OVERWIEV OF THE SURFACE CONDITIONS OF THE PHOTOCONDUCTORS BY THE IMAGE ANALYSIS METHOD

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ABSTRACT

Electrophotography, as the technique of the digital printing process is more and more present. Photoconductors in electrophotography are exposed not only to the mechanical activity because of the pressure of the printing form on the printing substrate but to the IR radiation by LED laser and to electrical charging which appeared in the developing phase.

The changes of the photoconductor surface in relation to the number of prints have been investigated in this work. The suitability of the image analysis application as the method for observing the changes of the organic photoconductors has been discussed. Durability of the photoconductors and the observing the damages in its surface is very important from the point of view of print quality and economy of the printing process.

KEY WORDS:

Indigo digital printing, organic photoconductors, surface damages, image analysis,

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INTRODUCTION

Organic photoconductors have replaced the semi-conducting selenium materials for many applications. However in some digital presses amorphous selenium is rather used than the organic photoconductor [1]. In general, organic photoconductor is the charge transport layer is coated. This duals layer is deposited onto an aluminized dual layer device having a thin charge generating layer on top of which a thicker polyester substrate.

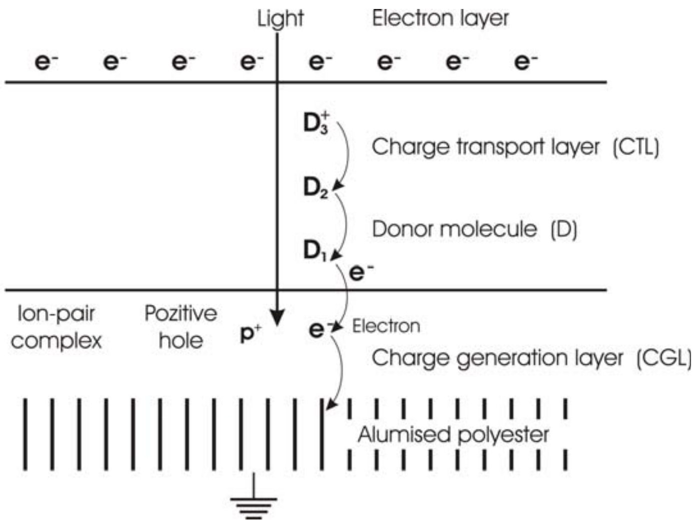


Figure 1. Organic photoconductor

The development of positive charging multi-layered organic photoconductor for liquid electrophotographic colour printing process was investigated by Lee and co-authors [2]. This photoconductor is composed of conductive substrate, charge transport layer, charge generating layer and overcoat layer.

Photoconductors are applied in digital printing as masterless printing forms. Such printing form has the property of a specific way of printing and exposing, which is performed in each rotation cycles. During the digital printing process Indigo photoconductor is in a physical contact with the following rotating parts of the machine: with the developing drum, reverse roller, wetting roller, squeegee roller, offset cylinder and the washing unit.

Among the photoconductor and the mentioned parts there is the liquid toner ElectroInk and paraffin oil. During the production process the unused ElectroInk and paraffin oil have been purified. Unfortunately by the time the contamination of these two substances appear and different impurities can mechanically damage the surface of the photoconductor (it can be scratched). The durability of the photoconductor is influenced by other factors such as voltage and radiation.

HP Indigo uses indirect printing technique which means that the photoconductor is in contact with the transfer rubber medium. The working principle of the printing machine can be presented in several phases: charging, exposition, developing, the first colour transfer, the second colour transfer [3]

Printing on HP Indigo machine begins with electrostatic charging the photoconductor surface with the voltage of - 700 V by means of scorotrone [4]. After that the image step follows. In this step the laser driven by an imaging computer writes the digitized light information onto the photoconductor [5]. The incident light renders the photoconductor conducting and charge corresponding to the shape of the light image leaks away, leaving a latent electrostatic image of the background area and an uncharged image area.

