

Original Scientific Paper – Originalan naučni rad

THE ANALYSIS OF THE SUBSTRATE INFLUENCE ON THE PRINT QUALITY PARAMETERS OF SCREEN-PRINTED TEXTILE

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ABSTRACT

Textile printing is an increasingly important area of the contemporary graphic industry, and screen printing represents a dominant technique in this field. The quality of the print depends on many parameters, such as the type of substrate material or the type of printing ink. The usual way to evaluate print quality consists of an objective assessment of the color and tone of the printed image. Quality parameters, such as contrast, sharpness, and macro non-uniformity, are not associated with color reproduction, but certainly affect print quality. These parameters are directly related to the quality of the lines and raster dots, which is an integral part of any image. Therefore, when evaluating print quality, it is necessary to analyse these elements. The aim of this paper was to investigate the influence of the textile substrate on the quality of print obtained by the screen-printing technique. Digital image analysis of the scanned image of the print, appropriate software application and visual evaluation of the prints, were used to determine the print quality. The obtained results show the importance of interaction between the textile material and printing ink and its influence on the print quality parameters.

Keywords: Screen printing, print quality, textile materials, digital image analysis.

INTRODUCTION

Quality parameters, such as contrast, sharpness, and macro non-uniformity, affect print quality, and they are directly related to the quality of the lines and raster dots, which have an influence on the appearance of the printed image. Therefore, during the assessment of print quality, in addition to analyzing color reproduction, it is also necessary to analyze these elements (Stančić, Kašiković, and Novaković, 2013; Plazonić, Bates, and Barbarić-Mikočević, 2016). Textile materials can be printed using various techniques such as screen printing, digital printing and thermal transfer printing, but screen printing is the dominant textile printing technique (Novaković, Kašiković, and Vladić, 2010). The screen printing technique is characterized by great flexibility with regard to printing on different types and forms of substrates, using different types of inks. This technique allows for various decorative and industrial applications that are not feasible in other printing methods. To understand the capabilities and characteristics of the textile screen printing, it is necessary to examine the effect of the printing system elements, in order to determine the adequate combination for achieving the maximum print quality (Lazendić, Kašiković, and Milošević, 2019). The reproduction of lines and dots can be affected by the properties of printing plate, ink or printing substrate (Ingram, 1999). Today, there are a large number of textile materials on the market with different physical and chemical properties, which are of great importance for the printing quality. The composition of the

printing substrate affects the ability of ink to penetrate into material structure, as well as the parameters such as fabric construction and elasticity. Natural fabrics tend to absorb the ink more readily than synthetic, which tend to be less porous and permeable. Fabrics such as cotton and cotton blends are soft and permeable, and synthetics are more flexible, making the fabric tear-resistant. Generally, synthetic textile materials have smooth, tight surfaces that offer little texture for ink adhesion. As a unique characteristic of the screen printing process, rheological behavior of the ink together with the mesh wettability, will also influence print quality (Szentgyörgyvölgy, and Borbèly, 2011). It is important that printing ink has good adhesion to the substrate (Kipphan, 2001). The aim of this paper was investigation textile substrate composition influence on the quality of prints obtained by the screen printing technique, applying a digital analysis of the scanned image of the print, appropriate software application and visual assessment.

MATERIAL AND METHODS

Fabrics with different material compositions were used as printing substrates (Table 1). A fabric made of a mixture of viscose and cotton fibers (viscose 45% and cotton 55%), 100% polyamide fiber fabric and 100% cotton fiber fabric were used (Figure 1). The listed materials were cut to 210 x 297 mm format before the printing process.

