Colorimetric Properties of Flexographic Printed Foils: the Effect of Impression

Ákos Borbély, Rozália Szentgyörgyvölgyi

Óbuda University, Faculty of Environmental and Light Industry Engineering, Institute of Media Technology, *email:* Borbely.Akos@rkk.uni-obuda.hu

***Abstract**: Flexographic printing technology underwent rapid development recently. For a long time the main objective of technological innovation was improvement of print quality. As a result of the development of the past decades achievable quality enabled flexographic printing to become a competitive of offset printing in certain areas of application. Recent innovations in flexographic technology are related to setting printing pressure. Flexographic technology is based on the principles of relief (or letterpress) printing. 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. The aim of our research was to investigate an important operational parameter of the technology and its effects on print quality. Our work focuses on flexographic printing characteristics on plastic foil substrates. We investigated the influence of some technological parameters (printing pressure, different types of inks and substrates) on the print quality with emphasis on the pressure between the plate cylinder and the substrate on the impression cylinder.*

***Kulcsszavak**: flexography, ink transfer, pressure*

1 Introduction

Flexographic printing is a key printing technology, which 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.

Flexography is a type of relief printing process, which uses a flexible printing form. Such 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 and its effects on print quality. Our work focuses on flexographic printing characteristics on plastic foil substrates. We investigated the influence of technological parameters (printing pressure, different types of inks and substrates) on the print color quality with emphasis on the pressure between the plate cylinder and the substrate on the impression cylinder.

2 Research Methods

In case of flexographic printing presses impression can be adjusted in precise increments. Impression may accidently change during normal production, for example settings may sometimes drift out of adjustment during the course of a run due to internal vibrations. Our intention was to gradually change the printing pressure in order to investigate and characterize the effects on print quality [4][5].

We produced a series of prints 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. Two types of inks were chosen, ink viscosity was 21 s (DIN4), the applied color sequence was YMCK. Two types 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 at different values of impression. Surface tension of the PET foil changed from and 40 to 38 mN/m (dynes/cm) while in case of the BOPP foil it increased from 38 to 40 mN/m. Both substrates were printed in 5 runs with both inks. 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 normal (this 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 (-0,06mm, -0,03mm, 0mm, +0,03mm, +0,06mm). Because the printing form is flexible, a reasonable consequence of the increased pressure is the geometrical deformation of the halftone dots the circular shape of the dots become gradually elliptical.

A test chart was constructed displaying 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 tone values were measured by GretagMacbeth SpectroEye spectrophotometer on white, non-fluorescent backing.

3 Results and Discussion

Density values were measured on the test prints first. Although optical density values carry no colorimetric information, they provide the printer with valuable data on ink thickness and coverage. Specimen obtained at different impression levels showed minor visual differences, mostly in case of 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 inherent in densitometric values. In table 1 the relative density values indicate how density change with increasing impression in case of the two inks and substrates, the maximum values are emphasised, optical density does not increase together with printing pressure.

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	
	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 (figure 1). Cyan and yellow colors were producing variations in the range of small color differences, while magenta have produced large shifts in case of ink 1 on Bopp substrate. For the large color differences in case of K the L^* value was responsible dominantly.

