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The Effect of Thermal Lamination Processes on Colorimetric Change in Spot Colours

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Abstract:

Understanding the effect of laminating processes on spot colours is of great importance in the offset printing process, especially given the application versatility of spot colours. Laminating process, as a very common process and one of the first in a sequence of finishing processes in graphics production, can affect print's visual impression to varying degrees. Spot colours, as mixtures of different ratios of inks, are subject to a change due to matt or gloss lamination process. The research examined the impact of thermal lamination processes on printed spot colours on different printing substrates. The degree of change on prints caused by laminating films in the thermal process was determined using spectrophotometric and densitometric methods. Particular emphasis is placed on the spot colour because of its specific characteristics. Research results are shown in charts and they are showing clearly the modality and the extent laminating processes effect the colorimetric difference in laminated and non-laminated prints. This scientific research provides objective conclusions that help in predicting the possible variations within the usage of laminating processes.

Keywords:

Laminating Process, Spot Colour, Colour Tolerance

1. Introduction

The inability of inks to adhere to the printing surface above the critical point is the limiting factor in increasing the reproduction gamut. The limiting factor is also dot gain which is one of the most important elements in the printing standardization. For this reason, many ink manufacturers opted for inks with increased pigment concentration. Higher tint density as well as higher gamut reproduction can be achieved with these highly pigmented inks, even with a standard layer of ink during the printing process. These inks are very common in today's printing processes and are used for several reasons. Most often they are called mixed or spot colours and are classified in the colour scales due to their very large number and due to the number of different manufacturers (Zjakić, 2007). Pantone colour system is certainly one of the most widely used colour systems. One of the reasons for the global acceptance of Pantone colour system, especially in the printing industry, is its extremely wide array of spot colours. Laminating process is often the first phase of the finishing process in graphic production. As a process that primarily serves to protect the printed product in the form of applying a matt or gloss film on the sheet surface, it is almost inevitable in most of everyday graphic products: book covers, magazine covers, brochures, catalogues, etc. One of the disadvantages of laminating processes is certainly their effect on change of colour on the printed sheets. Especially interesting is the effect that laminating processes have on the PMS (Pantone Matching System) colours and this effect is the subject of this research.

2. Colours and lamination

Colours from PMS colour system can be partly produced using ratios of the standard process colours. Using a certain percentage of process colours, and with the addition of special PMS system's colours, as well as with the optimal inking, it is possible to print all colours from PMS colour system in a real-printing process (Zjakić, 2007). Coated and uncoated printing substrates require different PMS printing colours. This study considers matt and gloss coated printing substrates because laminating processes are most frequently performed on them. The emphasis is on the dark blue colour from PMS system, which is labelled as PMS 281, with the average wavelength of 482 nm. The compositional ratio of this colour is 88.9% PMS Reflex Blue and 11.1% PMS Black (***, 2014a). This colour, due to its characteristic composition, is especially sensitive to the impact of print aging and also to the laminating processes, and represents one of the most demanding colours in the printing process. Primarily responsible for this fact is dominating component PMS Reflex blue which, in addition to a very low resistance to scratching, requires long, very slow drying process.

Printing inks are made primarily with resins, varnish, linseed oil, soybean oil, or a heavy petroleum distillate as the solvent combined with organic pigments (Bates, 2012). Although most printing inks have pigments in similar shapes, pigments in Reflex blue have jagged, irregular shapes. Reflex Blue gets its rich blue component from the pigments known as Alkali Blue, containing mineral Co (cobalt) (Leach, 1999). Therefore, producers must add surface active agents to the mix to enable wetting of the pigment. As a result, the ink retains a higher level of moisture and therefore printed colours take longer to dry. Colour-shift when over-coating with water-dispersible or UV varnish is primarily due to pH incompatibilities between the alkaline water-dispersible varnishes and certain alkaline ink pigments like Reflex Blue. The subsequent chemical reaction leads to a change in the way the colour pigments reflect light. In combination with laminating processes, deviations of colour values are even greater. Thermal lamination is very common in the printing industry. It is most often the first step in the graphic finishing process. It is important to mention Polypropylene (PP) - molecular formula $(C_3H_6)_n$ - as the base material of laminated thermal films, as well as its variation: biaxial oriented polypropylene (BOPP) (Jiang, 2014). In the final product - laminating film - one side has BOPP film properties, and the other side becomes a thermo-sensitive surface that is used for dry / thermal lamination. The main binder component of a laminating film that allows adhesion to the printed surface is ethylene-vinyl acetate (also known as EVA), molecular formula $C_6H_{10}O_2$ (NIIR, 2006). Figure 1 illustrates a cross-section of a laminated print and all of its components.

