2nd International Joint Conference on Environmental and Light Industry Technologies,
21 – 22 November 2011, Budapest, Hungary
Óbuda University

PRINTABILITY OF PLASTIC FOILS PRINTED BY OFFSET PRINTING

Rozália SZENTGYÖRGYVÖLGYI
Óbuda University, Rejtő Sándor Faculty of Light Industry and Environmental Engineering
Doberdó u. 6, Budapest, Hungary

Abstract:

Synthetic substrates such as plastic film and other nonabsorbent printing substrates are becoming more and more frequent in the printing sector, and particularly in offset printing. The challenge to find a suitable offset ink system for these applications include: good printability, improved running characteristics on increasingly faster presses, secure adhesion and scratch resistance on non-absorbent substrates. Special oil-based inks have been developed for synthetic substrates to accommodate special technical requirements concerning the quality of the printed product. However, a good compromise between fast drying, safe piling, adhesion and abrasion resistance remains a difficult thing to achieve with oil-based inks. In our research work we investigated print quality printed by offset technology. Test charts were printed on PVC and PP foil substrates with oil-based inks in Heidelberg CD/74 sheetfed offset press. The printability of a plastic film is essentially dependent on its surface tension. To enable the ink to adhere, the surface tension of the film must be higher than that of the ink. We investigated the surface properties of the foils and evaluated the abrasion resistance of the prints. We performed optical measurements to determine density values, tone values (TVI, %), colour differences to investigate the factors influencing reproduction quality.

Keywords: *PVC and PP substrates, offset printing, abrasion resistance, TVI, colour differences*

1 INTRODUCTION

Synthetic substrates such as plastic film and other nonabsorbent printing substrates are becoming more and more frequent in the printing sector, and particularly in offset printing. The challenge to find a suitable offset ink system for these applications include: good printability, improved running characteristics on increasingly faster presses, secure adhesion and scratch resistance on non-absorbent substrates. In contrast to most paper and carton substrates, the surface structure of typical plastic film does not allow the ink to set. Drying and adhesion support by filtration into the substrate is not possible [1]. Printing with oil-based inks or using UV technology?
Here the advantages of UV curing technology should be used, including

- immediate hardening of the ink layer,
- low influence of the amount of fount solution, and
- fast readiness for further processing.

Due to their absence of shrinking, oil-based systems continue to be used for special applications. Special oil-based inks have been developed for synthetic substrates to accommodate special technical requirements concerning the quality of the printed product. However, a good compromise between fast drying, safe piling, adhesion and abrasion resistance remains a difficult thing to achieve with oil-based inks. Additionally, the presence of fount solution in oil-based ink offset generally impairs the drying process. Therefore, a good ink-water balance is a key factor in influencing the drying process [2] [3].
Polyvinyl chloride (PVC) is the most widely used chlororganic plastic. According to Federal Environment Office figures, approx. 1.5 million tonnes of PVC were being produced and processed in Germany at the end of the 1990s. Some 10 to 20% of the PVC is used for packaging, and a further 20 to 30% for a diversity of articles for daily use. Polypropylene (PP) is the overall designation for a series of weldable thermoplastic polymers which stand out by way of their great hardness, rigidity and

heat resistance. PP is processed, for example, in sheets, buckets and bottles, and its pollutant-free incineration permits ecologically compatible disposal. According to Wikipedia, 30 million tonnes of PP were produced worldwide in 2001.
Our research work focuses on the examination of the quality of test prints made on PP (polypropylene) and PVC (polyvinyl chloride) substrates with the use of the oil-based offset printing technology.

2 EXPERIMENTAL

In our studies, two different types of plastic foils were used. Non-glossy, self-adhesive PVC (Foil #1) and glossy PP films (were subjected to various examinations (Table 1).

Table 1: Printing substrates

Property	**Foil #1**	**Foil #2**
type	PVC (Avery 420)	PP (Evacast N16)
surface	matte	glossy

In the first phase of the studies, the physical properties of the foils have been examined. Surface smoothness was examined with the use of a Beck smoothness tester. To check the surface stress, Manage Test Pens were applied (32–40 mN/m). Both base materials featured surface stresses suitable for printing (36 mN/m). Both substrates surface were rather rought. But the PVC substrate (#1) has less smooth surface. Substrate properties are listed in the Table 2.

Table 2: Substrate properties

Property	**PVC**	**PP**
caliper, mm	0.190	0.205
g/m^2	300	300
smoothness, s	2.0	10.5

Test printing was performed under special operating conditions.