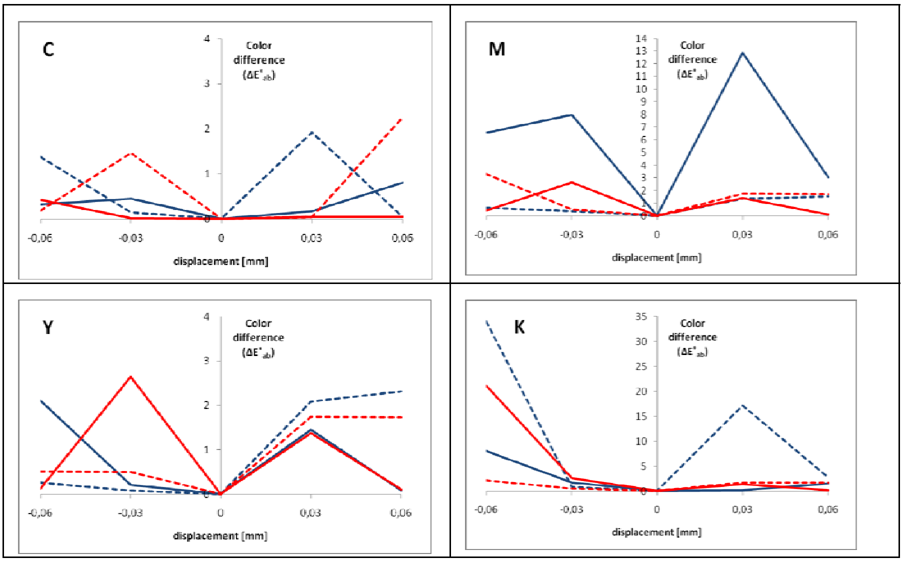
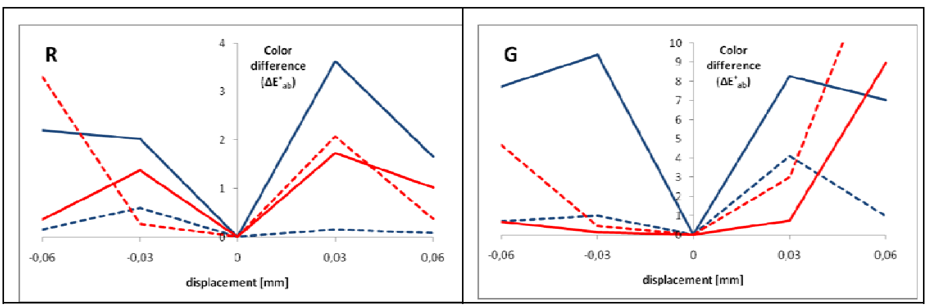


Figure 1

Color differences of solid patches of process colors (C, M, Y, K) at different displacement values. Blue lines correspond to ink 1, red lines represent ink 2, solid lines refer to Bopp and dashed lines refer to Pet substrates

Shifts of process color colorimetric characteristics eventually induce color differences of overprinted dots as well. We investigated secondary colors of printing (R, G, B) together with chromatic grey (CMY). Measurement results of the fulltones of R, G, B and a 37% CMY halftone patch are illustrated in the diagrams of figure 2. While red and blue show color differences not larger than then the chromatic process color, values of green exceeds this range at larger impression. In case of the CMY halftone patch ink 1 with Bopp substrate produces large differences, like in the case of magenta. The gradual changes of the dot structure of this 37% halftone sample due to the varying impression are revealed on the magnified images of figure 3.



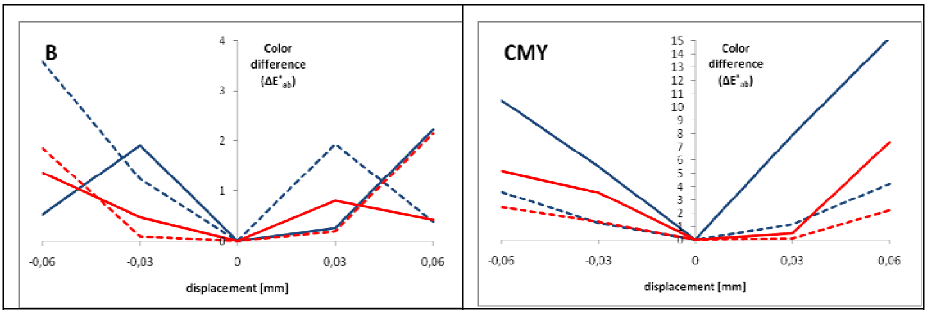


Figure 2

Color differences of solid patches of secondary colors (R, G, B) and a 37% halftone patch of CMY at different displacement values. Blue lines correspond to ink 1, red lines represent ink 2, solid lines refer to Bopp and dashed lines refer to Pet substrates

