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The colorimetric and microscopic analysis of differences in colorfastness to rubbing process caused by different composition of screen print inks

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Screen printing is dominant method for textile printing. Wide verity of textile products and their applications demands printing inks of different composition also. These differences among inks cause different exploitation characteristics. Having in mind that textile products are printed mainly in order to achieve aesthetic effect it is important to maintain constant color values throughout the products exploitation period. Among other influencing factors rubbing process is very important factor in color changes of textile products during its exploitation period. This paper aims to conduct the colorimetric and microscopic analysis of colorfastness to rubbing process caused by different the composition of the oil and water based screen print inks. Beside the ink composition, mesh count variation of the screen was also used (43 and 100 threads/cm). 100% cotton based textile material was used as a substrate. Results indicate that oil based inks and lover mesh count of the screen can produce better colorfastness, thus resulting in longer lasting printed products.

Keywords: colorfastness, rubbing, screen printing, cotton

1. INTRODUCTION

Textile products are most often sold to the final consumer with specific pattern or illustration applied to their surface. This makes textile products more desirable and more valuable. Textile printing can be defined as a process of applying color to fabrics through localized dyeing, or as the art and science of decorating a fabric with a colorful pattern or design [1]. The usual methods for textile printing are flat-bed screen printing and rotary screen printing, these two processes make nearly 80% of the total textile printing output [2]. Recreant introduction of digital ink jet printing provides some advantages, such as simplicity and customization possibilities. Ink jet textile printing is predicted to become even more popular in the near future as production speeds increase. But stil screen printing has a great advantage over digital printing in terms of cost when low-circulations are produced [3]. Ink jet printing demands at least three-pass printing on the pretreated cotton fabric in order to produce the same levels of color gamut, volume and saturation as screen prints [4]. A comparison of colorfastness properties between these two techniques proves the differences. Screen printed fabrics have better colorfastness to washing, perspiration and rubbing, while the ink-jet printed fabrics have better colorfastness to dry-cleaning and light [5].

Cotton is one of the most important fibers in the textile industry and its considered to account for more than 70% of all printed substrates [6]. Coloration of coton can be achieved with either dyes, by dyeing or printing, or with pigment by using a print paste/ink.. Printing with dyes and pigment inks use different chemical principles. Dye is soluble and has affinity to the fiber on which is applied, while pigments are not soluble and don't show affinity to the fiber [7]. Dye is fixed be the suitable bond formation between dye and fiber usually hydrogen bonds, Ionic or electrostatic bond and covalent bond. On the other hand pigments and fiber have no interaction the pigment is fixed a binder. Binder is external agent, which provides linkage between pigment and fiber. Although, dyed printing produces soft tactile textures, pigment printing is more popular for textile printing. Factors contributing to the pigment printing popularity are easy application on a variety of fabrics, simple ink preparation recipes, and the absence of fixation after printing are the primary factors contributing to the popularity of the method.

Printing ink also known as printing paste contains pigments, thickeners, binders, and auxiliaries. Depending on the class of pigment used

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and style of printing employed ink composition can vary. Therefore, it is worthwhile investigating the colorfastness characteristics of fabric prints achieved though using flat-bed screen printing and pigment dispersion systems.

There are numerous influences on the printed fabric during exploitation such as friction, color adhesion after washing, thermal load, washing process, friction, UV light, etc. [1]. The fastness property of pigment ink on the fabric depends on the adhesion between binder film and fiber and also on the strength of the binder film. Stronger the adhesion and stronger the film better would be fastness property. The binder film can be abraded, thus giving the pigment inks poor rubbing fastness particularly wet rubbing fastness. Characteristics such as softness, elasticity, plasticity, solvent stability, fastness requirements and the production cost of the textile product will most significantly influence the choice of binders [8]. Thickness of the ink film is also a factor, it is dependent on the pressure applied during the printing process and the mesh count. Fabric or mesh count is one of the most important parameters that influences printing quality. It corresponds to the number of threads/cm. Besides the mentioned printing process parameters, the pretreatment of the textile fabric can also influence the fastness properties [9]. The goal of this paper is to explore colorfastness to rubbing process caused by different composition of screen print inks and screen mesh used in the printing process.

