International Joint Conference on Environmental and Light Industry Technologies
18-19 November 2010, Budapest, Hungary
Óbuda University

THE CORRELATION OF SURFACE ROUGHNES PARAMETES OF PRINT ENHANCEMENT FOILS AND OPTICAL AND COLOURIMETRIC PROPERTIES OF OFFSET PRINTS

Igor KARLOVIĆ, Ivana TOMIĆ, Sandra DEDIJER, Magdolna APRO, Dragoljub NOVAKOVIĆ
Faculty technical sciences, Department for graphic engineering and design, Novi Sad, Serbia

Abstract:

The process of surface enhancement involves the application of some liquid (varnish, coating) or thin elastic films and foils. With the application of additional layer of material on the printed surface there is a change in the surface topography and change in the direction of the reflected light. The changes in the surface characteristics influence the direction of the reflected light and both the geometrical and colourimetric properties of the measured printed samples. In the experimental part we have used offset prints laminated with 24, 30, 100 i 125 micron thick PE foils (matte and glossy). After the application of the foils we have measured the instrumental gloss values and measured the colorimetric changes of the prints. For the gloss characterization we have used the 60^0 angle specified by the ISO 2813:1994 standard, and for the colourimetric measurement we have used a spectrophotometer with 0/45 measurement geometry with D50 standard illuminant and 2^0 standard observer. The surface roughness characterization was done with a stylus profilometer TR 200 and the appropriate ISO surface roughness factor R_a was calculated. The results have shown that with the application of a thicker gloss foils there is decline in average surface roughness values and increase in specular gloss properties. With the application of matte foils the thickness decreases the gloss value. The colourimetric properties also indicate a correlation between foil thickness and measured values.

Keywords: *lamination, surface roughness, gloss, colour difference*

1. INTRODUCTION

There are numerous graphic arts product applications where finished product expectations can be satisfied by an inexpensive overprint application of coating or varnish which we define as surface enhancement. The process of surface enhancement involves the application of some liquid (varnish, coating) or thin elastic films and foils. Films and other applied materials are used to provide gloss, protection and, in some cases, long-term ink fade protection [1]. With the application of additional layer of material on the printed surface there is a change in the surface topography and change in the direction of the reflected light. The CIE has initiated an approach to quantify the visual appearance of objects by instrumental methodology, and published its finding in the CIE 175:2006 report "A framework for the measurement of visual appearance" [2]. In this document are presented all the known characterization methodologies for the definition of the four basic components which define the optical properties of an object or surface. There is recognition that these measurements are interlinked and thus the colour can influence the gloss, colour will certainly have influence on transparency and translucency, and the texture of the material will have influence the other three basic optical properties [3]. The changes in the surface characteristics influence the direction of the reflected light and both the geometrical and colourimetric properties of the measured printed samples. Beland [4] has in his PhD thesis presented an array of experimental results and theories about the influence of the surface structure on the light reflection and thus pointed out the necessity of defining the surface characteristics when evaluating light measurement. The methods to quantify the surface texture in general can be quantified as contact and non contact, as well as three dimensional (surface) and two dimensional (surface profiles) [5]. The techniques which are used to measure the height of the surface with the point to point system with a measurement probe are very often useful and can be used to calculate a number of statistical parameters as well the functions of average surface heights and distances between these irregularities [6] The reflected light in the graphic arts industry is mostly measured in two ways where we make distinction between the geometrical part of the reflection for example gloss and the colourimetric part which is associated with the colour sensations as hue, saturation and lightness. Gloss as a important optical property can be defined as a light reflected from the surface and is a characteristics of a material [7]. The instrumental gloss measurement is used to check if the surface after lamination or any other surface treatment has achieved the desired specular gloss level or not. For the full characterization of gloss, an visual assessment should be used, but until now there no certain way to quantify this appearance. For this is the instrumental specular gloss used more often in the graphic arts industry. The coating and lamination can be performed on several types of prints depending on the type and methods to apply the foils. In paper by Stančík et al[8] investigated the possibilities of using varnishes and foils on inkjet prints to achieve certain colourimetric properties, while in paper by Karlovic et al [9] colourimetric attributes were tested on offset prints. These measurements are important because we can optimize the production and supply the data necessary for soft proofing and other colour prediction models.

