APPLICATION ANALYSIS OF WHITE FLEXOGRAPHIC PRINTING INKS ON BIODEGRADABLE FLEXIBLE FOILS

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Abstract: *Flexographic printing is one of the branches of domestic printing industry developing at the fastest pace. However, fast development also means a large burden for the printing houses applying this technology, as they need to print on different print surfaces with inks of different composition in order to produce good quality prints. (Borbély, Szentgyörgyvölgyi, 2011) In the following article the problems that emerge during the process of flexible packaging material production will be examined, with the application of environmentally friendly raw materials in case of printing white colour in flexographic printing, that do indeed degrade. Displaying white colour is a complex and difficult task itself, if it is not examined in active colour display (on screen), but from the aspect of passive (reflectional) printed colours. In order to reach the most optimal result during flexo printing, the coordinated operation of several elements of the process are necessary. In the article the theoretical research and practical work that has been carried out so far will be discussed, together with their results, and– direct and indirect – effect on the environment, moreover the future plans of research will also be outlined.*

Keywords: flexo printing, standardization, flexo plates, white ink

1 INTRODUCTION TO THE TOPIC

Flexographic printing is a relief printing process with flexible printing plates. Low viscosity ink is transferred onto the plates by a raster cylinder with a doctor blade. On the photopolymer plate the printing and non-printing elements are created by negative copying, as a result of UV radiation. The technology enables absorbent and non-absorbent materials to be used as print surfaces. (Flexography, 1999)

1. 1 The inspiration of raw material choice

Doubtlessly, the raw materials of products printed with flexographic methods – and subsequently research in flexographic areas – are mainly and in large volumes still non-degradable foils.

Nowadays it is becoming more and more urgent to find a reassuring solution to reduce the environmental impact of the packaging industry. Since the beginning of the mass production of plastic items in the 1960s, the majority of plastic waste has never been recycled. Moreover, the negative changes caused by the environmentally harmful effects of packaging material production also contribute to the drastic deterioration in the condition of Earth.

Changes in the attitude towards the environment have brought the spread of environmentally friendly packaging solutions. Based on a corporate research, nearly 40 % of specialists consider environmental solutions as the most important challenge of the sector, which must be met (DuPont, 2011). According to the research, in order to meet the green challenge, managers use different strategies, the most frequent of which is the statement of being „recyclable" on the packaging (65%), reducing the amount of packaging (57%), using recycled, bio (41%), or compostable materials (25%) (Dörnyei, 2019).

As opposed to generally widespread packaging films, professionally produced cellophanes without coating, or printed with suitable parameters are some of the most environmentally friendly solutions, as they are biodegradable and compostable.

Regenerated cellulose or viscose film („cellophane") enjoyed popularity a couple of decades ago, due to its good technological and functional properties. It was mainly used for food packaging. There are different methods used to improve its qualities. The significance of viscose films has decreased to a great extent lately. In Hungary, only a couple of – mainly licensed – products are packaged into it. Its application has also decreased in developed countries. It has been substituted by biaxially oriented polypropylene. (Kerekes, 1996)

In order to reverse this process, and to bring to the fore the use of degradable materials, there are efforts perceptible in different parts of the world to different extents. As a main pillar of my research, I consider the creation of the technological background of printing compostable packaging in the most efficient, and thus the most economical way, with the most optimal materials and tools. As the first step, I will deal with the problems of printing white, one of the most significant and most basic colours.

1. 2 The inspiration of research topic choice

Real white colour is one of the most difficult tasks in the printing industry, and within that in flexo printing. As the product – when placed on the market – will be displayed in surroundings with different parameters regarding light, it is an essential criterion that the reflectional spectrum reflecting from the surface should result in the same white shade in case of normal, illumination as well as of different spectra. The task is relatively simple on screen, as only the spectrum of the emitted light needs to be reproduced by using the appropriate ratio of the basic colours (RGB in most of the cases). In case of reflection, however, illumination may have different kinds of spectra. It is a difficult task for the spectrum of the reflected light to always produce white colour effect. In order to reach the desired colour – while retaining other quality properties of the product – the coordinated application of raw material, ink and printing plate is necessary.

Raw materials of offset printing often also contain whitening components, which means that the reflection of UV illumination which is out of visible range, is converted into the visible range, thus reaching extra whiteness. This may cause some problems in the colour management of printing, nevertheless the use of such components is not typical in flexo materials.

