(REFEREED RESEARCH)

THE INFLUENCE OF WASHING TREATMENT ON SCREEN PRINTED TEXTILE SUBSTRATES

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ABSTRACT

During exploitation period printed textile products are usually exposed to various influences. One of the most common influence is a washing treatment. The washing treatment causes modification of textile fibres and change of colours reproduction on materials. This paper presents the research of influence of washing treatment on print quality parameters of screen printed textile, i.e. cotton substrates. Besides the influence of series of washing treatments, the influences of printing screen mesh count and characteristics of printed material was also considered. The research includes analysis of basic print quality attributes: colour reproduction and macro non-uniformity. The results of the research point out that increasing the number of washing treatments causes significant colour differences between treated and untreated samples. Colour differences caused by printing screen mesh count were also noticed, as well as the influence of the washing treatments and substrate characteristics influence on macro non-uniformity of printed samples.

Key Words: Cotton, Screen printing, Washing treatment, Print quality, Colour reproduction, Macro non-uniformity of prints

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1. INTRODUCTION

Textile materials are used in production of various products, usually printed or dyed. Printing on the textile substrates can be achieved using variety of different techniques and machines (1). The most suitable printing techniques for textile substrates are: screen printing, digital ink-jet printing and thermal transfer printing (2). Screen printing is a dominant printing technique for textile substrate printing (3, 4, 5, 6). It has advantages in terms of total costs and productivity, as well as simplicity and speed in high printing volumes (7, 8). In addition, screen printing machines usually cost less compared to the machines using other printing techniques (7). Print quality factors of screen printing are related one to another (9). Colour tone reproduction greatly depends on printing screen mesh counts and fibre thickness (10), while line and raster reproduction are influenced by developed printing form, ink and substrate (11). Print quality is also influenced by process parameters, such as printing speed, squeegee hardness, squeegee pressure and distance between screen and printing substrate (snap-off distance). Pan et al. affirmed that squeegee hardness and printing speed have the most crucial influence (12).

Selection of printing ink is one of the most important factors of high quality screen printing (13). The most often used inks in textile screen printing are plastisol inks. These inks are dispersion of PVC particles in a plasticizer (11). When heated above 150 °C, the paste and plasticizer mutually dissolve each other and form the layer of ink. Plastisol inks penetrate into textile substrate structure, thus bounding with it. This feature makes printed products highly resistant to repeated washing and drying treatments. Plastisol inks are characterized by great covering capacity as well as and good behaviour during printing (14).

The additional advantage of screen printing is its applicability on various types and shapes of printing substrates. Materials made of cotton are most often used as substrate in textile screen printing. Cotton materials have a great market share due to its outstanding features: air permeability, diffusion of moisture and heat, softness, hypoallergenic and antistatic properties (15). Furthermore, cotton is a low-cost material, does not require any special attention, can be washed and is long lasting. Therefore, it is widely spread in clothing production, for example t-shirts.

T-shirts, as well as other clothes, are ordinary exposed to various influences such as washing, heating, friction, UV light etc. One of the most crucial factors to the quality of t-shirts is a washing treatment. It is proved that washing treatment causes specific physical and chemical change on fabric (16), as well as micro mechanical change (air permeability, tearing resistance, rigidity) (17). In addition, it was noted that washing treatment causes colour changes (18). The level of material changes depends on washing process, washing temperature, water hardness, washing period. Also, modern detergents are consisted of bleach suspensions, enzyme catalysts and ink transfer inhibitors, all of these substances can cause changes of printed colours (19). When investigated the influence of washing treatments on substrates, majority of researches normally use ISO105-C01 standard (16, 18, 20 - 23). ISO105-C01 standard dictates samples to be subjected to washing treatment for 30 minutes on the temperature of 60 ^{o}C using washing solution containing 5 g/l of textile soap with solution/weave ratio 50:1. After which samples are rinsed out with distilled water twice and then rinsed for 10 minutes with cold water, drained and dried on 60 ^{o}C.

Quality control in commercial printing usually implies spectrophotometric analysis of colour. This process is used to determine colour difference measured between two samples. Colour difference is determined by calculating the Euclidean distance between two colours in CIE Lab colour space, defined by coordinates (ΔL^*, Δa^*, Δb^*) (24, 25). It is expressed as a numerical value (ΔE) and expresses visual difference between two colours; described in Table 1 (26). There are numerous equations for calculating colour difference (1). The latest one is CIEΔE 2000 (27, 28). Regardless of colour space used, the fact is that changes of fabric structure causes colour differences (29).

