Meeting the Quality Requirements in the Flexographic Plate Making Process

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Adjustment of the photopolymer printing plates to match qualitative requirements includes consideration of basic parameters in the digital printing plate making process which are necessary for achieving high-quality imprints in flexography. Flexography is widely used in the packaging printing. It is characterized by a flexible and elastic printing plate and a printing ink of low viscosity which enables printing on different types of printing substrates. The aim of this research is to expand the knowledge about the photopolymer printing plates and the processing procedure which has high influence on the quality level of the plates. The flexibility and deformations of the printing plate which occur in the printing process are considered to be the technological limitations of this technique. Therefore, defining and explaining deviations in the printing process is necessary for achieving higher quality prints. The deviations induced by the printing process are detected by observing reproduction of the halftone values. This paper presents a model for adjustment of the photopolymer printing plates making process to achieve optimal reproduction results. The results have shown that creation of a closed reproduction system which includes the printing plate, the printing system and the printing substrate is a necessity for meeting high quality demands.

1. Introduction

Flexographic printing plates are mostly used in the packaging industry. They are characterised by a topological difference between printing and nonprinting areas and a flexible material which is elastically deformed for each imprint. The printing plate has the role of selective ink adsorption and transferring the ink onto the printing substrate under the pressure. Due to the plate's mechanical properties and the possibilities of ink transfer, they are applicable for printing on a wide range of printing substrates [1-2]. Flexibility of the photopolymer printing plate is the plate's advantage and the 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.

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 [3-5]. When exposed to UV radiation, photo polymerization occurs and exposed parts of the plate become insoluble in defined processing solution.

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.

One of the most present printing plate making procedure is based on the LAMS (laser ablated mask) technology [6-7]. In the Figure 1 one can see the production procedure of that kind of printing plates. In the first step, exposure of the back side of the plate has been performed in order to form a basis layer (Figure 1a). Ablation of the LAMS follows the back-exposure and forms a mask of the image which will be reproduced (Figure 1b). Printing elements have been formed by main-exposure through the LAMS mask (Figure 1c) and by chemical and mechanical developing non exposed areas of the polymer will be removed (Figure 1d). Drying and post-treatment (UVA, UVC exposures) improve the mechanical properties of polymer (Figure 1e,f).

The printing plate making process depends on a number of parameters which should be controlled, standardized and defined in the reproduction workflow. In addition, the properties of the printing substrate and interactions with printing inks should be characterised in order to predict the quality of the final product [8]. Therefore, adjustments of the plate making process must be performed to compensate deformations and material limitations in the workflow [9-12]. Considering these facts, the adjustments of the printing plate should be done by modifying the digital file in order to correct the calibration curves of the system.

In this paper the adjustment of the photopolymer printing plates to match qualitative requirements of different substrates has been presented. The influence of different printing substrates on printing plate curves adjustment has been observed.

2. Experiment

2.1 Digital workflow

In the flexographic printing plate making procedure, prior to the exposures and developing, necessary parameters that will enable production of plates of requested quality will be defined. A series of specific adjustments (tone reproduction curves) should be implemented in a digital file prepared for the reproduction. Adjustments are needed in order to modify information of the digital data values to the values which will be achieved in the printing process. It should correct possible deformations caused by interactions between the anilox roller and the printing plate and interactions between the printing plate and the printing substrate [13-14].

2.2 Materials

For the purpose of this research Esko Artwork digital workflow was used. Samples of flexographic printing plates (Asahi AFP) with LAMS mask were imaged on Esko CDI Spark 5080 unit. The hardness of these solvent based plates was 74,7 Shore A and they are optimized for high quality printing onto different substrates, i.e. plastic film, foil and paper [15]. Calibration of CDI unit was performed by means of computer-generated control wedge by manufacturer in order to monitor printing plate quality.

Sequent, a digital wedge with test fields (1,2, ..., 9,10,15,20,25, ..., 95, 100%) and different control elements was generated in order to monitor reproducibility of coverage values and fluent transition between the tones (Figure 2). Four sets of substrate samples S1, S2, S3 and S4 with screen ruling of 76, 99 and 121 lpi were made (one set of three samples for each different graphic product). These screens were chosen to observe changes on the printing plates with the most often used screen rulings in reproduction.