2. METHODS AND MATERIALS

For the experimental part we have used a 130 g/m^2 glossy coated paper which smoothness, whitness and other values confirm with the requirements of the ISO 12647-2:2004 standard. For the surface enhancement we have used four different thicknesses of 24, 30, 100 and 125 microns glossy and matte foils. The application of the 24 and 30 micron BOPP lamination foils we have used the Printlam smart 52 lamination machines with process parameters, while the 100 and 125 micron were OPP laminating pouches were done with GBC Heat Seal H 400 laminator. Both machines were operated using their standard temperature and pressure settings. The print samples were printed before the application of foils using Sun Chemical World Series conventional inks and the printing was done using the inking Lab values of the ISO 12647-2:2004 standard. On the prints we have used an ECI 2002 test chart which was used to determine the Lab values of the CMYK patches as well to construct the colour gamuts of the prints with different foils. The measurement was done using D50 standard illuminant, standard observer 20, and a 0/45 measurement geometry. The gloss characterization was done with a three angle specular gloss measuring device Glossmater, and the measurements were done using the ISO 2813:1994 standard procedures. The surface roughness characterization was done with a stylus profilometer TR 200 and the appropriate ISO surface roughness factor (R_a) was calculated from the measurements. The measuring range of 20 μm with corresponding resolution of 0.01 μm, evaluation or assessment length of 5 sampling lengths and the Gauss filtering method have been used for measuring all samples. We have measured the surface roughness on the full tone colour patches 12 times (6 times in the wide and 6 times in the length direction) and the data presented in the results are the averaged values of these measurements and calculations. After all the calculations we have calculated the correlation factors between measured surface roughness values, gloss and colour difference.

3. RESULTS

The results of the gloss measurements of the lamninated print samples in the 60^0 specular gloss measurement angle is presented in Figure 1. The presented results are the average values measured on the CMYK coloured patches.

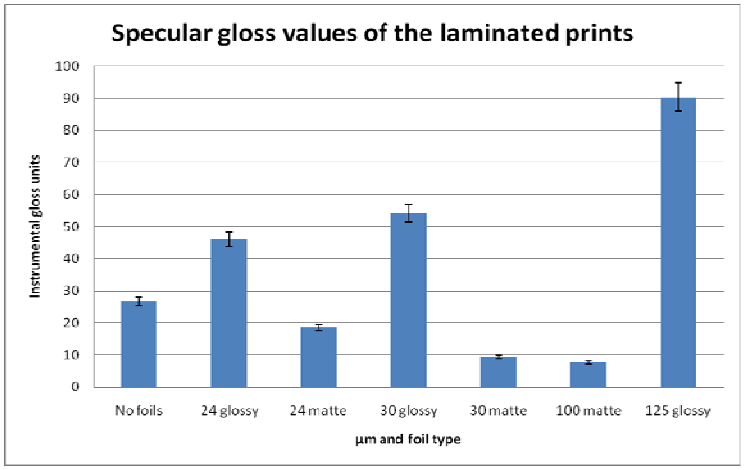
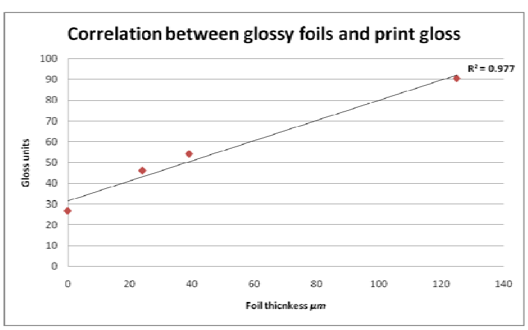


Figure 1. Gloss values of glossy and matte lamination foils with different thicknesses

As we can observe from Figure 1. the average gloss value of the print with conventional ink and no applied foil was 26.7 which was smaller value compared to all the glossy foils and larger compared to the all matte foils. For the glossy foils the largest measured gloss value had the thickest foil of 125 µm with the value of 90.46, the thinner foil of 30 µm had 54.11 and the 24 µm foil had the smallest gloss value of 46.09. The used matte foils showed a decrease in specular gloss with the raise in thickness of the matte foils. The largest gloss value had the 24 µm foils with 18.53, the 30 µm foil had the value of 9.39 and the thickest foil yielded 7.67 gloss units. When we calculated the correlation between the foil thicknesses we have observed that there is a strong linear correlation for the glossy foil thicknesses and measured gloss units. The matte foils yielded smaller determination factor values for the the linear correlation and a better one with the 2nd order polynomial fitting. These correlations are presented in Figure 2a and b.

