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INFLUENCE OF PRINTING PROCESS ON PRINTING PLATE'S SURFACE CHARACTERISTICS

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Abstract:
The difference between printing and non-printing areas in lithography is achieved through different physical-chemical properties. Non-printing areas must attract water based fountain solution which enables them to repel oil based printing ink. Printing plates are today made of aluminium sheet which must be mechanically, chemically and electrochemically processed to define specific micro rough surface with porous aluminium-oxide layer.
The aim of this paper is to determine changes of the non-printing areas surface characteristics, roughness and wetting properties during exploitation of the printing plate. Surface topography is one of the critical factors which could cause the instability in the quality performance and the durability of the printing forms during printing process.
Measurement of contact angle and surface roughness was made to determine roughness parameters and surface free energy. Measurements were made on thermal CtP plate before printing process and after 123 000, 177 000 and 300 000 prints.
Results have shown that contact angle values, surface roughness and consequently surface free energie values of non-printing areas (polar characteristics) have been significantly changed depending on the print run.
This research has proved that contact angle and roughness parameters has a specific and most important role in determination of wetting properties of the investigated surfaces.

Keywords: *non-printing elements, contact angle, surface free energy, surface roughness*

1 INTRODUCTION

The most used printing technique today is the offset printing. The printing and non-printing areas are nearly in the same plane. The difference between those areas is achieved by their physical and chemical properties. The printing elements are hydrophobic opposed to the non-printing elements which are hydrophilic. In order to achieve the ink-repellent properties of non-printing areas, water based fountain solution is applied.
The fountain solution consists of water and some additives which give this solution needed characteristics. One of main additives is surface active compound which decreases surface tension of water [1]. The value of fountain solution's surface tension is very important factor in achieving high quality print because a hygroscopic material, like paper, adsorbs humidity and changes its dimensions. If this change of dimension occurs in printing, result will be low quality of multi colour printing. With decrease of fountain solution's surface tension to enable coverage of non-printing areas with smaller amount of fluid. On the other hand, surface structure of non-printing areas has also great role in wetting process. On of the most important parameter in order to achieve high quality printing is stability of the surface structure of the non-printing areas [2]. As these surfaces are influenced by printing process, chemical structure, wetting properties and surface roughness of the printing plate's non-printing areas has to be monitored regularly, throughout the whole printing process.

2 THEORY

Important physical phenomenon which occurs on the surface of the printing plate in both the printing and the non-printing areas is adsorption. Adsorption is an accumulation in concentration of one phase on the boundary between two phases. There are many interactions happening on the lithographic printing plate's surface. On the printing plate is important to monitor interactions between aluminium-oxide, of which non-printing areas are built, and fountain solution but also interactions between fountain solution and printing ink to disable acceptance of printing ink on non-printing areas. Adsorption is based on free surface energy of the solid surface. Particles of the liquid of vapour move chaotically until they approach the solid surface. When they get close enough to the solid surface (at the distance of approximately 10^{-7}cm), the adsorption forces attract them to it, so that they become adsorbed to the solid surface. This type of adsorption is called physical adsorption. Adsorption forces are stronger as surface free energy of a solid is higher. One way of increasing the amount of surface free energy is to increase adsorbent's surface. Roughened surfaces adsorb more water based solution than the smooth ones [3].

To ensure needed roughness, first step in production of aluminium substrate used for printing plates is graining which could be mechanical or chemical. A degree of micro-roughness varies depending on how the graining has been done, but is also defined by printing plate's exploitation. The grained non-printing areas have its peaks and recessions, whose features are defined by certain roughness parameters [4]. In general, the salient surface points (peaks) of the wrinkles adsorb more water based solution due to the higher level of surface free energy in those areas. All the substances tend to minimize their energy state as it is the most stable state. To minimize their energy state, they have to minimize their number of boundary molecules and, therefore, have to minimize their surface area [5].

Wetting of the fountain solution on non-printing areas is also influenced by surface tension of fountain solution. To decrease surface tension of fountains solution a kind of surface active compounds is used. Usually for this purpose 2-propanol is used in graphic industry, but due to its bas influence on environment, investigations are made to find compounds with same effect, but better environmental behavior.

All of these parameters that influence prints quality are changed during printing process. Non-printing areas are in constant contact with fountain solution in which particles of paper as well as printing ink could be absorbed. This could have bad chemical influence on these areas, but in the same time wearing of printing plate occurs by friction between printing plate and offset cylinder and ink and fountain solution rollers. Pressure which occurs in these contact can be rise temperature in the printing press and cause problems [6].