Assessment of colour reproduction quality itself is not sufficient to define overall print quality. Series of experiments were used to determine that print quality cannot be represented as monotonic function of tone, brightness and saturation (30, 31, 32, 33). Although not directly related to colour reproduction quality attributes such as: contrast, sharpness, macro non-uniformity have a strong influence on print quality. These attributes are directly linked to the quality of lines and dots, the basic element of any figure (34). Contrast, sharpness, figure noise, ragged edges, resolution, text quality, micro and macro uniformity, uniformity of glow can be quality attributes of great significance (33, 35, 36). Although many researchers offered insight into importance of these quality attributes, none of them was singled out as the most important (33). In the study made by Lindberg (37) it was concluded that the macro non-uniformity, colour range, printing sharpness and colour difference has the greatest influence on print quality. This conclusion is in accordance to Engeldrum’s conclusions and states that an observer does not perceive simultaneously more than five quality attributes (38).

Table 1. Visual difference between two colours

ΔE between 0 and 1	Generally, difference cannot be noticed
ΔE between 1 and 2	Small colour difference, visible to “trained” eye
ΔE between 2 and 3,5	Medium colour difference, visible to “untrained” eye
ΔE between 3,5 and 5	Obvious colour difference
ΔE above 5	Massive colour difference

In this research special attention was paid to colour reproduction and macro non-uniformity as quality attributes of great significance. Macro non-uniformity is one of the most common defects of printed figures and represents undesired inequality in perceived optical density of the print. This can be caused due to uneven colour absorption into the material, causing smudged “clouded” areas of prints (34).

One of the aims of this research is to emphasise the influence of printing screen mesh counts on a quality of screen printed fabrics. The accent is set on washing treatments as an influence factor to which the fabrics are exposed to. Quality assessment of screen printing included the analysis of basic print quality attributes, i.e. colour reproduction and macro non-uniformity.

2. MATERIAL AND METHOD

2.1. Materials

Three different textile materials, all of them cotton based, with different weave type: single, pike, interlock were used. Material characterization was done according to following standards: material composition (ISO 1833), fabric weight (ISO 3801) and thread count (ISO 7211-2). These properties are presented in Table 2.

Table 2. Characteristics of material used in testing

Tests	Type of weaves	Material composition (%)	Fabric weight (g/m^2)	Thread count (cm^{-1})	
				Warp	Weft
Material A	Single	Cotton 100 %	138	14	19
Material B	Pike	Cotton 100 %	185	15	16
Material C	Interlock	Cotton 100 %	207	12	18
Method		ISO 1833	ISO 3801	ISO 7211-2	

2.2. Test charts

For the purpose of the research the special test chart was developed using Adobe Illustrator CS 5 application. The test chart size was 297 x 420 mm and consisted of various elements for print quality analysis. Areas sized 30 x 120 mm, 100% tone values of black process colour were analysed.

2.3. Printing process

The samples were printed using screen printing technique, M&R Sportsman E Series six-colour printing machine.

Pan et al. found four main parameters have a crucial effect on screen print quality (12). These parameters were kept constant during the printing of all samples. Printing speed was 15 cm/sec; squeegee hardness was 80 Shore Type A, printing pressure 275.8 10^3 Pa and 4 mm snap-off distance. Sericol Texopaque Classic OP Plastisol inks were used. Ink fixation was done on temperature of 160 ^oC, exposure time 150 seconds.

Printing form was made using printing screen mesh count 120, 140 and 160 threads per cm on aluminium tubing frames (58 x 84 cm). Size of the stencil, without frame, was 50 x 76 cm. Conventional exposure using linear positive films. Optical density of transparent areas of the film was 0,3 and 4,1 on opaque areas. Film lineature was five times smaller than printing screen mesh count. Photosensitive Sericol Dirasol 915 emulsion was used. Light exposure was done using metal-halogen UV lamp (1000 W) at a 1 m distance from the mesh. Exposure time for each stencil was calculated using control tape Autotype Exposure Calculator by Sericol Company. Light exposure time for each stencil is represented in Table 3.

Table 3. Exposure time of stencils

Thread count (threads/cm)	Light Exposure time (min)
90	3
120	2,6
140	1,6
160	1,3

2.4. Washing treatment

The samples were treated according to ISO 105-C01 standard (39). The process was repeated 10 times. All the print quality parameters as well as colourfastness to washing were measured repeatedly four times: before washing treatment, after first, fifth and tenth washing treatment.

