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**PRINTING SUBSTRATE AS A QUALITY  
PARAMETER IN FLEXOGRAPHY**

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*The research described in this paper studies the reproduction quality of imprints on different types of printing substrates used in flexography. Flexography is a printing technique which uses a flexible photopolymer plate with relief printing elements and is suitable for printing on different types of printing substrates, such as coated and uncoated paper, and non-porous substrates like metalized foils and polyester films. Flexography is constantly increasing its capabilities and quality, and is used primary for packaging printing, but in the other areas of graphic production too, such as printed electronics. In this paper, by using methods for surface coverage measurements and analysis of the microscopic images, the reproductions of the same printing plate on uncoated paper, coated paper and polyester film was analysed. Results indicated a decrease in the reproduction quality of highlights and fine elements on uncoated paper, coated paper and polyester film. The quality of the imprints has been decreased in the shadows too, primary on uncoated paper and film.*

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## Introduction

Flexography is a printing technique which was primarily developed for printing of the low-quality imprints on corrugated materials. However, a number of chemical and technical advances in flexography resulted in dramatic quality improvements and rapid expansion in its usage. Nowadays, it can be used for printing of high-quality packaging products.

Flexible printing plate, low pressure during the printing process and anilox roller, which is used to define the thickness of the ink film on the printing substrate, are the main characteristics of flexography [1]. This technique is suitable for printing on many types of substrates, such as coated and uncoated paper, and non-porous substrates [2-3].

Nowadays, flexography expands its capabilities and increases quality which allows spreading in other areas of graphic production and different types of printing substrates, for example printed electronics.

### Printing Plates and Substrates in Flexography

Flexographic printing plates are mainly made from photosensitive monomers and a number of additives, such as photo initiators and plasticizers, to obtain high level of their quality [4-6]. When exposed to UV radiation, photo polymerization occurs and exposed parts of the plate become insoluble in processing solution [7]. In the last decade, a great improvement has been made in the flexographic printing plate workflow and in the usage of newly formed materials for the plates. These processes have increased the quality of the printing plates overall and made the plate making procedure ecologically friendlier.

The process of a flexographic plate can be made in different digital workflows. One of the newly present printing plates making procedure is based on the TIL (Thermal Imaging Layer) usage [8]. In Fig. 1, one can see the production procedure of that kind of printing plates.

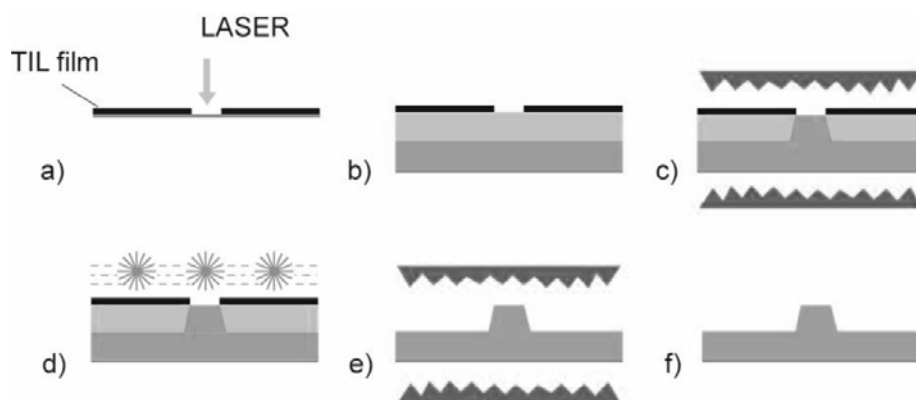


Fig. 1 Photopolymer printing plate making process

In the first step, negative image has to be formed in a TIL-mask, a specifically formulated thermal ablative layer (Fig. 1a) [1]. Following exposure, the imaging layer is laminated to the photosensitive polymer plate (Fig. 1b). The third step in the plate production is the main and back-exposures of the photopolymer (Fig. 1c). These exposures have to be performed in order to form the printing elements and to strengthen the basis of the cliché. In the next step, by processing (mechanical and chemical) the unexposed parts of the photopolymer have to be removed (Fig. 1d). Additionally, UVA and UVC finishing enhance the polymerization process and improve mechanical and surface characteristics of the printing plate (Fig. 1e). Figure 1f presents the finished printing plate.

Flexibility of the photopolymer printing plate is the plate's advantage and its weakness at the same time. It enables printing on a wide range of materials, such as paper, paperboard, corrugated board, films, laminates, foils and metal. On the other side, due to its flexibility, the transferred images can be deformed and changed in the printing process because of the straining on the plate cylinder and the pressure on the substrate [9-10].

