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Studies of technologies for exposing photopolymer plates in a controlled atmosphere and their application on a corrugated post print

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The new technologies for digital plate making proved key to achieving a higher quality of corrugated post print.

The goal of the present study is to examine the technologies of exposing photopolymer plates in a controlled atmosphere and their optimal use in flexo corrugated post print.

The main problem with the flexo corrugated post-print is the flouting effect on the printed image. It is caused by the difference in the impression corresponding with the waves of corrugated board, forming an unstable dot gain in half tone areas of the image and generating visible stripes. The purpose of this study will be to determine whether and to what extent the technology for exposing photopolymer plates with flat top dot technologies in controlled atmosphere can reduce or eliminate these problems.

Keywords: flexo printing, photopolymer plates, corrugated

INTRODUCTION

The flexographic technology is gaining ground as a major and dominant method for printing on packaging. This applies to both flexible packaging, where flexo successfully overtook gravure printing, as well as to printing of corrugated board, selfadhesive labels and others where it appears as an alternative to offset printing. This huge growth in flexo technology we see in recent years is due to the significant increase in printing quality. By analyzing consumer demand it turns out that their main requirement from flexo is improvement of printing quality, stricter quality control, optimization and standardization of the printing process. This is made possible mainly due to the new technologies, especially in pre-press, which proved key to achieving a higher quality printing. They include some key factors such as dot gain compensation, gradation in highlights, transition to zero, tonal range extension – features, on which designers and print buyers are focused [1].

Some studies report that about 90% of the packaging, produced from corrugated board printing, is full color and in most cases the used print technology was flexo post print. The printed images vary from one- and two-color printing (with just some basic information about the product and the company) to sophisticated four- to seven-color images. The advantages of direct post-print to pre-print on offset or flexo can be achieved only if the used flexo technics provide a significant quality improvement on the reproduction [1,2].

The increase in the quality requirements for printing on corrugated cardboard also lead to the introduction of new technologies such as using thin photopolymer plates, while compensating the difference in thickness with compressible foam, which allowed for the digital plate making technology to enter this area.

A key issue for quality printing on corrugated board is the so called wash-board, or fluting, effect, which occurs when the flat halftone images are reproduced with stripes that follow the waves of the corrugated board.

In order to make such stripes less visible, the common practice is that the printed liner should be with a higher mass than what is required in order to achieve the desired strength for the corrugated board. The reason is that the liner with a higher mass does not bend as much around the waves of corrugated board, thus reducing the fluting effect on the printed images. However, this raises the cost of production.

ANALYSIS OF THE PROBLEMS AND PREVIOUS STUDIES

In our previous studies we were testing and analyzing the main screening technologies, including stochastic and hybrid screening as well as HD Flexo technology. They were compared to regular screening with round and circular dot shape, and checking reproduction in highlights and shadows while printed in actual production conditions.

Other things analyzed were if and how much the used methods increase the ink transfer, gradation and tonal range, the maximum optical density and

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color intensity. To increase the ink transfer a different methods to increase roughness by generating microcells on the surface of printing elements were tested

The main problem with printing directly on the corrugated board is the image striping, which occurs due to the copying of the waves of the corrugated cardboard on the image. The effect of image striping when printing on corrugated board is caused by the different effective pressure of the screens in the different areas: depending on whether the waves confront or not, the resistance of the printed material is different, which generates the difference in the effective pressure during printing. The difference in the pressure results in a different dot gain and creates a visible striping on the image.

Therefore, the goal of this research is to study how the different technologies to expose photopolymer plates compare to the conventional plate making in the corrugated post print, in the areas of the floating effect, ink transfer, ink transfer and uniformity and to determine the optimal plate making method for flexo post print for corrugated cardboard in production conditions.

TERMS OF THE EXPERIMENT AND ANALYSIS OF RESULTS

Used material

- Kraftliner White 135g,
- Corrugated board B-Flute 125g
- The control test targets on DPC 155, produced via the conventional digital platemaking technology in the presence of oxygen.
- The control test targets on DPC 155, made via the DigiCorr technology, replacing the air with nitrogen with a nitrogen content of 99.999%.
- The control test target on DS2 45, made via a conventional digital plate making technology in the presence of oxygen.
- The control test target on DS2 45 made via the DigiFlow technology replacing air with inert environment with controlled atmosphere with 1.3%.oxygen

Methods and equipment

- Printing press BOBST Masterflex HD
- Printing press W&H Primaflex
- VIPflex 333 - tools to control the dot size on the black mask for laser engraving and screen dots.
- FLEX 3 PRO to control the profile of screen elements and microphotography.
- Spectrophotometer CyFOS Spectro 2000.
- Spektrodensitometer PRESTOdE.

