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THE ANALYSIS OF PARAMETERS THAT AFFECT PRINT QUALITY OF SCREEN PRINTED PVC FOILS

ANALIZA PARAMETARA KOJI UTJEČU NA KVALITETU TISKA DOBIJENOG TEHNIKOM SITO TISKA NA PVC FOLIJAMA

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Abstract

Screen printing technique is used to apply transfer images to a wide variety of substrates. PVC foils can also be used as substrates. In the screen printing process on PVC foils different type of substrates, inks, as well as different mesh types, can be used. In this research, we used two types of substrates (ORACAL 640 - Print Vinyl and LG Hausys LP2712), three different kinds of ink (Hi-Gloss 35 000, 85 000 and Ondaflut Texilon 58.000), and screens with three different mesh counts (77, 120 and 140 n/cm). These substrates are exposed to various environmental factors including, light, etc. The aim of this paper is to determine differences between samples caused by variation of mentioned parameters on lightfastness.

Keywords: *PVC foils, screen printing, print quality, lightfastness*

Sažetak

Tehniku sito tiska karakteriše sposobnost tiska na velikom broju različitih podloga, pa se tako ovaj postupak tiska primjenjuje i pri tisku PVC folija. U procesu tiska na ovu vrstu podloge, može se vršiti varijacija različitih procesnih parametara, kao što su podloge, boje i gustine tkanja sita. Upravo zbog toga u ovom istraživanju korištene su dijve vrste tiskarskih podloga (ORACAL 640 – Print Vinyl i LG Hausys --------+LP2712), tri različite vrste boje (Hi-Gloss 35.000, Ondaflut 85.000 i Texilon 58.000), kao i sita sa tri različite gustine tkanja (77, 120 i 140 n/cm). PVC folije koje su predviđene za aplikaciju na vetrobranska stakla izložene su vremenskim uslovima. Cilj ovog rada je da se utvrdi, koliko će se postojanost uzoraka na svjetlost razlikovati ukoliko se promene parametri podloge, vrste boje i gustine tkanja sita.

Ključne reči: *PVC folije, sito tisak, kvalitet tiska*

1. Introduction

1. *Uvod*

Screen printing technique is known as a technology that enables printing on a large number of different substrate materials such as paper, plastics, textiles, ceramics, metal, wood, glass and many others [1]. Using this printing method, substrates of various thicknesses, as well assubstrates with irregular surface shapes can be printed, which contributes to the high applicability of this printing technique. Regarding printing on plastic materials, the most frequently used substrates are PVC self-adhesive foilsthat are available on the market in the form of rolls or sheets cut into different formats, as well as in various colors. Also, printing on hard PVC materials can be successfully accomplished. In addition, the screen printing technique can be used for printing on the polyethylene, which is used for making various kinds of bags. While the greater ink deposit is necessary in the printing process of plastic materials due to their exposure to environmental influences, it is a common thing to use screens of different mesh counts because it affects ink deposit on the substrate material, and thus final print quality[2]. Besidesmesh count of the screen, important parameters that affect print

quality are the material of mesh, weaving method, the thread thickness, and the snap-off distance [3]. One of the many applications of screen printing technology is for labels intended to be applied on the windshields of cars. Such prints are exposed to many environmental influences. Subjecting the samples to light and weather conditions have a significant impact on product quality, mainly because it causes certain changes in the color reproduction. This is a huge problem because the final appearance of the product cannot be predicted [4]. Light exposure of the printed samples can be done in accordance with the following standards ISO105 - B02-B01-1999 ISO105, ISO105-B03 -1997, ISO105-B04-1997, ISO105-B05-1996, ISO105-B06-1999, ISO105-B07 2009, ISO105-B08: 1999.
Concerning the light exposure of the printed samples, many authors selected standard ISO105 - B02 [5; 6; 7;8, 9;10;11], while certain authors opted for multiple standards, combining AATCC Test Method, Japanese Industrial Standard L0841 and British Standard 1006:B01/1-7 [12]. On the other hand some, are opted to test lightfastness using domestic standard, Chinese Standard GB/T8427-2008[13].
The aim of this research is to determine the effect of different substrate material types, different ink types, and various screen mesh counts, on the lightfastness of the printed samples.