2.5 Print quality analysis

Print quality analysis included colour difference analysis and macro non-uniformity analysis. Colour differences (ΔE) between samples with same material composition and different fabric weight and thread count were calculated using measured CIE L* a* b* C* h° coordinates of full black tones. Besides that, measurements of reflectance of printed samples, before and after washing, were taken and spectral curves were created. CIE L* a* b* C* h° coordinates of the colour were determined using spectrophotometer HP 200 (Illumination types D65, standard observer angle 10º, measurement geometry d/8, measurement aperture 16 mm). Reflexive spectral curves were created using spectrophotometer Techkon SpectroDens (Illumination types D50, standard observer angle 2º, measurement geometry $0^o/45^o$, measurement aperture 3 mm). Measuring was repeated 10 times for each sample and results shown are a mean value.

Macro non-uniformity was determined by digital analysis of image using Image J application with add-on developed by Muck and associates (40). Samples were scanned on flatbed scanner Canon CanoScan 5600F. Scanning resolution was set at 600 spi and auto correction was turned off. Image elements of the significance to this measurement were saved as separate TIFF files and they were analysed afterwards.

SEM microscopic analysis gives high quality microscopic insight of yarns (41) and provided further material for analysis of the causes for changes on textile prints. Analysis was done on JEOL 646O LV electronic microscope and it was used to observe changes on fabrics caused by the printing and washing treatment. According to the lab procedure, samples were categorized, labelled and prepared. Samples were also steamed with gold in order to ensure electro conductivity.

3. RESULTS AND DISCUSSION

3.1. Colour reproduction analysis

Spectrophotometric measurements were used to determine CIE L* a* b* C* h° coordinates of colours after printing and washing treatments. Measured values are shown in Table 4.

Table 4. CIE L* a* b* C* h° coordinates of colours and colour differences after printing and washing treatments

Sample	L*	a*	b*	C*	h°	ΔE
90A-P-K	24.26	0.11	-0.08	0.14	322.22	/
90A-W1-K	23.608	0.062	-0.334	0.364	270.586	0.701373
90A-W5-K	29.468	-0.024	-0.478	0.486	265.586	5.224904
90A-W10-K	30.286	-0.334	-0.31	0.46	222.87	6.046711
120A-P-K	22.39	0.18	-0.238	0.31	312.77	/
120A-W1-K	24.702	0.116	-0.366	0.396	287.77	2.316425
120A-W5-K	30.49	-0.244	-0.336	0.42	234.01	8.111682
120A-W10-K	32.438	0.054	-1.154	1.156	272.828	10.09045
140A-P-K	25.412	0.21	-0.054	0.302	290.796	/
140A-W1-K	29.266	0.278	-0.156	0.326	326	3.855949
140A-W5-K	32.452	0.102	-0.57	0.594	291.824	7.059711
140A-W10-K	39.398	-0.016	-0.356	0.36	267.43	13.99109
160A-P-K	30.266	0.478	0.018	0.548	174.786	/
160A-W1-K	30.7	0.354	0.044	0.394	222.41	0.452115
160A-W5-K	37.114	-0.06	-0.23	0.24	255.38	6.873576
160A-W10-K	48.712	0.134	-1.964	1.97	274.546	18.55537
90B-P-K	24.064	-0.022	-0.352	0.366	262.64	/
90B-W1-K	25.114	-0.114	-0.196	0.318	233.02	1.065505
90B-W5-K	29.304	-0.112	-0.522	0.536	257.32	5.243529
90B-W10-K	30.51	-0.232	-0.456	0.51	243.03	6.450258
120B-P-K	21.506	-0.114	-0.796	0.834	260.578	/
120B-W1-K	25.662	-0.092	-0.362	0.388	254.198	4.178657
120B-W5-K	29.718	-0.066	-0.5	0.526	255.248	8.217473
120B-W10-K	30.86	-0.236	-0.456	0.51	242.64	9.360972
140B-P-K	26.306	0.294	-0.29	0.472	259.256	/
140B-W1-K	28.286	0.224	-0.246	0.356	313.89	1.981726
140B-W5-K	32.226	0.032	-0.348	0.358	271.028	5.926079
140B-W10-K	32.134	-0.23	-0.362	0.43	237.57	5.851952
160B-P-K	25.542	0.106	-0.454	0.54	253.996	/
160B-W1-K	28.926	0.348	-0.148	0.392	337.382	3.406414
160B-W5-K	30.412	-0.11	-0.388	0.412	254.114	4.875235
160B-W10-K	36.052	-0.166	-0.296	0.34	240.72	10.51471
90C-P-K	23.932	-0.012	-0.236	0.252	264.2	/
90C-W1-K	26.252	0.022	-0.418	0.428	272.396	2.327376
90C-W5-K	29.012	-0.054	-0.304	0.498	263.144	5.080629
90C-W10-K	29.928	-0.268	-0.57	0.63	244.82	6.010749
120C-P-K	26.57	0.158	-0.34	0.386	289.06	/
120C-W1-K	25.966	0.122	-0.436	0.456	286.188	0.61264
120C-W5-K	29.558	-0.022	-0.508	0.522	265.162	2.998127
120C-W10-K	31.376	-0.27	-0.488	0.56	241.05	4.82729
140C-P-K	35.13	0.594	-0.352	0.694	330.032	/
140C-W1-K	30.79	-0.008	-0.5	0.514	267.534	4.384052
140C-W5-K	30.778	-0.244	-0.278	0.37	228.73	4.432564
140C-W10-K	28.508	0.118	-0.288	0.32	289.858	6.639394
160C-P-K	34.048	0.448	-0.058	0.496	208.998	/
160C-W1-K	33.894	0.018	-0.266	0.27	273.87	0.501876
160C-W5-K	35.414	-0.188	-0.314	0.37	239.09	1.528394
160C-W10-K	31.01	0.378	-0.298	0.498	321.532	3.048269

