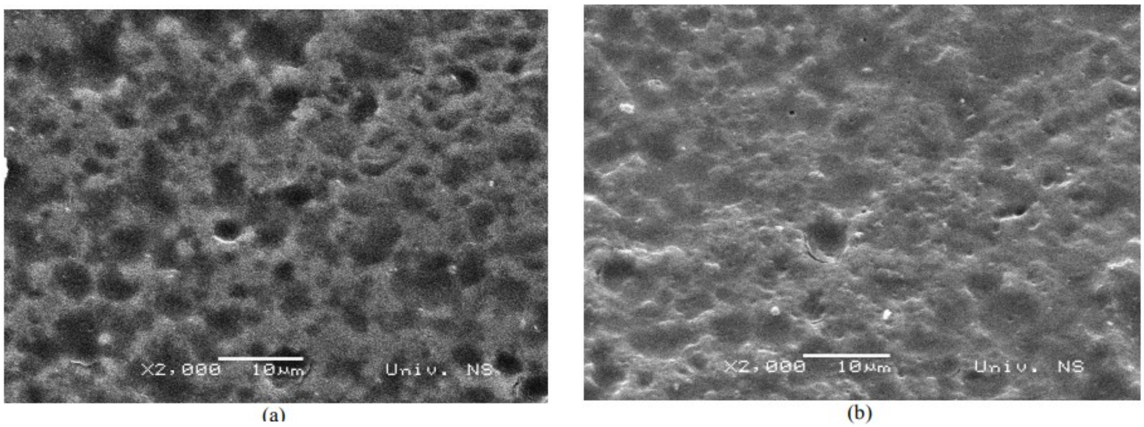


FIGURE 4. SEM micrograph of printed forms after 300 thousand hits a) black color and b) yellow color

RESULTS OF ROUGHNESS PARAMETERS

Changes in surface topography observed in SEM micrographs were quantified by measuring roughness, and profiles of the non-printable areas of the printing form were presented. Results of the Ra roughness parameters are presented in Fig. 5 , the average roughness (Ra) with print run decreases faster on the black color printing form, with up to 125,000 prints decreasing by nearly 25%. After the first reduction in roughness, the Ra of the black printing form is almost constant as the number of prints made increases. On the other hand, the Ra of the printing form for the color yellow shows a linear decrease depending on the length of the run. The roughness parameter Ra decreases at a different rate, but with the same value for the printing form after 300,000 impressions. This behavior indicates a greater impact of paper dust on the black printing plate at the start of the printing process in the first printing section of the machine.

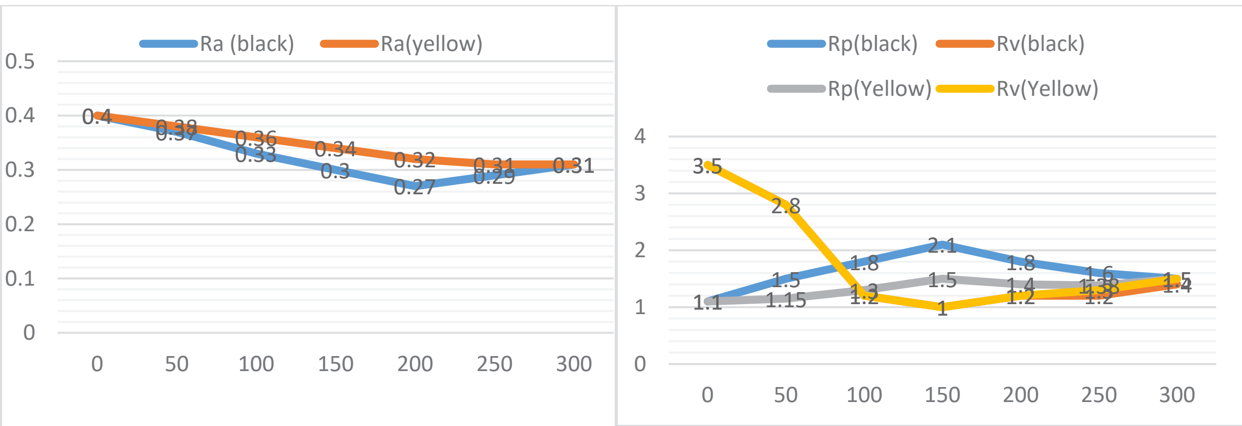


FIGURE 5. Roughness parameters Ra(b) and Ra(y); Rp(b) and Rp(y); Rv(b) and Rv(y) versus circulation (x-circulation strokes x103; y-values of roughness μm)

A better insight into the differences in topography is provided by parameters that differentiate the behavior of peaks (Rp) and troughs (Rv). In fig. 5 it can be seen that Rp increases its value for both samples, in the first third of the study printing continues, but the continued printing process leads to a decrease in Rp. The two printing forms, for black and yellow, have a similar behavior when considering the parameter Rp. The printing form for yellow has a slightly higher value for this parameter, and the results suggest that the printing process causes tip wear, but the rough surface of the printing form is uneven (Fig. 2) and is related to the rough surface and structure of the offset a blanket that can create conditions for a new texture with more pronounced peaks. The parameter Rv decreases with the increase in the number of prints made. Comparing the results of a reference sample and a printed form sample after 125,000 impressions, a huge drop in value of more than 50% is noticed (3.5 to 1.3 for black and to 1.2 for yellow). After this first decrease to a high value, Rv stabilizes its value with a slight decrease (Fig.5).

FIGURE 6. Roughness parameters Rz vs. circulation (x-circulation strokes x103; y-values of roughness µm)

The results of the Rz parameter confirm SEM micrographs in Fig. 2, 3 and 4. The structure of the surface of the printing form is strongly affected by the printing process at its beginning (printing form after 125,000 impressions), but then stabilizes with the roughness having slightly reduced values on the printing forms for both colors. The Rz parameter of the printing plate for black has a large decrease in value at the printing plate after 125,000 impressions, slightly increased at the printing plate after 180,000 impressions to drop again at the printing plate after 300,000 impressions. This behavior of the printing form for black color shows the role of the paper powder in the surface roughness, but also the influence of the wetting solution, which also has the role of cleaning the surface of the printing form.

CONCLUSION

This research was done to determine the influence of the printing process on the printing form and in particular its typographic surface. Evaluation of the surface and its properties was done by SEM micrographs, measurements of roughness parameters. The results of this research prove that the surface structure of the non-printable areas of the printing form changes during the printing process. A strong decrease in the roughness parameters at the beginning of the printing process indicates the high influence of paper dust, which is also seen by a difference in the roughness of the printing form for the black and yellow colors. An analysis of the above clearly shows a non-linear nature of change in the roughness indicators of the printing form. This research provides guidance that the analysis should take into account the wear of the printing form, the study of non-printable areas, as they are essential as part of the printing process and are significantly changing during printing. The theory could justify a number of expectations for this type of research, which will invariably include characteristics such as dot gain, more clearly expressed in low tonal densities and even reaching maximum values with a different type of modulation, respectively a change in the optical color density and derivatives its parameters; changes in color gradation and gray balance; lowering the detail of the image; loss of some of the tonal densities under the more aggressive printing conditions, leading to the destruction of the color-carrying layer, and everything listed up to this point is subject to a number of theoretical assumptions as research perspectives establishing different points of view. At the end of the analysis, one main factor related to what has been described so far and influencing all the parameters of this research can be highlighted, this factor is the pressure in the printing area. This is a factor proven important by many studies and analyzes showing the influence of pressure in the printing process. As a research trend, the study and analysis of the influence of the pressure change on the layers of the printing form and the impact on the print quality can be pointed out.

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