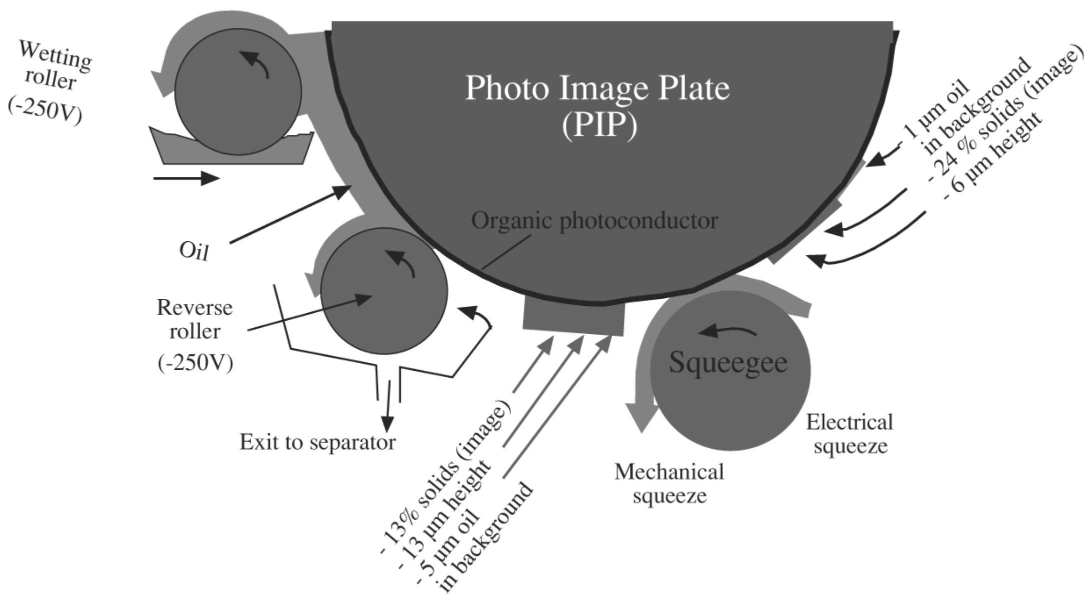


Figure 2. Image development

After exposition the inking with the liquid Electroink is the following phase. The developing drum develops selectively the image on the photoconductor and attracts the ElectroInk from the negatively charged parts of photoconductor surfaces, that is from the nonprinting areas. After the additional developing, ElectroInk is on the surface of the photoconductor. The contact zone of the photoconductor and the offset cylinder (the first transfer) must be the least possible because of the good image transfer. The offset rubber on which the ElectroInk is transferred must be heated. The surface of the offset cylinder is charged which guarantees a qualitative acceptance of ElectroInk. The transferred ElectroInk on the heated rubber starts the thermo polymerization, becomes thicker and stickier.

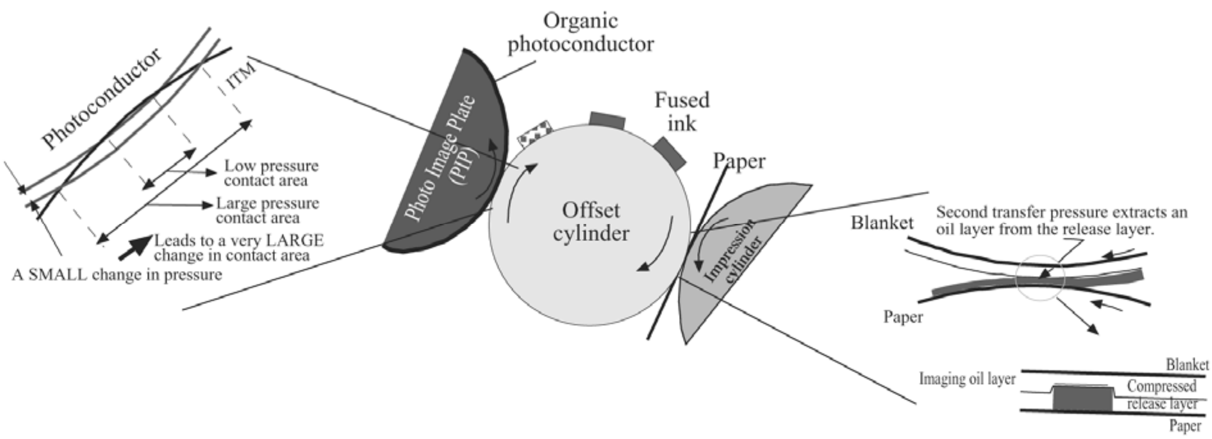


Figure 3. Image transfer: PIP- blanket –supstrate

In the following phase of the printing process, the plate cylinder comes into contact with the washing unit. It cleans the photo image plate from ink and removes the charge from the surface. The plate cylinder is ready for the new printing cycle. At the same moment the second ink transfer happens. The ElectroInk is transformed into the liquid plastic mass and comes into contact with the printing substrate which is colder than the rubber blanket. The ink solidifies, sticks to it and peels off completely from the blanket. This enables the application of the new ink in the next revolution of the cylinder.

The investigation results of the damage of the organic photoconductor surface in the dynamic working conditions have been presented in this work. The surface and the number of damages on the defined photoconductor surface in relation to the number of prints have been discussed.

EXPERIMENTAL

For observing the problems of organic photoconductor wearing the digital offset HP Indigo TurboStream machine was used. The principle of producing the print and of inking with ElectroInk is identical for all the models of Indigo machines, but there are some differences in details. The sheet-fed TurboStream machine uses Multi-shot technology where there is defined difference in the second ink transfer in relation to the One-shot technology.

For testing the wearing of photoconductors a special printing form was created which contained classic printing elements for observing the reproduction quality, graded CMYK wedges and standard achromatic and chromatic illustrations. Except that, the form contained patches the size of which was 7,62x 7,62 cm, 100% covered with black ink designed for observing the damages of photoconductor. Patches for observing the damages were arranged on four marginal and one middle position of the printing form.

Fine art paper with the grammage of 150g/$m^2$was used in printing.

The testing cycles comprised 131806 prints. The following prints were researched by the image analysis: 13146, 31124, 75329, 87183, 98644, 114680 and 131806. Except that, at the and of the run, the photoconductor was exposed to extreme wearing, after which the image analysis was made directly on its surface, as well as on the print in order to evaluate the successfulness of the method for observing the damages.

The damages of the photoconductor surface were assessed by means of image analysis, so that they were observed as the negative in the photosystem. In general, the principle of this method in this case is the usage of the difference in contrast between the damages of the surface as the light blotches on the fields covered with black.

The image obtained by the flat-bed scanner (or, alternatively, camera) is digitally converted into pixels whose size depends on the visibility field and the image depends on the scanner resolution. Identification of the damages is based on the differences in grey values.

The value between 0 and 255 is given to each pixel in accordance with its reflectance. The image segmentation converts the digitalized grey value image of the camera to a binary, black-and-white, image. In this way all the pixels with the grey value above the determined threshold value are identified as the damages and they get the value 1 in the binary image. Pixels with grey values below the threshold are considered as the background. The image analysis ends in measuring the demages and in producing the data output.

Procedure of determining the damages of the photoconductor is presented in figure 4.