2. EXPERIMENTAL

2.1. Materials

Printing substrate used for this experiment was 100% cotton material. Deposition of the ink was done using conventional screen printing technique. SEFAR Basic mesh was used, in two variations of screen printing mesh count, 43 threads/centimeter and 100 threads/centimeter, characteristics are shown in Table 1.

Table 1. Characteristics of screen printing mesh

Screen printing mesh: SEFAR BASIC									
Mesh number	Mesh count [/cm]	Thread diameter nominal [μm]	Weave	Tolerance of mesh count [± n/cm]	Mesh opening [μm]	Open area [%]	Mesh thickness (woven) [μm]	Tolerance of mesh thickness [μm]	Theoretical ink volume [cm^3/m^3]
100/25 5-40 PW	100	40	1:1	3.5	55	25	75	6	20
43/110-80 PW	43	80	1:1	2.0	149	41	130	10	53

Synthetic rubber squeegee 75 shore, was used. Variation of binder type in ink composition and color was used. Specifically Oil based Sericol Texopaque Classic OP plastisol inks (black OP 001 and red OP 134), and water based Texiscreen Aqua AJ (black WBA 70 and red WBA 22) print inks.

2.2. Method

Samples were printed using the variation of the mention screen printing mesh, ink composition and color according to ink manufacturer instructions, honoring recommended drying and fixating process. The patches of color were printed on to the substrate, and later cut in to peace's, adequate for testing, dimensions 10 x 10 mm.

Electronic crockmeter Testex textile instrument LTD. TF411, was used for testing colorfastness of textiles to dry rubbing. Rubbing head diameter 16 mm, vertical pressure 9 N, rubbing stroke 104 mm, according to the ISO 105x12/D02 standard. Colorimetric measurements and microscopic analysis of the samples were taken after printing and after 20, 40, 60, 80, and 100 rubbing repetitions.

Colorimetric of the samples were taken using HP200 colorimeter, D65 lighting, 2° standard observer and d/8 measuring geometry. Spectrophotometric measurements using X-Rite Eye One Pro, 0/45° measuring geometry. Microscopic imagery was made using Vitiny VT 300 microscope at 10x optical magnification and 1600 x 1200 px resolution.

After colorimetric measurements were taken, color differences were calculated according to the CIE 1976 (ΔEab) color difference formula shown below.

$$\Delta E_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

where $\Delta L^* = L_1 - L_2$, $\Delta a^* = a_1 - a_2$, $\Delta b^* = b_1 - b_2$, L is the brightness value, a is red/green color value, b is yellow/blue color value.

Color difference value can be translated to human perception reference as $\Delta E_{ab} < 0.2$ - the difference is not perceivable, ΔE_{ab} between 0.2 and 1 - the difference is noticeable, ΔE_{ab} between 1 and 3 - the difference can be seen, ΔEab between 3 and 6 - the difference is easy to see and ΔE_{ab} over 6 - obvious color difference [10].

3. RESULTS AND DISCUSSION

Results of the color differences analysis between prints just after printing and after rubbing treatment repeated 20, 40, 60, 80 and 100 times are shown in figures 1 and 2 for samples printed using 100 thread/cm screen, black and red Oil based Sericol Texopaque Classic OP plastisol ink and water based Texiscreen Aqua AJ ink, respectively. Figures 3 and 4 show the results for samples printed using 43 thread/cm screen with same combination of ink.