3 MATERIALS AND METHOD

3.1 Sample preparation

The investigations were performed on the Kodak Sword Ultra T98 CtP positive offset plates of 0.3 mm thick with a thermal active layer and the Kodak Goldstar premium developer. Printing was performed on the UPM Ultra H web gloss-coated 56 g/m^2 paper with the Sun Chemical heat-set top gloss colors.

The Kodak Sword Ultra is an aluminum-based, electrochemically grained and anodized plate. Due to its polar characteristics, the Al_2O_3 layer creates the non-printing areas on the printing plate. The Kodak Sword Ultra plate is rated for up to 400,000 impressions if unbaked. However, if baked, it can achieve run lengths of 1,500,000. For this experiment, the run length was 300.000 impressions with unbaked printing plate. Printing process was performed by a web offset printing machine, Komori 38 D which has the ability to print with heat-set printing inks, maximal printing areas of 1250x960 mm, top speed 36,000 prints per hour.

For the purpose of investigation, samples of printing plate were taken at four stages of print process. Sample 1 was unused printing plate (was not used for printing), Sample 2. printing plate after 123,000 prints, Sample 3 printing plate after 177,000 prints and Sample 4 printing plate after 300,000 prints. To analyse possible diversity in surface properties change depending on position on printing plate, five samples were taken from each printing plate (*R*=1.5cm), positioned along the line of printing pressure in the printing units and with center-to-center interval of 20 cm (Fig. 1) [6].

Fig. 1. Positions of the taken samples on the printing plate

To determine changes in wetting properties, two types of fountain solution were prepared. Solution 1 was a commercial fountain solution which is used in web offset, made of distilled water with additives and Solution 2 was also web offset fountain solution, prepared with substitutes for 2-propanol as a additive which decrease solutions surface tension (ecologically friendlier fountain solution).

2.2 Measuring methods

The SEM micrographs of the samples were made by JEOL JSM 6460 LV scanning electron microscope. To assure the uniform electrical properties and to avoid the charging/discharging of aluminum oxide surfaces, the printing plate samples (radius 1,5 cm) were gold coated by ion sputtering (15.0 nm thick, density 19.32 g/cm^3). The images were taken at working distance of 15 mm, voltage 20kV and scanning angle of 35^o with magnification of 5000x.

The profilometric parameters were measured with the Portable Surface Roughness Tester TR200 [7] provided with a diamond tip with 2 μm radius. The TR200 is capable of evaluating different roughness parameters: *Ra, Rz, Ry, Rq, Rt, Rp, Rmax, Rm, R3z, S, Sm, Sk, tp*, and hybrid parameters: primary profile (*P*), roughness profile (*R*), tp curve (material ratio *Mr*) defined according to pertinent ISO standards [8, 9]. The measured surface roughness parameters used in this study are compliant to the geometric product specification standards [8, 9] and listed below:

- R_a - average surface roughness:

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

- R_q- root-mean-square deviation (R_{ms}):

$$R_q = \sqrt{\frac{1}{i}\int_0^1 y^2(x)}$$

- R_{zDIN} – mean value of the single roughness depths Z_i:

$$R_{zDIN} = \frac{1}{n}(Z_1 + Z_2 + ... + Z_n)$$

- R_p- leveling depth, distance between highest peak and the reference line

Functionality of the non-printing areas was investigated by applying two different types of fountain solutions and measuring contact angle between fountain solution and non-printing areas.
Measurement of the contact angle was performed by Dataphysics OCA 30, a video based, optical contact angle measuring device. This kind of device ensures the static and the dynamic characterization of liquid/solid interfaces by contact angle measurement procedure [10].
In this paper contact angle was measured by using the Sessile drop measuring method with computer controlled dosing unit which ensures same drop volume. Volume of a drop was defined at 1 μl, measurements were conducted at room temperature.
Before measurement, Samples of printing plate were washed out in distilled water in ultrasonic washing unit Bandelin Sonorex at temperature of 65°C.

4 RESULT AND DISCUSSION

Prior to roughness and contact angle measuring, visual analyses by taking SEM pictures were done. They involved detecting the differences between investigated Samples 1 – 4.

