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

FEATURES OF THE UV-VARNISHED PAPER-BASED CARD'S COLOUR MANAGEMENT

Ildikó ENDRÉDY[1], Erzsébet NOVOTNY[2]
[1] Óbuda University
[2] Állami Nyomda Nyrt/State Printing Company

Abstract

Surface refining procedures have an increasing significance in satisfying quality and other special demands made on printing house products. Besides the effects intended to be achieved (gloss, mechanical protection) surface refining technologies occasionally can go together with other changes of the optical appearance of the prints.
Our tests focused on the effect of varnishing on print appearance. The purpose was to determine the extent and direction of colour changes occurring when paper based cards are produced using different print carrier and varnish combinations.
We examined the change of metric chroma as a function of sample brightness, the change of brightness as a function of the saturation of the samples. We realised that the Sericol type varnish on mat paper samples showed the biggest, and Wessco type varnish on glossy paper samples the smallest change.

Keywords

Card printing, UV-varnishing, colour measurement

1 INTRODUCTION

Besides plastic cards the market continues to demand considerable quantities of cards using paper as base material, such as prepaid phone cards, certain ID cards, loyalty cards, club membership cards and cards associated with certain bank cards, containing the PIN-code. These paper based cards represent a value both for the issuer and the card holder. Security elements providing protection against forgery, long-term usage and representation of brand names are important for them. Value in use, durability, and aesthetic value can be increased by surface refining– in the case of cards by varnishing – after printing. [1] For the production of cards the so-called UV varnishing is most suitable, mainly from face protection aspects. UV-varnish layers can equally be glossy or mat, colourless or coloured. They can contain substances that change their colour and character depending on the angle of view.
UV-varnish layers – unlike conventional varnish – can be very thick or can also make the application of extremely thin layers possible. Thick prints can create a 3D impression and be palpable, extending in space. [2]
The purpose of our test was the examination the effect of the selected varnishes on the colour of the prints after application. Colour modification due to varnishing is known to those dealing with the subject. [3] However, it was very important in our case to examine how the logos of card issuing companies change depending on the varnish applied, what is the colour difference that has to be taken into account in certain cases when preparing the CMS colour profile, and – in case of direct (spot) colours – in what direction should the colour of the ink be modified to achieve the desired result.

2 EXPERIMENTAL

For the tests a test chart was produced containing the logo colours of 20 companies (banks, insurance companies, airlines etc.) and colour fields that covered the range that could be reproduced by the CIELAB colour space in four-colour printing as much as possible.

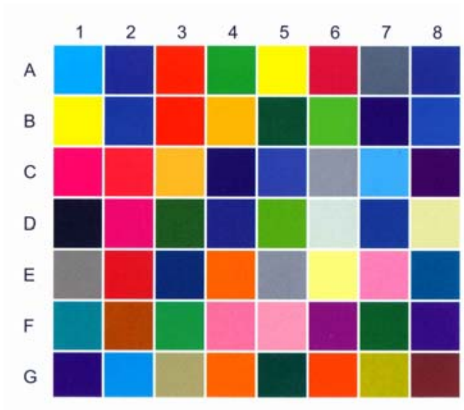

Figure 1: The test chart

Printing was done on 250 gr/m^2 matt, 300 gr/m^2 glossy art printing papers used in card and card-mailer production, on Heidelberg Speedmaster printing machines. Varnishing was done on a screen printing machine (screen 150 l/cm). Two types of varnishes were used for our tests. Wessco UV34.238.15 and Sericol Uvibond UV371.