Note: first number of the sample name represents screen mesh counts; letters A, B and C represent materials; P is the mark of printed sample; W1 is the mark of the sample after the first washing treatment, W5 - after the fifth washing treatment and W10 - the tenth washing treatment.

Colour difference (ΔE) between printed samples, for each sample and mesh counts, before and after washing treatments were calculated. Results shown in table 4 suggest that increased number of washing treatments leads to increase of colours differences, and this is noticeable for every material and screen mesh counts variation. Observing results of material A, it can be seen that colour differences of prints made by printing screen mesh counts of 90 and 160 threads/cm, is not visible to human eye after the first washing treatment. However, material A printed using 120 threads/cm screen mesh shows medium colour differences and it can be noticed by „trained“ eye. Samples printed using 140 threads/cm mesh have obvious colour difference. Colour difference after fifth and tenth washing treatment for every mesh count is massive. After the fifth washing treatment the lowest value of colour difference have the sample printed by 90 threads/cm mesh and the highest value showed the sample printed by 120 threads/cm mesh. After the tenth washing treatment the highest colour difference was noticed on the sample made using 160 threads/cm mesh (ΔE= 18.6).

Observing material B, after the first washing treatment that colour difference of samples printed using 90 and 140 threads/cm mesh is very small and it can be visible only to a „trained“ eye. Colour difference of print made using 160 threads/cm mesh has a medium value which can be visible to an „untrained“ eye, while print made using 120 threads/cm mesh show massive difference in colour. After the fifth and tenth washing treatment all calculated values of colour difference were greater or close to value 5, which puts them in a group of massive colour difference. The highest one being ΔE= 10.5 calculated for material B printed using 160 threads/cm mesh.

Samples printed on material C using 120 and 160 threads/cm screen mesh did not show visible colour difference after first washing treatment. When printed using 90 threads/cm mesh, colour difference has a medium value and it can be visible to an „untrained“ eye. However, if printed using 140 threads/cm mesh colour difference has a massive value. Fifth washing treatment of the material C showed that prints made using 90 threads/cm mesh have massive colour difference; 120 threads/cm mesh have medium colour difference; on 140 threads/cm mesh have massive colour difference; print made on 160 threads/cm mesh have colour difference, visible only to a „trained“ eye. Tenth washing treatment of material C on samples printed using 90 and 140 threads/cm mesh show massive colour differences; on 120 threads/cm mesh have obvious difference in colour; while the sample printed using 160 threads/cm has medium colour difference, visible to an „untrained” eye.

At the same time as CIE L* a* b* C* h° coordinates were measured, measurements of reflectance of printed samples before and after series of washing was done and reflexive spectral curves were created. By this the influence of printing screen mesh count and washing treatment on the printed surface reflection was observed. Due to a large number of graphs created, figure 1 presents only one typical spectral curve of the sample (material A printed using different mesh counts, before and after washing treatments). Material B and C showed just about the same behaviour of the spectral reflection. According to figure 1, it can be concluded that samples printed using 90 and 160 threads/cm mesh showed no change in spectral reflection compared to the unwashed samples. At the same time, samples printed using 120 and 140 threads/cm mesh showed specific exceptions. After fifth washing treatment deviations in spectral reflection are noticed for all mesh counts. After tenth washing treatment deviations are even more pronounced. Summing the result of the spectral curve analysis, it can be concluded that increased number of washing treatments provoke the rise of spectral reflection for all mesh counts. This is due to washing off of the ink from the surface, which evoke higher light reflection from the material surface.