Due to the flexible printing plates and fast-drying inks which are used in flexography, it is also possible to print on substrates of different roughness. Initially, corrugated board was mostly used as a printing substrate, but with the improvements in technique, the application of flexography has been expanded. Nowadays, flexography is used for printing on different types of coated and uncoated paper and corrugated board [2-3]. Besides these porous substrates, flexography is suitable for non-porous substrates such as plastic films (polyethylene, polyester, polypropylene, cellophane, vinyl, polyamide) and metalized foils based on thin aluminium or other metals attached to a flexible plastic film. Non-porous substrates are often not suitable for accepting printing ink, and because of the low surface energy, the surface treatment is necessary. Surface treatment increases the surface energy in three possible ways: corona treatment which uses ionized air, plasma treatment which uses electrical ionization of gas, and flame treatment which uses flame to burn away surface contaminants [11].

The aim of this paper was the defining the quality level of imprints reproduced on three different substrates by usage of the same printing plate sample.

## **Experimental**

### **Materials and Methodology**

In this paper the imprints were made with same printing plate sample on three different substrates: plastic film (polyethylene), coated and uncoated paper. The

samples of the substrates were designated by S1 (uncoated paper), S2 (coated paper) and S3 (plastic film).

The digital wedge with test fields of 1,2, ..., 9,10,15,20,25, ..., 95, 100 % of coverage values and different control elements was generated in order to monitor the reproducibility of coverage values and fluent transition between the tones. The printing plate sample was made by Kodak FlexcelNX Digital Flexographic System workflow and measured by Vipflex, a device for film, imprint and flexographic printing plate analysis. For visual analysis of samples, the images were made by Olympus Metallurgical Microscope BX51.

## Results

The results of the measured and nominal (digital) coverage values measured on the printing plate are presented in Fig. 2. The figure shows the results obtained for highlights (0-10%), results of the whole reproduction tone scale (0-100 %) and coverage values in the shadows (90-100 %). One can see that the coverage values of the whole reproduction have linear trend due to whole tone scale. If the highlights and shadows are observed it is obvious that the highlights have been reproduced correctly contrary to shadows. The minimal value that can be seen on the plate is 3 % of coverage and lower values could not be correctly measured. In shadows, maximum value measured on the plate is 96% and there has no regularity between 95 and 100%.

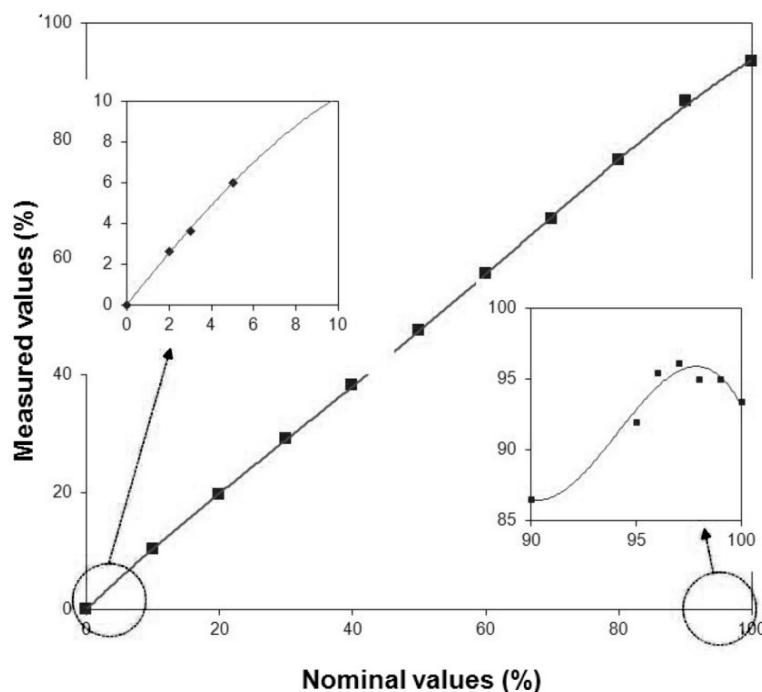


Fig. 2 Results of coverage values from 0 to 100% measured on the printing plate

Figure 3 presents the results of measured coverage values on the observed substrates (S1 - uncoated paper, S2 - coated paper and S3 - plastic film) for highlights and shadows. It is obvious that results of the coverage values are different. The highest values were performed on film and the lowest on the uncoated paper. Similar deviation in highlights was measured in coated paper (S2) and film (S3). The difference between the coverage can be seen in the shadows too. The smallest deviation was measured on coated paper (S2), and the highest on the film substrate (S3).