All tests were made in accordance with the standard printing conditions used in the factories.

Conducting the study and analyzing the results

The application of various alternative technologies in a controlled atmosphere was studied against the conventional platemaking for corrugated board, including both direct printing on corrugated board, and pre-print on paper for producing corrugated boards.

The first part of the study was to determine whether and how the flat top dot technologies allow for reduction of the floating effect on corrugated post-print.

In order to determine this, test forms were printed, produced in a controlled atmosphere with a fixed presence of oxygen (DigiFlow), with complete absence of oxygen (DigiCorr), with lamination of a protective membrane on the engraved black mask (LUX), which prevents contact with air, as well as tests whose main exposure was obtained via powerful UV exposure with high intensity - UV LED sources (NExT and Full HD), which significantly limit the impact of oxygen due to the short time of impact were analyzed. To achieve optimal results, the test plates were produced by the developers of the technology and were compared to conventional digital platemaking obtained on the same photopolymer plates. Tests with the usage of laminated membrane and high intensity UV LED sources showed similar results with those using controlled quantity of oxygen (DigiFlow), which is why further researches and comparisons were focused on the DigiCorr and DigiFlow methods.

The test trials were printed on BOBST Masterflex HD in production conditions. The test elements included screen test targets with 32 lpcm screen ruling, oriented parallel and along the waves, as well as full color images. The printed targets were mounted together and the print test was made with both plates (produced via conventional and alternative technologies) to exclude the impact of the specific settings of the printing press on the tested technology. It should be emphasized that in the separate printing of the two plates alone, better results can be expected due to the possibility of setting the printing press according to a specific plate type, but this would lead to doubt whether the difference in results is not due to the printing conditions.

Tests were printed on corrugated boards with B, E and F waves, but for the comparative analysis, the fingerprints on the B waves were used, where the flouting effect on the image is the most pronounced. For the purposes of the study, test targets printed on Kraftliner - white 135g and B-Flute 125g were analyzed. For corrugated board

with E and F waves, the difference was not so strongly visible.

The results presented below are for control test targets on DPC 155, made on conventional technology in the presence of oxygen and also with replacing air with an inert gas technology - DigiCorr. The main exposure of digital photopolymer plates was done in the absence of oxygen by replacing the air in the exposure chamber with an inert atmosphere (exposure under a nitrogen atmosphere with nitrogen content 99.999%). In this case, we notice the best improvement in reducing flout effect and the best results were achieved, compared to the conventional plate making and other alternative methods. Comparison to technologies with a controlled amount of oxygen – DigiFlow, showed no improvement in this parameter.

The results of the direct post-printing on corrugated board using plates made with oxygen-free and conventional technologies are fundamentally different, which is well illustrated by photographs made for flat 30% halftone screens fields (Figure 1).