2.3 Method

In the first step the calibration of the plate making procedure, i.e. duration of ablation process, back- and main-exposures, developing time and post-treatment has been performed according to the manufacturer recommendations. Coverage values on the samples in set were measured and obtained results were defined as "calibration curve".

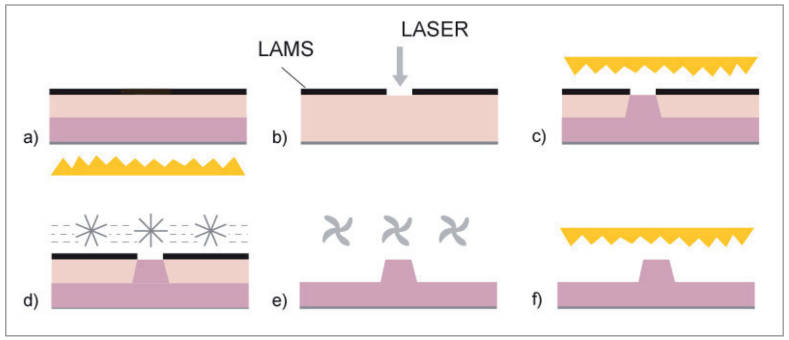

Figure 1: Photopolymer printing plate making process.

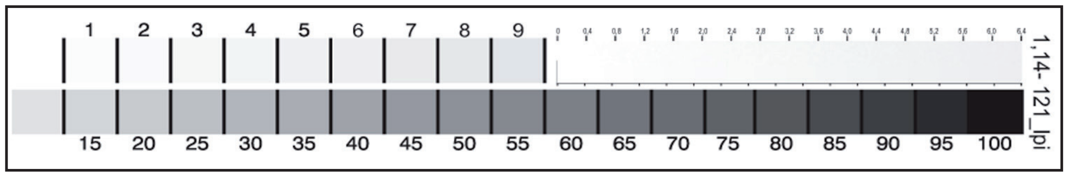

Figure 2: Digitally generated control wedge.

Reproduction of the highlights is often known as a limitation in flexography and can be optimally corrected by adjustments of the lower tone values. It can be defined through the minimum dot phenomenon, which appears from the fact that during the main-exposure light energy must pass through a mask to start the polymerization and harden the photopolymer enough to form a printing element [16]. The opening in the mask must be large enough to allow enough light energy to react with the plate polymer for a given exposure time. If the opening is too small, the polymerization will not start and the dot will not be completely formed. Furthermore, shape and dimension of smallest dots on the plate are very impression sensitive in the printing process. This can compromise the quality of the imprint, especially the one with gradations in the highlights.

Therefore, in the next step highlights and lower mid-tones were adjusted due to plate's limitations. Procedure for adjustment of highlights requires the usage of bump-up curve in a digital file that will increase the size of small dots to a specified value. The bump-up was defined according to the manufacturer recommendations. According to this information the proofs were made with the proofing system which was calibrated to match the printed result. When the proofs were made, the bump-up value was adjusted to enable the forming of small dots due to the used screening and other press capabilities.

After applying bump-up curve, third step of the printing plate adjustment was conducted in order to adjust the reproduction curves to the specifics of the printing system. Therefore, profile of the system was made and corrected curves were made for four types of printing substrates (designated by S1, S2, S3, S4).

Considering the fact that the plate is imaged flat, and mounted on a round cylinder, the original file must be reduced (distorted) in the printing direction, in order to compensate the stretching and deformation of the printing elements [8]. Distortion factor was calculated by means of the software for calculation of flexography plate distortion and the resulting value was entered in the application that allows customization of these values in the reproductive system. It calculates the distortion based on the known total plate thickness, repeat length and tape thickness.

Measurements of coverage values on the samples were performed by VipFlex – a device for film, imprint and flexographic printing plate analysis. For visual analysis of printing plate samples the images were made by Olympus Metallurgical Microscope BX51.

3. Results and discussion

3.1 Influence of the bump-up curve on tone reproduction curve

The results of the measured and the nominal (digital) coverage values are presented in Figures 3 and 4. Figure 3a shows the results obtained for highlights (0 – 10%), and Figure 3b shows the results of the whole tone reproduction scale (0 – 100%). The difference in measured coverage values for printing plates performed with calibration curves (designated with C76 for 76 lpi and C121 for 121 lpi) and by usage of bump-up curve (designated with B76 for 76 lpi and with B121 for 121 lpi) can be seen.