Table 1. Properties of textile materials used as a printing substrate

Sample	Type of weaves	Material composition [%]	Fabric weight [g/m ²]	Thread count [thread/cm]
Polyamide	Canvas	Polyamide 100	110	Vertical: G _v = 23
Cotton	Canvas	Cotton 100	140	Horizontal: G _h = 19
Viscose/cotton	Twill	Viscose 45 Cotton 55	116	Vertical: G _v = 34

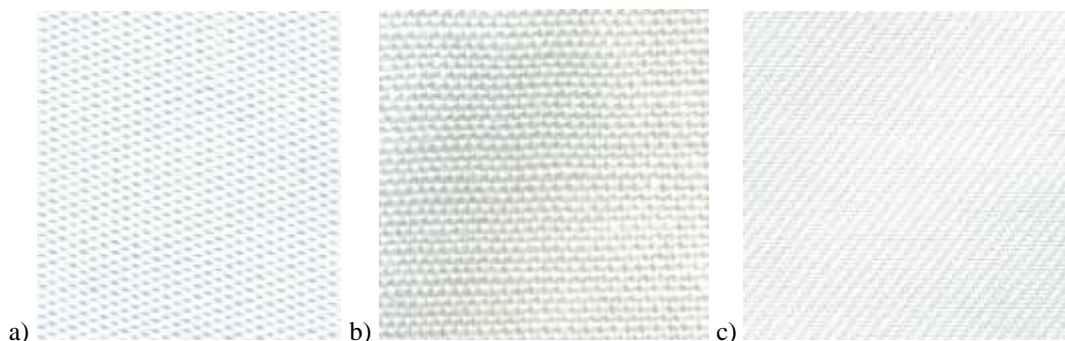


Figure 1. Material surface before printing: a) Polyamide, b) Cotton, c) Viscose/Cotton

The printing speed was 15 cm/s, the hardness of the squeegees was 85 (Shore Type A), and the screen mesh distance from the printing material was 4 mm. Printing was performed by Texopaque Classic OP ink, which is a conventional plastisol ink designed for printing most common natural and synthetic fabrics. The printing plate was developed conventionally using linearized positive films. Sericol Dirasol 22 emulsion was used as the photosensitive layer. The illumination was performed with a R-UVA lamp (40 W) for 90 seconds at a distance of 20 cm.

An Epson Perfection V10 scanner was used for printed samples scanning. The automatic image correction option was turned off before scanning samples. Samples were scanned at a resolution of 1200 dpi. ImageJ application was used for image processing and analysis. ImageJ is a Java-based image processing program, that can display, edit, analyze, process, save and print various image types (Collins, 2007). The test form was generated using the Adobe Illustrator CC software application. The form contains all the elements needed to analyze the sharpness of the print based on the quality of the reproduced line. The form contains a series of vertical and horizontal lines of

different widths (Figure 2). It also contains a series of different diameters dots for analysis based on the quality of the reproduced dot (Figure 3). For analysis of lines reproduction, fields with horizontal and vertical lines of 2 pt thickness and 15 mm length are required. Fields with dots 0.6 mm in diameter are required to analyze dot reproduction.



Figure 2. The part of the test form for analysis of line reproduction



Dot Quality: 0.1,0.2,0.3,0.4,0.5,0.6 mm dots

Figure 3. The part of the test form for analysis of dot reproduction

RESULTS AND DISCUSSION

The quality of line reproduction was determined by analyzing the surface area and circumference of the line 2 pt (0.7 mm) wide. The values were measured by ImageJ software. The ideal line, which is used to measure the deviation of the measured values, was computer generated. Analysing the Figure 4 it can be observed that during the printing on different substrates there is a slight increase in the line surface relative to the ideal value. The highest deviation was observed on viscose/cotton fabric, then on polyamide and finally on cotton. However, the difference between the measured values of polyamide and cotton is negligible. The measured line circumference values are above the ideal line value. The largest deviation in the value of the line circumference occurs when printing is performed on cotton. The smallest deviation was measured on polyamide. The measurement results are shown in Figure 5.