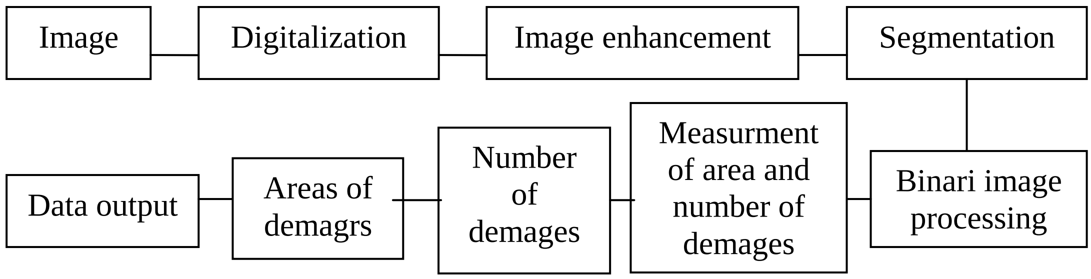


Figure 4: Image analysis procedure.

Number and the surface of the damages were assessed with image analysis-based software systems: Spec*Scan (Apogee System). Spec*Scan system utilizes a flat-bed scanner Epson Perfection 2400 Photo to digitize the image; its resolution was set to 600 dpi. Threshold value (100), white level (75) and black level (65) were chosen after comparing computer images to the damages of the photoconductor.

RESULTS AND DISCUSSION

In figure 5 the number and the surface of the damage of the photoconductor during the run for chosen prints have been presented.

As one can expect, during the printing process the number and the surface of the damage of the photoconductor surface is increased. From the investigation results

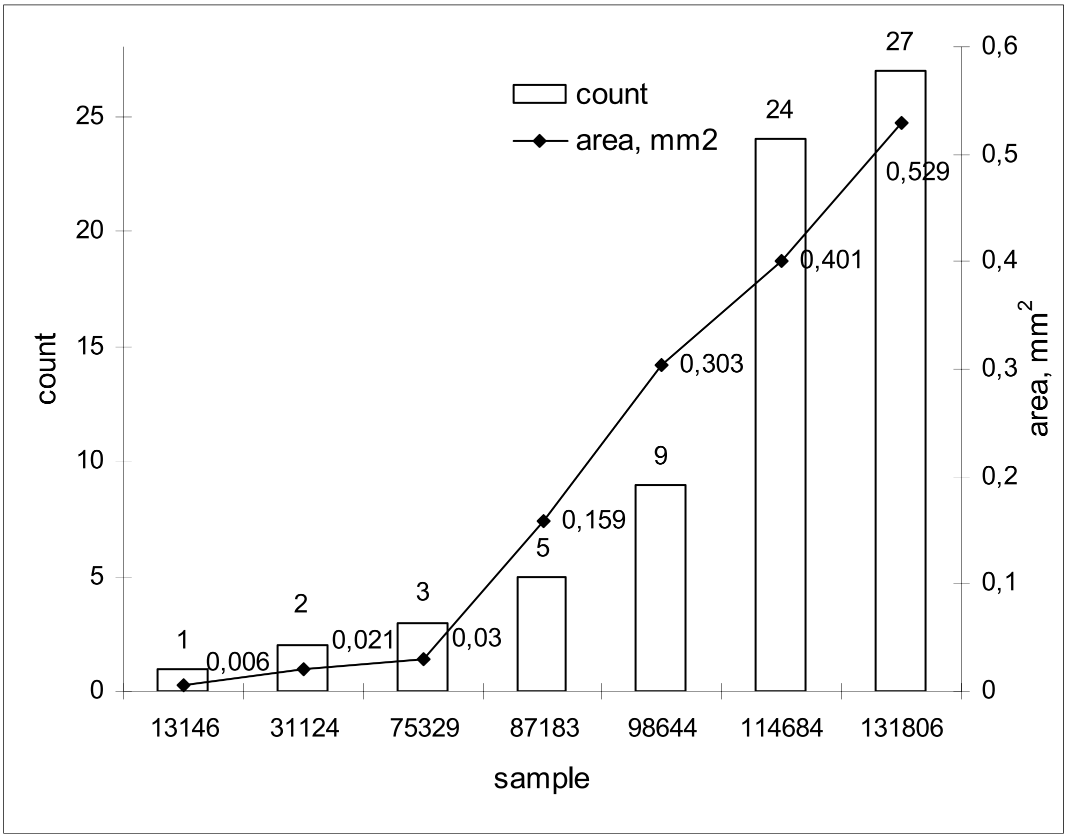
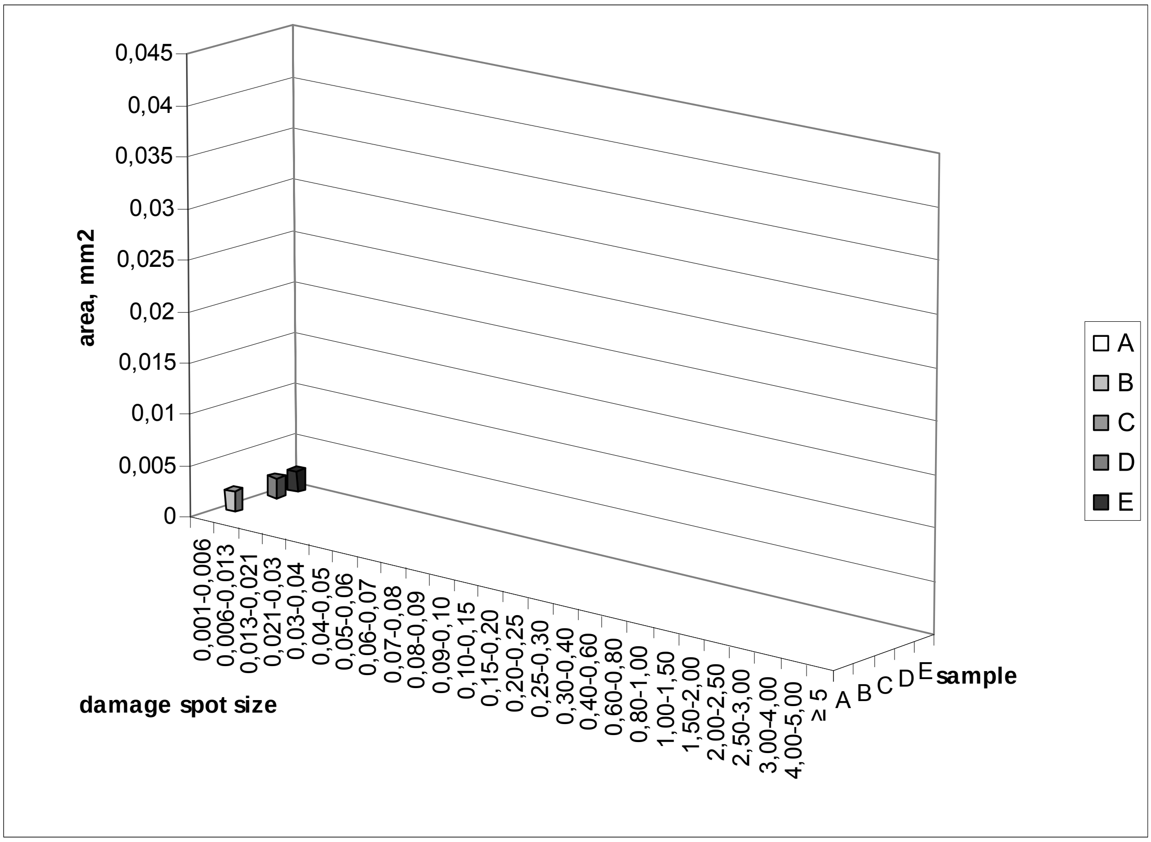


