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THE EFFECT OF FLEXOGRAPHIC PROCESS PARAMETER ON THE PROPERTIES OF PRINTS ON NONABSORBING SUBSTRATES

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Abstract:

The importance of flexographic printing technology lies in being an emerging impact technology with a large variety of applicable inks and substrates. To take advantage effectively of the rapid development printers require information on the effects of individual technological parameters. Ink transfer in the flexographic printing process happens in three stages: inking of the anilox roll, ink transfer from the anilox roll to the printing plate and from the plate to the substrate. Ink is delivered from the plate to the substrate in the presence of printing pressure. In this study we performed an experimental investigation to explore the effect of printing pressure on the print quality. Test prints were produced at gradually increasing printing pressure on an eight unit flexographic press with central impression cylinder while other parameters of the process were kept constant. We used non porous substrates: BOPP and PET plastic foils, and two types of CMYK ink sets. All test prints obtained at different printing pressure settings fell in the range of visually acceptable quality. Colorimetric and densitometric quantities were measured and calculated for the objective evaluation of the changes. The results of our investigation have shown that changing the flexographic printing pressure in case of nonabsorbing substrates may appear negligible by visual evaluation only, but it has a significant effect on the color quality of the reproduction.

Keywords: *flexography, foil substrates, print quality*

1 INTRODUCTION

Flexographic printing technology underwent rapid development in the past decades. Its fast evolution makes adaptation to this emerging technology demanding for most of the printing houses, as they have to print on porous and non-porous substrates with very different surface properties using a variety of inks. Packaging printing is the primary sector to apply this technology, common substrates are plastic films. The flexible printing form and low viscosity flexographic inks allow the printing of substrates with uneven or patterned surfaces [1]. Non-absorbing plastic foils are common substrates used in the packaging industry. The trend of technological innovation was improvement of print quality for a long time. Development efforts of the past decades resulted achievable quality enabled flexographic printing to become a competitive of offset printing in certain areas of application (in packaging printing 40% of the market uses flexography, while offset technology holds only 35%). Many recent innovations in flexographic technology are related to printing pressure [2].

Printing happens in the presence of printing pressure in traditional (impact) printing technologies; there is physical contact between the printing form and the ink, as well as between the ink and the substrate. Flexographic technology is based on the principles of relief (or letterpress) printing; on the flexible printing form (rubber or photopolymer) printing areas emerge from the plane of the non-printing areas. Inking characteristics are influenced by a number of factors including ink thickness on the printing form, press speed, printing pressure, temperature, printing form and substrate properties. Ink transfer to the substrate is one of the key parameters during the flexographic printing process [3]. The aim of our research was to investigate The operational characteristics of the technology is comprised of a number of process parameters, all of them influence print quality. Our research work focused on the investigation of printing characteristics in the special case of plastic foil substrates. The effects of technological parameters, such as printing pressure, different types of inks, and substrates were investigated on the print color quality with emphasis on the pressure between the plate cylinder and the substrate on the impression cylinder as a key parameter.

2 EXPERIMENTAL

Impression (printing pressure) can be adjusted in precise increments on flexographic printing presses. Its value may accidently change during normal production, for example settings may drift out of adjustment during the course of a run due to internal vibrations of the press. In our experiment we gradually changed the printing pressure in order to investigate and characterize the effects on print quality [4][5]. The test prints were produced with different impression settings on a Soma Flex Midi 105-8 EG type press using DuPont Cyrel thin (1.44 mm) printing plate with 54 l/cm screen ruling, under typical production conditions of the printing house. Two types of inks were chosen, ink viscosity was 21 s (DIN4), and the applied color sequence was YMCK with both inks. Two types of substrates were used, BOPP and PET foils with 0.025 mm and 0.012 mm thickness, respectively. Surface tension values of the substrates were measured on the non-printed area of the substrates: its value fell between 38 and 40 mN/m. Both substrates were printed in 5 runs with both ink sets. After the first run the impression was modified within the range of getting visually acceptable images on the test chart. Impression was first set to the usual setting was a company standard based on visual evaluation of the test prints and professional experience, then pressure was gradually altered by increasing and decreasing the gap between the impression cylinder and plate cylinder in steps of 0.03 mm displacement (-0.06 mm, -0.03 mm, 0 mm, +0.03 mm, +0.06 mm). The increased pressure caused the geometrical deformation of the halftone dots from circular shape to elliptical on the flexible printing form. Some increase of dot area was also expectable.

