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THE INFLUENCE OF THE FLEXO PLATE MOUNTING FOAM BACKING ON THE QUALITY OF MAGENTA COLOUR REPRODUCTION

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Abstract: *Flexographic printing technology is relevant for producing flexible packaging. The quality of reproduction in flexographic printing is influenced by various factors such as the screen frequency, the volume of the anilox roller cells, and the hardness of the plate mounting foam backing. This study aims to investigate the impact of different plate mounting foam backings with varying hardness (Tesa Softprint Soft, Tesa Softprint Medium, and Tesa Softprint Hard) when used with the standard NX raster produced by Kodak (STD_NX). Additionally, different volumes of anilox roller cups ranging from 3,8 cm^3/m^2 to 11,6 cm^3/m^2 were considered. NX plates were produced on a Kodak Flexcel large CtP device and printed using a WGH VISTAFLEX CL8 machine with a printing speed of 300 m/min. The printing was done on a 60 µm low-density polyethylene substrate using process magenta solvent ink. The printed samples were analysed using a densitometer and a spectrophotometer (TECHKON SpectroDens) to obtain and compare the reproduction curves with the ISO printing standard 12647-6 (FOGRA 39 reference data). Furthermore, a detailed visual analysis of the printed samples was conducted using a Dino-Lite Edge digital microscope. The results of this research will provide guidance on the selection of the appropriate plate mounting foam backing in combination with the standard Kodak Flexcel NX screen and the suitable anilox cell counts in the roller. It was observed that the finest anilox (400L/cm = 3.8 cm^3/m^2) yields the highest quality magenta prints and the smallest tone value increase. Additionally, the soft Tesa plate mounting foam backing offers the most accurate initial reproduction curve, staying closest to the allowed tolerance area.*

Key words: flexography, plate mounting foam backing, print quality, reproduction curve, anilox rollers, Kodak Flexcel NX screening

1. INTRODUCTION

Flexo printing has been a key contributor to the growth of the packaging, label, and commercial printing markets over the last five years. With a satisfactory stability, these areas have seen significant growth: packaging printing market (+2.1%), label printing market (+2.9%) and commercial printing market (1.8%). While other areas of application of flexo printing are slightly stagnating, the overall picture is one of robust growth and promising potential. In total revenues (in billion US dollars) related to output by print process, we see an increase in revenues of 2.1%, or 0.4% in print equipment sales (Smyth, 2017).

Flexo printing is a direct rotary printing technique, similar to letterpress, that uses resilient relief image plates primarily used for packaging production. The relief printing form is made of rubber or polymer, on which the printing elements have a spatial frequency from 20 to 60 lines/cm. The thickness of polymer plates can be different. Plates with a thickness of 1,14 mm are used for high-quality reproductions, while thicknesses from 2,52 to 6,35 mm are used for packaging printing. The flexographic printing units use the rotary principle (cylinder-cylinder) and consist of a plate cylinder, an impression cylinder, and an inking device (Figure 1). The ink is placed in the ink fountain. The surface of the ink fountain roller is partially immersed in the ink fountain with the ink, and by rotation, it transfers the ink to the surface of the distributor roller and further to the printing form (FFTA Flexography, 1999; Petrović, 2020).

Modern flexographic machines are equipped with special anilox rollers made of ceramic or chrome, which ensure precise ink application. The surface of these rollers is screened in spatial frequency from 75 to 400 L/cm, and depending on the spatial frequency used, the amount and thickness of the ink applied to the printing surface are defined. In flexographic printing, the application of ink on the substrates is between 0,8 and 1 µm, demonstrating the precision and quality of the technique. When printing packaging, three types of flexographic inks are used: alcohol-based inks, water-based inks, and UV cured inks.

Solvent-based flexographic inks contain 40-60% aqueous or alcoholic solvent, 15-25% binder, 10-25% pigments, and 5-10% additives. Viscosity, which ranges between 0,05-0,5 Pa·s, is regulated by the amount of solvent in the ink (Rogers, 2011).