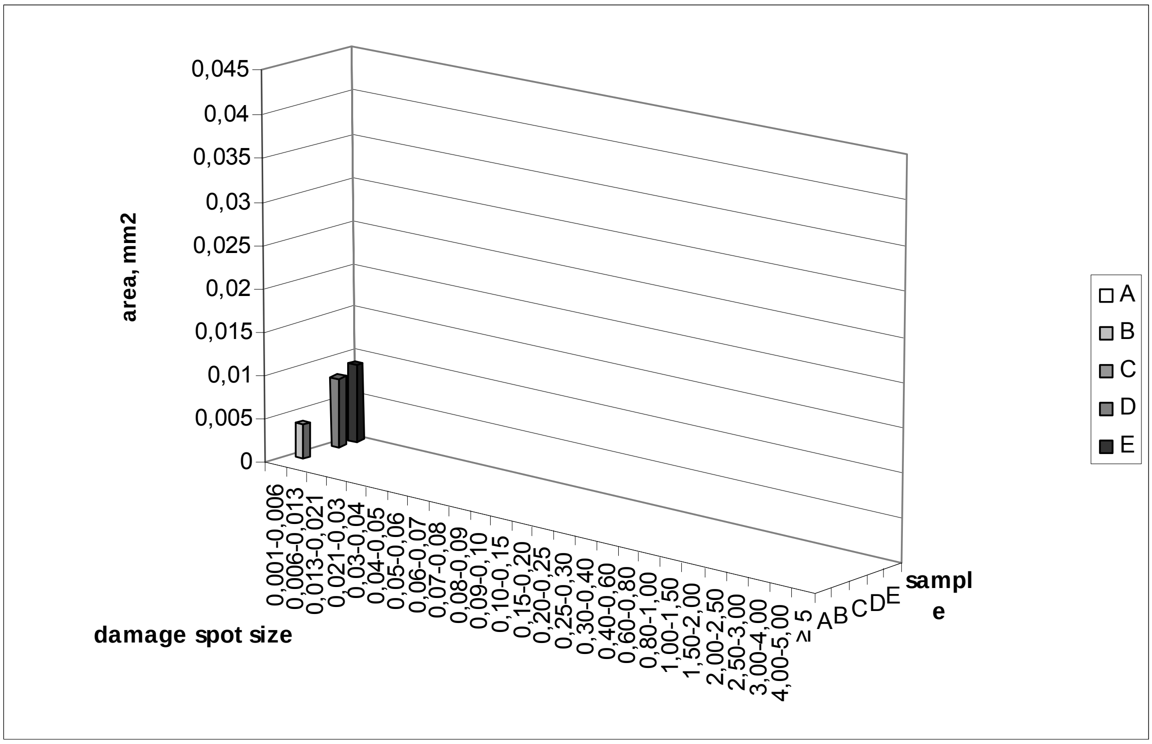
Figure 5. Total number and the surface of the photoconductor damage

the following damage characteristics can be noticed. About 75000 prints have micro damages not visible with the naked eye in a small number of cases. They increase further in the printing process by wearing and by the complex activity of the particles from the substrate and from the ink. At the print 114684, ten times increase of the damages can be noticed but not such increase of the surface of the damage.