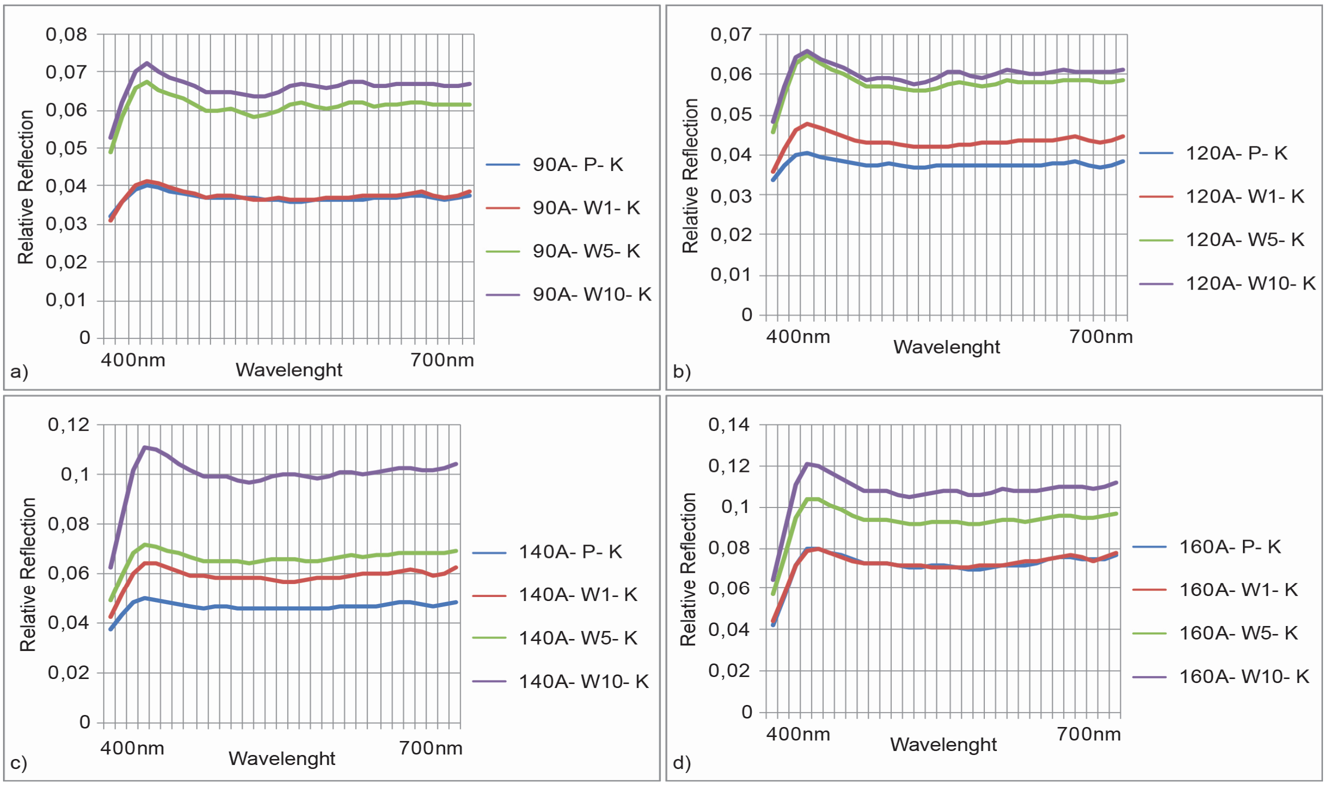

Figure 1. Spectral curves after printing and washing treatments (material A) of the samples printed on different mesh counts: a) 90 threads/cm, b) 120 threads/cm, c) 140 threads/cm, d) 160 threads/cm. Note: P is a mark of the printed sample; W1 marks the sample after first washing treatment, W5 - marks the sample after fifth washing treatment and W10 - marks the sample after tenth washing treatment.

3.2. Macro non-uniformity analysis

The level of macro non-uniformity is defined by non-uniformity index. Figure 2 represents values of macro non-uniformity analysed on material A after printing (with different mesh counts) before and after series of washing treatments. Samples printed using 90 threads/cm mesh showed that increased number of washing treatments leads to increase of macro non-uniformity index value. In case of samples printed using 120 threads/cm mesh macro non-uniformity value decreased after the first washing treatment compared to the unwashed sample. Further increasing in number of washing treatments increased the value of macro non-uniformity index above. Prints made using mesh with 140 threads/cm and washing, samples showed rise in macro non-uniformity index, while samples printed using 160 threads/cm mesh showed fall of the same parameter.