Our test chart contained uniform samples, step wedges for densitometric and colorimetric measurement as well as visual elements for evaluating the overall appearance of the printed image. Colorimetric and densitometric values were measured on white, non-fluorescent backing using a GretagMacbeth SpectroEye spectrophotometer.

3 RESULTS AND DISCUSSION

Samples obtained at different impression levels showed minor visual differences, mostly in case of test chart elements oriented in machine direction. Tone gradation, dot area as well as dot shape of the flexible printing form were affected the most [6] by impression variations. Optical density values carry no colorimetric information, however they provide the printer with valuable data on ink thickness and coverage. In table 1 the relative density values indicate how density changed with increasing impression in case of the two inks and substrates, the maximum values are emphasised (bold). Changes in optical density values did not follow the increase of printing pressure for any of the process colors.

Table 1. Relative density values of yellow (Y) process colors as a function of printing pressure on PET and BOPP substrates printed with both ink1 and ink 2.

Y	PET		BOPP	
displacement	Ink 1	Ink 2	Ink 1	Ink 2
-0.06 mm	**1.00**	0.98	0.99	0.95
-0.03 mm	0.95	0.93	0.98	0.98
0 mm	0.97	0.94	**1.00**	0.91
+0.03 mm	0.96	0.94	0.96	0.91
+0.06 mm	0.97	**1.00**	**1.00**	**1.00**

Together with the density values it is necessary to obtain and investigate color differences that occur in case of full tones of the process colors as a function of increasing impression. Cyan and yellow process colors were producing variations in the range of small color differences ($\Delta E^{*}_{ab}<5$), while magenta have produced large shifts in case of ink 1 on Bopp substrate. Large color differences were found in case of the K process color which is in accordance with the density changes. Shifts of process color colorimetric characteristics eventually induce color differences of overprinted dots as well.

The changes affecting the process colors and overprinted colors will modify the range of reproducible colors (gamut). Estimation of gamut changes was conducted using a software applicationf for proofing color workflows to visualize and compare the achieveable largest color solids on the substrates investigated. The software tool uses printer profiles as input, these were generated using X-Rite EyeOne Pro measurement device and profiling software. A standard CMYK test chart with 323 patches was printed on the foil substrates by both printing presses. The profiles were loaded to the gamut visualization tool, which calculated printable gamut in CIELAB color space volume units. Relative printable gamut sizes are shown in table 2, the largest gamut is taken as reference for every ink-substrate combination. Table 3 shows relative values calculated for the largest gamut of all for ink-substrate combinations.

Table 2. Relative values (the reference value was the largest of every substrate-ink combinations) of computed printable gamut volumes on Bopp and Pet substrates using two types of inks at different impression (displacement values)

	PET		BOPP	
Displacement	Ink 1.	Ink 2.	Ink 1.	Ink 2.
-0.06mm	0.95	0.90	0.96	0.92
-0.03mm	0.97	0.96	0.96	0.92
0mm	0.98	0.97	**1.0**	0.95
+0.03mm	**1.0**	**1.0**	0.99	0.96
+0.06mm	0.98	**1.0**	0.99	**1.0**

Table 3. Relative values (the reference value was the largest gamut of all cases) of computed printable gamut volumes on Bopp and Pet substrates using two types of inks at different impression (displacement values), ink 1. produces approx. 3% larger gamut

	PET		BOPP	
Displacement	Ink 1.	Ink 2.	Ink 1.	Ink 2.
-0.06mm	0.95	0.88	0.94	0.86
-0.03mm	0.97	0.94	0.94	0.87
0mm	0.98	0.95	0.98	0.90
+0.03mm	**1.0**	0.98	0.97	0.91
+0.06mm	0.98	0.98	0.97	0.94

The CMYK test chart with 323 samples was also used for evaluating color shifts caused by the impression changes inside the reroducible color solid. Figure 1 shows average and maximum color differences for the possible ink-substrate combinations relative to the 0 mm setting. The deviations experienced were larger than typical tolerance values in the graphic industry.

