Influence of the pad printing plate' printing element depth on the quality of the printed product

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Abstract: *One of the biggest challenges in mass printing is repeatability and stability of the ink transfer from the printing plate onto the printing substrate. The pad printing is characterised by indirect ink transfer from a gravure printing plate. Beside area of the printing elements, on the pad printing plate one should take into account their depth as it is a factor which directly influences the printing ink quantity, i.e. overall quality of the printed product. The photopolymer pad printing plate production includes two exposures with UV irradiation, first to make difference between printing and nonprinting areas and second to form partitions (walls) in the printing elements. The duration of the second exposure directly influences the final depth of the printing elements. The aim of this paper is to determine influence of the second exposure on the depth of the printing elements, consequently on the reproduction of the pad printing plate elements. For this purpose four pad printing plate samples with various coverage tone value fields will be made by variation of the second exposure duration. Results have shown that second exposure duration significantly influences the printing elements size and therefore should be defined precisely in order to form printing elements of desired depth.*

Keywords: *pad printing, polymer printing plate, plate making process*

Introduction

Pad printing is an indirect gravure printing process that involves an image being transferred from the printing plate via silicone pad onto a substrate. The transfer pads are today almost exclusively made from silicone rubber since the silicone materials are the best known release agents for this printing process. For specialized applications there is also usage of polyurethane pads.

The printing plates in pad printing are usually made of steel or photopolymer. The steel printing plates are made in a complex procedure including photographic image transfer and then etching process. The etch depth for the printing plates vary, but is usually between 15 to 38 μm.

The printing process and ink transfer are depending on many factors, printing plate, transfer pad, ink composition, printing environment etc. The theoretical lay down ranges from 12 to 16 μm, depending upon etch depth i.e. depth of the printing elements [1]. Commercial coloured pad printing inks are designed with a fast volatile solvent mixture to form a tacky ink-film in the engraved printing form and on the pad [2].

The transfer pad is very important in the pad printing process. The required curvature of a pad depends on the shape, roughness and fragility of the substrate to print on and on hardness of the pad. For printing on a flat substrate, e.g. solar cell, the pad must have a steep curvature. This shape allows the air between the pad and the solar cell to escape and enables the pad to roll the print on without distortion. Nowadays, all pads used for ink transferring are moulded with condensation-polymerised or addition-polymerised silicone rubber [3]. The hardness of the pad is determined by the amount of silicone oil added to the silicone rubber during formulation. The more silicone oil is added, the softer the pad will be. Adding silicone oil also lowers the tensile strength and the swell resistance of the silicone rubber. For fine-line printing on flat objects the pad should be chosen as hard as possible because a hard pad shows less distortion. Printing on uneven surfaces also requires a hard pad to print down into the surface dimples without slur. The fragility of the substrate limits the possible hardness of the used printing pad [4].

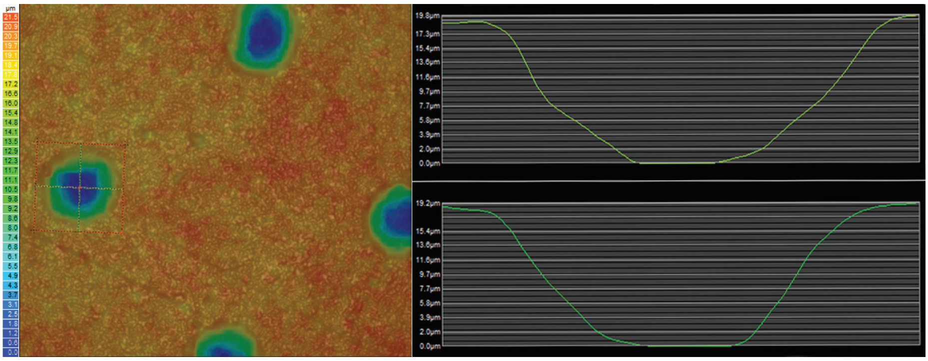
Similar to the other plate making process, pad printing plate is made by two main processes, exposure and then developing to ensure image transfer and finishing (in case of metal plates etching and removal of the remaining photoactive layer, by polymer plates post exposure). The exposure it by pad printing plates, regardless on material, made in two step procedure, first exposure through image carrying film, which defines shape of the image areas and then exposure through positive halftone film to define walls (which are usually dot shaped) of the future printing elements [5]. By the polymer printing plates, the second exposure also influences the size of the image areas (cells) because of the light's angle of incidence. Therefore, the aim of this paper was to define influence of the second exposure duration on the printing element's depth.

Materials and methods

For the purpose of this research Nyloprint WS (water washable) 0,73 mm thick steel based printing plate was used. The plate making procedure was made by BASF Nyloprint CW 22x30 machine. Four samples of the printing plates were made by altering second exposure duration. First exposure was 80 s, which is optimal exposure according to the plate manufacturer. Second exposure differs for every plate sample: 30, 40, 50 and 60 s. Further processing of the plate was conducted according to the manufacturer specifications – the developing time of 150 seconds at 28 ºC and drying time of 13 minutes at 80 ºC.

In order to investigate influence of the second exposure time on the printing elements depth, a sample image containing different halftone patches was created. The patch values were from 0–5% and 95–100 % by a step of 1%; 5–25 and 70–95 % by a step of 5%; 30–70% by a step of 10%. These patches enable detailed overview of the lowest and highest coverage values, where one would expect deformations in the printing element's formation. Resolution of image carrying positive film used for the first exposure was 150 dpi, while the second exposure of printing plates was done through a halftone film with resolution of 200 lpi.