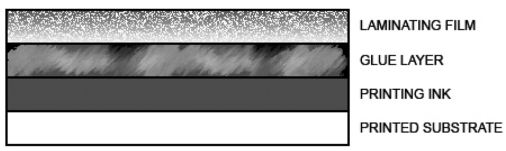

Figure 1. Schematic cross-section of a laminated print

Table 1. Advantages and disadvantages of laminating processes in graphic production

Advantages	Disadvantages
Increased mechanical resistance to external influences	Increased drying time before laminating process
Increased resistance to abrasion	Laminated films are more adhesive to unprinted than to printed surfaces
Higher print resistance to UV radiation	The possibility of static electricity
Resistance to wetting	Difficult application to the small weights printing substrate
Improved visual impression of the print	Dependence on the surface structure and on the direction of the printing substrate fibres
Enabling more rapid other finishing processes	Change in visual and objective colour perception

Besides their visual benefits, gloss or matt laminating films also provide a very effective way of protecting graphic products from scratching and wetting and they increase print longevity (Kipphan, 2001). Given gloss or matt laminating film in a combination with gloss or matt coated printing substrate, it will usually come to some degree of reduction of gamut reproduction. Although laminating film seems transparent, it has certain opacity and will retain a certain percentage of light that would otherwise be reflected by the print if it was not laminated. Also, light path to the print is different due to the laminating film. The consequence of the above is that when comparing non-laminated and laminated prints, changes occur in all parts of the CIE L*a*b* system. Value of raster element increment is increased on laminated substrates, primarily because laminating film acts as a magnifier, so it is really about a significant optical increment of raster element (Barba, 2008). Table 1 presents some advantages and disadvantages when using laminating processes.

3. Materials and methods

Producing prints with the above mentioned spot colour PMS 281 C was the first step in performing this study. The colour was mixed according to PMS recipe and ingredients were from a reputable printing inks manufacturer - Flint. The prints were printed on a newer generation printing press in an offset technique, under standardized conditions according to ISO 12647-2:2013 standard that defines parameters of process colours' separation, proof sheet parameters and parameters of printing process (***, 2014b). In-line densitometric measurement method with an appropriate control measuring strip was used for printing quality control. Laminating process was carried out 24 hours after printing in order to attain sufficient drying process of the circulation. The prints were produced on matt and gloss coated printing substrates characteristics of which are shown in Table 2

Table 2: Technical characteristics of gloss and matt coated printing substrate

Characteristics	Standard	Measure	Matt coated	Gloss coated
Basis weight	ISO 536	g/m2	300	300
Gloss	Hunter	%	55	79
Brightness D65	ISO 2470-2	%	97	96
CIE Whiteness		%	127	127
Opacity	ISO 2471	%	99,8	99,8
Gloss	Lehmann	%	52	77
Smoothness	PPS 10	μm	2,5	0,95

Table 3: Technical characteristics of matt and gloss thermal laminating film

Characteristics	Standard	Measure	Matt thermal	Gloss thermal
Thickness	GB/T6672	μm	26	25
BOPP Thickness	GB/T6672	μm	13	12
Adhesive Thickness	GB/T6672	μm	13	13
Max/min thickness tolerance	GB/T6672	%	±8	±8
Tensile Strength	GB13022	Mpa	MD≥60 TD≥100	MD≥70 TD≥130
Wetting Tension	GB/T14216	mN/m	Adhesive≥50 BOPP≥44	Adhesive≥50 BOPP≥38
Heat Shrinkage	GB/T10003	%	MD≤1,5 TD≤1,0	MD≤1,5 TD≤1,0
Haze	GB2410	%	70±10	<5
Gloss level	ASTM 2457	45°	-	≥125
Transmittance	GB2410	%	-	≥90

Table 3 outline the technical characteristics of matt and gloss laminating films used in the research.