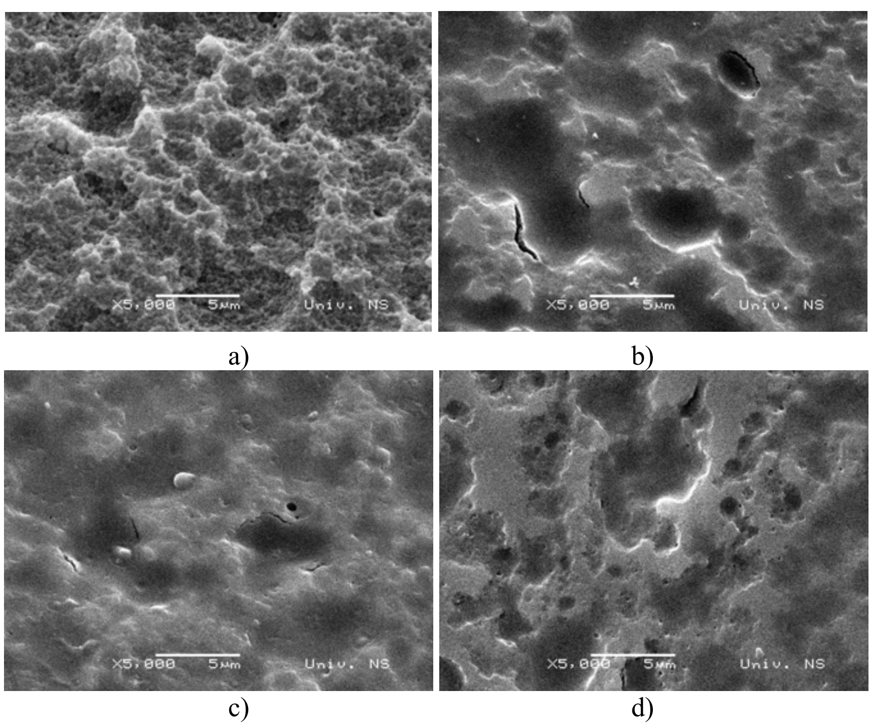

Fig. 2. SEM micrographs od a) Sample 1 b)Sample 2 c)Sample 3 and d)Sample 4

The surface roughness can be seen on the plate which was not used in the printing process. SEM micrographs of surface topography of an unused printing plate and samples after different impressions are shown in Fig 2. The changes in surface topography induced by multiple usage of printing plate are clearly seen and manifested as lowering of the peaks and flattening of the valleys. Multiple applications of pressure during printing eventually result in flattening of the surface and smoothening of its features (Fig 2 b,c,d).

Results of roughness parameters measurement can be seen in Fig. 3. Results of investigated roughness parameters show similar behaviour as seen in SEM micrographs.
Changes in printing plate surface topography result in changes of the corresponding roughness profiles. Compliant with the visual change of surface topography due to multiple use of printing plates noticeable in SEM micrographs (Fig. 2.), measured roughness profiles indicate decrease in roughness by increase of printing plate exploitation. These changes imply that some flattening of the printing plate's surface occurred during printing process. This is manifested as a decrease in values of all roughness parameters. It could be seen that highest change is by R_z which implies that printing process causes filling of valleys lowering their depth.

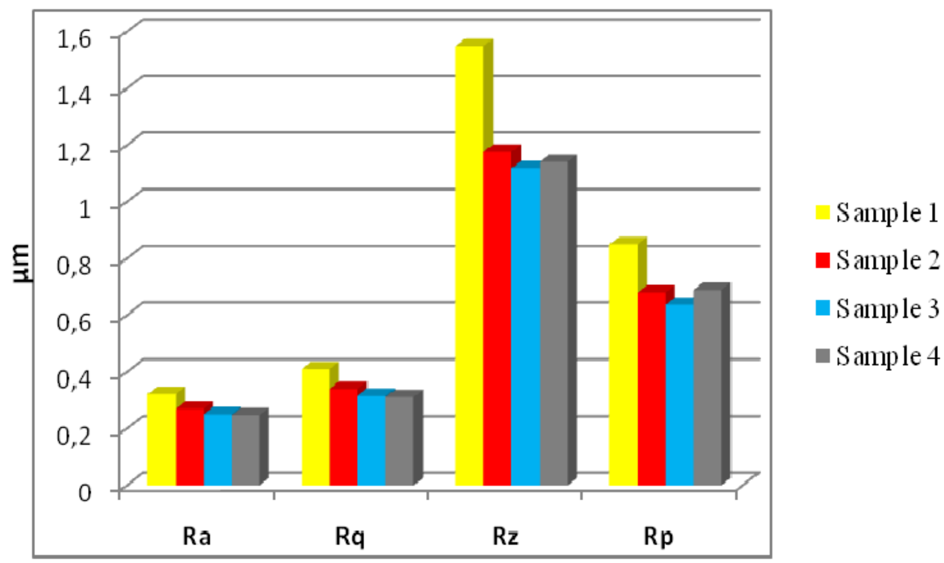

Fig. 3. Roughenss parameters of Unused printing form and printing forms after 123.000, 177.000 and 300.000 impressions for Yellow colour