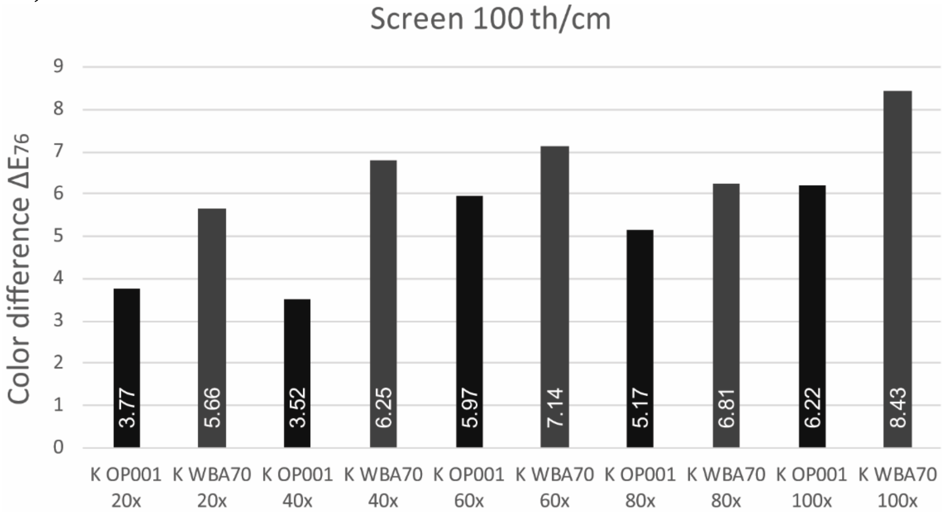

Fig. 1. Comparison of color differences between samples printed using 100 thread/cm screen, black Oil based Sericol Texopaque Classic OP plastisol ink (OP 001) and water based Texiscreen Aqua AJ ink (WBA 70)

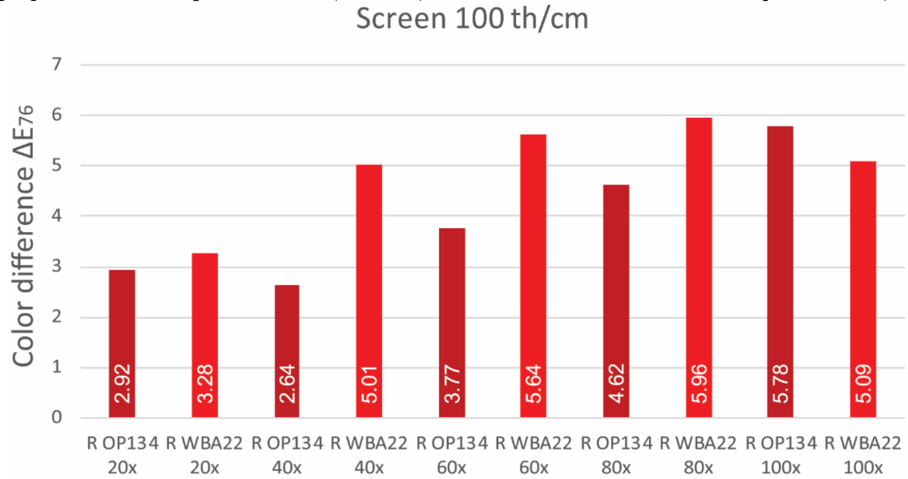

Fig. 2. Comparison of color differences between samples printed using 100 thread/cm screen, red Oil based Sericol Texopaque Classic OP plastisol ink (OP 134) and water based Texiscreen Aqua AJ ink (WBA 22)