Values of macro non-uniformity index for material B are shown on figure 3. In case of samples printed using 90 threads/cm mesh, macro non-uniformity index values almost match the values of the unwashed samples. Generally increased number of washing treatments leads to increase in macro non-uniformity index value. However, after the first washing treatment samples printed using 120 threads/cm mesh showed that this value decreased, but every following washing treatment contributed to the rising of macro non-uniformity index, above the value of the unwashed sample. Samples printed using 140 threads/cm mesh also showed that index of macro non-uniformity rises with the repetition of washing treatments. Macro non-uniformity value of the samples printed using 160 threads/cm mesh dropped after the first washing treatment, but macro non-uniformity index value kept rising after the fifth washing treatment until tenth where it started declining again.

Observing the changes of macro non-uniformity on material C (figure 3), it can be seen that increased number of washing treatments results in macro non-uniformity index decreasing in case of all samples except of those printed using 90 threads/cm mesh. This sample showed reversed trend of macro non-uniformity index compared to other samples of material C.

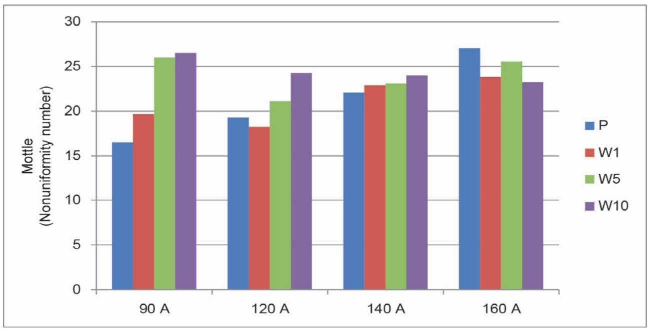

Figure 2. Macro non-uniformity index value of the material A after printing using different mesh counts and series of washing treatments

It can be concluded that in case of materials A and B printed using printing screen with mesh count from 90 to 140 threads/cm macro non-uniformity index value rises with a number of washing treatments. When printed using mesh with 160 threads/cm count samples showed opposite trend. It can be assumed that increased number of washing treatments leads to uneven wash off of the ink from the material surface and therefore increases macro non-uniformity index value. When more dense mesh was used, like 160 threads/cm mesh, ink is concentrated on some parts of the print, which is washed of and print is evened out, resulting in decreasing value of the macro non-uniformity index. Material C analysis showed that rougher material surface also caused ink concentration of ink on some parts of the surface, which was later washed off, thus resulting in decrease of the macro non-uniformity index. Figure 5 shows side by side comparison of the macro non-uniformity for all the material and print screen combinations.

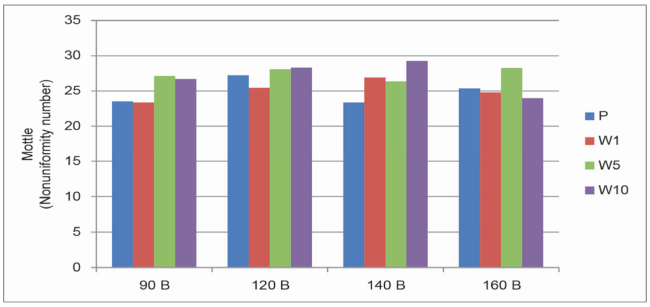

Figure 3. Macro non-uniformity index value of the material B after printing using different mesh counts and series of washing treatments

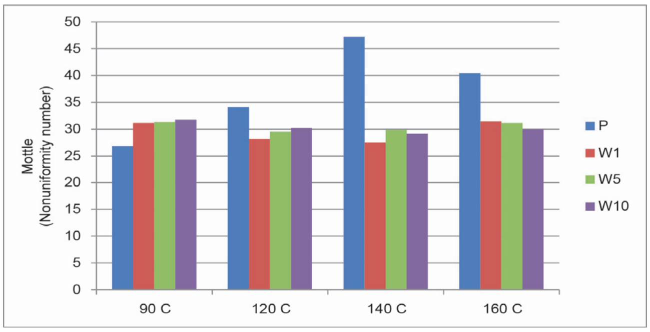

Figure 4. Macro non-uniformity index value of material C after printing using different mesh counts and series of washing treatments