The effect of surface treatment on the colour of samples was tested by means of colour stimulus measurement. The measurements were carried out using a GretagMacbeth SpectroEye colorimeter/spectrophotometer, with D50 illumination, 45/0° measurement geometry, and 2º observer. The CIELAB colour stimulus coordinates of the test fields were measured on the samples, first on prints without varnish, then with varnish. Based on the results, L^*, a^*, b^*, C^*_{ab}, $h°_{ab}$, ΔE^*_{ab} colour difference and differences in colour stimulus characteristics (ΔL^*, ΔC^*_{ab}, ΔH^*_{ab}) were calculated. [4]

Besides the CIE ΔE^*_{ab} formula, the CIE ΔE_{00} formula was also used because this colour stimulus determination method takes into account local distortions in various parts of the colour space, combining the advantages of the CIE 94 and CMC formulas, and therefore the colour stimulus differences calculated with the formula more closely match visually perceived colour stimulus differences. [5]

3 RESULTS AND DISCUSSION

3.1 Colour difference

We found that both types of varnish change their colours depending on the print carrier. With both types of varnish, there were smaller colour stimulus differences on the glossy cardboard than on the matt print carrier. This is explained by the fact that the colour saturation effect of the varnish coating is already initially less noticeable on glossier surfaces.

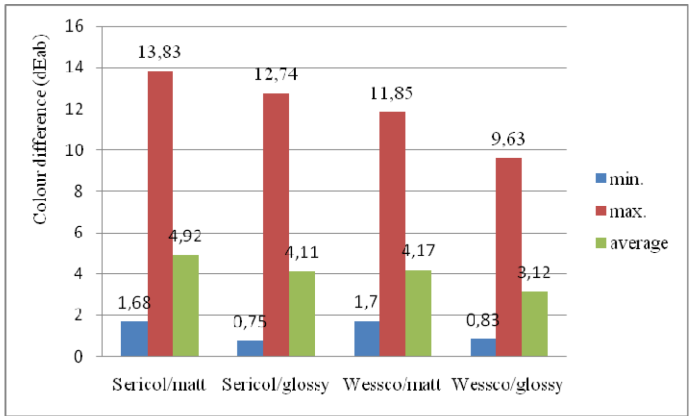

Figure 2: Minimum, maximum and average colour changes of test printsbased on the ΔE^{*}_{ab} formula

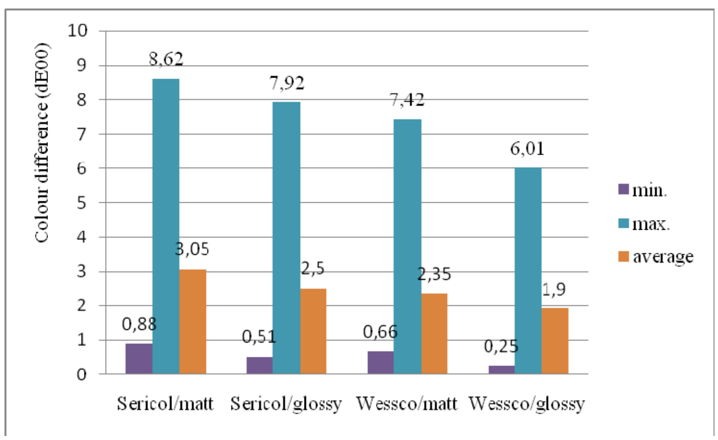

Figure 3: Minimum, maximum and average colour changes of test prints based on the ΔE_{00} formula

The order of samples based on average colour stimulus difference was unchanged with the ΔE_{00} formula, with the SM sample showing the biggest and the WF sample showing the smallest variation. The colour stimulus difference of 75% of the samples falls in the category "visible colour change" in the case of the Wessco varnish. The colour stimulus differences represented by the Sericol varnish are substantially larger. Examining the fields showing a large colour stimulus difference, we found that they appeared with the same colours, virtually irrespective of print carrier or varnish.

Table 1: Colour differences of basic colours and secondary colours

	SM		SG		WM		WG	
Field	ΔE^{*}_{ab}	ΔE_{00}	ΔE^{*}_{ab}	ΔE_{00}	ΔE^{*}_{ab}	ΔE_{00}	ΔE^{*}_{ab}	ΔE_{00}
C	5,9	1,16	1,37	1,2	2,03	1,2	0,97	0,7
Y	4,5	1,63	3,24	0,73	5,74	1,15	2,39	0,49
M	4,23	3,08	4,19	1,6	4,14	1,39	3,14	1,16
K	2,07	1,59	1,75	1,46	4,5	3,21	1,03	0,93
K50%	13,83	4,43	8,96	7,92	8,13	7,02	6,87	6,01