Inks based on alcohol solvents are applied to non-absorbent aluminum and polymer foils. Such inks are dried by vaporization and evaporation of the solvent, which is accelerated by exposing freshly printed imprints to high temperatures. Water-solvent inks are applied to more absorbent printing substrates with a rougher surface (paper and cardboard). Prints obtained with such inks require a slightly longer drying time (FFTA Flexography, 1999).

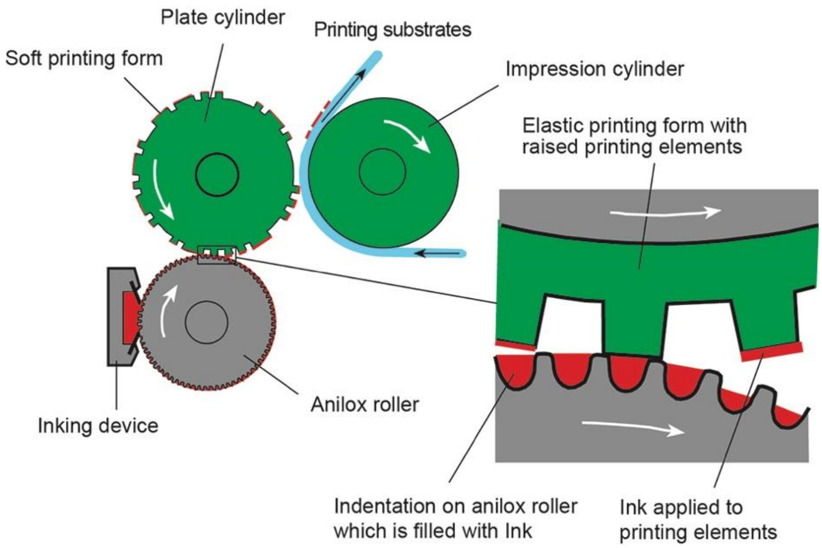

Figure 1: Flexographic Printing Unit

UV-cured inks do not contain solvents and are composed of 55-80% binders, 10-20% pigments, 5-15% photoinitiators, and 5-10% additives. When the printed material is exposed to UV radiation, immediate drying occurs. The photoinitiators in the ink start the polymerization process upon illumination, resulting in solidification. These inks produce high-quality prints with good mechanical and chemical properties, making them suitable for printing on substrates such as paper, PVC, aluminium foils, and laminates. The tone values of the print depend on the pressure force between the plate and the impression cylinder. Compared to other letterpress printing techniques, a lower pressure is required to achieve a visible print, with a maximum pressure of 1,5 MPa achievable with harder polymer forms (White, 1998).

Double-sided plate mounting tapes were introduced in 1975 for mounting photopolymer and polymer printing forms on the plate cylinder. Some companies producing mounting tapes also introduced plate mounting foam backing to the market. The addition of compressible foam improved the compressibility of the mounted printing forms and enhanced uniform pressures in the NIP zone, reducing tonal value increases during printing (FFTA Flexography, 1999). The foam compound provides consistent pressure compensation and maintains a constant return force even after significant changes in thickness. When using rigid forms, there is a continuous increase in the intensity of the return force from the initial contact (Bin, 2009).

The composition of the plate mounting foam backing may differ structurally to achieve these results (Figure 2). Both flexible and classic plate mounting foam backing share the same three top layers (liner, plate-side adhesive, PE reinforcement film) and an underlying adhesive layer for binding with the sleeve cylinder (TESA, 2024). In the case of the softer, flexible construction, there is a thin unique PE reinforcement film beneath the PE foam, while the hard strip utilizes a central lamination adhesive layer (above the PE foam layer). The central layer of PE foam (with a thickness of 0,3 and 1 mm) acts as a shock-absorbing component, reducing pressure on specific parts of the printing form, and exhibits 1800 compressions and recoveries per minute (Lee, 1998).