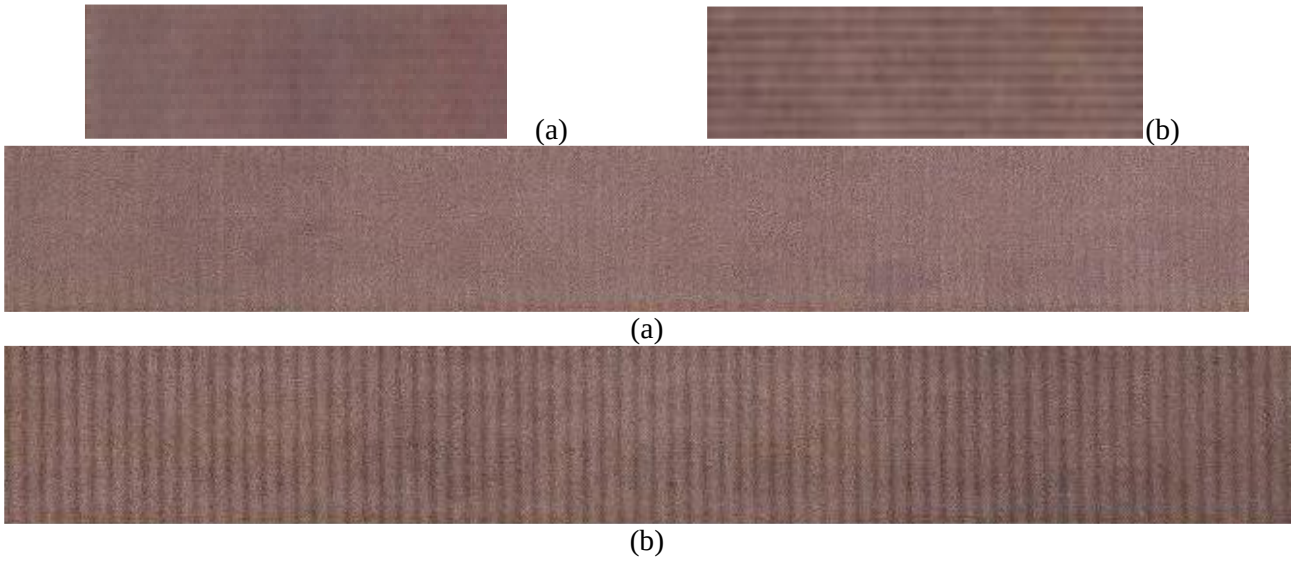


Fig.1 Printing on corrugated board with test plates made in atmosphere in (a) absence of oxygen and (b) with conventional plate making in the presence of oxygen, when the image is parallel or along to the waves direction.

Studies have shown that the method of plate making has a significant influence on the flouting effect, most visible in flat screen tone, and depends on the gradation of the image. Images printed with plates, produced in the absence of oxygen, look better and are more uniform, and the fluting effect is drastically reduced. The lighter and darker lines on the printed images follow the waves of corrugated board and are the result of different impression during printing. The settings of impression when printing on corrugated board usually exceed the minimum necessary pressure to avoid irregularities in the surface of the print material, which in this case are significant. This is most noticeable in the flat halftone areas.

The printed control strips in the interval 0-100% were analyzed as well. It was found that flouting effect is visually most noticeably in the midtones, in the area of transition from positive to negative dots, where the dot bridging occurs. The impact of technology depends on other factors related to the dot gain, such as plate hardness, the presence of compression pad, ink viscosity and print impression. Additionally the impact on the gradation in direct post-print on corrugated board was analyzed. It was found that a higher dot gain is typical for the plate making technology without oxygen.

To determine the reasons of these differences in the halftone printing, we compared the microphotography of screen elements reproduced in different technologies – analog, conventional digital and DigiCorr, and analyzed how the profiles of the screen elements will behave during printing in the print contact area and how it could reflect to the dot gain (Figure 2).

The microphotographs of screen elements reproduced in different plate making conditions show a difference in the slopes profile and give reason to assume that this could be the explanation for the different results in corrugated post-print. Comparing the top of the dots in the plates produced by the analog and conventional digital plate making and the ones reproduced in DigiCorr technology in an inert gas outlines the differences in these elements.

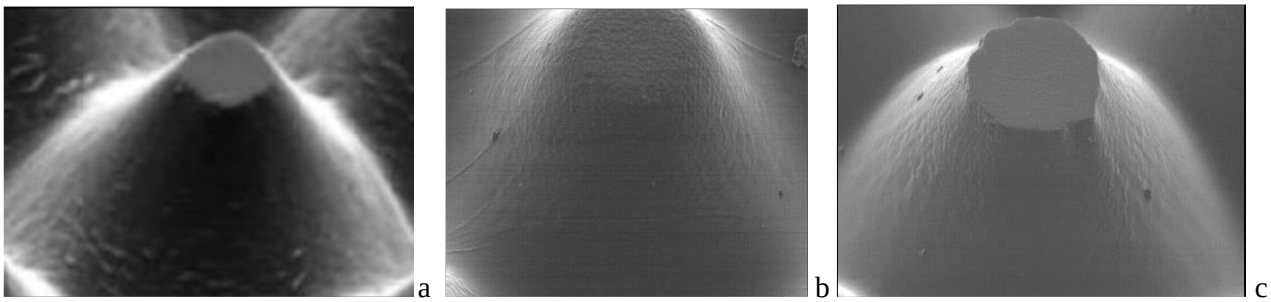


Fig. 2. (a) Analog; (b) Conventional digital; and (c) DigiCorr screen elements

The screen dots on the analog plate are with flat surface and gentle slopes. This will lead to a higher but stable dot gain during printing. This effect is well known since the old times when only analog plates were used.

For the conventional digital platemaking, screens are with the rounded dot profile and steeper slopes. The rounded dot shape makes the dot gain more sensitive to non-uniformity of the print pressure. The steeper dot shoulders of the rounded dots additionally make them more critical to the impression during printing. The combination of both factors makes the print contact of a rounded top dot and wavy corrugated board much more unstable. In the areas of reduced and increased print impression the dot gain will vary significantly.