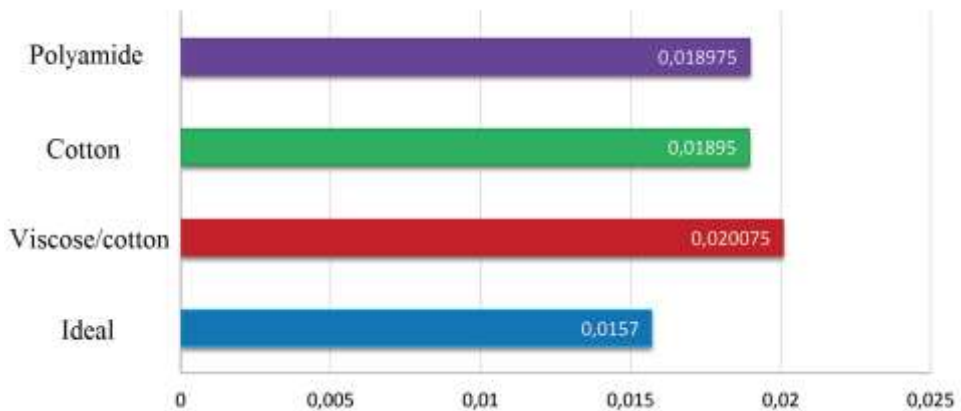


Figure 4. Surface area of 2 pt (0.7 mm) lines

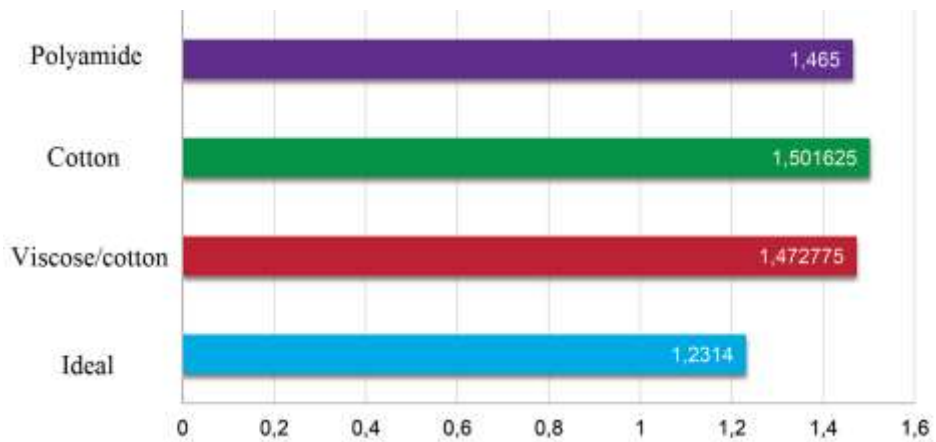


Figure 5. Circumference of 2 pt (0.7mm) lines

After analyzing the values of the surfaces and the circumference of the lines, the roundness of the dots printed on different substrates was analyzed. The dot roundness was also measured by ImageJ software. Dots 0.6 mm in diameter were measured. The average values of the dot surfaces are presented in Figure 6.

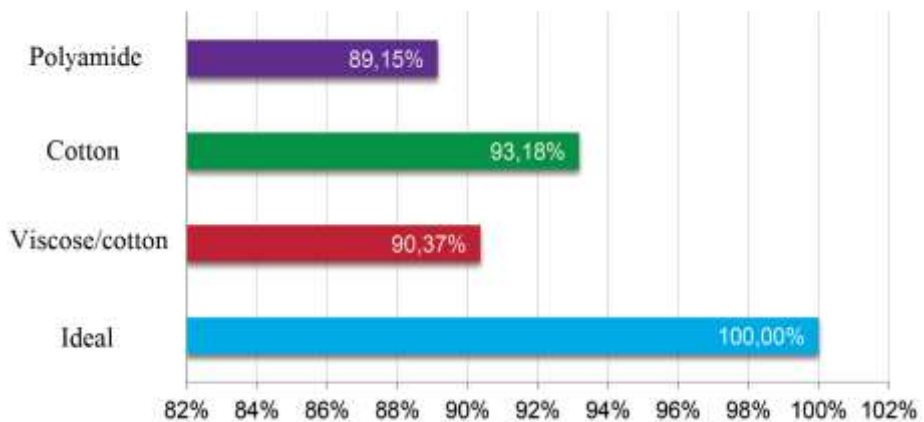


Figure 6. Roundness of dot with diameter of 0.6 mm

According to the obtained results, the values closest to the ideal dot roundness are obtained on the cotton substrate. The values measured on viscose/cotton and polyamide are lower than the values on cotton and therefore the ideal dot roundness. To analyze the text printing quality, the area and circumference of the letter "S", size 12 pt (4.23 mm) were measured (Figure 7). The obtained values of the surfaces and the circumference are shown in Figures 8 and 9.