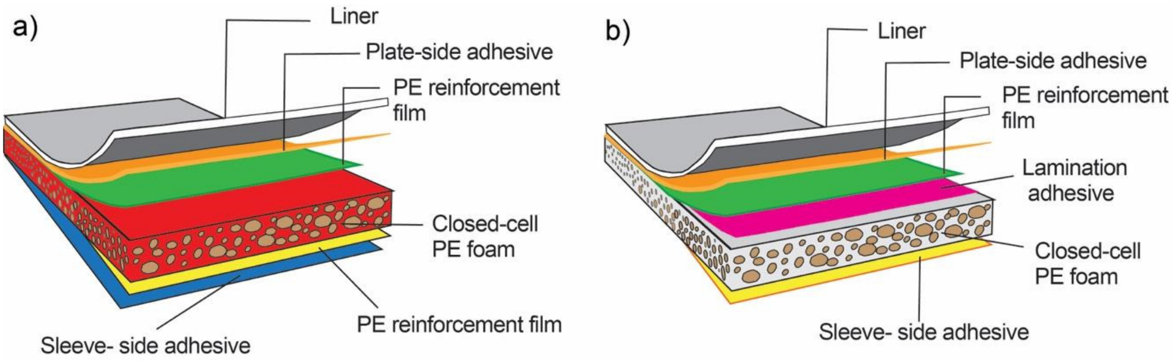

Figure 2: Structure of plate mounting foam backing: a) flex foam; b) Classic foam

The influence of plate mounting foam backing on the reproduction quality in flexographic printing is not just a crucial area of investigation, but a key aspect that significantly impacts the printing industry. Research by various authors has shown that the hardness of the printing forms plays a pivotal role in determining the printing quality. The choice of plate mounting foam backing can lead to different printing results. Softer printing forms adapt better to the printing surface. In contrast, harder ones deform less, reducing the increase in tonal values and contributing to a longer lifespan of printing forms (Anderson & Vreeland, 2019). For instance, five different double-sided plate mounting foam backings have been shown to change the optical density of solid tone surfaces from 1,34 to 1,66 (Lee, 1998). This underscores the importance of plate mounting foam backing in achieving optimal flexographic printing results.

According to the author's paper (Joyce et al., 2014), the increase in the width of screen elements (line) is one of the main disadvantages of the flexographic printing process. It is caused by the compression of the printing form that occurs when the colour is transferred to the substrate, and it can be controlled by the correct selection of plate mounting foam backing, as well as fine adjustment of the pressure-softer plate mounting foam backing results in a more significant increase in print element thickness. If the tape is too hard, it may bounce during printing (FlexoTech, 2019). The density and compressibility of PE foam can also vary, but generally, softer plate mounting foam backing is used when reproducing tonal values, and harder ones for full-tone printing. Therefore, when combining motifs, the choice of strip is a critical parameter.

For good results of flexo printing, the assembly of the plate mounting foam backing for the sleeve cylinder is also essential. In the case of insufficient adhesion, the formation of bubbles and lifting of the ends of the printing forms can occur, which decreases the stability and quality of the printing process. Lifting the ends of the printing forms is a major technical problem that often arises due to the ink penetration between the plate mounting foam backing and the printing form. Also, the degradation of the adhesive by the action of cleaning agents has the same effect. Ultimately, this leads to errors in the registry and a decreased quality of the printed product (Mark Andy, 2018). Some versions of the plate mounting foam backing are designed to have micro-channels that allow air to flow through the adhesive, which helps eliminate bubbles between the plate mounting foam backing and the printing form.

2. METHODS

Currently, the densitometric method is most commonly used to control and determine the quality of flexible packaging. In this paper, the authors discuss the exciting possibility of printing on the WGH Vistaflex CL8 printing machine at a printing speed of 300 m/min. For the experiment, five anilox rollers with precisely defined cubic capacities were varied on the machine, of which anilox 3,8 cm^3/m^2 was used, which corresponds to a spatial frequency of 400 L/cm, anilox 5,5 cm^3/m^2, which corresponds to a spatial frequency of 340 L/cm, anilox 7,7 cm^3/m^2 which corresponds to a spatial frequency of 280 L/cm, anilox 10 cm^3/m^2 which corresponds to a spatial frequency of 200 L/cm and anilox 11.6 cm^3/m^2 which corresponds to a spatial frequency of 160 L/cm.