Press: Heidelberg CD-74-5-L sheetfed offset press, without UV-dryer
t=21-23 ºC,   RH 40–45%

As the printing machine was not equipped with an UV curing unit, the ink was added with a drying agent (5%).
The square meter unit weight of the substrates was 300 g/sq m, their surfaces were rather rough, and therefore printing required larger pressure. In the course of printing, special care needed to be taken for the proper adjustment of the ink–water balance, as this technology demanded 5–10% less dampening liquid, and for this reason it was very important to check the print frequently in order to prevent prints from becoming prematurely dry [4] [2].

To improve the process, powder spraying was operated at the maximum rate with the application of powder of rough particles.
Due to the lengthy drying time, the prints were allowed to stand for 72 hours, and then they could be delivered to the binding for further processing.

The test image was designed with the use of the Adobe Indesign CS2 program. The test image contained the measuring fields, as well as the test stripes to be used for the purpose of our measurements (Figure 1).

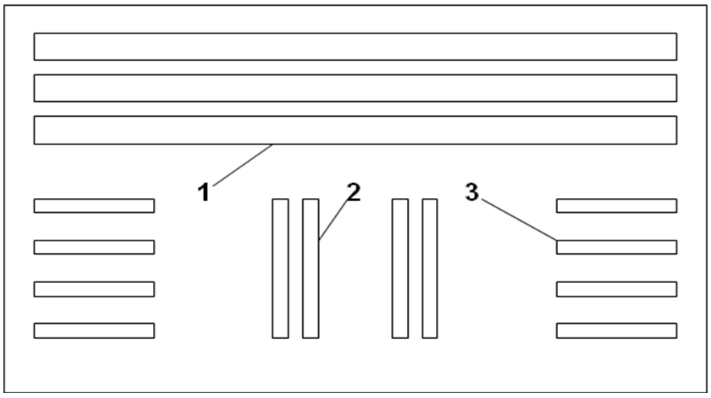

Figure 1: Test image

1 – color control patches of CMYK and RG, 2 – 10 step CMYK wedges, 3 – full tones of CMYK for evaluation of abrasion resistance

To perform color measurements on the test prints, an X-Rite SpectroEye spectrophotometer was used, (The conditions of measurements were as follows: (380-780 nm spectral range, 0°:45°a measurement geometry, 4.5 mm aperture diameter, D65 filter). Density, tone value increase (TVI), and colour differences were measured [5] [6].

3 RESULTS AND DISCUSSION

3.1 Tone value increase of CMYC prints

After the completion of the printing process, the density of the colours was measured with an X-rite SpectroEye spectrophotometer in the test prints. The measurements were carried out for each colour separately on the solid tone fields of the tonal scale. The average density values of the 10 samples for both materials are shown in the Table 3.

Table 3: Average optical density values of the 10 samples on substrates PVC and PP

Substrate	**Optical density, D**			
	C	**M**	**Y**	**K**
PVC	1.09	1.14	1.12	1.31
PP	0.87	1.26	1.35	1.47

We measured tone values of the 50% process colour tone patches of the test chart on the 10 prints in case of both (PVC and PP) substrates (Figure 2-3). Average tone values (TV_a) and variation (s^*) of TVs on the 10 sheets are shown in the Table 4.