a) 

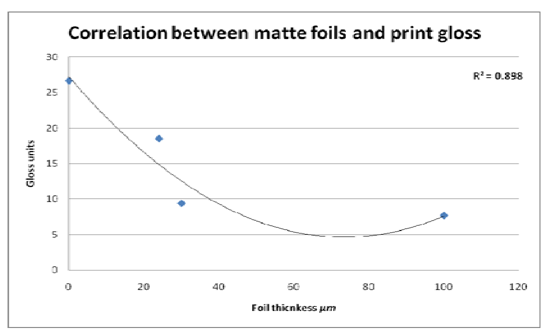
b) 

Figure 2a. Correlation between a) glossy and b) matte foils of different thicknesses and gloss units

After the the gloss measurement we have measured the colour difference values of the prints the results are presented in Table 1. The reference value for the colour difference calculation was the printed but not laminated sample.

Table 1. The colour difference values of laminated prints samples compared to the printed but not laminated samples

Sample	ΔE94	Max ΔE94	ΔE* C	ΔE* M	ΔE* Y	ΔE* K
Glossy 24 µm	3.91	8.81	0.53	1.17	0.90	5.07
Glossy 30 µm	3.96	8.99	0.56	1.15	1.01	5.69
Glossy 125 µm	4.64	9.60	2.06	2.12	2.79	5.74
Matte 24 µm	3.67	9.38	1.55	1.80	0.44	3.52
Matte 30 µm	3.94	11.11	2.05	2.25	0.84	4.88
Matte 100 µm	5.44	16.73	2.74	4.01	2.34	9.70

From Table 1. we can observe that with the increase of both glossy and matte foil thicknesses there is an increase in colour difference, and the largest colour difference for all of the colour patch samples had the black colour patches. To observe the overall colour changes we have made ICC profiles from the foiled prints and have constructed their gamut projections. In Figure 3. we can observe the influence of the glossy foils on the expanding of colour gamut, and in Figure 4. the shrinking of the initial gamut with the applied matte coatings.

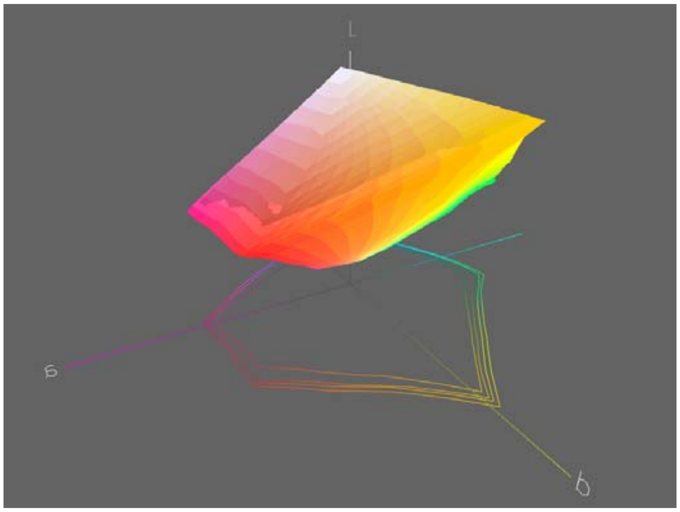


Figure 3. The colour gamuts of glossy foiled prints samples compared to the print with no foil (the smallest gamut is without foil, and the subsequent gamuts are the gamuts with the increased foil thicknesses).