All measurements on observed non-laminated and laminated prints were carried out using X-Rite SpectroEye device. Results the device displays when measuring laminated surfaces are similar to those the device is displaying when measuring UV matt and gloss coatings, as well as other varnishing techniques (Radencic, 2008).

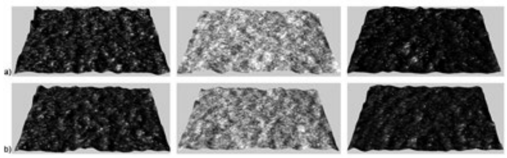

Figure 2. Samples with different lamination methods: from left to right, without lamination, with matt lamination, with gloss lamination a) matt coated printing substrate; b) gloss coated printing substrate

First step was spectrophotometric and densitometric measurement on non-laminated matt and gloss printing substrates. Measured results were compared with C (coated) PMS colour scale and reference colour PMS 281 C. Measurement with spectrophotometric method was performed afterwards on prints with matt and gloss laminated application. The results were correlated in order to define ΔE that laminating film is causing on spot colour prints.

4. Experimental part

A common problem of change of colorimetric values due to the application of thermal laminating films on printed sheets is causing inconsistency in the graphic reproduction process. The problem is particularly noticeable after applying laminating films on prints with spot colours. In this context, research is focused on PMS 281 C colour which has particularly dominant and interesting PMS Reflex blue component in its composition. Measurements were done on the measuring wedge with the fields 100% RTV PMS 281 C. Figure 2 shows the surface of the measured samples observed using 200x magnification.

5. Results and discussion

Figure 3 shows measured CIE L*a*b* values on the observed samples. Measured samples are labelled as: C-coated, G-gloss paper, M-matte paper, GL-gloss lamination, ML-matte lamination.

It is noticeable that samples 5 (CG-ML) and 6 (CM-ML) with matt lamination showed significantly higher L* value. Figure 4 shows the deviation that matt and gloss laminating processes cause on the samples.

Matt laminating processes, especially CM-ML sample, showed the highest deviations with ΔE > 20 in comparison to non-laminated sample of same substrate type. CM-GL sample showed the lowest deviation with ΔE < 2 in comparison to non-laminated sample of same substrate type.

Correlating measured samples with reference sample (R) results with CIE L*a*b* diagram as shown on figure 5.

What can be noticed is deviation of the measured sample R in a* and L* direction, which can be partly explained by the age of PMS reference colour scale (R sample is part of PMS reference colour scale). All variations of the real offset process measured samples from the reference sample PMS 281 C are displayed in Figure 6.

Matt laminating process on matt coated printing substrate (CM-ML) in this situation also shows the highest deviations: ΔE > 20.