Similar to the results with analog plates those obtained with platemaking technology when plates are exposed to a controlled atmosphere with oxygen 1.3% (technology DigiFlow). The pixel structure of the dots' edges is reduced and creates better round dot shape, but at the same time makes the slopes gentler and generates some rounded top dots, even if it is not as strongly visible as the standard digital platemaking. However, such technology doesn't show improvement of floating effect and we can't recommend it for corrugated post print.

The dots on the plates with DigiCorr platemaking technology are flat top dots with pixel structure of the edges, which in general will lead to a higher dot gain. But at the same time the top of the dot has a cylinder profile. Such profile of the dot makes the dot gain process less critical to the difference in the impression when printing directly on corrugated board and the printing of the smooth halftone areas is more visually more uniform.

The difference in the print results with plates produced through different platemaking methods is obvious. To find the origin of such effect the chemical process during the plate making was analyzed.

We believe that comparison of the various chemical reactions in the digital to analog platemaking technology is the key for the explanation of the observed effect.

When analog plates are exposed, there is a limited quantity of oxygen (through vacuum). For digital platemaking it is the opposite – the whole main exposure is taking place in the presence of air, respectively with oxygen. Such chemical reaction during the main exposure is studied in details, when the digital plate-making technology based on engraved black mask was invented. It was found that due to the presence of oxygen during the main exposure, the polymerization process activated by the UV-A energy is accompanied by blocking part of the radicals of the photo-initiator by the oxygen in the air. The process is known as inhibition. Such inhibition of the radicals reduces the polymerization at the edges of the dots and makes them with steep slopes [1].

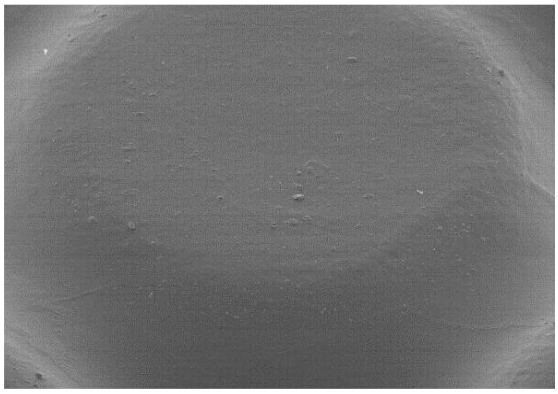
The shrinking of the dots and the steep slopes, resulting from the processes of inhibition during the main exposure, made such platemaking process preferable to flexo printing for tags and labels, as well as for flexible packaging. It was a revolution in the flexo print quality due to very fine highlights, the transitions to zero and the reduction of dot gain compared to analog plate making. But such plates required more precise printing process as they are more sensitive to the pressure during printing. At the same time the round top dot when is used for corrugated post print is making the flouting effect more visible.

On the microphotographs of the plates made in an inert atmosphere the dot profile is very interesting – it is like a cylinder at the top part of the screen dot. The size of the cylindrical profile is only a few tens of microns, but has a significant impact on the printing properties of the plate in corrugated post print. This cylindrical profile can be explained by the presence of a very little amount of oxygen, which limits the inhibition to only a thin surface layer next to the screen and solids and forms the specific cylinder profile of the flat top dot. The use of plates, reproduced in almost

full absence of oxygen and the formation of an area with a vertical profile reduces the sensitivity of dot gain caused by uneven pressure characteristic in direct corrugated post print. This is strongly confirmed by tests and results.

The reduction of fluting effect is different depending on the type of cardboard, but improved print results were observed in the majority of printed products. The differences are obvious and are illustrated on the print test photos Figure 1.

A comparison of microphotographs screen dots produced in oxygen and an inert environment showed strong reproduction of the pixel structure of the dot's edges. In the oxygen environment the pixel structure disappears due to the dot shrink while in an inert atmosphere the pixels are well copied (Figure 3a,b).


a

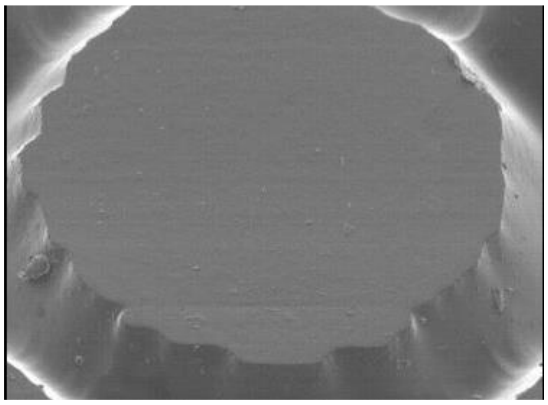

b

Fig.3. Microphotography of dots on plates made in a) oxygen environment, b) in an inert atmosphere.

