PRELIMINARY STUDY OF PRINT MOTTLE ANALYSIS IN FLEXOGRAPHY USING GLCM METHOD

Dedijer S., Jurič I., Tomić I., Pál M., Milić N.,
Kašiković N., Vladić G.
University of Novi Sad

Abstract

Flexography is a printing technique frequently used for printing the large solid tone areas on different substrates. The print quality of such an imprint is, among others, dependable on screen ruling of used anilox roll. If it is not chosen properly, it might influence often seen print defect in flexography – print mottle. Print mottle is manifested as an uneven ink lay or undesired unevenness in perceived print density especially visible in large solid tone areas. In this preliminary study, we have used Gray Level Co-concurrence Matrix (GLCM) for the print mottle evaluation on one colour (cyan) flexo printed polymer samples printed in full coverage using anilox rollers of different screen ruling. GLCM was chosen with the idea that a simple, statistical approach used for texture analysis can also be successfully utilized in the mottle analysis. The following parameters were used for print mottle characterization: contrast, homogeneity, correlation, energy and entropy. The analysis was done on samples scanned using different scanning resolutions. The study has implied that GLCM method has a potential to be used for flexo print mottle evaluation where scanning resolution has more influence on contrast, entropy and correlation rather than on homogeneity and energy. Results have also indicated that with the higher ink coverage, the higher print mottle can be expected.

Keywords: *flexography, print mottle, GLCM method, anilox roll*

Introduction

Flexography is a fundamentally direct rotary printing technique which uses flexible printing plate with raised image and low viscosity, rapid drying fluid inks to print on a variety of substrates. This printing technique is suitable for printing on paper as well as on non-porous substrates such as metallised or polymeric films (Zołek-Tryznowska, Izdebska, & Tryznowski, 2015). It is often used for printing the large solid tone areas where the print quality of such an imprint is, among others, highly dependable on the ink properties and used anilox roll (Rentzhog & Fogden, 2006). If it is not chosen properly, it might influence the print non-uniformity which appears most notably as striping and mottling (Holmvall & Uesaka, 2008). Striping is the periodic print density/gloss variations which occur in both full-tone and halftone prints (Holmvall & Uesaka, 2008). Mottling (unwanted reflectance variation patterns) can be defined as undesired unevenness in perceived print density (Fahlcrantz & Johansson, 2006). Mottling in flexography is an important quality parameter, and it needs to be monitored efficiently. Since in flexography variability of the contact force between printing substrate and printing form is quite often, it causes variations in ink transfer and dot gain and thus consequently variations in reflectance (print mottle) (Teleman, Christiansson, Johansson, Fahlcrantz, & Lindberg, 2005).

Over the years, several models for objective print mottle evaluation have been introduced. Also, an ISO Standard for the evaluation of reflectance inhomogeneities in prints was published (Fahlcrantz & Johansson, 2006). One of the methods which can be used for print mottle evaluation is Gray Level Co-concurrence Matrix (GLCM). It is an image based method, originally used in problems related to the texture analysis. GLCM contains information about how many times a combination of two neighbouring pixels occurs in the image which can also be thought of as a probability of the occurrence of such pixel gray level combination. From the GLCM the calculations that can be derived are second order statistical features and most commonly used ones for the further analysis are contrast, homogeneity, correlation, energy and entropy (Gebeješ, Tomić, Huertas, & Stepanić, 2012).

Contrast is the measure of local gray-level variations in an image (Gebeješ, 2013; Math Works, 2013). If the contrast has zero value than the print/image is considered uniform.

Correlation measures the linear dependency of grey levels of neighbouring pixels in a texture image, and high values of correlation correlate to the uniform print surface (Gebeješ, 2013; Math Works, 2013).

Entropy is a feature related to getting a conclusion if the surface can be considered statistically more chaotic (Gebeješ, 2013; Math Works, 2013).

Homogeneity gives information about the amount of change in a print where the value of 1 corresponds to homogeny print surface with no variations (Gebeješ, 2013; Math Works, 2013).