Y50%	11,7	6,05	12,74	3,84	11,85	3,88	9,63	2,93
M50%	9,88	8,62	10,53	5,74	10,16	5,23	8,86	4,66
G	3,58	1,17	0,75	0,62	2,49	0,66	1,03	0,25
R	2,21	0,88	2,23	0,73	3,38	1,15	1,85	0,57
B	2,58	1,89	1,75	1,28	3,25	1,73	1,67	1,22

SM: Sericol/matt, SG: Sericol/glossy, WM: Wessco/matt, WG: Wessco/glossy

Looking at the results indicated in the table, it is apparent that, with the exception of cyan, basic colours significantly changed, and that their 50% fields showed more than double colour stimulus difference. At the same time, colour stimulus differences determined using the ΔE_{00} formula only reflect a significant change at the 50% tonal value, which corresponds to visual experience.

3.2 Colour shifting in the a^*-b^*system

The unvarnished and varnished values of all samples are represented in the a^*-b^* coordinate system, where the direction of shifting due to the application of varnish is well noticable.

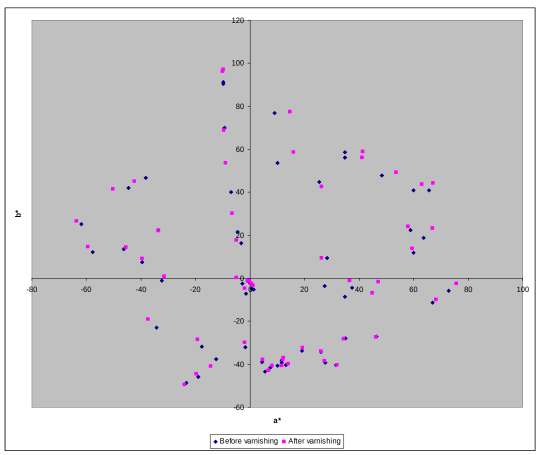

*Figure 4: Colour shifting of samples in the a*b* coordinate system after varnishing*

Minor shifts do not reach a level that would be noticeable in print runs, so it is recommended to neglect such shifts during the study of the colour changing effect of varnish. Accepted levels of colour fluctuation for print runs are between ΔE^*_{ab} 2-2.5. In our study, eight samples showed a value around this figure of maximum 3. We disregarded those samples in further evaluations.

3.3 Metric chroma difference

Metric chroma variation was examined in relation to the brightness of samples. The figure shows the points of the selected SM system, the corresponding regression line, as well as the regression lines determined based on the measured values of SF, WM and WF. We observed that saturation changes of varnish are also influenced by the surface characteristics of the print carrier. Differences on matt print carriers are larger than those on glossy ones, and the two types of varnish also show a difference.

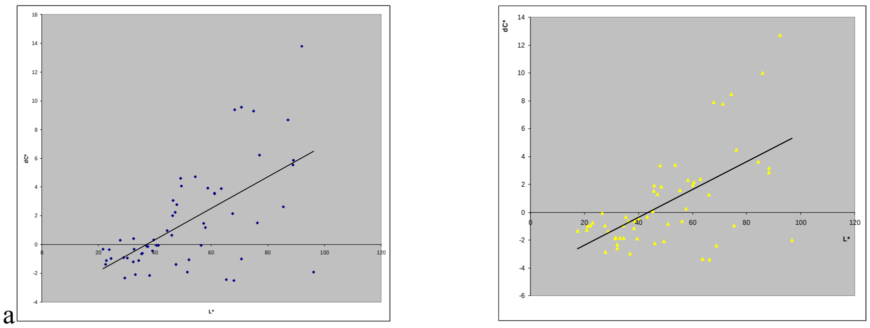

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Figure 5: Metric chroma changes in relation to brightness in case of Sericol varnish on matt (on the left) and glossy (on tht right) substrates