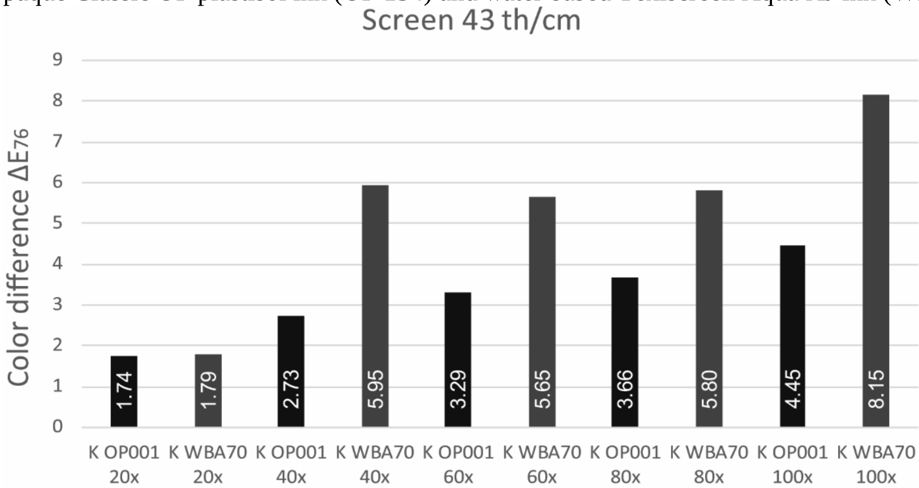

Fig. 3. Comparison of color differences between samples printed using 43 thread/cm screen, black Oil based Sericol Texopaque Classic OP plastisol ink (OP 001) and water based Texiscreen Aqua AJ ink (WBA 70)

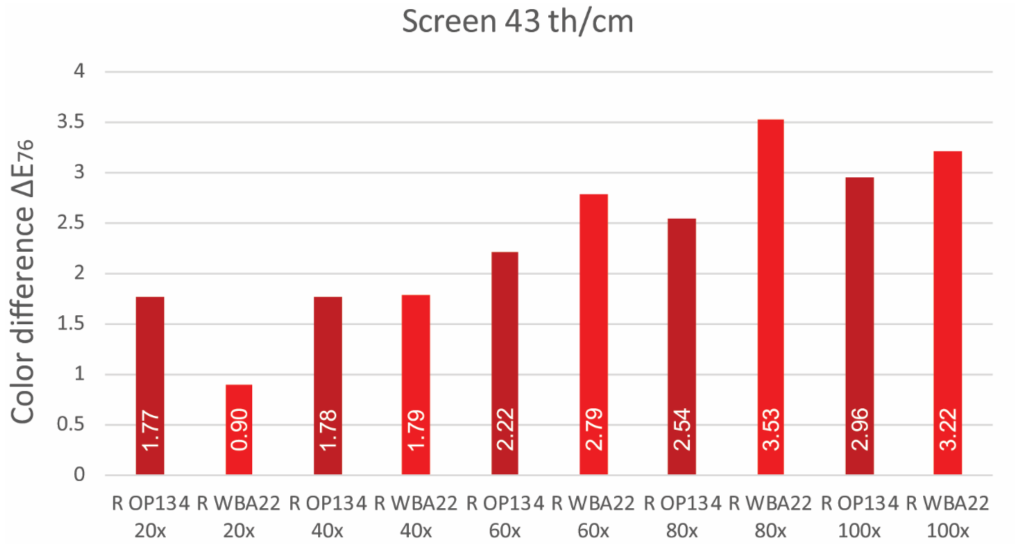

Fig. 4. Comparison of color differences between samples printed using 43 thread/cm screen, red Oil based *Sericol Texopaque Classic OP plastisol ink (OP 134) and water based Texiscreen Aqua AJ ink (WBA 22)*

Results show significant differences between sample printed with different inks and different print screen mesh count. In case of samples printed using print screen mesh count 100 threads/cm, which causes less ink to be deposited, color differences progress significantly as number of rubbing cycles increases. This is the case in booth oil and water based inks. Water based ink shows more changes and some ink smearing. Black colored ink suffers greater changes than red one, presumably because black pigment is soot based.

The samples printed using print screen mesh count 43 threads/cm, with higher ink deposition have proven to be more resilient to the rubbing than prints made using 100 threads/cm screen. Trends observed for oil and water based inks black and red colored inks are similar as in samples printed using print screen mesh count 100 threads/cm. Black colored ink suffers greater changes than red one.

Analysis of the spectral reflectance did not show significant changes caused by rubbing treatment. Changes in all samples whether printed using 100 threads/cm or 43 threads/cm screen, oil or water based inks, black or red, showed minimal changes in spectral reflectance. Figure 5 shows results for spectral reflection changes of samples printed using 45 threads/cm, oil based black ink.