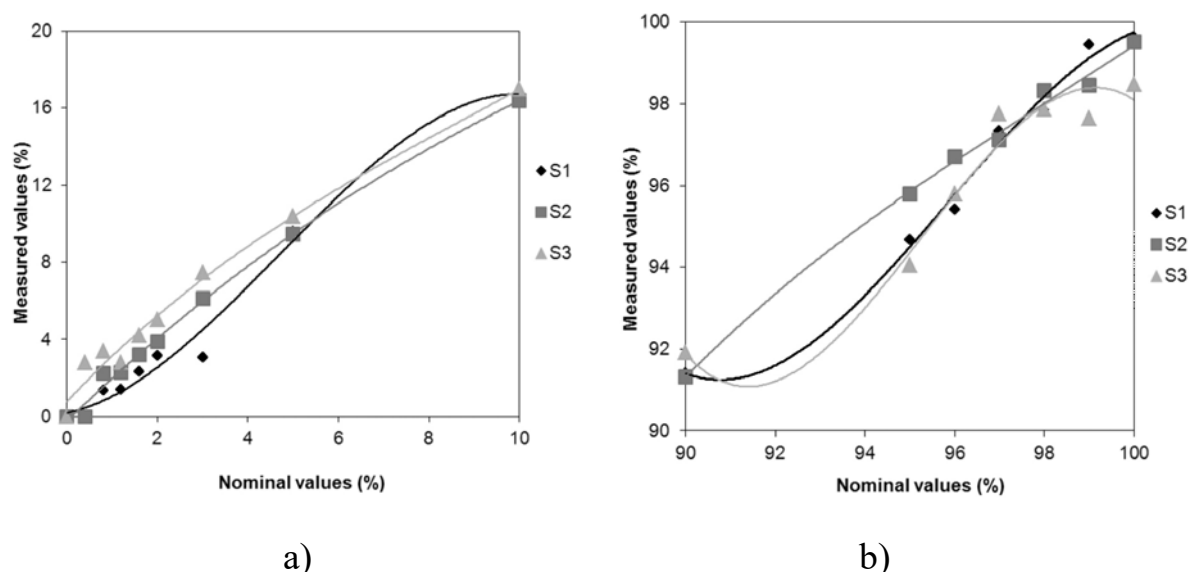


Fig. 3 Results of coverage values from measured on substrates (S1 - uncoated paper, S2 - coated paper and S3 - plastic film); a) highlights (0-10 %), b) shadows (90-100 %)

## Discussion

The results obtained in this paper cover the measurements of imprints reproduced on three different substrates by usage of the same printing plate sample. The measurements of the whole tone scale on the substrates showed similar results. Small deviation was measured between the curves in the area from 50 to 80% of coverage. Considering the fact that the same printing plate was used for printing on observed substrates, it can be assumed that the similar results were obtained by adapting the pressure between the printing plate and substrate during the printing process.

Figure 2 presents the results of coverage values from 0 to 100 % measured on the printing plate. One can see that the coverage values of the whole reproduction scale have a linear trend. It is obvious that the plate making process has been correctly calibrated, and that the compensation curve for tone correction has been not applied. On the other hand, the deviation from linear trend can be

seen in the highlights and shadows. It can be seen in Figure 4, which presents the microscopic images of different coverage values captured on the printing plate, that the printing elements have been correctly formed. It can be seen that the printing element of 2 % of coverage has been formed of 3 pixels and that the printing element has size of app. 15 microns.

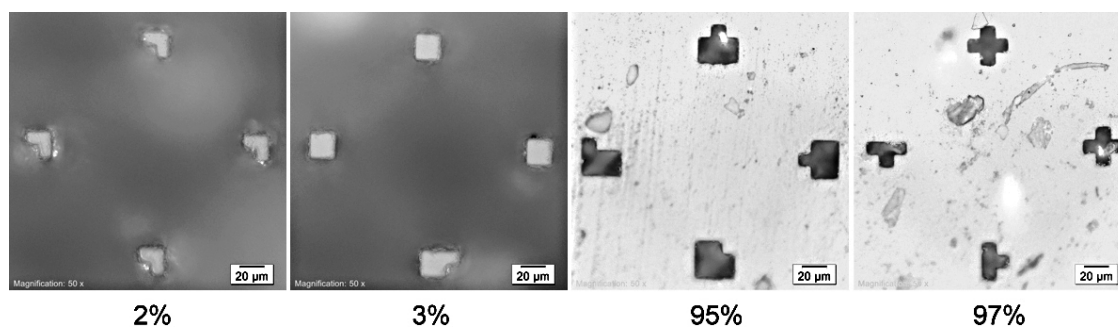


Fig. 4 Microscopic images of different coverage values captured on the printing plate