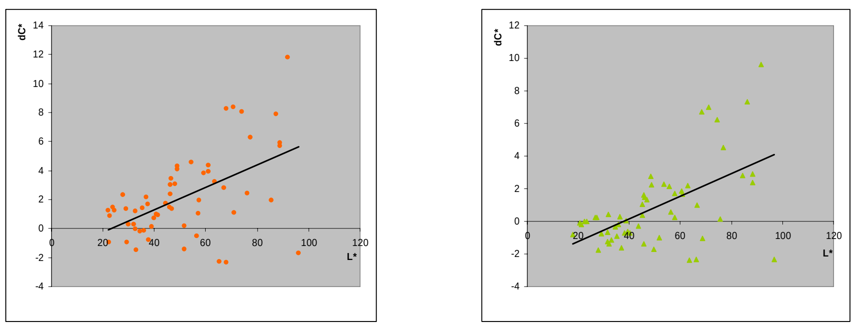

Figure 6: Metric chroma changes in relation to brightness in case of Sericol varnish on matt (on the left) and glossy (on tht right) substrates

Furthermore, we found that changes in the saturation of colour fields after applying the varnish are smaller for fields that are initially characterized by lower colour saturation.
From among the examined samples, this occurred with samples printed on matt coated cardboard varnished with the Wessco varnish. Even though the variation of points is relatively large, there is an obvious link between changes in brightness and colour saturation.

3.4 Brightness difference

Our continued research into the SM system revealed that all samples except for two darkened due to the application of varnish. By representing brightness differences between varnished and unvarnished colour fields in relation to colour saturation, and using regression lines, it is possible to determine the saturation level above which colours become lighter due to the application of varnish. This is caused by the difference between the refraction coefficients of varnish and ink. According to professional literature, if the refraction coefficient of the varnish is higher than that of the ink underneath, the colour will get darker, while in the opposite case, it will get lighter.

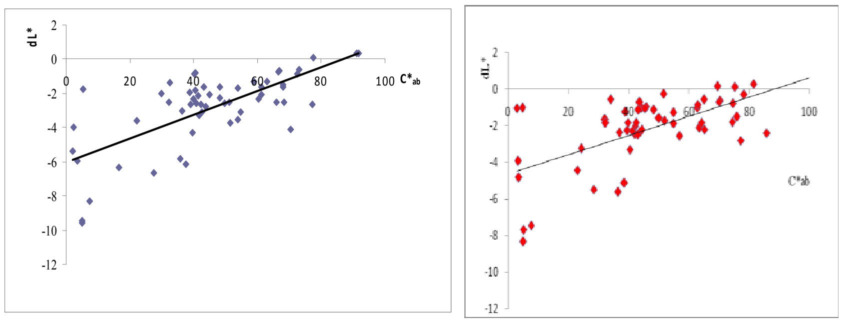

Figure 7: Brightness differences of the Sericol/matt, Sericol/glossy samples in relation to colour saturation

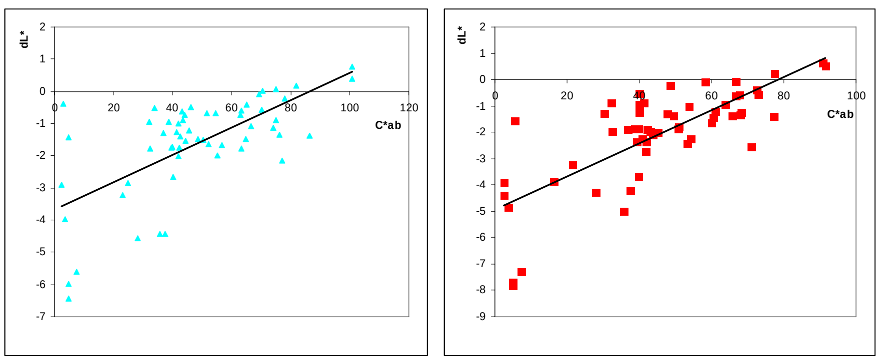

Figure 8: Brightness differences of the Wessco/matt, Wessco/glossy samples in relation to colour saturation

Based on our measurement results, it is apparent that, on the one hand, the lighter the sample, the more saturated it becomes, on the other hand, the more saturated the colour, the higher degree of darkening is caused by the varnish.