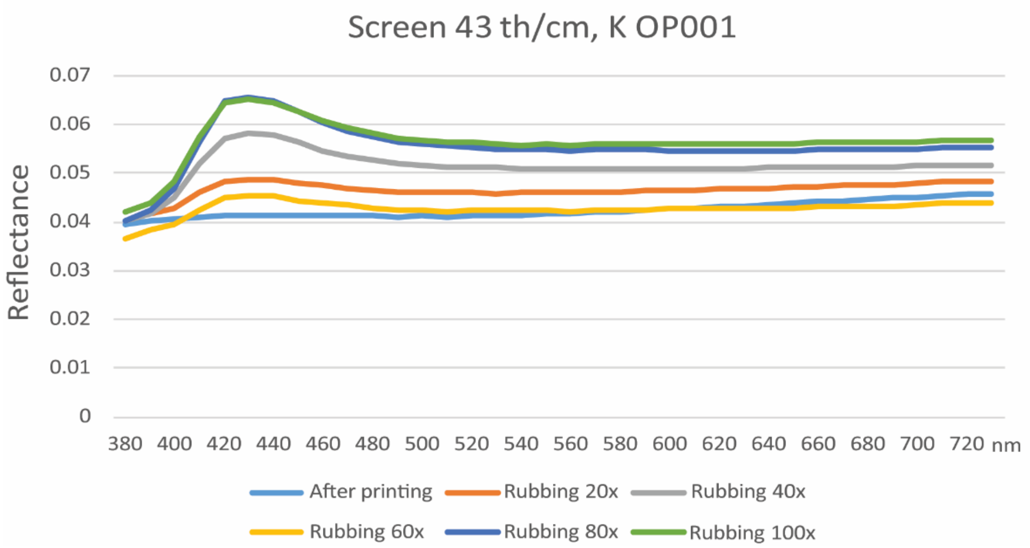

Fig. 5. Spectral curves for samples printed using 43 thread/cm screen, black Oil based Sericol Texopaque Classic OP plastisol ink (OP 001)

Changes in reflectance under 2% can be observed throughout the whole specter and only in 400 nm segment the changes are nearing the 4%, these small changes are typical for all samples. All the samples showed good ink penetration into the material and sufficient deposition of ink which could not be rubbed off, exposing the substrate, even submitted to the hundred rubbing strokes.

4. CONCLUSIONS

The study have been made to evaluate the rubbing/crocking fastness properties, of samples printed using screen printing technique varying 100 threads/cm and 43 threads/cm printing screen mesh count, oil and water based and black or red colored inks. Following conclusions are revealed from the results. It is observed that the color fastness to rubbing of printed fabric can be improved by the appropriate selection of ink, mainly having in mind its binder properties. The influence of right amount of ink deposited showed to be crucial for good color fatness to rubbing. Manipulation of the ink deposition is possible by variation of printing screen mesh characteristics. As there are far more mesh characteristics than just mesh count they could be investigated in future studies. Analysis of the spectral reflectance changes showed no significant effect, proving all the samples had good ink penetration into the material and sufficient deposition of ink which could not be rubbed off.

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КОЛОРИМЕТРИЧЕН И МИКРОСКОПСКИ АНАЛИЗ НА УСТОЙЧИВОСТТА НА ЦВЕТОВЕТЕ НА РАЗЛИЧНИ СЪСТАВИ НА СИТОПЕЧАТНИ МАСТИЛА

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(Резюме)

Ситопечатната технология е основен метод за печат върху текстил. Широкото разнообразие на текстилни продукти и тяхното приложение изискват различни състави, а от тук и различни свойства на мастилата за сито печат.

Една от важните характеристики на текстилните продукти е тяхната естетическа стойност, като тук важно условие е максималното запазване на цветовите характеристики на сито печатното изображение през целия експлоатационен период.

Устойчивостта на изтриване и цветови промени по време на експлоатация на текстилните продукти е особено важна характеристика.

В настоящата разработка са направени изследвания на устойчивостта на изтриване на цветовете на различни като композиция сито мастила на водна и маслена основа при линиатури на мрежата от 43 до 100 нишки на см. Използван е 100% памучен материал. Резултатите показаха, че мастилата на маслена основа и с по-ниска линиатура дават по-добра устойчивост на изтриване на цветовете.

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