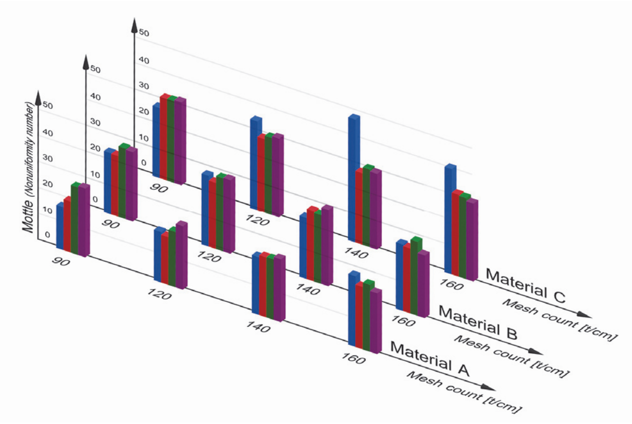

Figure 5. Macro non-uniformity index values of the materials A, B and C printed using different mesh counts

3.3 SEM microscopic analysis of the samples

SEM microscopic analysis was performed on all samples before and after printing process, as well as after washing treatments. Due to a large number of images, figure 6 shows only typical samples (material A, material B and material C printed with mesh count of 120 threads/cm). Figure 6 shows the following states: a) material A before printing, b) material A printed with mesh count of 120 threads/cm, c) material A after printing and ten washing treatments, d) material B before printing, e) material B printed with mesh count of 120 threads/cm, f) material B after printing and ten washing treatments, g) material C before printing, h) material C printed with mesh count of 120 threads/cm, i) material A after printing and ten washing treatments