The pixel structure of the dot edges leads us to the following conclusions. When the main exposure during platemaking is done in a controlled atmosphere at a complete absence of oxygen, then the processes of inhibition is very very limited. This is proven by the pixel structure of dot's edges. At the same time it can be seen, that some less pronounced smoothing of reproduced pixels exists. This fact is practically immaterial in terms of dot shape, but confirms the conclusions for the creation of the cylinder profile on the top of the dot.

At the same time, test trials confirmed that the pixel structure of the dot shape typical for all flat top dot technologies can be ignored for corrugated post print, since the used screen rulings are low, and because of the water-based inks used on the absorbent surface, the pixels structure at the dot edges disappear during printing.

Test trials for corrugated pre-print

The impact of platemaking technology in corrugated pre-print was also examined. In this case for the test trials was used a DS2 45 plate type, produced in conventional digital and in a controlled atmosphere with 1,3% oxygen - DigiFlow technology with and without structuring the black mask to generate roughness on the solids.

The test was printed on W&H Primaflex printing press on Kraftliner White 135g substrate.

Since it is printed directly on paper for corrugated board, the risk for floating effect is not applicable.

It was tested whether the surface structuring of solids with DigiFlow technology will improve the ink transfer. No increase of optical density or improvement of the ink uniformity was found, which can be explained by the fact that printing is performed with water-based inks on the absorbing substrate, so surface tension on smooth ink transfer had no negative impact unlike what was observed when printing on films. Based on this, further research on the impact of structuring was conducted.

Studies have shown that for the platemaking with flat top dot technologies, creates a dot gain of about 10% in the mid tones compared to conventional digital plate making without an increase of the optical ink density and ink uniformity as it was observed when printed on polymer films. This could be a problem and make the application of alternative platemaking methods unattractive for the corrugated pre-print. These results can be explained by the nature of the ink transfer for the water-based ink on absorbent substrates like paper.

CONCLUSIONS

The results obtained in this experiment are important for practice.

The examined alternative technologies for platemaking for flexo printing for corrugated significantly improve the image quality by reducing floating effect at corrugated post print. This is most pronounced in the platemaking methods at complete absence of oxygen during the main

exposure.

The results when such technology was used show significantly reduced flouting effect especially in mid and flat tone area.

The effect is varying depending on the type of corrugated board used and is most pronounced in corrugated boards with B wave. In this case, improving the quality of image reproduction is most pronounced and the advantages of the technology are visible.

At the same time, we observe the typical for flat top dot technologies higher dot gain and higher tonal jump in the gradation at the transitional area, where the positive dot is converted to negative at mid and ¾ tonal gradation.

The platemaking technology with controlled presence of 1.3% oxygen worsen rather than improve gradation due to printing with water-based inks on absorbent surfaces, which is why we do not recommend the use of these technologies in the pre-print for corrugated.

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ИЗСЛЕДВАНЕ НА ТЕХНОЛОГИИ ЗА ЕКСПОНИРАНЕ НА ФОТОПОЛИМЕРНИ ФОРМИ В КОНТРОЛИРАНА АТМОСФЕРА И ТЯХНОТО ПРИЛОЖЕНИЕ ПРИ ДИРЕКТЕН ПЕЧАТ ВЪРХУ ВЪЛНООБРАЗЕН КАРТОН

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(Резюме)

Новите технологии за изработване на цифрови форми за флексо печат се явяват ключови за постигането на високо качество при директния печат върху вълнообразен картон.

Целта на настоящата работа е да се изследват технологиите за експониране на фотополимерни печатни форми в контролирана атмосфера и да се определи тяхното оптимално използване при директния флексо печат върху опаковки от вълнообразен картон.

Основният проблем при директния флексо печат върху вълнообразен картон е ефекта на раиране на отпечатваното изображение. Това се дължи на разликата в натиска при печат, съответстващ на вълните на вълнообразния картон, което води до неравномерно нарастване на растеровия тон в полутоновите участъци и пресъздаването на вълните на картона върху изображението. Целта на това изследване е да се определи дали и до каква степен изработването на фотополимерни печатни форми с технологии с плоска точка в контролирана атмосфера може да намали или да премахне този проблем.