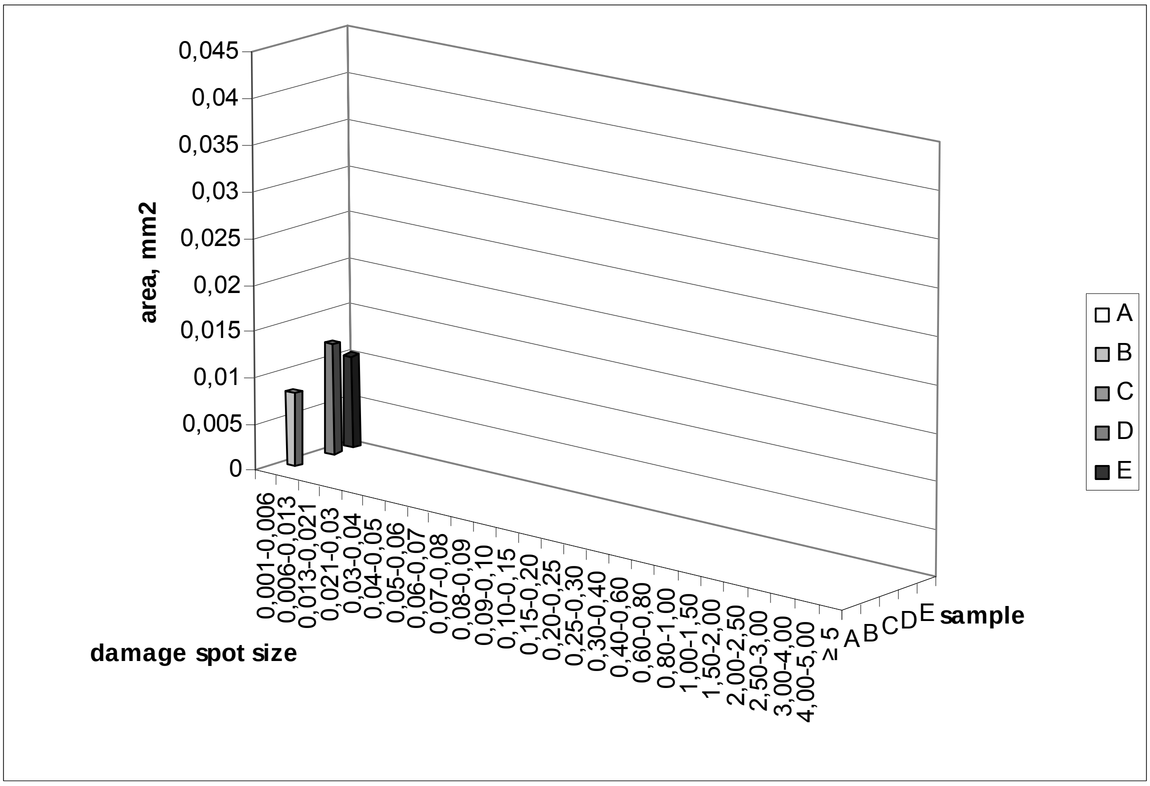
In order to determine the surface damage of the photoconductor and to observe the influence in relation to the print quality the distribution of damages according to the class sizes was monitored. The results of these investigations are presented in figure 6.