Our experience shows that within flexo printing materials, thicker white polyethylene films are the best from the aspect of their whiteness. Unfortunately their transparency is quite high, therefore the whiteness of the film can only be measured by laying more (4-6) layers on top of each other. This nearly matches the white values of good quality proof paper, however there is no optical whitening component included, and laminated with further barrier films – as opposed to cellophane – they cannot be considered environmentally friendly materials. Reaching good whiteness is on the other hand a basic criterion – with any raw material – to produce good prints with great colour dynamics.

Products printed with flexographic technology may consist of more layers of various materials due to different packaging demands. White print may be necessary during printing both in reverse and in direct print. In these cases the opacity of the white ink layer is the most frequent priority. The easiest way to handle this is increasing ink application. On the other hand, it is also necessary for the ink to dry. If the white ink is also used to print letters and logos, the amount of applicable ink is also restricted in order to reach finer resolution. If the aim is to create raster shades, even more finely controlled ink administration is needed, which can be carried out only with a thinner ink layer. From the perspective of prepress, it is possible to separate the two needs into two different white prints by preparing more layers of white. One of the layers may be rougher with higher amount of ink transfer, and the other with lower amount of ink applied with fine details or raster. In case of such demands the microstructured surface of the flexo printing plate proves to be very useful, as it is suitable to improve opacity even in case of lower amount of white ink due to the more even ink application, thus enabling the fulfilment of the two opposing demands using a single layer

Based on the arguments above, it can be seen that beside choosing the most suitable raw materials, it is also an important criteria to use the most optimal ink and plate for the task together in order to reach the targeted result. The efficiency of ink application is influenced by a number of factors: ink uptake of the plates, printing speed, print pressure, temperature, and the properties of the printed material (Johnson, 2003). It is the white colour, during the printing of which emerging difficulties can be exponentially present. At the same time this field of problems has few results, which also work well in practice. That is why it was chosen as one of the pillars of the present study.

2 EXAMINED PRINTING DIFFICULTIES AND THEIR POSSIBLE SOLUTIONS (RESEARCH TOOLS, METHODS)

Flexo printing is one of the fastest improving branches of the printing industry nowadays. Its expansion is due to the soaring quality improvement within the sector in the last couple of years, as well as the quick and efficient production of special products in the packaging industry. Using flexo printing with a suitably developed machine configuration it is possible to produce products in one go, on-line (eg. labels, boxes, scratch cards, etc.), which would require four to five separate printing and binding sessions in a sheetfed offset printing house.

Taking into consideration the shorter and shorter lead times and decreasing quantities of orders, the explosive development in the sector is readily understandable.

Besides the large-scale improvement, meeting increasing quality and environmental requirements has also become a basic market demand. Not accidentally, one of the most significant parts of improving print quality lies in the application of white inks, as it is the printing of white colour that poses several obstacles.

The first visual problem is coverage, which simply put means the opacity and saturation of white ink. This bears major significance at the printing of strong, contrasting colours, as a weak white with low opacity can make even a good quality print appear grey-veiled. A further problem is posed by the visibility of products of various colours through the design of the packaging material.

Under the term printability, we mean drying and ink buildup around dots. Due to the quick drying of the ink, the area between small raster dots gets filled up with dry ink.

The next problem is the printability of motif edges, under which we mean the TEV effect (= trailing edge void). It means the negative line (the void) at the trailing edges due to ink transfer. Another problem is the doughnut effect, which also results from the lack of ideal ink transfer. Instead of a round raster point, a doughnut shaped point will be visible in print.

In order to try and eliminate the difficulties listed, we have to examine what kind of factors influence print quality. For the tests 3 kinds of ink types and 4 kinds of printing plate types have been used, which has resulted in 12 different test prints.

3 inks with different titanium pigments have been used for printing:

- Test 1: 41.2% matt TiO_2 made from normal slow drying solvents.
- Test 2: 45.5% glossy TiO_2 made from normal slow drying solvents.
- Test 3: 3% matt and 42.3% glossy TiO_2, 1.5 times slower drying.