The purpose of the experiment was to investigate the influence of plate mounting foam backing on the reproduction quality in flexographic printing. For the experiment, a printing form was first made that contained two types of elements: elements for monitoring the optical density (Density) and elements for monitoring the tone value (printing wedge from 3% to 100% of the patch in steps of 10% of the screen tone value). For printing purposes, a Kodak Flexcel NX 74° Sh A printing form was used, which was made on a Kodak Flexcel Format Large 5080 CTP device. Standard_NX raster was selected.

The produced plates were fixed in different ways, using three plate mounting foam backings of varying hardness: Tesa Softprint hard plate mounting foam backing, Tesa Softprint medium plate mounting foam backing, and Tesa Softprint soft plate mounting foam backing. In the experiment, only one separation was used: a magenta solvent ink produced by Gecko and a 60 µm LDPE film produced by Di. Ri. Plast was used as a printing substrate.

During the experiment, 15 possible combinations were meticulously made, where changes were made to five different anilox rollers along with changes to three plate mounting foam backing. All combinations were measured with a TECHKON SpectroDens spectrophotometer and densitometer, based on which we obtained the results of the relative tonal value of the print and the optical density of the magenta tones. The obtained results are displayed in the Origin application. A microscopic image magnified 176 times obtained with a DinoLite microscope was used for detailed analysis. The microscopic image was used to evaluate the results obtained visually. Figure 3 shows a schematic representation of the performed experiment.