Diagram in Figure 3a presents the lower surface coverage where the influence of usage of bump-up curve can be clearly seen. Because of the mechanical properties of photopolymer material and small dimensions of the printing elements in the low coverage value areas, they are often not reproducible and therefore must be adjusted in order to acquire correct reproduction of highlights. Shape of used bump-up where defined according to the minimal dot value that can be reproduced in the system. One can see that after applying a bump-up curve, the tone reproduction curves have been changed. It results with similar values for screen ruling 76 lpi and 121 lpi. Other tone values of reproduction values (10 to 100%) show no significant difference after applying bump-up curve (Figure 3b).

In Figure 4 tone reproduction values obtained for different products and calculated according to the proofs have been presented. The samples of the printing plates prepared for that products are designated in diagram with S1, S2, S3 and S4. One can see that samples of the printing plates marked with S1, S3 and S4 have similar reproduction curves. Sample S2 has higher measured values and indicate that the plates were prepared for substrate with significantly different surface characteristics. Based on these results, one can see that different printing substrates with different adsorption properties result with different tone reproduction curves. The type of ink curing, hardness of flexographic printing plate and distortion resulted by mounting the plate on the plate cylinder can also affect the reproduction of coverage values. The results for 76 lpi and 121 lpi ruling are similar. Substrate S2 differs from others and indicates that the surface structure of the substrate has higher influence on compensation values than screening.

Results have shown how the printing plate adjustment procedure can result with different coverage

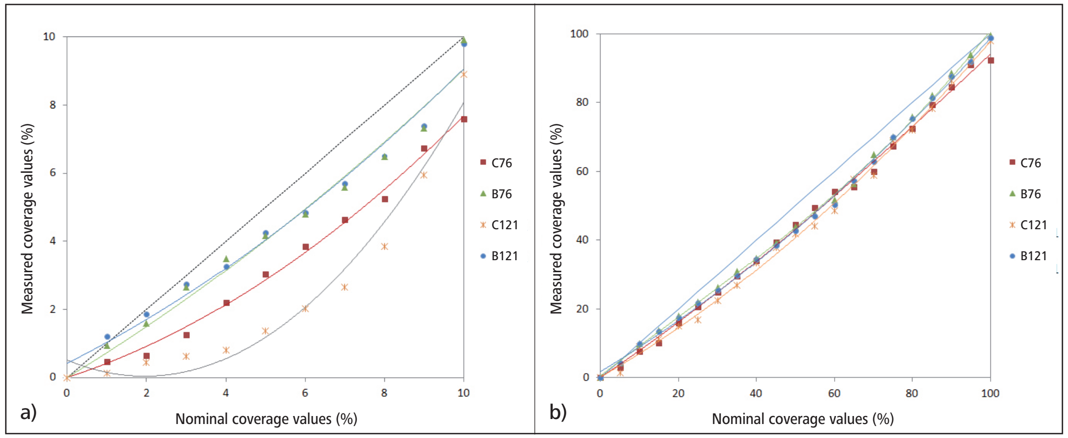

Figure 3: Measured and nominal (digital) coverage values; a) highlights (0-10%), b) whole tone scale (0-100%).

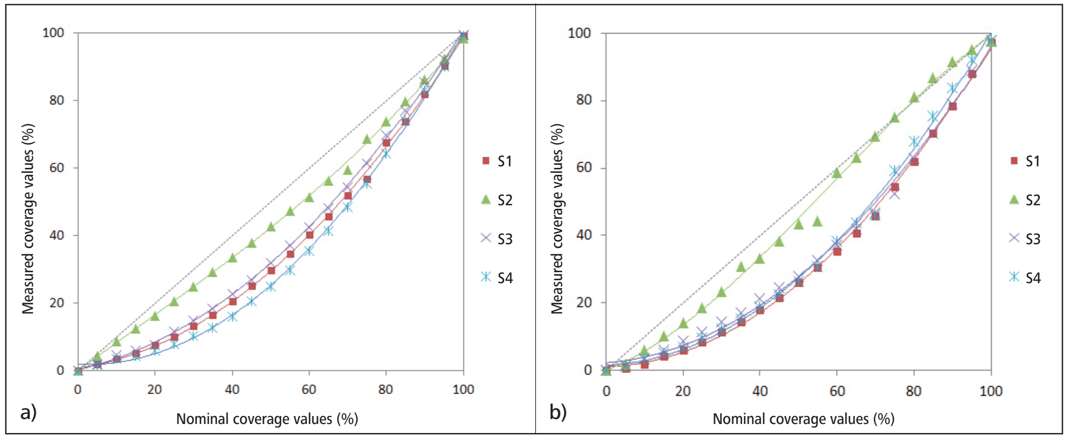

Figure 4: Corrected reproduction curves; a) screen ruling 76 lpi; b) screen ruling 121 lpi.