2. Method

2. *Metod*

In the experiment were used two types of self-adhesive PVC foils (ORACAL 640 - Print Vinyl and LG Hausys LP2712), both having the same material composition, thickness (80 μm) and color (transparent). It is important to emphasize that both substrates are intended for outdoor use, where, according to the manufacturer's specifications, durability in the outdoor environment of the ORACAL 640 foil is 3 years and 2 years for LG foil. As a test pattern for printing, the logo of the Faculty of Technical Sciences in Novi Sad (10 x 10 cm) was used. This logo enables examination of the basic printing parameters. It possesses a large area of full tone and very thin lines that can indicate the quality of the ink transfer onto the substrate under certain conditions. During printing of large solid areas, the squeegee pressure must be reduced to avoid pouring ink under the stencil as well as smearing of the ink on the surface of prints, while on the other hand, lower printing pressure may lead to breaking of the thin lines. Only when all the parameters are appropriately set (mesh count, stencil, ink, snap-off distance) it is possible to obtain quality prints. Also, the printed thin lines are the best indicators of differences in screen resolution caused by different mesh count application.
Screen mesh used for printing process is SAATI-SAATILENE HITECH (Italy), a polyester mesh. This mesh is characterized by its stability and easy stencil production, sharp details of the prints, good control of the ink passage through the mesh, efficiency in terms of ink consumption, fast printing process, squeegee stability, high resistance to abrasion. These characteristics provide advantages over previously applied meshes made of natural silk. Basic mesh characteristics used for printing in the experiment are presented in Table 1.
Aluminum screen printing frames were used as the holders of the printing mesh. The size of printing plate without printing frame was 35 x 50 cm. Printing plates have been developed

Tablica 1 *Karakteristike sita korišćenih u eksperimentu*
Table 1 *Screen meshes characteristics*

Mesh count	Weave type	Mesh opening	Percentage of open area	Thread diameter	Theoretical ink consumption	Recommended mesh tension
threads/cm	PW TW	μm	%	μm	cm3/m2	N/cm
77	PW	70	36	80	29	24-26
120	PW	45	29	54	16	24-26
140	PW	38	28	48	13	20-20

using conventional linearized positive films. The optical density of the transparent parts of the film was 0.03, and opaque parts 4.1. Films resolution was five times lower than mesh count. As a photosensitive layer, Manoukian Argon ZERO-IN DUAL SV PLUS VIOLA emulsion was used. UV exposition of the plates was performed by metal halide UV lamp (1000 W), at a distance of 1 m from the mesh. In this particular case, exposition time for three screen meshes used in the experiment (77, 120 and 140 threads/cm) were 4, 3.5 and 3 min.
The printing of the samples was carried out by screen printing technique, using SITOTEHNIKA - SB2V printing machine. Printing speed was 15 cm/s, and a snap-off distance 3 mm. The choice of squeegees is very large because each substrate requires appropriate rubber squeegee. Eventually SERILOR HR 1 white polyurethane squeegee with rectangular profile (50x9 mm), the hardness of 75 Shore A Type, was selected. This squeegee possesses high resistance to chemicals and abrasives which allows easy cleaning using solvent.
For the experiment, three inks (MANOUKIAN Argon manufacturer) with the same hue, but different characteristics were used. The inks have the same hue (85.401 cobalt blue). For each used ink (Hi-Gloss 35.000, Ondaflut 85.000 and Texilon 58.000) there is a suitable solvent from the same manufacturer. The easiest one to work with is Texilon 58,000, which is also the most viscous one. It proved to be the best one in terms of ink transfer to the printing substrate. This is due to its high viscosity, so pouring of the ink on the underside of the stencil, nor ink smearing when separating the mesh from the substrate do not occur. Despite its high viscosity, Texilon ink has great transfer characteristics (through the mesh), which allows simple printing process of large full tone areas as well as fine lines at the same time.
To obtain data on the effects of the environment on which the printed samples can be exposed during exploitation period, printed samples were placed in the test chamber Xenon Alpha, Atlas that simulates environmental conditions, in order to establish the effect of light and weather conditions on the printed samples.
The samples were exposed to exactly defined conditions (temperature, light exposure, relative humidity), in order to reveal the behavior of materials under the influence of simulated conditions of the aging process (ISO 105-B02).
The print quality analysis includes the color reproduction analysis after printing and after subjecting the samples to the light. Color reproduction was analyzed by measuring CIE Lab coordinates of solids (full tones), and by determination of the color differences (ΔE2000), between the solely printed samples and the same samples after the light exposition. CIE Lab color coordinates of the samples were determined using a spectrophotometer SpectroDens (illumination D50, the standard observer 2º, measuring geometry 0°/45°, aperture 3 mm).
Visual difference between two colors was evaluated regarding following criteria [14]: ΔE between 0 and 1 - the difference cannot be noticed, ΔE between 1 and 2 - a very small difference, ΔE between 2 and 3.5 - mean difference, ΔE between 3.5 and 5 - a big difference, over 5 ΔE - massive difference.
In order to include the appearance of fine lines into tests, microscopic analysis of the samples was performed using Sibress Pit digital microscope, with the ability to magnify sample 140 times.