The tests have been carried out using the printing plate types below:

- Flint ACE-D: Standard digital printing plate; FLAT TOP: created with nitrogen chamber UV-A exposure; surface pattern created during lasering; Shore A hardness: 78 Sh A.
- Flint ACT-D: Standard digital printing plate; FLAT TOP: created with nitrogen chamber UV-A exposure; surface pattern created during lasering; Shore A hardness: 74 Sh A.
- MacDermid LUX ITP-60: inherently FLAT TOP printing plate; surface pattern can be created during lasering; Shore A hardness: 78 Sh A.
- DuPont EASY ESE: inherently FLAT TOP printing plate with engineered surface („built-in surface pattern”); Shore A hardness: 74-76 Sh A.

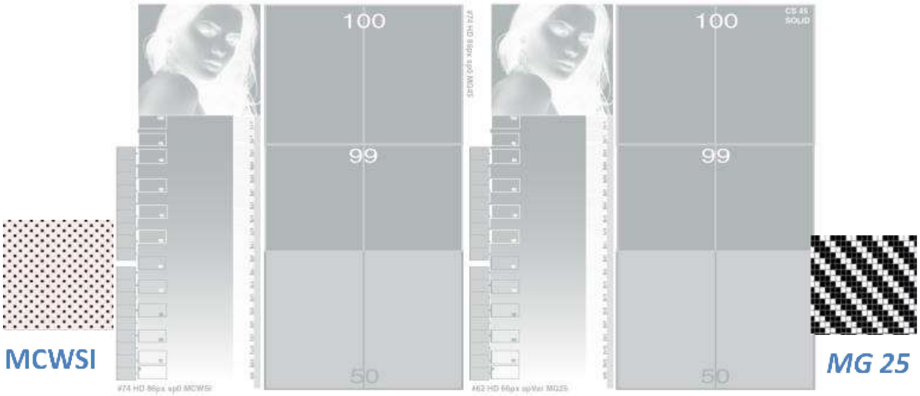

Figure 1: Test chart (printed on a W&H Novoflex press) with the surface patterns of the applied printing plates

After selecting the suitable printing plates and ink types, the testing process was started. The test was printed on a Soma Midi press. The related test chart can be seen on Figure 1. The top left part of the test chart used for our examinations contained a woman's face for testing complex image visualization. Below that, there was a transition started from 100% and fading out to 0%, to check the printability of the complete tonal range. The top right area had the 100% tones to measure solids. On the left, we applied MCWSI surface pattern, while MG25 pattern was used on the right.

3 RESULTS

In the next phase of the analysis, the results of test printing were at first evaluated by a visual inspection. Our findings are summarized in Table 1.

Table 1: Comparing test prints by visual inspection

Ink types	***Plate types***			
	ACE-D	***ESE***	***ACT***	***ITP***
Test 1	*OK*	*Buildup*	*OK*	*OK*
Test 2	*Buildup*	*Buildup*	*OK*	*Very good*
Test 3	*Mild buildup*	*Buildup*	*OK*	*Very good*

Regarding buildup, the best results were achieved with the ITP plate in case of every ink type. The ACT plate also produced acceptable, fine image quality.

Subsequent to that, we carried out 2 kinds of measurements on the test prints. During these examinations, we used a spectrophotometer for measuring lightness, and a Peret Flex^3 Pro device for measuring fill ratio and geometrical values.

The initial measurement determined the coverage levels of the opaque white relative to each other. This means that we measured the achievable whiteness in CIE L*a*b* values after laminating onto a black base foil. Here, we examined absolute values, that is how much we could approximate the ideal colorimetric white (L*=100 a*=0 b*=0). The level of coverage always depends on the backing material. We may also measure the ΔE (L*a*b*) colour difference between the covered/uncovered parts of the base material. However, it is important in every case to exactly identify the backing material in order to be able to provide the same for future measurements as well. Under these conditions, we need to focus mostly only on the L* value of the CIE L*a*b* measurements, and the absolute values of a* and b* need to remain less than 2-3.

Table 2: Coverage values

Ink types	***Plate types***			
	ACE-D	***ESE***	***ACT***	***ITP***
Test 1	*68.87*	*70.32*	*69.45*	*69.35*
Test 2	*68.20*	*69.60*	*69.56*	*68.46*
Test 3	*69.25*	*69.80*	*70.29*	*69.49*

When examining coverage values, we could see that the best coverage was provided by Test ink 3 in case of every plate type except ESE. For ESE, Test ink 1 gave the best result.

During the second measurement phase, we took microscopic images of different halftone values of the prints (10, 30, 50, 80%), with the help of which we can present the differences in ink transfer when using the chosen plate and ink types. In case of a printing plate with microcells, halftone dots become more uniform, with smaller hollows in the centre (Figure 2).