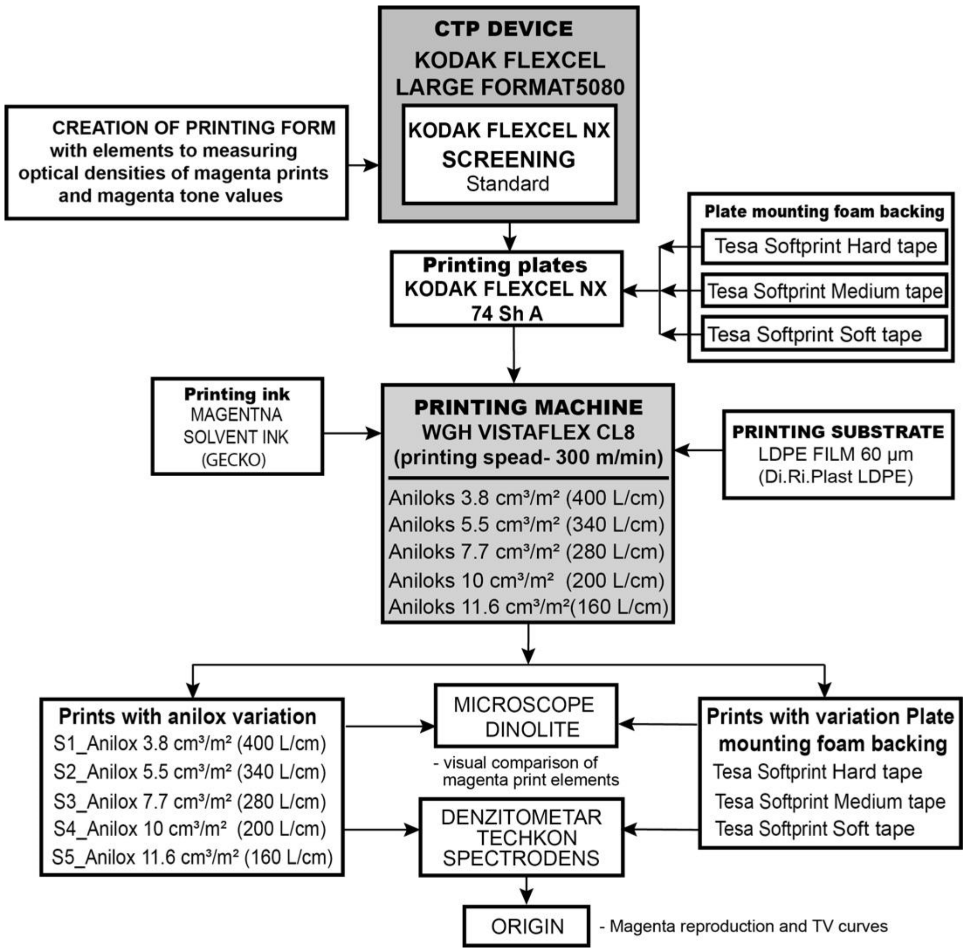

Figure 3: Schematic representation of the performed experiment

3. RESULTS AND DISCUSSION

The appropriate combination of plate mounting foam backing is applied to achieve the desired (controlled) deformation of the NX flexo plate. Figure 4 shows reproduction curves and magnified segments of light tonal areas of magenta prints created with five anilox rollers (160, 200, 280, 340, and 400 L/cm) along with the show of the permissible limit of colour deviation according to the FOGRA 39 standard.