Energy is a measure of local homogeneity, therefore, it represents the opposite of the entropy, where the value 1 stands for a constant, homogeny print surface (Gebeješ, 2013; Math Works, 2013).

In this paper, we have supposed that GLCM method has a potential to be used for flexo print mottle evaluation. We have varied scanning resolution during digitalization of prints printed with different anilox rolls to preliminary establish the influence of anilox roll screen ruling and theoretical volume as well as scanning resolution on print mottle.

Materials and Methods

In the study, we have used 12 anilox rolls, different in theoretical volume and screen ruling (Table 1) for printing cyan ink in full coverage on polymer substrate (polypropylene BOPP foils). All samples were printed on the same flexo printing machine using the same printing conditions (printing speed and printing pressure). After printing, two samples, without visible damages or impurities, for each anilox roll were selected for the further evaluation. The samples were then scanned using CanoScan f5600 scanner and three different scanning resolutions: 300, 600 and 1200 spi. All picture enhancing functions during scanning were set to off mode. Using Adobe Photoshop software, scanned prints were divided into parts sizing 20 x 20 mm, whereas six samples from each of the two scanned prints were randomly selected for further analysis. Samples were saved as .tiff files with native sRGB colour profile and corresponding scanning resolution. The analysis using Gray Level Co-concurrence Matrix was done in MATLAB R2012b image analysis software. For all five analysed parameters, the average value of 12 samples (for each of 12 anilox rolls) were later on used for analysis and discussion.

Table 1. Anilox rolls used in the study

anilox roll	screen ruling L/cm	Theoretical volume cm/m^2
1	470	3.0
2	200	3.2
3	470	3.3
4	460	3.7
5	400	4.0
6	280	4.6
7	200	6.7
8	195	6.8
9	185	7.2
10	180	7.5
11	180	8.5
12	120	9.4

Results and Discussion

From the results presented in Figure 1, it can be seen that the average contrast values are rather low, regardless of used anilox roll and scanning resolution used. The exceptions are samples 9, 11 and partly 12 as well as 7 but for only scanning resolution of 600 dpi. It was expected that the higher theoretical volume of anilox roll would result in higher ink coverage thus more uniform print with lower contrast values. However, on the contrary, prints obtained using anilox rolls 9, 11 and partly 12 (highest theoretical volume) have the highest contrast value. It can also be noticed that with higher scanning resolution contrast value is slightly higher.

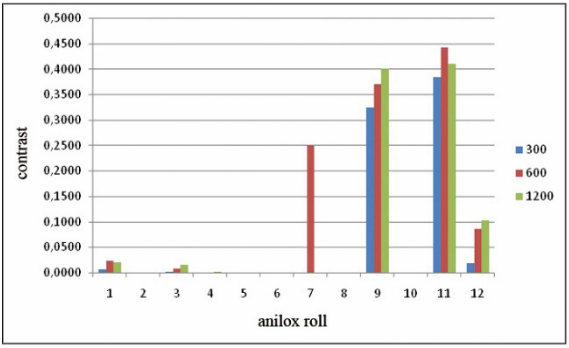

Figure 1. The average contrast values (different scanning resolutions: 300, 600 and 1200 dpi)

The correlation values are presented in Figure 2. From the results given, we can see that the values are rather low, regardless of anilox roll as well as scanning resolution used. Also, it can be stated that values of this parameter are dependent on scanning resolution and generally, the higher the scanning resolution, the higher correlation value can be expected. Also, it can be seen that the higher theoretical volume of anilox roll results in prints of the higher correlation value.

On Figure 3 are presented energy values. It can be seen that scanning resolution has low or no impact on final values. It is also interesting to notice that the prints obtained with anilox rolls with higher theoretical volume (9,11 and 12) have quite lower energy values.

On Figure 4 the one can see the average results of entropy. It is evident that the average entropy values are rather low, regardless of used anilox roll and scanning resolution used. The exceptions are samples 9, 11 and 12. It can also be noticed that with higher scanning resolution entropy value is slightly higher.