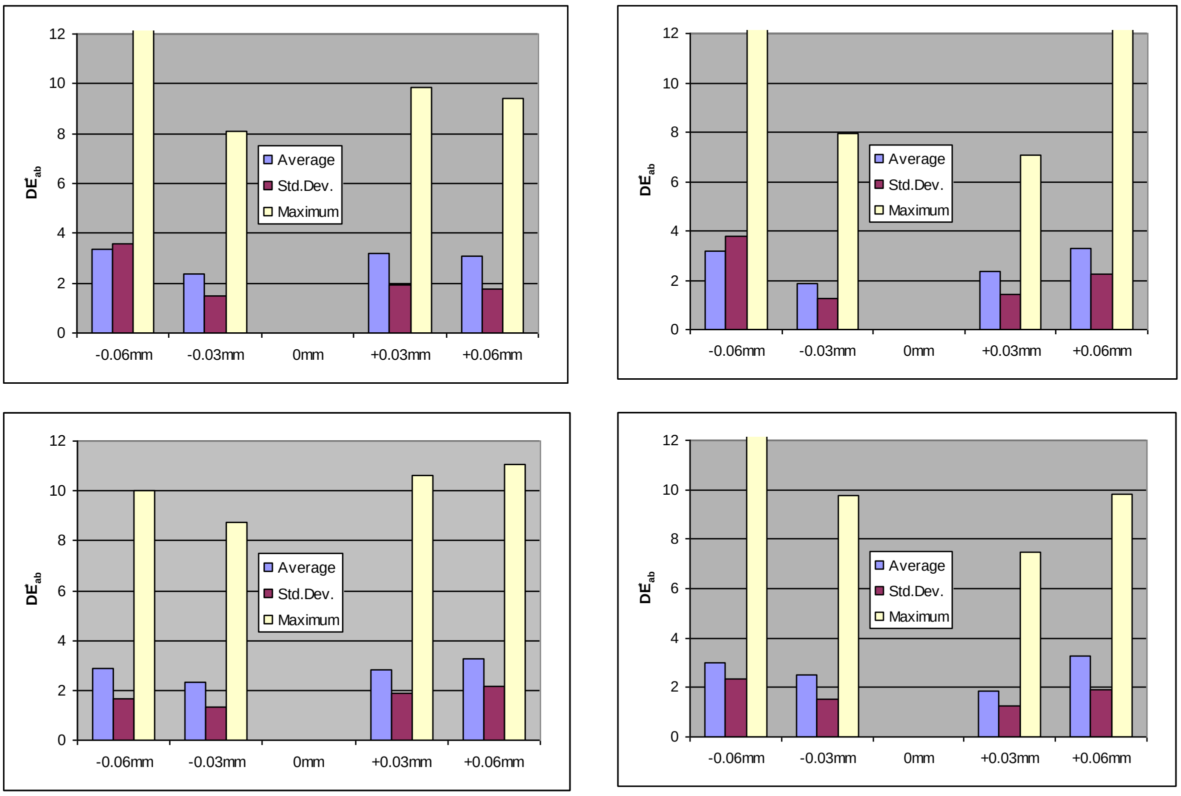

Figure 1. Color differences compared to the "normal" impression settings computed using the measured spectral reflectance curves of the 323 test chart samples under D65 illuminant on PET (upper row) and on BOPP (lower row) substrate (Ink 1: left, Ink 2: right)

4 CONCLUSIONS

Our investigations revealed, that while changing flexographic printing pressure flexographic printing on foil substrates may appear negligible by visual evaluation only, the measured optical properties of prints changed significantly. As visual image quality fell within the acceptable range the measured color shifts exceeded standard tolerance values. We experienced changes in the reproducible color gamut within 10%. While dot deformation increased with printing pressure, density values showed a different behavior.

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