values on the plates to meet the different qualitative requirements. In order to see what is happening with printing elements in the low coverage values the microscopic images were made. Figure 5 shows the printing plates' images with system calibration conducted on surface coverage of 1%: 5a sample C76 and 5b sample C121 are magnified 100×, 200×, 500×.

The images presented in Figure 5 show the surface structure of the printing elements of 1% of coverage where adjustment by using a bump-up curve was not applied. It is obvious that printing elements are not properly shaped; protruding parts (triangular shape) should be formed as a relatively regular circular shape. It can be assumed that by laser imaging of the LAMS mask and the main-exposure through the openings in the LAMS, initiated polymerization of the polymer layer, but as the dimension of the openings in the LAMS layer is small, the photon energy is not sufficient to induce full polymerization of the polymer layer. For this reason, the structures that can be seen in the images are irregular and undefined. Furthermore, the irregularity of the surface has happened due to the oxygen inhibition in the polymer surface, resulting with the changes in a dot top.

Figure 6 represents images of printing plates on 1% of coverage for 76 lpi (Figure 6a) and 121 lpi (Figure 6b) with application of the bump-up curve (magnification

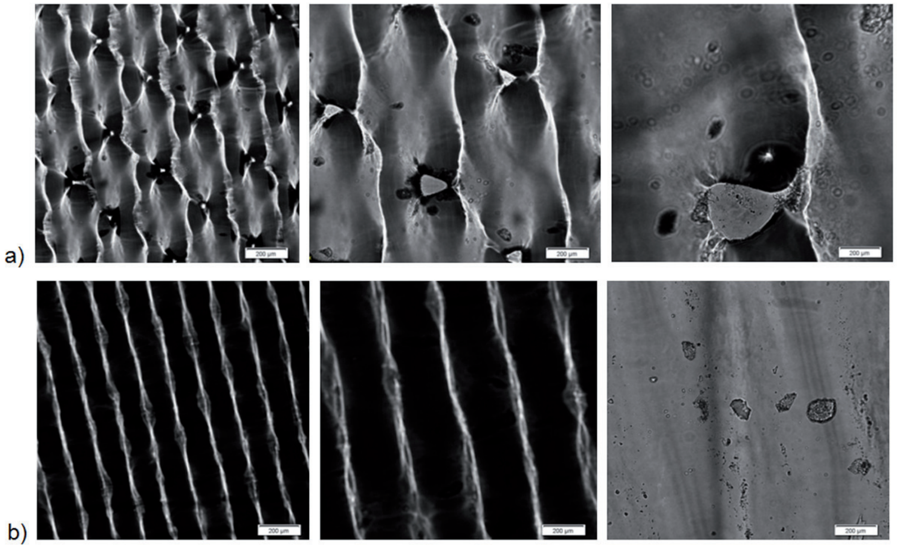

Figure 5: Printing plates' images with system calibration (without bump-up); a) sample C76 and b) sample C121 are magnified 100×, 200×, 500×.