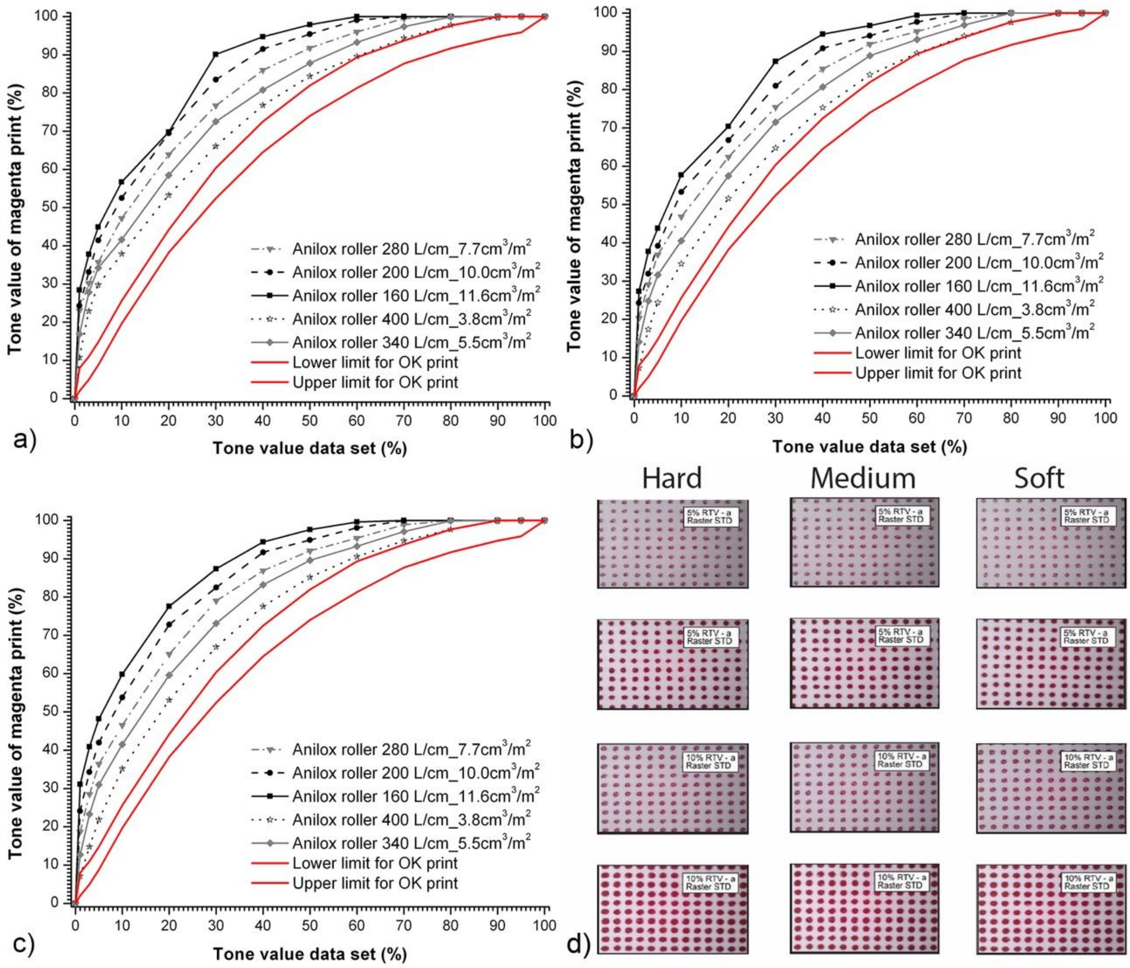

Figure 4: Influence of anilox rollers on the magenta reproduction curve when using the NX standard plate fixed with plate mounting foam backing: a) Tesa Softprint Hard; b) Tesa Softprint Medium; c) Tesa Softprint Soft; d) enlarged view of wedge segment with anilox 400 L/cm and anilox 160 L/cm

By applying a hard plate mounting foam backing in combination with a standard NX flexo plate (made with the screen option STD_NX) and printing with all experimental anilox rollers, reproduction curves were achieved that do not correspond to the values of the target ISO 12647-6 2013. At the same time, the anilox of the largest cubic capacity will give the worst, and the anilox of the shallowest cubic capacity will get the best results. The measured patches with the most negligible surface coverage (the lightest magenta tones) achieve a significant colour tone change, the tone value increase of which is ($TVI_{5\%TV}$=15,1%). After that, the magenta curves maintain a uniform increase, which is most pronounced in the tone area of 30% ($TVI_{30\% TV}$=24%). Minimal oscillations occurred in the range of higher tonal values ($TVI_{80\%TV}$=2,3%), after which their matching occurs.

By applying a medium hard plate, mounting foam backing in combination with an NX flexo plate made with the screen option STD_NX, and printing with five experimental anilox rollers, reproduction curves corresponding to the tone values (area) of the FOGRA 39 standard are also achieved. Thus, anilox 160 L/cm will give the worst results, and anilox 400L/cm will provide the best results. The measured patch with the most negligible surface coverage (the lightest magenta tones) achieves a significant magenta colour change, the increase of which is ($TVI_{5\%TV}$=19,4%). After that, the magenta curves maintain a uniform increase, most pronounced in the tone value area of 30% ($TVI_{30\%TV}$=22,6%). Minimal oscillations occurred in the range of higher tonal values ($TVI_{80\%TV}$=2,3%), after which their matching occurs.

Applying soft plate mounting foam backing and NX flexo plate made with the STD_NX screen option and printing with five experimental anilox rollers do not achieve the desired reproduction curves and do not correspond to the tone values (area) of the FOGRA 39 standard. Thus, anilox 160L/cm will give the worst results, and anilox 400L/cm will provide the best results.

The measured patches with the most negligible surface coverage (the lightest magenta tones) achieve a significant colour change, the increase of which is ($TVI_{5\%TV}$=26,3%). After that, the magenta curves maintain

a uniform increase, most pronounced in the tone value area of 20% ($TVI_{20\%TV}$=24,5%). Minimal oscillations occurred in the area of higher tonal values ($TVI_{80\%TV}$=2,3%), after which they became uniform.
The experimental application of five anilox rollers and three hardness plate mounting foam backing showed that the combination of anilox with the most minor spatial frequency and the most significant cup volume (160 L/cm = 11,6 cm^3/m^2) will be the worst, while the combination of anilox with the most significant spatial frequency and the smallest cup volume (400 L/cm = 3,8 cm^3/m^2) to be the best.
By applying all three plates mounting foam backing and anilox roller 3,8 cm^3/m^2 tone value in the range of 3 to 5% TV, the effect of print elements with visible central white will be maintained. In doing so, a shift of the white to the upper right edge can be observed, thereby reducing the ideal magenta tone. Anilox 11,6 cm^3/m^2 retains solid print dots, simultaneously achieving a higher optical density of magenta tone. Only the fields of 10% TV created with anilox 3,8 cm^3/m^2 are optically well realized and do not have whiteness within the print dots (barely noticeable). By using anilox with three times higher cubic capacity, a more contrasted magenta print will be realized with rapidly larger print dots reproduced. The most significant changes in the reproduction curve will be realized with the application of the largest and smallest cubic capacity of the anilox roller. Figure 5 shows the curves of mutual differences created using anilox of 3,8 cm^3/m^2 and 11,6 cm^3/m^2.