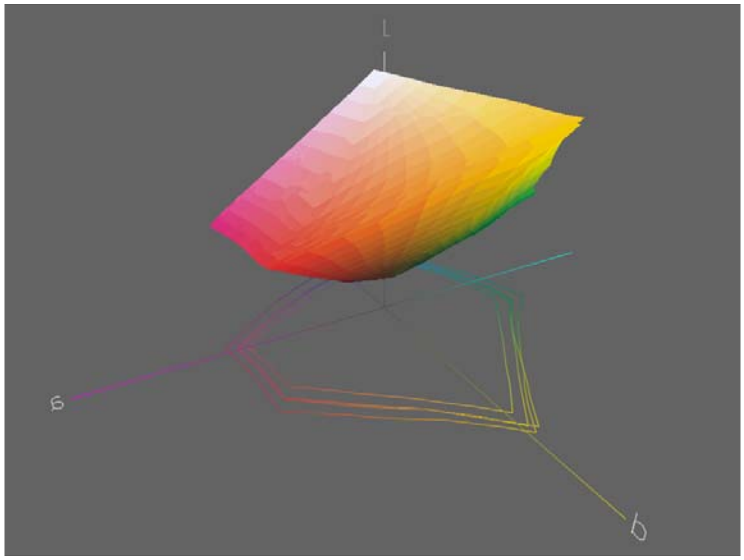


Figure 4. The colour gamuts of matte foiled prints samples compared to the print with no foil (the largest gamut is without foil, and the subsequent gamuts are the gamuts with the increased matte foil thicknesses).

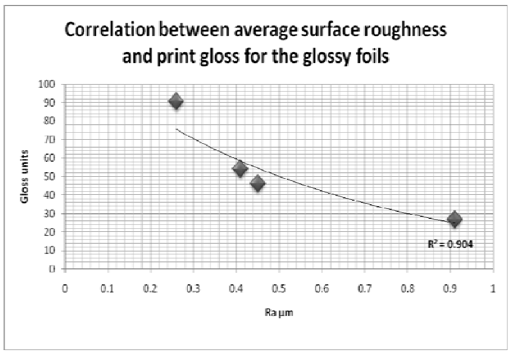
The surface roughness of the foiled printed samples and the reference printed but not enhanced samples were performed using the TR 200 surface roughness tester. The results of the Ra the average surface roughness of the samples are presented in Table 2.

Table 2. The average surface roughness (Ra) values of samples

Sample	Ra µm
No foil	0.91
Glossy 24 µm	0.45
Glossy 30 µm	0.41
Glossy 125 µm	0.26
Matte 24 µm	0.63
Matte 30 µm	0.83
Matte 100 µm	0.94

From Table 2. we can observe that the surface for printed paper without the applied foil is 0.91 µm and the subsequent application of the glossy foil decreases the average surface roughness to 0.26 µm for the thickest glossy foil of 125 µm. The matte foils increase the surface roughness up to the value of 0.94 µm for the thickest matte foil of 100 µm.

To investigate the correlation between gloss and surface roughness parameters we have calculated the appropriate determination factors both for glossy and matte coated samples. They are presented in Figure 5.a and b.

a) 

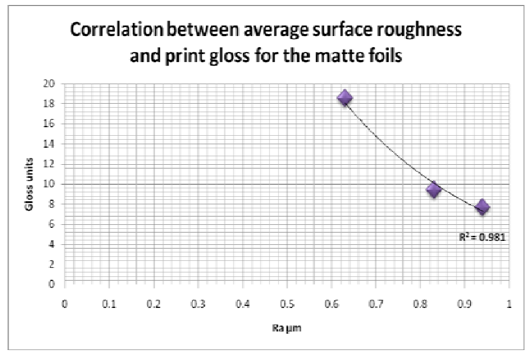
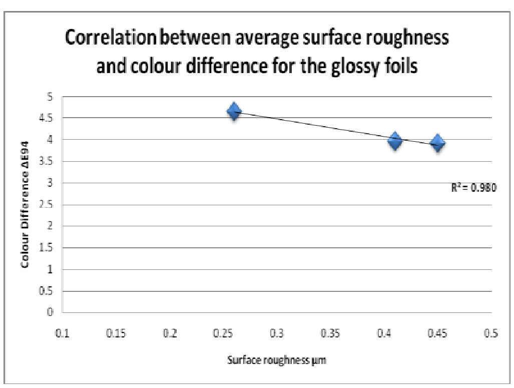
b) 

Figure 5a. Correlation between a) glossy and b) matte foils of surface roughness values and gloss units

As we can see in Figure 5a and b the correlation between the average surface roughness Ra in µm and print gloss units yields the heighest determination factor of R^2=0.904 for the glossy foils using the exponentital fitting and 0.981 also for the exponential fitting for the matte foils (when the paper without foil is excluded). We also calculated these factors for the relationship between average surface roughness and mean colour difference. The results are presented in Figure 6a and b.