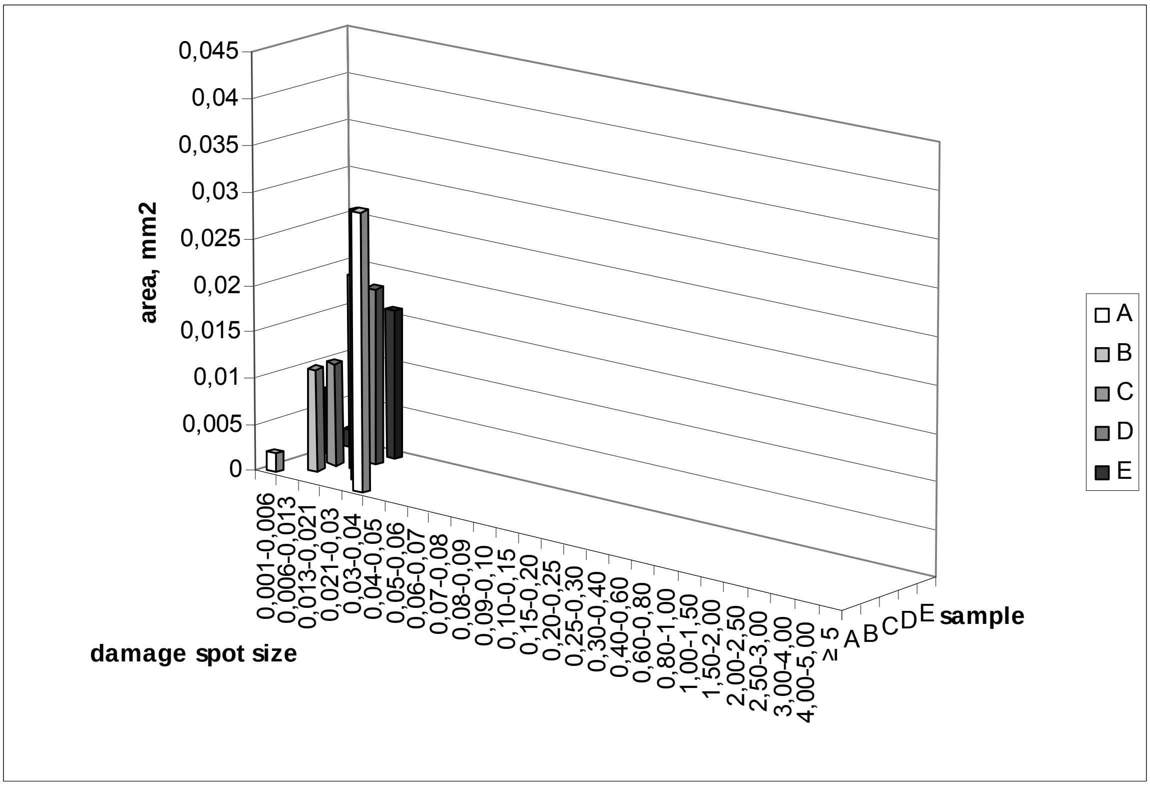
Print 13146



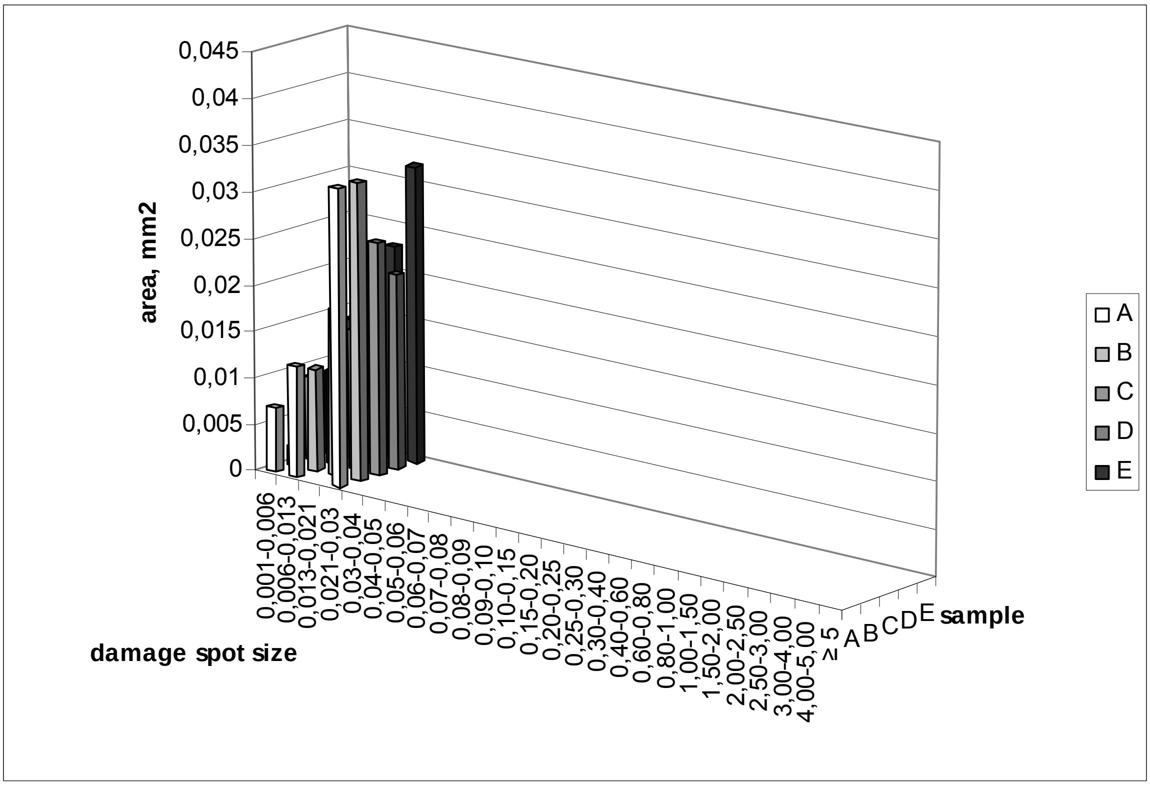
Print 31124



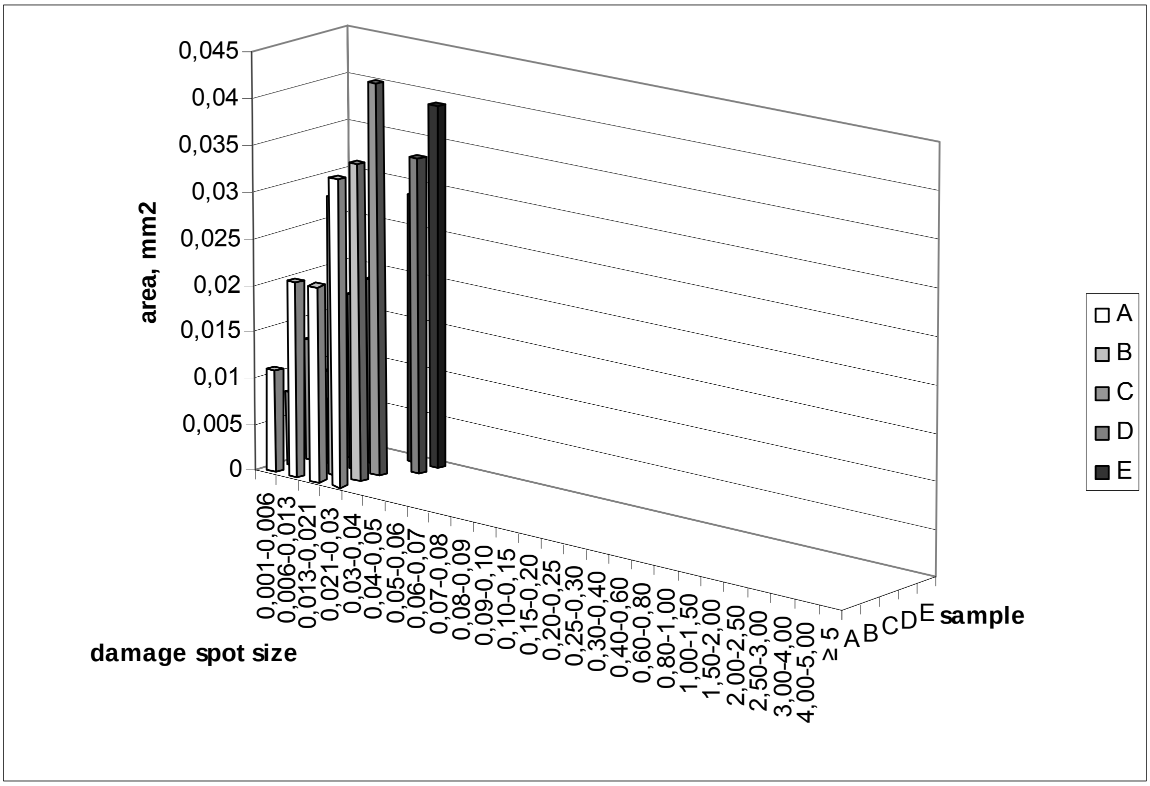
Print 75329



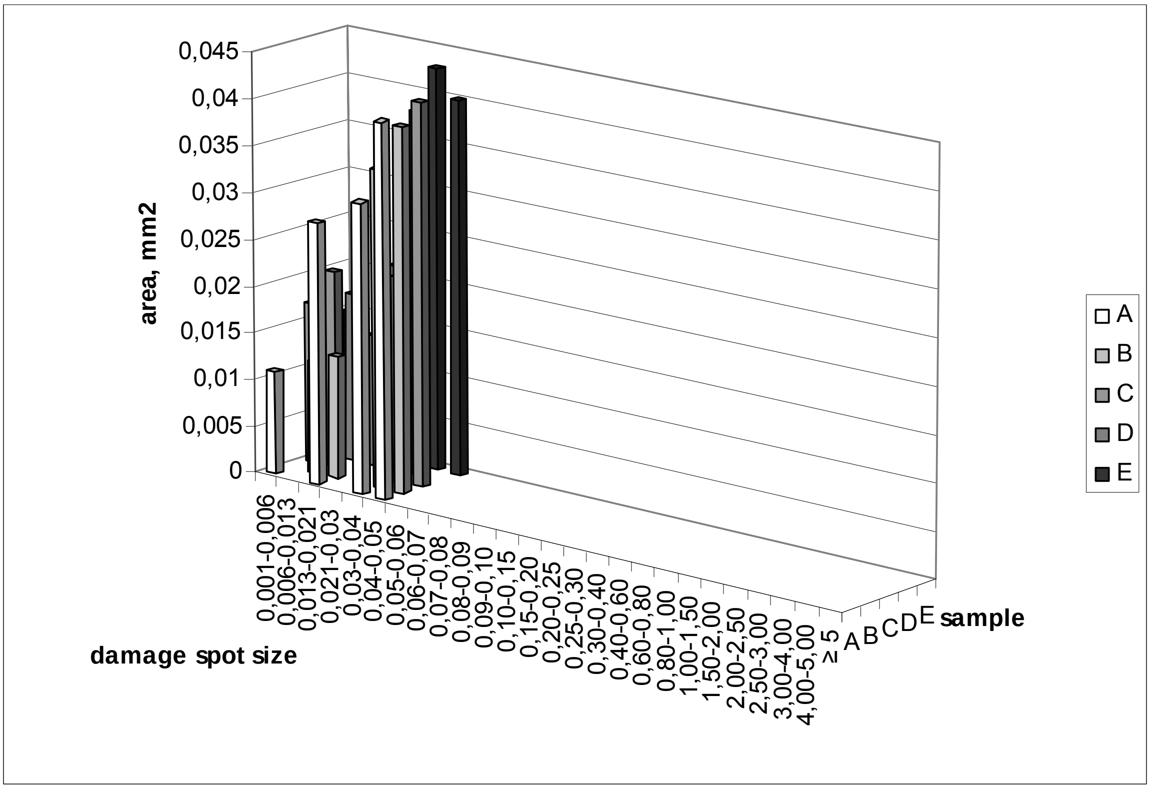
Print 87183



Print 98644



Print 114684



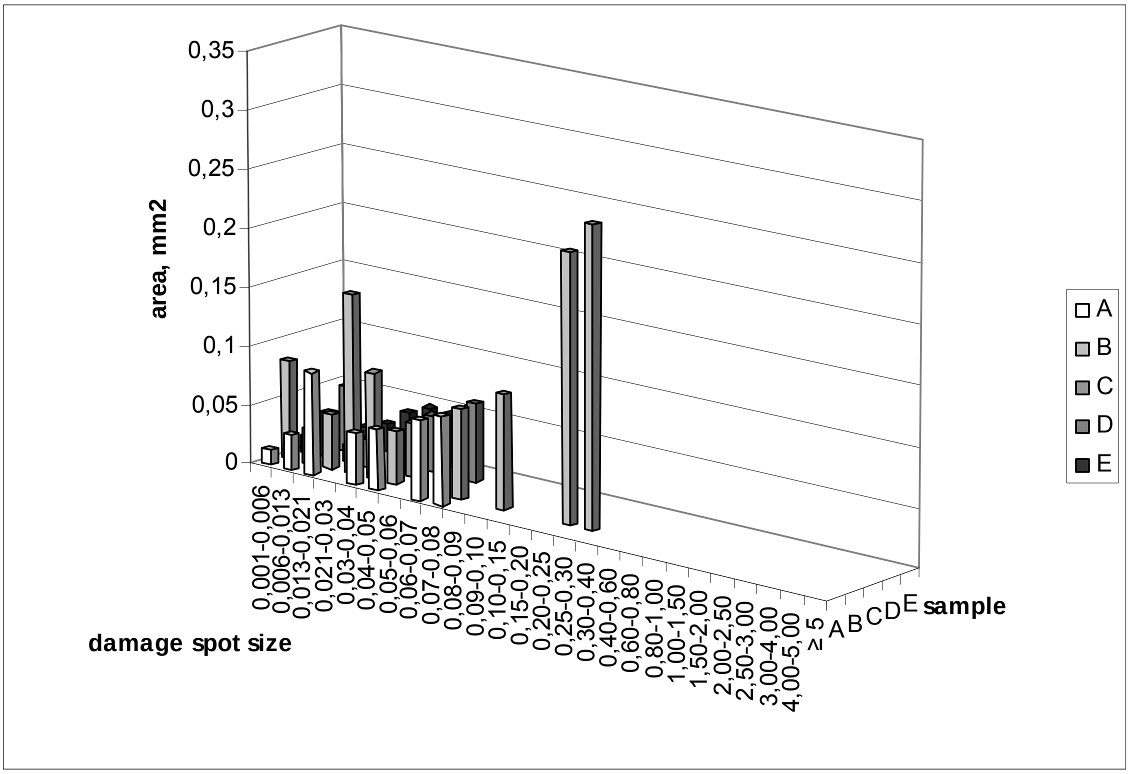
Print 131806

Figure 6. Distribution of the damage of the photoconductor surface according to class sizes

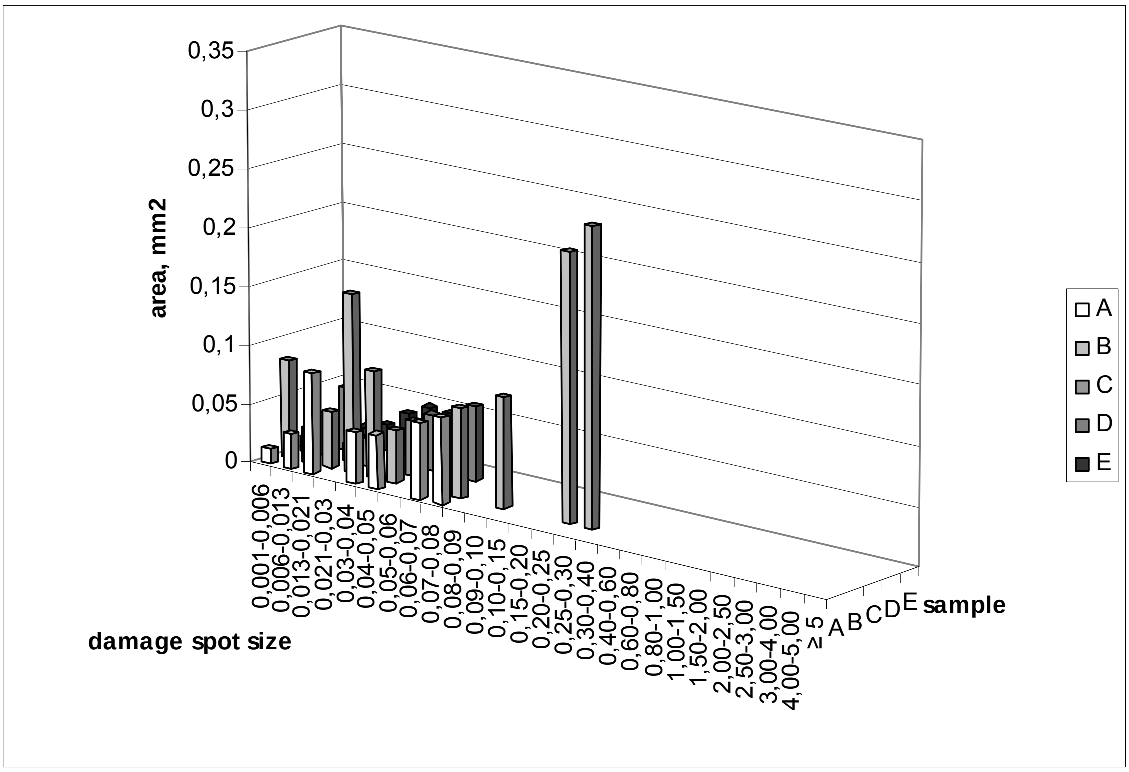
It is visible from the research results that by using the new photoconductor the damages of the surface in the class sizes of 0,001- 0,006 mm^2 can be noticed on the print 13146.In regard to the size of the damaged surface, it could not influence the print quality. By increasing the run to 75329 prints, the number of surface damages increases too, but they stay connected to the lowest class.

By further printing the surface damages of photoconductors have somewhat changed trend. Except the number of damage increases in the lowest classes, the damages