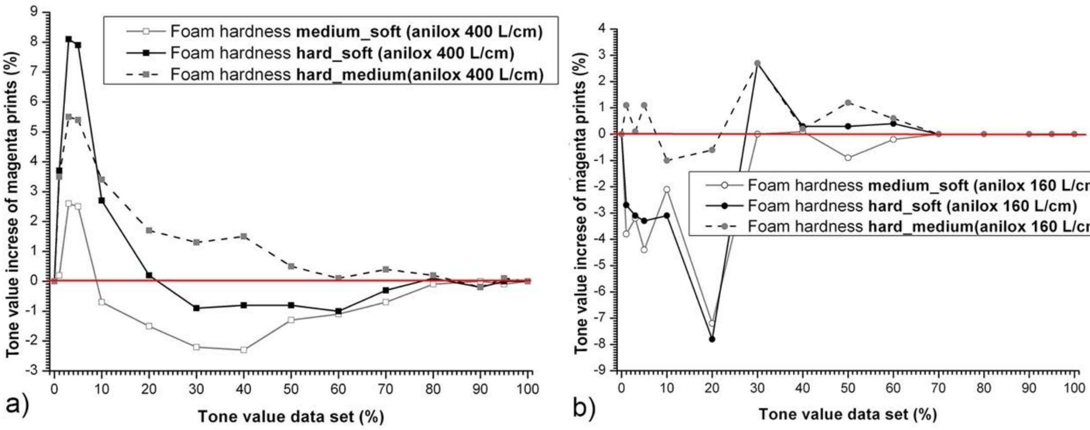

Figure 5: Comparison of changes in the reproduction curves resulting from direct variation of the hardness of plate mounting foam backing: a) with anilox 400 L/cm b) with anilox 160 L/cm

When using different plate mounting foam backings with the shallowest anilox, we observed large deviations. The most significant positive increases were achieved only up to the 5% tone value area. Changing from soft to medium plate mounting foam backing will result in the smallest increase ($\Delta TVI_{5\%TV}$=2,5%), while changing from hard to soft will provide the most significant growth ($\Delta TVI_{5\%TV}$=7,8%). Changing from medium to hard will also cause positive deformation of the printing elements (ΔTVI_{aver}=1,05%). All other combinations of plate mounting foam backing result in negative changes, with the most significant decrease occurring when changing from a medium-hard to a soft plate mounting foam backing (ΔTVI_{aver}=-1,07%). Using a 400 L/cm anilox roller with varying plate mounting foam backing hardness will result in minor oscillations within standard limits (+/- 2% TV). Adjusting the LUT curve in the CTP device's prepress will easily achieve optimal halftone printing. The least favourable combination with the least impact on the print is the variation from hard to soft plate mounting foam backing, which results in the printing elements closing after 80% TV.
When using the 160 L/cm anilox and different plate mounting foam backing hardness, no significant changes are observed in the reproduction curves. Positive changes occur when changing from hard to hard plate mounting foam backing, but there is visible instability in the print in the 10 to 20% tone value range ($\Delta TVI_{10\text{-}20\%TV}$=-1%). Other plate mounting foam backing combinations also show instability in the achieved changes, resulting in negative tone in the reproduction curves. The maximum decrease in the 20% TV patch area is $TVI_{20\%TV}$=-8. However, all other measured patches (covering more considerable surface) will not result in visible changes in increments ($\Delta TVI_{30\text{-}90\%TV}$= 0,2%).

4. CONCLUSIONS

The use of Tesa plate mounting foam backing with a Kodak NX flexo plate and various anilox rollers did not produce reproduction curves that align with the FOGRA 39 standard tone values. As a result, it will be necessary to create plate compensation curves for the analysed anilox rollers.