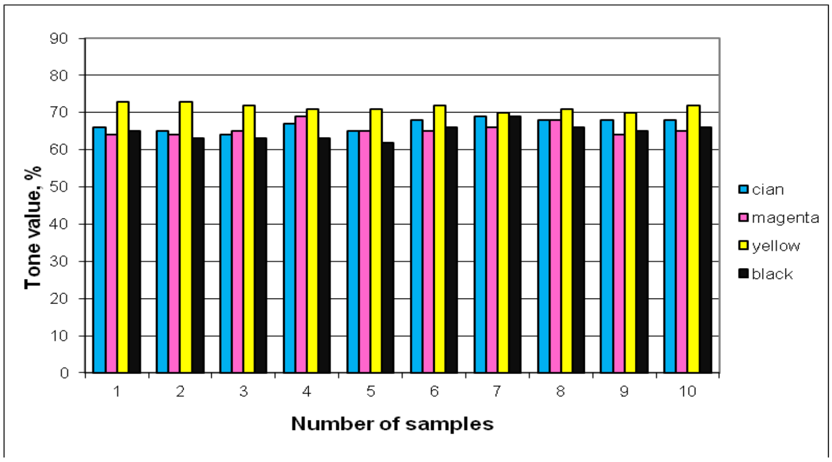

Figure 2: Tone values of the 50% process colour tone patches on PVC prints

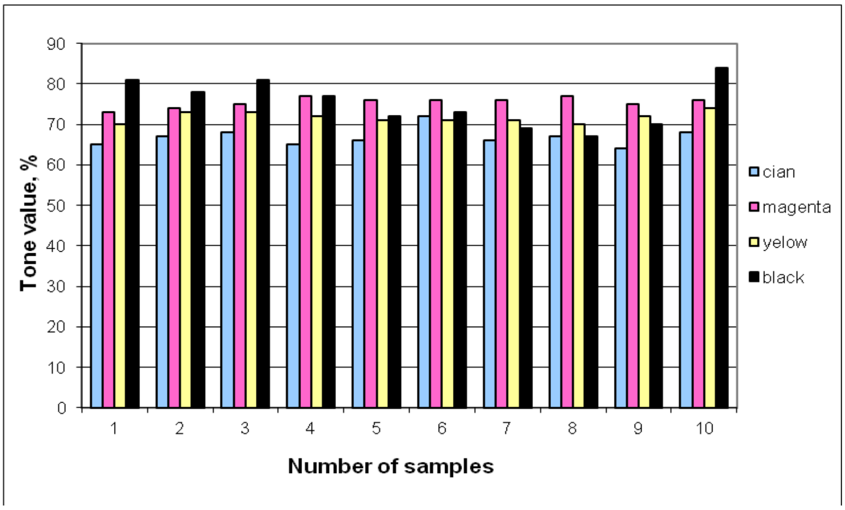

Figure 3: Tone values of the 50% process colour tone patches on PP prints

Table 4: Average TV_a and variation (s^*) of TVs on the 10 PVC and PP prints sheets

Colour	**PVC**		**PP**	
	TV_a	**s^***	**TV_a**	**s^***
Cian	66.8	1.6865	66.8	2.2509
Magenta	65.5	1.7159	75.5	1.2692
Yellow	71.5	1.0801	71.7	1.3374
Black	64.8	2.0976	75.2	5.8080

We found that tone value increases of magenta and black colours were higher in the case of PP substrates but the yellow colour was in the case of PVC substrates. Variation of tone values of the 10 samples was higher on the smoother PP substrates.

3.2 Colour differences

In the printing run, an important quality criterion is the colour evenness of the individual prints. Within certain limits, even the last copy of the printing series should show the same colours as the signed copy regarded to be the standard reference [6]. The measurements were performed on color control patches of CMYK, with the use of the GretagMachbet X-rite SpectroEye spectrophotometer. The L*a*b* colour coordinates were measured on the prints. and ΔE^*_{ab} colour differences in relation to the etalon print were calculated. For each colour, the ΔE^*_{ab} colour difference in relation to the standard reference (sample no. 1 in this case) was examined. The examinations were performed on 10 test prints for both material, and for each colour the ΔE^*_{ab} colour difference in relation to etalon was calculated. From the ten copies, the first one was regarded to be the standard reference to which the colours of the other samples were compared (Figure 4-5).

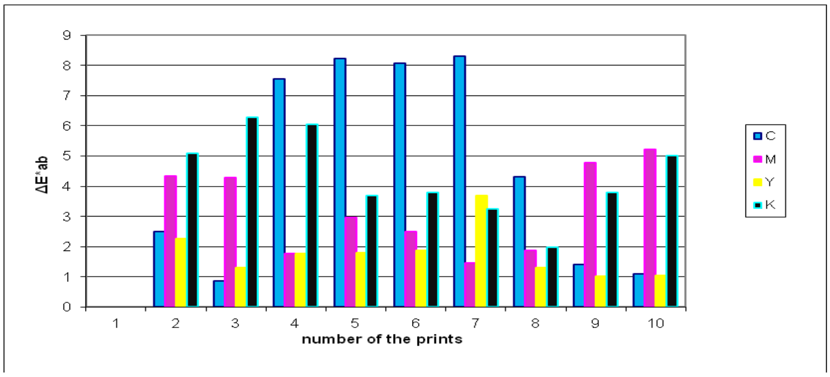

Figure 4: ΔE^*_{ab} colour differences on 10 PVC samples

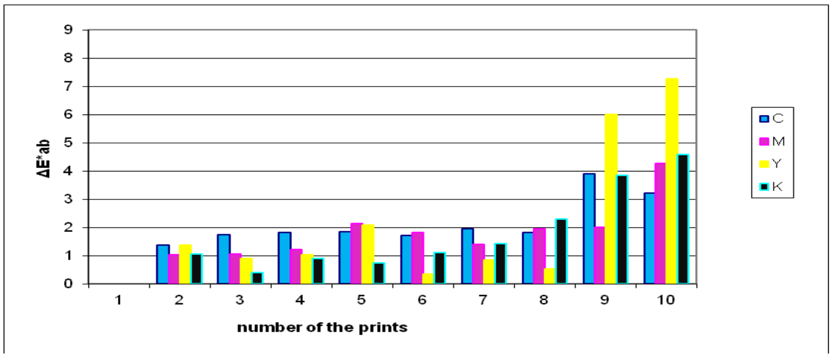

Figure 5: ΔE^*_{ab} colour differences on 10 PP samples

For the evaluation we calculated the variation (s^*) of the ΔE^*_{ab} of 10 prints printed on PVC and PP substrates (Figure 5).