4. CONCLUSIONS

4.1 Brand colours

It was determined that – irrespective of the varnish selected – in case of brand colours it is better to print on print carriers with a glossy surface, in order to obtain proper colour reproduction. These systems show an even smaller colour difference with Wessco and Sericol varnishes than in case of matt print carriers.

Table 3: Brand colours with 3< ΔE_{00} colour difference

Colour	Field	Company	ΔE_{00}
P660C	C5	UPC	3,01
P308C	E8	UPC	3,13
P104C	G7	CIB	3,22

P321C	F1	UPC	3,47
P160C	F2	UNIQA	3,78
P130C	B4	Burger King	3,83
P165C	E4	ING	3,99
P298C	C7	Pannon	4,02
P158C	G4	UPC	4,02
P1235C	C3	Lufthansa	4,16
P616C	D8	Volksbank	4,59
P441C	D6	Malév	5,48
P451C	D8	CIB Corporate	5,63
P211C	D6	Szerencsejáték	6,25
P1905C	F5	Szerencsejáték	6,54
P Cool Gray 7C	C6	Lufthansa	8,25
P431C	A7	LG	8,35

The P431C grey (ΔE_{00} 8,35) in the LG logo produced the biggest change, almost as big as the Cool grey of Lufthansa (ΔE_{00} 8,25). The P1905C pink of Szerencsejáték Zrt. showed a smaller but quite big difference with ΔE_{00}=6,54. Out of 20 brand colours 17 colours have more than ΔE_{00}=3 units falling into the "fully visible" or "big" categories.
The average colour difference belongs also to the "fully visible" category. Several of the tested sample pairs resulted in colour differences bigger than ΔE_{00}=6 units which corresponds to a "big" colour difference. The majority of these were detected at the changes of secondary colours too.

4.2 Basic (prime) and secondary colours

There are only insignificant changes regarding brightness and saturation at the basic colours. The main component of colour difference is the hue change, which is bigger at the yellow and magenta colours, but is determinant at cyan also. On average, it can be stated for the colour modification effect of varnishing that the average colour difference belongs also to the „fully visible” category.
The purpose of the examination of the secondary colours was to find out if any conclusion can be drawn for the given secondary colour which arises out of the common features of the two primary colours producing the secondary colour.
The biggest average colour difference was measured for the green colour, and the smallest for the red, but all three colour differences fall into the "fully visible" range. It can be stated that the order of average colour differences was the same as with basic (prime) colours.
The change of brightness values does not reach the upper limit of the "hardly noticeable" range. However, the deviation from the results obtained for basic (prime) colours is that the saturation of all three colours increased, and the change of the red and green colours reached the visually "noticeable" range. Changes of hue (a determinant factor here also) was for green, blue and red – in order of priority from the biggest to smallest – but the average values are smaller than that of the basic (prime) colours.
It can be stated that the average colour difference of secondary colours falls into the "fully visible" category, on average the colours became more unsaturated, and saturation is noticeably higher, than in case of basic (prime) colours.

4.3 Proposals

Summarising our test-results the followings were determined regarding varnishing:

- colour changes that occur during varnishing belong to the "fully visible" category from the point of visual judgement,
- as an effect of varnishing it is mainly the tone that changes,
- bigger colour change occurs when applying matt paper at the varnishing than with glossy one at the varnishing,

Based on it we propose:

- to take back from the yellow colour when preparing the printing plates,
- to take into account the considerable darkening effect of varnish on unsaturated bright colours,
- for brand colours printed with direct colours corrections have to be made in the contrary direction than is the direction of the colour change when making special brand colour inks
- to prepare a collection of varnished and unvarnished standard pairs for the printing workshop in case of brand colours.
- to follow the examination to direction of other printing substrates and types of varnish.

Acknowledgements

Special thanks to Dr. Péter Schulz Mr Péter Rauscher for measurements and taking part in our work.

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Corresponding author:
Erzsébet NOVOTNY PhD
Állami Nyomda Nyrt/State Printing Company
Halom utca 5.
H-1102 Budapest, Hungary
Phone: +36 1 4311 351
Fax: +36 1 4311 350
E-mail: novotny@any.hu
www.allaminyomda.hu