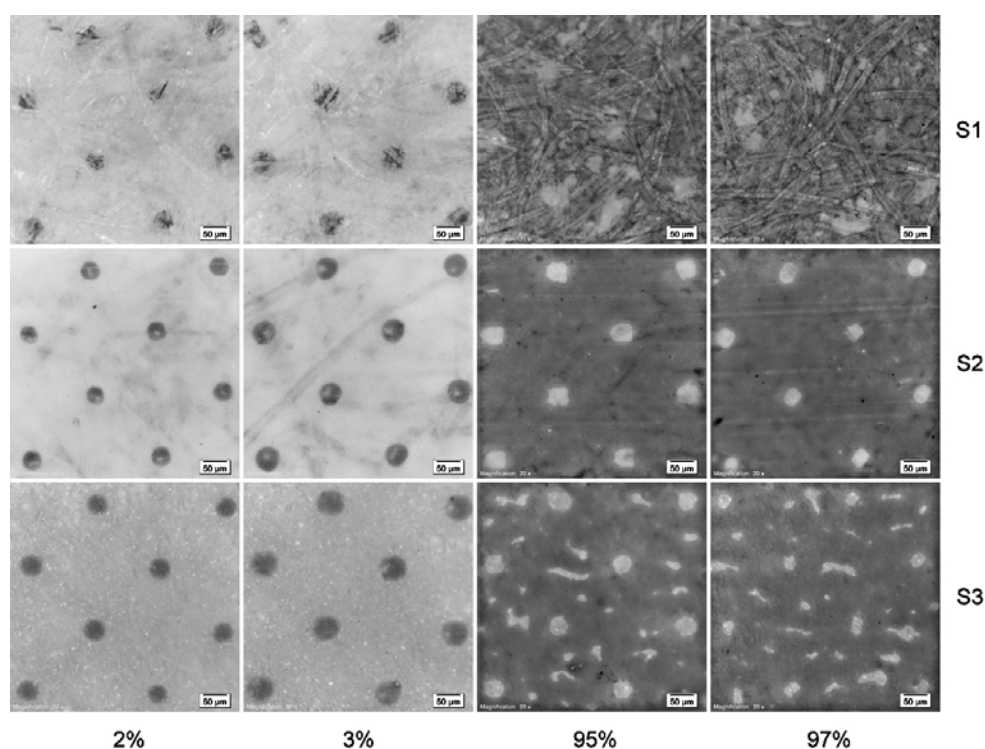


Fig. 5 Microscopic images of different coverage values captured on the S1 - uncoated paper; S2 - coated paper; S3 - film

Figure 5 presents the images of different coverage values captured on uncoated paper (S1), coated paper (S2) and film (S3). It is visible that the raster elements have different shape and structure. Raster elements formed on uncoated paper (S2) are of irregular shape and not uniform due to paper fibres which can be

seen under magnification. This irregularity of the substrate surface structure has a significant influence on the imprints quality. On the other hand, on coated paper (S2) elements are circle shaped with lowering the density level in the centre of the raster elements (2 and 3 %), a characteristic of flexography. The raster elements are correctly formed on the film (S3) but their radius is visually higher. This observation corresponds to the results obtained by measurements presented in Figure 3 and to the ISO standard related to flexography [12]. In shadows, on 95 and 97 % of coverage, one can see that printing ink has not been correctly adsorbed on the film surface. This can be the consequence of different and not completely compliant materials which were used in the reproduction process. The lower adsorption on the film is not seen in highlights but is visible in shadows.

## Conclusion

The aim of this paper was to define the differences in the surface coverage measurements on imprints where the same printing plate was used for reproduction on different substrates (uncoated paper, coated paper and polyester film).

In order to see the changes in coverage values which occur due to ink transfer from the printing plate to the substrate, the coverage values of the whole tone scale on the printing plate were measured. It was visible that surface coverage on the plate in the whole tone scale has a linear trend and that tone reproduction curve adjustment has not been applied. Coverage in the highlights and shadows had certain deviations and minimal tone value that has been correctly reproduced was 2 %, and the maximum was 95 % of coverage. The results of coverage measured on the substrates and captured by microscope showed rarely similar tone transition between the plate and surfaces. The main difference was measured in highlights and in the shadows.

By analysing the surface coverage measurements and microscopic images one can conclude that different printing substrates, due to their surface properties, are an important quality parameter in the flexographic reproduction. Fibres in uncoated paper deform the shape of the printing element on the imprint, which is especially visible in the highlight and shadow areas. Furthermore, regardless the surface treatment of polymer substrates such as plastic film, their surface properties could still be inadequate for the correct transfer of coverage values. The consequence could be the unsatisfactory adsorption of the printing ink in the shadows area, and combined with the pressure in the printing process, excessive dot gain in the highlights could be obtained. Therefore, further correction of the printing plate reproduction curve must be applied for these types of printing substrates.

The results had shown that creation of a closed reproduction system which includes printing plate, printing system and the printing ink and substrate is a

necessity for meeting high quality demands. Despite the similar tone reproduction curves obtained on different substrates, the visual impression of the imprints and ability of ink transfer should be taken into consideration, as well.

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