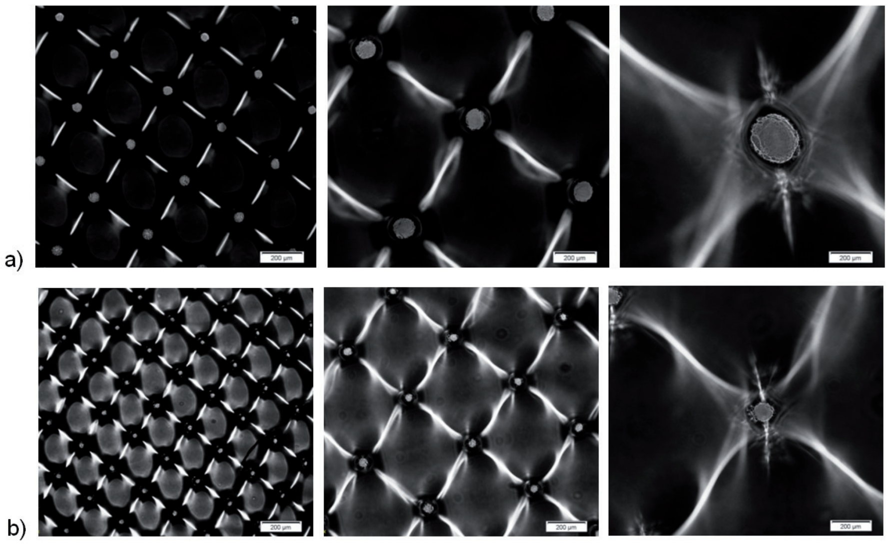

Figure 6: Images of printing plates on 1% of coverage with bump-up curve; a) 76 lpi; b) 121 lpi.

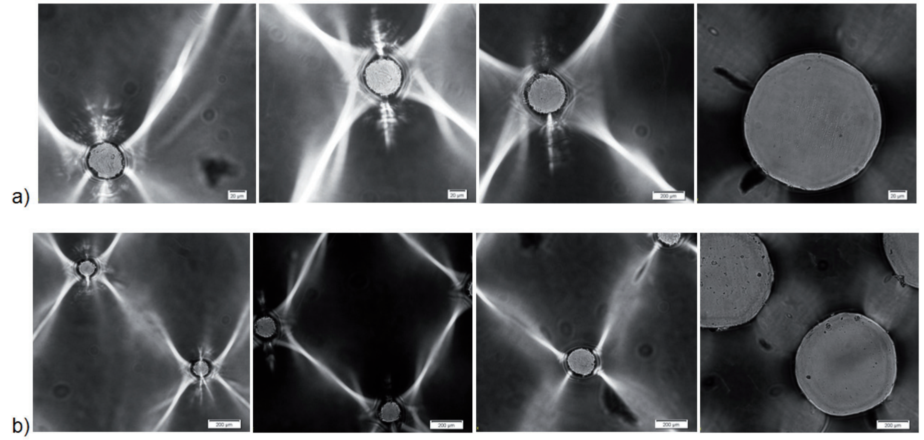

Figure 7: Images of printing plates with corrected curve for 1, 3, 5 and 50 % of coverage; a) 76 lpi; b) 121 lpi.

100×, 200×, 500×). It is visible that printing elements have been correctly defined and formed for both samples.

The images of printing plate with application of curve adjustment procedure (S4) for 1, 3, 5 and 50 % of coverage values at screen ruling of 76 lpi have been presented in Figure 7a (magnification 500×). Figure 7b presents images of same sample with screen ruling of 121 lpi. It is visible that all printing elements have been correctly formed and that the edge of the printing element is sharp and circular shaped.

4. Conclusion

The objective of this research was to expand the knowledge about the flexographic printing plates and the processing procedure which has a high influence on the quality level of the plates. The procedure of preparing digital files for four types of different printing substrates was presented. Reproduction curves were made by measuring different coverage values for three different screens on the flexographic printing plate. The aim was to ensure the optimal quality of the imprint for different graphic products.

The results obtained in this research prove that the bump-up curve has increased the low coverage values on the printing plate. The coverage values of the highlights were different considering the fact that the same bump-up was used and that the digital files were prepared for different printing substrates.

Correction curves were defined according to the printing system and the distortion factor was included in the calculation of a digital file which was prepared for reproduction.

Furthermore, the compensation curve shows polynomial dependence of coverage values on printing plate and nominal coverage values. Differences in coverage values on a printing plate and nominal values are considerable at low coverage values (up to 40%), but decrease at higher coverage values.

Results and images showed that deviations of the coverage values of printing elements are present and are influenced by many factors: screening, press capabilities, printing substrate and required quality. The deviations are present due to the oxygen effect in the polymer surface, too. The high concentration of oxygen in the atmosphere inhibits the polymer cross-linking near the surface, resulting with a dot reduction during the data transfer from a digital file to the finished plate.

This paper shows that the printing plate making phase and the adjustment of coverage values reproduction are important and highly demanding procedures which depend on various parameters. Adjustments in the reproduction system and implementation of a model for the adjustment of digital data which will compensate distortions in the printing process are necessary to meet the increased qualitative requirements which are present in flexography today.

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