a) 

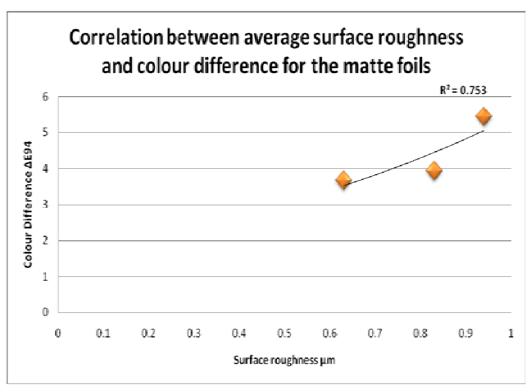
b) 

Figure 6a. Correlation between a) glossy and b) matte foils of surface roughness values and colour difference

As we can observe from Figure 6a and b for the glossy foils and average surface roughness the determiantion factor was R^2=0.98 for the linear fitting and R^2=0.753 for the exponential fitting for the matte foils applied over the same printed samples.

5. DISCUSSION

The application of foils changes the surface of the prints which can be observed from the changes in surface roughness. The increase in the foil thickness in glossy foils decreases the surface roughness and increases the print gloss values and the colour difference values of the measured print samples. These changes are best fitted with a linear trend line. The matte foils as expected also change the initial surface roughness and produce a rougher surface from the glossy coated samples. This change results in smaller gloss and larger colour difference values for the increasing foil thicknesses. The results for the colour gamut indicate an increase of the colour gamut of the samples for the glossy foiled offset prints, where the thickness is an important parameter, while for the matte foils this trend is also indicative but in the opposite way- the thicker the foil the smaller the gamut. The results of these investigations are important as an initial step in gathering enough empirical data for a model which could be used for the computer simulation of the foil thickness influence on the colourimetric and geometric properties of printed samples. Further investigation is needed in different production parameters and foil types in order to gain full knowledge of the surface effects of these kind of enhanced prints.

References:

1. GREISE E. Gloss & Protection Corkind Industries Tech Talk, 04/02 [online], updated 23.09.2010 [cited 25.9.2010]. Available online: < http://www.corkind.coml02yr04ctln.pdf >.
2. CIE 175:2006 A framework for the measurement of visual appearance, International Commision on Illumination, 2006
3. EUGENE C., The Measurement of Total Visual Appearance: A CIE challenge of soft metrology, In 2nd IMEKO TCI & TC7 Joint symposium on Man, Science and Measurement, September 3-5, Annecy, France, 2008 [cited26.9.2010].Available online: < http://www.imeko.org/publications/tc1-tc7-2008/IMEKO-TC1-TC7-2008-006.pdf>.
4.BELAND, M.C. Gloss Variation of Printed Paper: Relationship between topography and light scattering, PhD Thesis, The Royal Institute of Technology, Stockholm, Sweden, 2001
5.ASME B46.1-2002 Surface Texture (Surface roughness, waviness and lay),American National Standard, ASME, New York, 2001
6. VORBURGER T.V., RHEE H.G., RENEGAR T.B., SONG J. F., ZHENG A., Comparison of optical and stylus methods for measurement of surface texture, The International journal of advanced manufacturing technology , 33, 1-2, pp.110-118
7.KIPPHAN, H.,. Chapter 1 : Print Quality. In *Handbook of print media*, Edited by XY.: Springer Verlag, 2001, pp 111.
8.ŠTANCIK J. VESELY M., DZIK P.: Lamination and varnishing as a tool for inkjet prints protection", *In Proceedings 0/IXSeminar in Graphic Arts, Pardubice, Czeh Republic, 2009, pp 60-66*
9.KARLOVIĆ I.,NOVAKOVIĆ D., TOMIĆ I.: Uticaj debljine folija na geometrijske i hromatske osobine ofsetnih otisaka, In Proceedings of XVI International symposium in the field of pulp, paper, packaging and graphics, Zlatibor, Tehnološko metalurški fakultet u Beogradu, June, 2010 pp 141-145

Corresponding address:
Igor KARLOVIĆ
Department for graphic engineering and design
Faculty of technical sciences
University of Novi Sad
Trg Dositeja Obradovica 6
21000, Novi Sad
Serbia
Phone: fax: e-mail: karlovic@uns.ac.rs