The printing plate samples were analysed using Troika AniCAM 3D scanning microscope. This measurement unit enables measurement and 3D analysis of the flexographic plates, anilox rolls and gravure printing plates/rolls. Its design allows camera to be placed on flat material but also on the round cylinder. The unit generates 3D images are generated from number of photos taken at different focus depth which can be stepped in fractions of the micron. The unit's software (Troika QC) combines the sharp parts of each image and creates the 3D representation of the observed surface (Figure 1). The measurements were made using x10 lens which gives 100× enlargement of the observed surface. The 3D representation was made by generating 150 image slices.



a) b)

Figure 1: 3D image representation made by Troika AniCAM
a) height thermograph, b) printing element's profile

Results and discussion

The emphasis of the measurements was put on the lowest and highest coverage values as there was expected most deformations. On all four plate samples one could see that printing elements at lowest coverage values (0–5%) were not formed. The light sources on the processing unit are UV light tubes which are relatively close to the printing plate in the exposure process (cca. 4 cm) causing an acute angle of incidence of the UV light. To small image dots on the image film are not wide enough to stop UV light from initiating photopolymerisation even under the mask on the image film. The smallest cell formed on the printing plate was spotted on the patch with nominal coverage value of 5%.

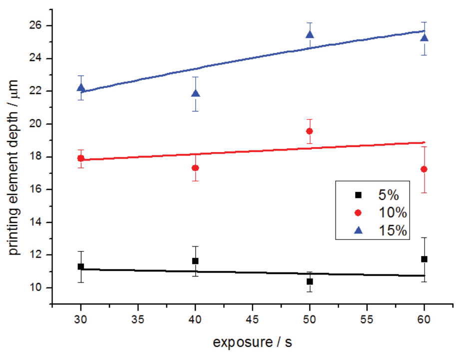


Figure 2: Printing element's depth in low coverage values depending on second exposure duration

In the Figure 2 one can see the dependence of the element's depth on the duration of the second exposure. The results show that in the patches with coverage value of 5 and 10% the printing elements' depth is almost constant through investigated periods of second exposure duration. The influence of the second exposure duration is increasing by the increase of the coverage value. The reason for this behaviour could be the consequence of the photopolymerisation process in which volume contraction occurs [6]. With the increase of the dot size, more irradiation energy reaches the monomer and causes polymerisation.

The influence of the second exposure duration is enhanced in the higher coverage values, but the values of the printing element's depth are nearly the same (Figure 3). The differences in the printing element's depth depending on the second exposure duration are round 7 μm. Increase of the second exposure duration causes decrease of the printing element's depth. This is probably also consequence on the amount of irradiation energy which arrives at the printing plate in an acute angle of incidence causing more monomer to polymerise on the bottom of the printing element, overcoming the volume contraction.

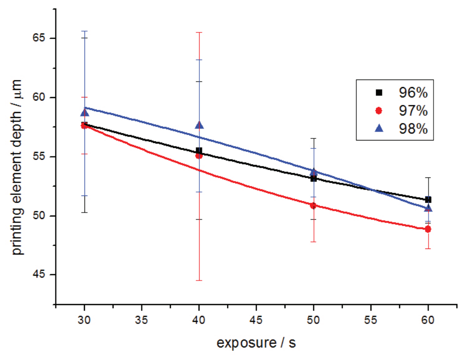


Figure 3: Printing element's depth in high coverage values depending on second exposure duration

Furthermore, one could see that standard deviations in measurements are higher than the ones in the measurements by low coverage values. This could mean variance in the amount of the light energy passing through the material (monomer and formed polymer) and arriving closer to the steel base, causing there higher or lower degree of photopolymerisation.

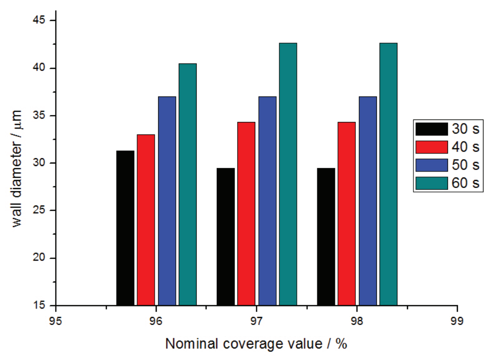


Figure 4: Wall diameter in the high coverage values depending on second exposure duration

In Figure 4 one can see the value of the wall diameter by high coverage values. The results show that wall diameter is nearly the same regardless on the nominal coverage value, but is significantly influenced by second exposure duration. This is probably the consequence of the under copying which occurs when light comes on the printing plate surface in an acute angle of incidence [7].

Conclusion

This research was made in order to give insight of the printing elements characteristic when changing the plate making procedure (the second exposure duration) of the photopolymer pad printing plate.

The results have showed that lowest coverage values, 0–4 % nominal value, could not be formed on this kind of printing plates. The influence of the second exposure duration on the printing elements' depth is enhanced with the increase of the nominal coverage value. There is opposite effect of the second exposure duration on the printing elements in the low and high coverage values, in the low coverage values it is causing increase of their depth, while in the high coverage values it is decreasing their depth. Furthermore, decrease of the printing amount could even be more as the diameter of the wall in the high coverage values is increased by increase of the second exposure duration.

In conclusion, this research has proved that the second exposure duration influences depth and size of the printing elements which directly influences the amount of ink on the printing plate, i.e. ink lay on the printed product. Therefore, this process should be observed and optimized in order to achieve reproducible and highly qualitative imprints in the pad printing.

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