connected to the higher classes appear as well and they could influence the print quality because of their size. This statement refers to the prints 98644, 114684 and 131806.

In figure 5 the results of the image analysis of the photoconductor surface are presented, which are deliberately damaged in the determined patch with the aim to control the applicability of the used method for surface wear monitoring during printing. Except that the aim of this measurement was to determine the size of the direct and indirect measuring of the damaged surface.



Print



Photoconductor

Figure 5: Image analysis of the photoconductor measure directly and over the prints

The measuring results show the good results matching between the direct measurements of the photoconductors and prints, which is particularly interesting in the cases of impossibility of its dismantlement. The percent of aberration data for the determined classes is calculated for the given conditions of the experiment. For smaller class sizes these aberrations are greater and they are 7,32%, while in higher classes they are under 15% in the framework of the experimental conditions.

CONCLUSION

Photoconductor should have carrier liquid resistance, mechanical wear resistance and excellent electrostatic characteristic. Based on the investigation results of the mechanical damage of the organic photoconductor in printing, one could conclude that in run printing of about 80 000 prints the damage of its surface does not appear, which could influence the print quality. However, in further work the damages are noticed that belong to the class of 0,07-0,08 mm^2 in the described experimental conditions which could influence the quality of the printed reproduction.

The image analysis method shows to be good for monitoring the photoconductor damage by the indirect process over the prints in higher classes, which is particularly interesting for the described problems.

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