Densitometric measurements indicated that the finest anilox (400 L/cm = 3,8 cm^3/m^2) produced the highest-quality magenta prints with the smallest increase in tone value. On average, all combinations of plate mounting foam backing and halftoned surfaces resulted in a 67,7% tone value increase.

Conversely, the anilox 160 L/cm (11,6 cm^3/m^2) led to the poorest magenta prints and the highest dot gain increments, with an average tone value increase of 79,55%. The average difference between the best and worst reproduction curves was 11,85%.

The use of soft Tesa plate mounting foam backing resulted in the most accurate initial reproduction curve, closest to the allowed tolerance area. Transitioning from the soft plate mounting foam backing to the medium plate mounting foam backing while using the shallowest anilox led to a slight negative dot gain increase and improved reproduction of the brightest areas of the image. However, using the 160 L/cm anilox resulted in unsatisfactory dot gain increments, with minimal impact from the variation in plate mounting foam backing. Nonetheless, changing the hardness of the plate mounting foam backing from medium to soft still achieved an increased curve within the ISO standard tolerance 12647-6. The use of Tesa plate mounting foam backing with a Kodak NX flexo plate and various anilox rollers did not produce reproduction curves that align with the FOGRA 39 standard tone values. As a result, it will be necessary to create plate compensation curves for the analysed anilox rollers.

7. REFERENCES

Anderson & Vreeland. (2019) *Nyloflex® FTF Digital. FlintGroup*. Available from: https://www.andersonvreeland.com/wp-content/uploads/2015/09/nyloflex_FTF_EN.pdf [Accessed 26th June 2024].

Bin, D. (2009) *Dot Gain in the Digital Flexographic Process by Varying Screening Techniques and Pressures*. PhD thesis. Institute of Printing and Packaging Engineering, Xi'an University of Technology, Xi'an, China.

FFTA Flexography. (1999) *Principles & Practices 5th Edition Volume 1 Flexography, Principles And Practices.* n.p., Foundations of FTA.

FlexoTech. (2019) *New hardness level for Flint Group's rotec Compressible Sleeve. FlexoTech, Whitmar Publications.* Available from: https://www.flexotechmag.com/news/18958/new-hardness-level-for-flint-group-s-rotec-compressible-sleeve/ [Accessed 21st June 2024].

International Organization for Standardization (ISO). (2013) ISO 12647-6:2013. *Graphic technology – Process control for the production of half-tone colour separations, proof and production prints.* Geneva, Switzerland.

Joyce, M., Avuthu, S. G. R., Emamian, S., Eshkeiti, A., Atashbar, M., Fleming, P. D. & Donato, T. (2014) Contribution of Flexo Process Variables to Fine Line Ag Electrode Performance. *International Journal of Engineering Research & Technology (IJERT)*. 3(8). Available from: doi: 10.17577/IJERTV3IS080608

Lee, B. (1998) *Design characteristics unique to the flexographic printing process*. PhD thesis. Rochester Institute of Technology, New York.

Mark Andy. (2018) *Secure Your Workflow: Best Tapes for the Job.* Available from: http://blog.markandy.com/secure-your-performance-best-tapes [Accessed 21st June 2024].

Petrović, S. (2020) *Characterization of composite flexographic printing plate carriers and their influence on cardboard packaging print quality*. PhD thesis. Faculty of Technical Sciences, Novi Sad.

Rogers, A. (2011) *Choosing the right anilox-roll engraving for the application*. Available from: https://www.harpercorporation.com/media/downloads/Choosing%20the%20right%20engraving_Converting%20Q%204thQrtr2011.pdf [Accessed 21st June 2024].

Smyth, S. (2017) *The Future of Global Printing to 2022.* Surrey, United Kingdom, Smithers Pira.

TESA. (2024) *Complete package for high quality label printing: tesa® self-adhesive tape assortment for flexographic label printing*. Available from: www.///Users/igor/Downloads/Complete%20package%20for%20high%20quality%20label%20printing.pdf [Accessed 27th July 2024].

White, A. (1998) *High Quality Flexography, Second Edition*. Leatherhead, Pira International.