Printing process and friction between printing plate and rollers have impact on surface properties of offset cylinder surface. Peaks of the aluminium-oxide layer certanly wear during expolatation of the printing plate. On the other hand, printing plate is in constant contact with fountain solution and particles of paper dust. This could lead to the filling of recessions with $CaCO_3$ [1] or paper particles which causes decrease of polar part of aluminium-oxide layer.

To determine how changes in roughness of printing plate's non-printing areas influence on their functionality, contact angle between fountain solution and those areas was measured. Measurement were made by application of two different types of fountain solution in order to investigate dependance of non-printing areas functionality on used fountain solution. In Fig. 4. one could observe behaviour of contact angle between non-printing areas and fountain solutions as a function of print run.

As it could be expected, increase of the print run causes decrease of wetting ability. It can bee seen that contact angle of Solution1 is higher on all printing form samples, but in the same time it is more stable. Contact angle of Solution2 is signifantly lower at the Sample 1 than the one of Solution1, but difference between them is constantly decreasing with increase of the number of impressions - print run.

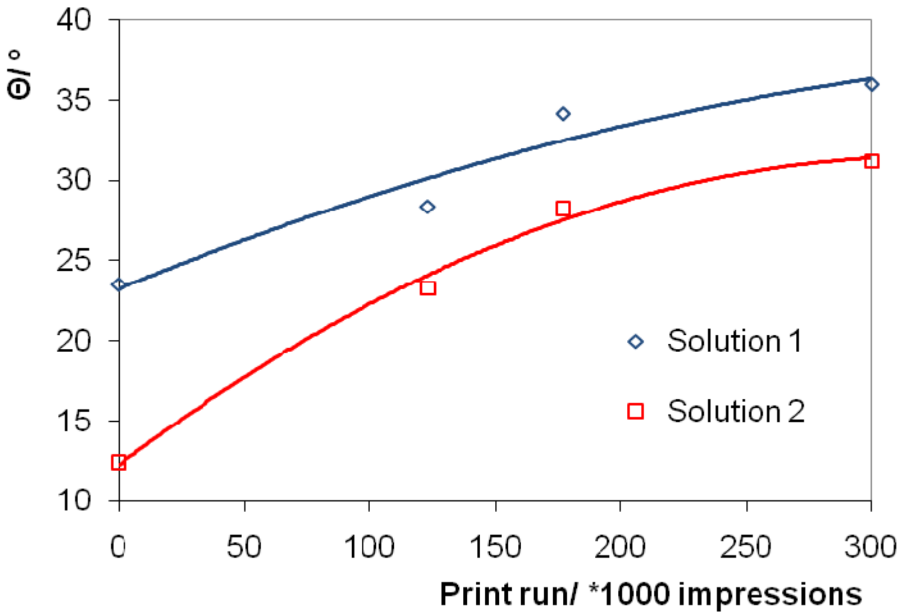

Fig. 4. Contact angle of fountain solutions in dependence on print run

This behaviour of fountain solution – non-printing areas of printing plate is expected as it could be seen in prior results that surface of aluminium-oxide is lowering with printing process.

5 CONCLUSION

Aim of this paper was to determine influence of printing run on surface characteristics of offset printing plate's non-printing areas. Presumption was that during printing process printing plate is wearing due to mechanical influence of printing machine parts that come in contact with it and chemical influence of fountain solution.

Investigation proved the presumption. Printing plate's surface characteristics are changed considerably by exploitation. In SEM micrographs it could be seen that micro pores of aluminium-oxide are filled and in the same time, peaks are flattened.

Results of visual analysis were proved by conducted measurements of surface roughness parameters. They showed that surface roughness of printing plate is constantly decreasing.

Measurement of the contact angle has showed that non-printing areas are diminishing their functionality as print run increases. Functionality is also influenced by used fountain solution as it could be seen that Solution 1 has higher contact angle implying worse wetting, but on the other hand shows more constancy in wetting properties.

These investigation have proved that investigation of printing plate's surface properties must be conducted in order to better understand printing process and its influence on printing plate. In addition, obtained results of this investigation are step forward in prediction of printing plate's wearing process to enable printing quality of highest level throughout whole printing run.

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