3. Results and discussion

3. *Rezultati i diskusija*

The magnified image of the samples printed by Texilon ink on the ORACAL 640 substrate material reveals that printed lines on the samples printed with higher mesh counts possess more accurate shape, i.e. the extent of discontinuity and raggedness is less present, comparing to the samples printed with screens that possess lower mesh counts (Figure 1).
Although the analysis showed that for the better lines, and characters reproduction quality, it is better to use screens with higher mesh counts, the lightfastness results provide different information (Table 2).
The results showed that with mesh count increase, lightfastness of the samples decreased, regardless of ink type or substrate material used. As the most stable ink – the ink that shows the best lightfastness property, had proved to be HI-Gloss 35,000 ink because the samples printed with this ink type had

Slika 1 *Snimak uzoraka odštampanih sa Texilon bojom na ORACAL 640 (77, 120 i 140 n/cm)*

Figure 1 *Prints made with Texilon ink on ORACAL 640 (77, 120 and 140 threads/cm)*

Tablica 2 *Postojanost uzoraka na svjetlost*

Table 2 *Lightfastness of the samples*

Sample	ΔE	Sample	ΔE	Sample	ΔE
1-A-77	1.5	1-B-77	1.7	1-C-77	1.8
1-A-120	1.89	1-B-120	2.02	1-C-120	2.15
1-A-140	2.1	1-B-140	2.25	1-C-140	2.4
2-A-77	1.8	2-B-77	1.87	2-C-77	1.93
2-A-120	2.07	2-B-120	2.15	2-C-120	2.28
2-A-140	2.21	2-B-140	2.5	2-C-140	2.6
Remark: 1 – ORACAL 640, 2 - LG Hausys LP2712, A - Hi-Gloss 35.000, B - Ondaflut 85.000, C - Texilon 58.000, 77, 120 and 140 – mesh count					

lower color difference values comparing to the samples printed using other two ink types. The analysis showed that ORACAL 640 substrate material has better lightfastness comparing to LG Hausys LP2712 substrate, which was expected, because the manufacturer provided information about the greater durability of this material in the specification. Generally, the results show that the lightfastness of all samples is quite good, because all of the color difference values between solely printed samples and those which were after exposed to light fell into two groups: ΔE between 1 and 2 - a very small difference, ΔE between 2 and 3, 5 - mean difference.

4. Conclusion

4. *Zaključak*

The obtained results of the investigation showed that besides the selection of printing ink, screen mesh count and the substrate material, the dominant motives that are going to be printed have to be considered as well. Thus for the prints that possess a big amount of lines and characters, it is better to use screen meshes with higher mesh counts because the lines and letters will be more continuous without line interruptions, which will not have bigger effect on lightfastness of the samples. If the design that needs to be printed possesses dominant full tone areas, then the better optionis to select lower mesh counts. Also, the type of substrate material for printing process is not negligible parameter, so if required printed product is not designed for longer exploitation period, it is advisable to choose a cheaper type of substrate material, which will give relatively good stability of printed samples to light exposure. In case of the printed products that require long exploitation period, high-quality substrate materials have to be selected. The choice of inks is also an important thing because even the ink type can enhance the lightfastness of the samples.

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