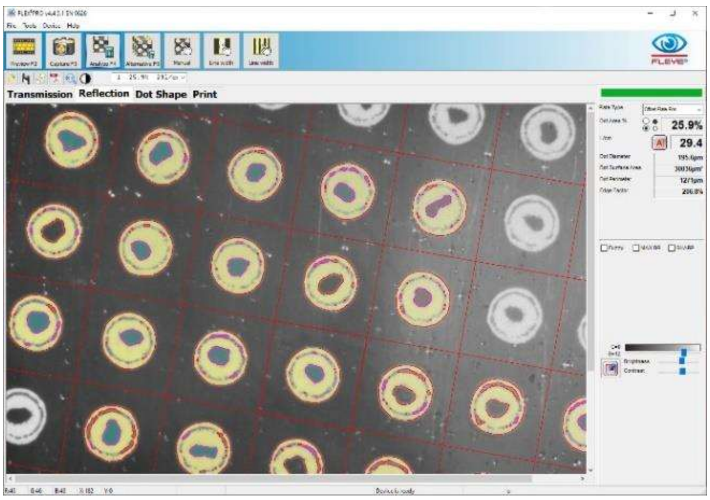

Figure 2: Magnified image of a test print that was printed with microcelled printing plate

Table 3: Dot gain values

Test 1				
Plate type	**10%**	**30%**	**50%**	**80%**
ACE-D	9.6	25.9	39.5	77.7
ACT	8.6	25.9	43.4	79.6
ITP	8.8	27.3	46.6	88.5
ESE	7.9	23.8	35.2	82.5
Test 2				
Plate type	**10%**	**30%**	**50%**	**80%**
ACE-D	9.4	25.9	39.9	77.5
ACT	8.6	25.6	42.2	78.9
ITP	9.1	29.6	51.1	88
ESE	8.3	24.1	37.2	83
Test 3				
Plate type	**10%**	**30%**	**50%**	**80%**
ACE-D	10.1	27.5	44.6	79.4
ACT	9	27.1	43.5	80.3
ITP	9.5	30.1	50.3	89.6
ESE	8.6	24.4	36.6	83.8

With regard to dot gain values, we concluded 2 important findings:

- In the range below 50%, we measured the best values with the ESE plate type with all of the 3 ink types.
- In the range above 80%, the minimum dot gain was performed by the ACE-D printing plate with Test ink 2.

4 SUMMARY, AIM AND UTILIZATION AREAS OF THE RESEARCH

Based on the examinations, we concluded that the MCWSI surface pattern is more advantageous than the MG25 pattern. Higher coverage and better ink transfer are provided, and finer dot shapes can be printed by that.

In case of general halftone printing, the usage of ITP and ACT printing plates are optimal. When it comes to printing highlights with minimum dot size being important, the ESE plate may be the appropriate choice.

At 10%, the best result was achieved with ESE plate and Test ink 1. Figure 3 shows 10% dots printed with an ITP60 plate, while Figure 4 shows 10% dots printed with an ESE plate. It is easily perceivable that the doughnut effect is much stronger when using ITP60 plate.

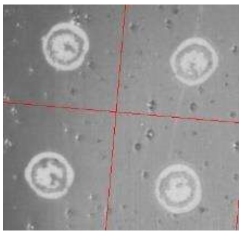

Figure 3: 10% dots printed with an ITP60 plate

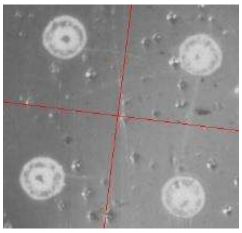

Figure 4: 10% dots printed with an ESE plate

The examination results above and the research area chosen as one segment of the possibilities residing in flexo printing technology, may by themselves have significant economic impact in the fields of efficiency, savings, and last but not least, as a result of these, also on environmental protection. The results achieved by applying printing industry products with appropriate characteristics, along with cost savings and increased productivity due to fast print setups and low waste, all decrease the repro work deriving from inadequate quality, as well as the related material and energy usage and waste production.

Despite the sudden crisis of last year – unlike many other sectors – the packaging industry and the flexo area within that have not lost any momentum, which opens the door to numerous new research and development projects in the future. Thus, our future research plans include the creation of new surface patterns, printability analysis of text elements, study of prints with certain screen types, and the examination of the possibilities of increasing ink coverage.

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