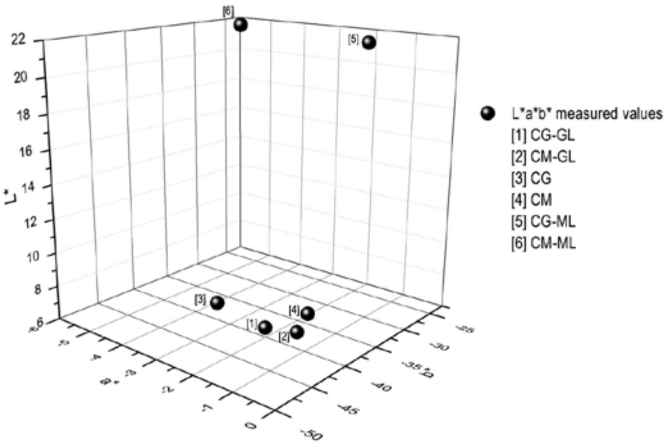

*Figure 3. CIE L*a*b* values of different measured samples*

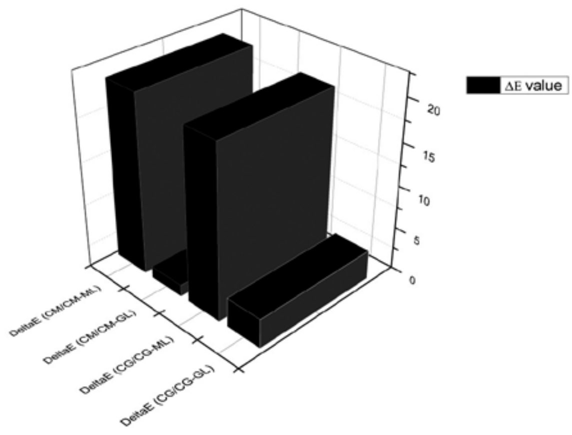

Figure 4. ΔE values in regard to different laminating processes

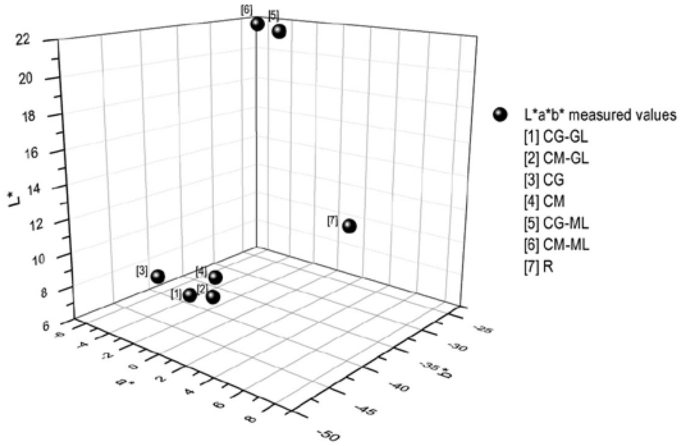

*Figure 5. CIE L*a*b* values of different measured samples from real printing process in correlation with reference sample*

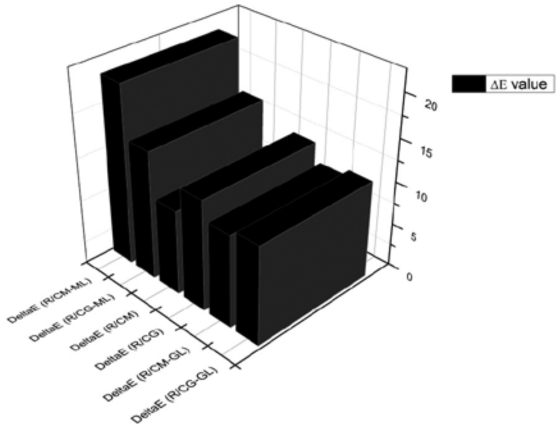

Figure 6. ΔE values of the reference sample in correlation with the samples from the real printing process

6. Conclusions

this research has implied several conclusions. Reflex Blue, an especially dominant component of PMS 281 C ink, is particularly sensitive to thermal laminating processes. Even though thermal laminating processes help the improvement of the visual appearance of the finished printed products, and, among other things, enable greater mechanical stability of graphic material, they also greatly affect the colorimetric changes of the print. This is especially noticeable when using spot colours, like tested PMS 281 C colour. Colorimetric changes that occur due to thermal application of laminating films are certainly the greatest in the L* component. When considering tested identically coated printing substrates with and without laminating process, moderate deviations ($\Delta E<2$) are visible on matt coated printing substrate and matt coated printing substrate with thermal gloss laminating process.

Slightly higher deviations (ΔE≈3) were measured for gloss coated printing substrates and gloss coated printing substrates with gloss laminating process. The greatest deviations (ΔE≥20) showed samples that had matt thermal lamination, especially ones having a combination of matt coating printing substrate and thermal mat laminating process. Considering the presented results, research has proven that when printing spot colours with dominant Reflex blue component, which will be in further graphic production treated with thermal laminating processes, it is necessary to take into account the colorimetric changes that thermal laminating processes will generate on prints. This is an important fact that can certainly affect the improvement of consistency and standardization of reproduction processes, as well as put an end to dilemmas when printing spot colours that are intended for later application of thermal laminating processes.

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