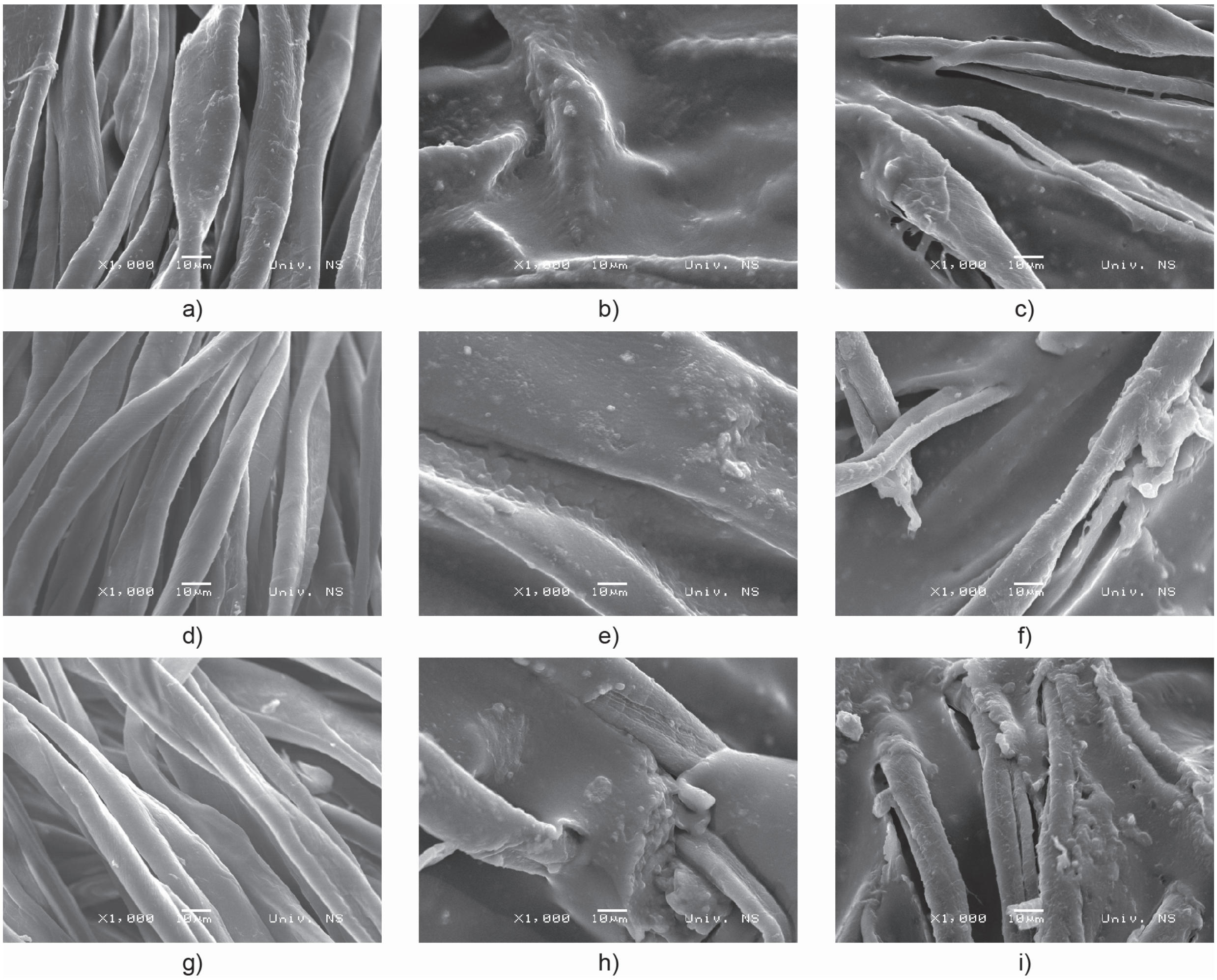

Figure 6. SEM figure (enlargement 1000 times): a) material A before printing, b) material A after printing (mesh count of 120 threads/cm),c) printed sample on material A after 10 washing treatments (60 ^{o}C), d) material B before printing, e) material B after printing (mesh count of 120 threads/cm), f) printed sample on material B after 10 washing treatments(60 ^{o}C), g) material C before printing, h) material C after printing (mesh count of 120 threads/cm), i) printed sample on material C after 10 washing treatments(60 ^{o}C)

Figure 6 shows modification of the printed samples surface morphology. Figures 6a, 6d and 6g clearly show the smooth surface of fibres, while figures 6b, 6e and 6h show the particles of ink on fibre surface deposited in the printing process. It can be said that fibres are covered with ink due to thick ink layer. After the series of washing, one part of the ink layer is washed off from the fibre surface which is noticeable on figures 6c, 6f and 6i. Due to washing, the fibre surfaces becomes smothering, one part of the ink was removed and uniformity of the ink layer was compromised. Figures 6c, 6f and 6i show ink removal of the fibres, leaving the cracks in ink layer. This can be explained by destruction of the ink layer due to washing treatments. Washing out the ink from the fibre surface leaves the fibres exposed thus increasing reflectiveness, because there is smaller amount of pigment which would absorb the light. In addition, this causes the higher colour difference between unwashed and washed samples. All these observations are confirmed by spectrophotometric analysis.

4. CONCLUSION

Cotton based textile products are exposed to various external factors during exploitation period. One of the most common significant influence factors is washing. This paper researched the influence of washing treatments on print quality of the cotton materials printed by screen printing, varying printing screen mesh counts. In order to assess print quality, the spectrophotometric analysis of reproduced colours was performed, as well as macro non-uniformity analysis and SEM microscopic analysis of the samples, before and after series of washing treatments.

CIE L* a* b* C* h° colour coordinates were measured, based on those measurements colour difference (ΔE) was calculated. Spectral reflectance was measured and analysed. Throughout these analyses the printed samples were tested and measured before and after series of washing treatments. The analyses confirmed that increased number of washing treatments lead to increase of colour difference compared with unwashed samples. It was noticed that changes of colour are influenced by printing screen mesh count used in printing process. Materials A and B showed smaller deviations of colour difference when lower mesh count, like 90 threads/cm, printing screens were used. On the other hand material C showed the lowest deviations on samples printed using mesh count of 160 threads/cm. According to the analysis of spectral reflection, it can be concluded that increased number of washing treatments caused increased spectral reflection of the samples. This pattern was observed in all fabrics and all mesh counts used in this research. It appears that due to a partial wash off of the ink layer and smaller amount of pigments on the surface light absorption was lower.

Macro non-uniformity analysis confirmed that this print quality parameter also changes with a repetition of the washing treatments. When subjected to washing treatments, the ink layer is washed off unevenly from the material surface and macro non-uniformity of prints is increased. In addition, it is important to point out that characteristics of the fabric have a strong influence on macro non-uniformity value. Thus, when printing rough substrates non-uniform concentration of ink may occur. Subjecting to washing treatments, value of macro non-uniformity in this case decreases due to ink removal and relative evening out of the ink layer across the printed surface.

SEM microscopic analysis of the samples showed changes of the surface structure before printing, after printing and after series of washing treatments. This confirmed that washing treatments lead to a partial ink layer wash off from the surface of the material, causing greater colour differences between unwashed and washed samples.

Summarising all the results, it can be concluded that washing treatments, as well as its repetition, have a crucial influence on print quality of the textile materials in screen printing. Besides that, print quality is partially influenced by fabric characteristics and mesh count used in screen printing process. In further studies plan is to conduct researches of washing temperature influence and other external factors on print quality of the textile materials. Performed research includes prints made only by screen printing technique. As becoming more popular, prints made by digital ink-jet printing should be also subjected to this type of research.

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