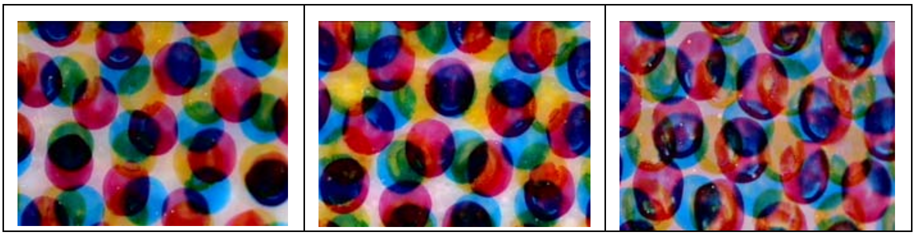


Figure 3

Magnified images of halftone CMY sample 40% dot area on BOPP substrate using normal (left), and increased impressions obtained by 0.06 mm (middle) and 0.12 mm (right) displacement of the impression cylinder.

Table 2

Relative values of computed printable gamut volumes on Bopp and Pet substrates using two types of inks at different impression (displacement values), based on spectral measurements of a CMYK test chart containing 323 halftone patches

	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

Changes in the process colors and overprinted colors will consequently modify the range of reproducible colors (gamut). We used a software tool commonly applied in proofing color workflows to visualize and compare the color gamut achievable on the substrates investigated. First, printer profiles were generated using X-Rite

EyeOne Pro measurement device and profiling software. A standard CMYK test chart with 323 patches was printed on the substrates of this study, by both printing presses to sample the printable color solid. 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 1, the largest gamut is taken as reference for every ink-substrate combination.

Conclusions

We studied the colorimetric characteristics of plastic foils printed with flexographic technology. Printing pressure, a process parameter was changed gradually during our investigations in the range of visual acceptability. We observed significant variations in factors determining the quality of reproduction of color. As visual image quality fell within the acceptable range the measured shits in the optical density and reproducible color gamut in the order of 10%. The magnitude of color differences exceeded the industry standard tolerance levels.

References

[1] *Flexography: Principles And Practices*. Fifth Edition Published by the Foundation of Flexographic Technical Association, Inc. Printed in the United States of America. Copyright ©1999 by the Flexographic Technical Association, Inc. and the Foundation of Flexographic Technical Association, Inc.

[2] Johnson, J:. *The Influence of Moisture, Temperature, Pressure Pulse and Substrate on Print Quality in Flexographic Printing.* Karlstad University Studies, 2003 ISBN 91-85019-29-1

[3] Johnson J, Peter R.: *Dinamic Nip Measurements in a Flexographic CI-Printing Press.* Presented at the Technical Association of Graphic Arts Conference, Montereal, Canada, 6-9 April 2003

[3] Kajondecha P., Hoshino Y: *Halftone Dot Size Variation in Offset, Electrophotographic, and Flexographic Printing and Its Perception*, J Imaging Sci Technol 52(6):060503-7 (2008)

[4] D.C. Bould, S.M. Hamblyn, D.T. Gethin and T.C. Claypole: *The Effect of Impression pressure and anilox specification on solid and halftone density.* http://www.swansea.ac.uk/printing/research/Published%20papers/Journal/index.htm (Accessed: 20.06.2011.)

[5] M. F. J. Bohan, P. Townsend, S. M. Hamblyn, T. C. Claypole and D. T. Gethin: *Evaluation of Pressure in Flexographic Printing.* Published by the Foundation of Flexographic Technical Association, Inc. Printed in the United States of America, 2003

[6] Á. Borbély, R. Szentgyörgyvölgyi: 38th IARIGAI International Research Conference, Budapest-Debrecen, 2011