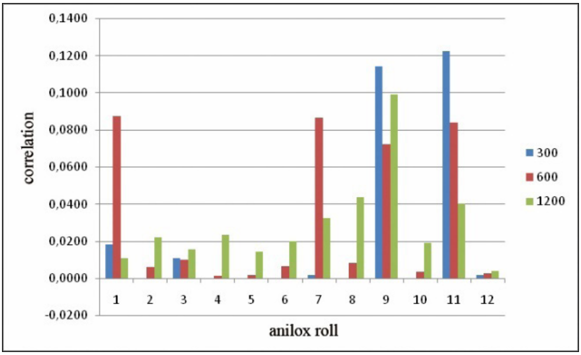

Figure 2. The average correlation values (different scanning resolutions: 300, 600

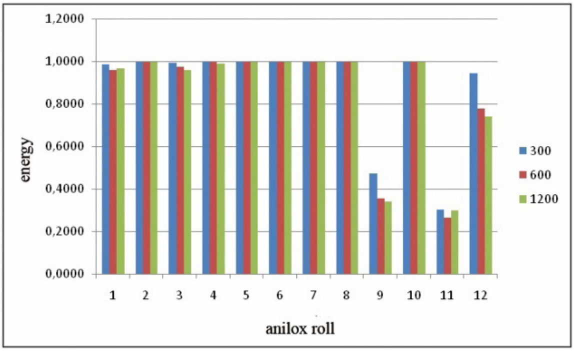

Figure 3. The average energy values (different scanning resolutions: 300, 600 and 1200 dpi)

The homogeneity values are presented in Figure 5. From the results given, it can be seen that the values are rather high and for the majority of samples equal to 1, regardless of anilox roll as well as scanning resolution. Lower homogeneity values are calculated for samples 9, 11 and 12. The scanning resolution has insignificant influence on homogeneity value of samples.

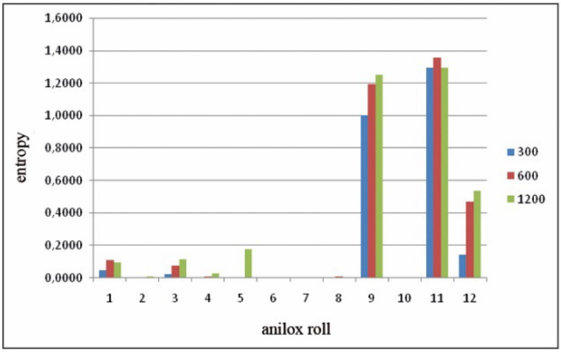

Figure 4. The average entropy values (different scanning resolutions: 300, 600 and 1200 dpi)

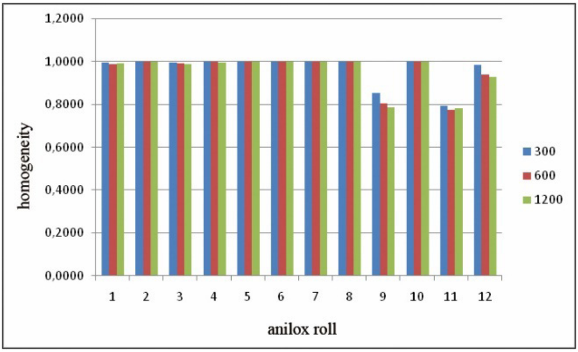

Figure 5. The average homogeneity values (different scanning resolutions: 300, 600 and 1200 dpi)

Conclusion

This preliminary study has shown that the Gray Level Co-concurrence Matrix (GLCM) can be used for the print mottle evaluation on one colour flexo printed polymer samples. The analysis has shown that scanning resolution has more influence on contrast, entropy and correlation rather than on homogeneity and energy values. Results have also indicated that with the higher ink coverage, the higher print mottle can be expected since the samples that were printed with anilox rolls of the higher theoretical volume had lower energy and homogeneity, but higher contrast and entropy values. The one must have in mind that this can also be the consequence of inadequate sampling, result processing error or it can be because the defined theoretical volume of anilox roll, in reality, does not correspond to physical one.

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