Figure 5: Average ΔE^*_{ab} values and the variation of the ΔE^*_{ab} on 10 PVC and PP prints

Colour	PVC		PP	
	ΔE^*_{ab}	s^*	ΔE^*_{ab}	s^*
Cian	4.7	3.3280	2.1	0.8225
Magenta	3.2	1.4336	1.9	0.9946
Yellow	1.8	0.8203	2.3	2.5413
Black	4.3	1.3854	1.8	1.4635

We measured higher ΔE^*_{ab} values on PVC substrates. And we found that the variation of ΔE^*_{ab} values of the 10 samples was higher on these PVC substrates.

3.3 Abrasion resistance

Abrasion resistance of the prints was studied with the use of a Prüfbau Quartant abrasion tester. One of the two plastic substrates was selected, and in addition a glossy art paper was also tested. We measured the 100% solid tone stripes on the prints. During the examination of abrasion resistance, the PVC print was examined after 50 abrasion strokes, the polypropylene print after 100 abrasion strokes. We used a circle round sheet of white paper as scouring material. Plastic materials showed a large extent of abrasive wear even after this small number of strokes. On the paper-based print, the extent of the abrasive wear after 200 strokes corresponded to the wear on the PVC and polypropylene print after 50 strokes and 100 strokes, respectively. The largest extent of surface damage could be experienced on the met PVC foil.

In general, it can be claimed that without surface treatment (varnising, film laminating) the prints made on plastic media with offset technology are less resistant to abrasion. In general, it can be claimed that without surface treatment (varnising, film laminating) the prints made on plastic foils with offset technology are less resistant to abrasion, and thus surface damage may be caused even by the circumstances of handling (movement, packaging, transportation).

4 CONCLUSIONS

In our study we investigated offset prints on two types of plastic substrates, printed with oil-based inks on the same sheetfed offset press. As the printing machine was not equipped with an UV curing unit, test printing was performed under special operating conditions. Higher density and higher TVI (on 50% middtone) were produced in the case of PP substrate. But abrasion resistance of prints printed on the smoother PP was better. Larger colour differences beetwen patches of full tone process colours were measured on prints printed on PVC substrate.

Our findings may contribute to developments aimed at the improvment of the interaction of different offsett inks and plastic substrates.

5 REFERENCES

[1] Wasmann, F.: MODERN MEDIUM WITH GREAT POTENTIAL. *PROCESS 5*. ISSUE 1 (2008) PP. 18-20. *AVAILABLE FROM* HTTP://WWW.KBA.COM/FILEADMIN/USER_UPLOAD/KBA_PROZESS/PROCESS5-EN.PDF *ACCESSED:* 2011-10-25

[2] Psotta P.; Bolliger W. J.: OIL-BASED AND UV-CURING INKS FOR FILM AND FOIL PRINTING. *PROCESS 5.* ISSUE 1 (2008) PP. 18-20. *AVAILABLE FROM* HTTP://WWW.KBA.COM/FILEADMIN/USER_UPLOAD/KBA_PROZESS/PROCESS5-EN.PDF *ACCESSED:* 2011-10-25

[3] Kipphan, H.: *HANDBOOK OF PRINT MEDIA*, SPRINGER-VERLAG, ISBN 3-540-67326-1 BERLIN, 2001

[4] Oller, S.: PLASTIC PRINTING TECHNICS HTTP://AMERICANPRINTER.COM/SEARCHRESULTS?TERMS=PLASTIC+PRINTING+TECHNICS&ORD=D&X=0&Y=0 *ACCESSED:* 2011- 10-25

[5] Debeljac, M.: PRINTABILITY OF SYNTHETIC PAPERS BY ELEKTROPHOTOGRAPHY, *ACTA GRAPHICA*, 3-4/10 (2011) PP. 14-17, ISSN 0353-4707

[6] Szentgyörgyvölgyi, R.; Borbély, Á.: QUALITY OF ELECTROPHOTOGRAPHIC PRINTS ON FOILS, *JGED JOURNAL OF GRAPHIC ENGINEERING AND DESIGN*, VOL. 2. NO. 1. (2011), PP. 1-7, ISNN 2217-379X

Corresponding author:

Rozália SZENTGYÖRGYVÖLGYI
Institute of Media Technology and Ligh Industry
Rejtő Sándor Faculty of Light Industry and Environmental Engineering
Óbuda University
Doberdó u. 6. Budapest
H-1034 Hungary
Phone: +36 1 666-5958 e-mail: szentgyorgyvolgyi.rozsa@rkk.uni-obuda.hu