Figure 7. Text printing quality: a) polyamide, b) cotton and c) viscose/cotton

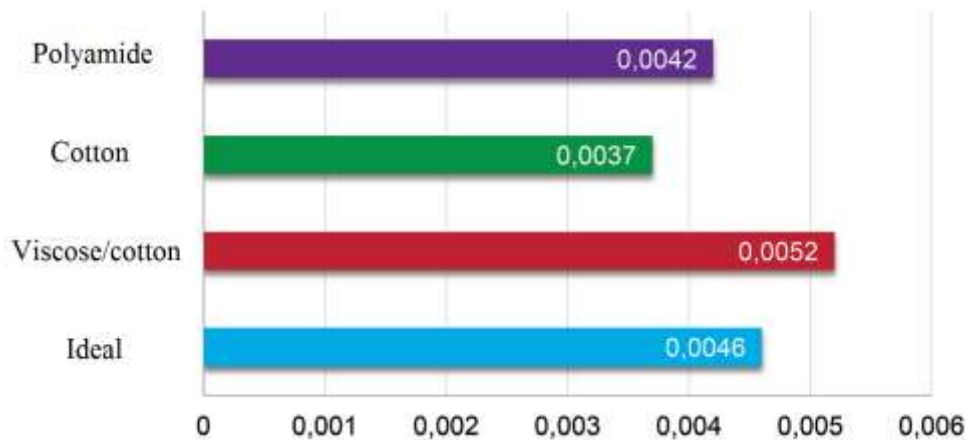


Figure 8. Surface area of letter “S” 12 pt (4.23 mm)

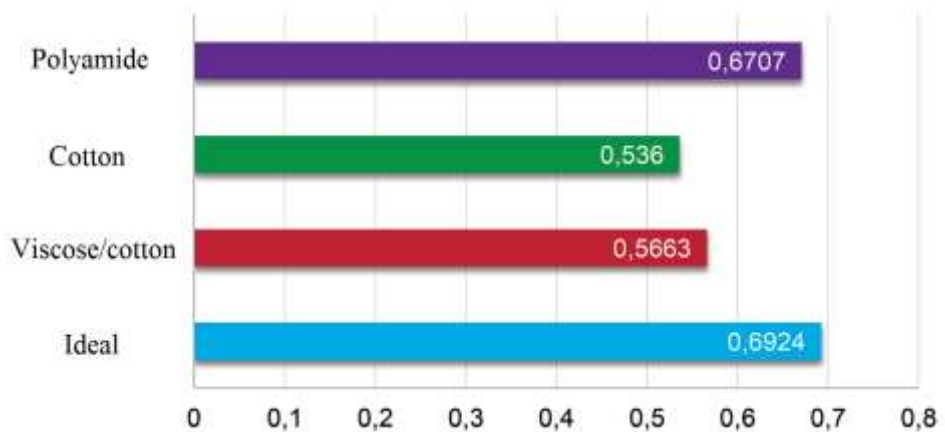


Figure 9. Circumference of letter “S” 12 pt (4.23 mm)

The highest value of the letter surface area was measured on viscose/cotton substrate. The lowest value was measured on cotton, which can be attributed to good absorption, while on polyamide the surface area of the letter is closest to the ideal. The values for the letter circumference (Figure 9) are lower than the ideal value on all three substrates. However, the closest value is also observed for printing on polyamide. Cotton substrate has the lowest value of letter circumference.

Macro non-uniformity of the surface is defined by the macro non-uniformity index measured in ImageJ software. The obtained values of the macro non-uniformity are shown in Figure 10.

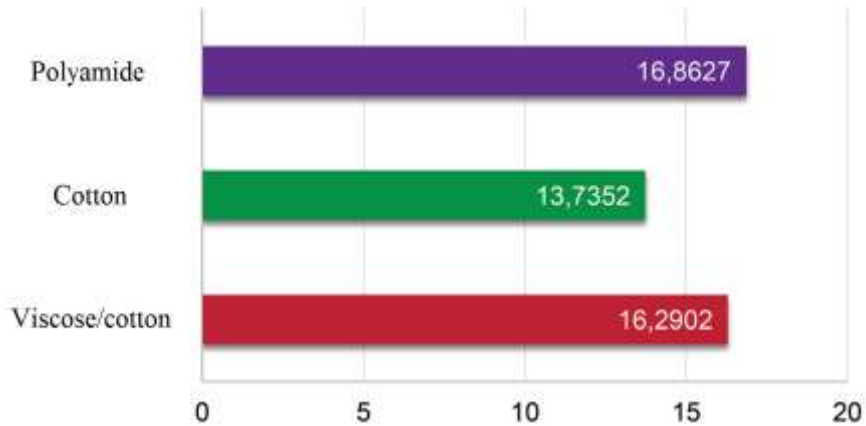


Figure 10. Macro non-uniformity of printing substrates

The macro non-uniformity index is in the range from 13 to 16, which is common for textile substrates. The ideal value of macro non-uniformity is zero, so a lower value represents better macro non-uniformity, and a smaller surface pattern in the print. The lowest value of macro non-uniformity was obtained for printing on cotton, which was expected according to its good absorbency. On the other hand, the highest value was measured on polyamide. Figure 11 shows catted printed samples, which were used for measuring the macro non-uniformity index. By the visual evaluation of the prints, the same results can be noticed.

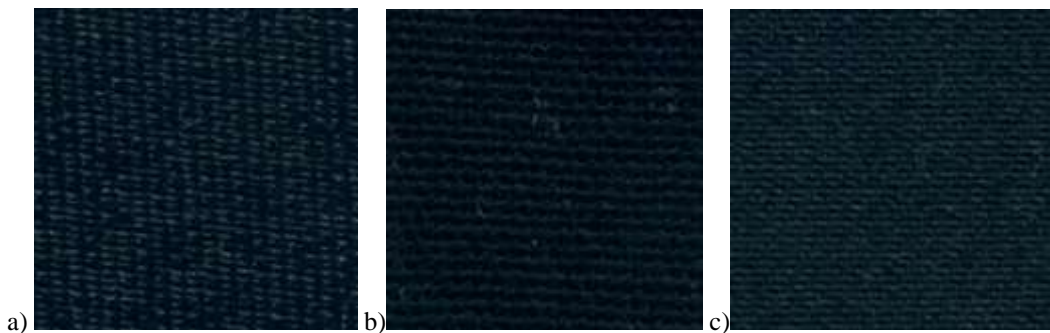


Figure 11. Printed samples: a) polyamide, b) cotton and c) viscose/cotton

CONCLUSIONS

An important factor for printing on textiles is the selection of substrate materials. The composition of the material with its physical and chemical properties can significantly affect the print quality. In this paper, to analyze the influence of different textile substrates on print quality, the test forms were printed by screen printing technique on cotton, polyamide and a mixture of viscose and cotton fabric. The following parameters of print quality were analyzed: line and dot reproduction, printed text quality and macro non-uniformity. The analysis of line reproduction indicates an increase in the values of the line surface area and the circumference, relative to the ideal values. The highest deviation of the line surface area is observed on viscose/cotton fabric, while deviations in the line circumference are noticeable with all three materials, however, the difference between them is minimal. The analysis of dot reproduction indicates that dot roundness values are significantly less than the ideal value. The highest dot roundness was observed on cotton, which was attributed to its absorbency. Printing on polyamide and viscose/cotton fabrics results with dots with

lower roundness. An analysis of the text quality indicates that printing on polyamide result with a value closest to ideal, while printing on cotton gives a value less than ideal. For printing on viscose/cotton fabrics, the value of letter surface area is higher and the circumference is lower than the ideal value. The highest macro non-uniformities were observed for printing on polyamide and viscose/cotton fabric, although the difference between their values is not significant. The lowest macro non-uniformity was noticed on cotton, which indicates that ink layer is the most uniform on this substrate.

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