(REFEREED RESEARCH)

INFLUENCE OF INK LAYERS ON THE QUALITY OF INK JET PRINTED TEXTILE MATERIALS

MÜREKKEP TABAKALARININ INK JET BASKILI TEKSTİL MALZEMELERİNİN KALİTESİNE ETKİSİ

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ABSTRACT

This paper will discuss research concerning the influence of the number of ink layers deposited by ink jet for textile printing. With the aim to establish the optimal number of layers as to achieve good quality prints, it discusses the good colourfastness during longer time period and exposure to different environmental factors including temperature, light etc. Three typical materials with the same raw material compositions, but different fabric weight and thread count were chosen and printed with digital ink jet technology. Materials were printed with variations in the ink layers number and the correlation between K/S factor and number of applied ink layers was determined after the printing process. Upon finished printing process, the samples were treated with heat, light and other simulated environmental influences in line with the appropriate international standards. The changes were detected by common visual ranking methods (gray scale and blue wool reference scale) as well the spectrophotometric measurements for obtaining spectral data of the colourfastness and staining, what was followed by additional testing of the heating element with thermo vision camera. Microscopic view of the changes on the printed surfaces upon exposing them to different simulated factors was obtained by SEM microscope. It can be concluded that increase of printed ink layers will lead to a better quality of final product in terms of resistance to various environment influences. This research offers insight in the influence of one parameter in textile materials printing process on longevity of flag products, which can also be applied to any other product printed on polyester material.

Key Words: Polyester, Ink jet printing, Colourfastness, Heat, Light fastness

ÖZET

Bu makalede ink jet tekstil baskıcılığında aktarılan mürekkep tabakalarının sayısının etkisi araştırılmaktadır. Uzun zaman periyotlarında sıcaklık, ışık, vb. gibi farklı çevresel faktörlere maruz kalma sonucunda iyi renk haslıklarına sahip kaliteli baskıların elde edilmesi için optimum mürekkep tabaka sayısının belirlenmesi amaçlanmaktadır. Aynı hammaddeden üretilmiş fakat farklı gramaj ve sıklık değerlerine sahip üç tip malzeme seçilmiş ve dijital ink jet baskı tekniği ile baskı yapılmıştır. Malzemeler aktarılan mürekkep tabakası sayısı değiştirilerek basılmış ve baskı sonrasında elde edilen K/S değerleri ile uygulanan mürekkep tabaka sayısı arasında korelasyon saptanmıştır. Baskı işlemi tamamlandıktan sonra kumaşlar uluslarası standartlar göz önüne alınarak ısı, ışık ve diğer simüle çevresel faktörlere maruz bırakılarak renk değişimleri incelenmiştir. Renk değişiminin değerlendirilmesi görsel derecelendirme metotlarının (gri skala ve mavi skala) yanı sıra renk haslığı ve solmaya ait spektral verilerin elde edilebilmesi amacıyla spektrofotometrik ölçümler kullanılarak da gerçekleştirilmiştir. SEM mikroskobu yardımıyla çeşitli simüle faktörlere maruz kalma sonucunda baskılı yüzeylerde ortaya çıkan değişikliklerin mikroskobik görünümleri alınmıştır. Sonuç olarak mürekkep tabaka sayısının artmasının çeşitli çevresel etkilere karşı dayanım açısından son ürünün kalitesini iyileştirdiği saptanmıştır. Bu araştırma, tekstil baskıcılığındaki bir parametrenin özellikle bayrakların uzun süre dayanımına etkisine ışık tutmaktadır, ayrıca sonuçlar poliester baskıcılığı ile elde edilebilen diğer tüm ürünlere de uygulanabilir.

Anahtar Kelimeler: Poliester, Ink jet baskı, Renk haslıkları, Isı, Işık haslıkları

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1. INTRODUCTION

In recent years, numerous innovations have been introduced in the techniques of digitally printed textiles. At present, the most dominant printing technique for textiles is screen printing, although digital ink jet printing is rapidly expanding in the textile markets. The efficacy of ink jet printing as a flexible ink transfer method is primarily based on its cost and time saving for small print runs (1). What more, this printing technique enables achieving better visual effects, far more flexible formats, besides with the repeated printing process better reproducibility and consistent quality is achieved (2, 3). Ink is also one of the influential factors in behaviour of the prints in usage. It is disputable which ink type is the most stable in relation to light and heat. Different authors render different opinions on dye and pigment based inks. Hence, one group of authors claim that dye inks have poor light fastness and inadequate thermal resistance, while pigment based inks have lesser gloss quality (4), the other maintain higher optical density, wider gamut of prints and better endurance of exploitation conditions for pigment inks (5). Nanocolorants, such as the ones used in this trial, are the combination of two earlier mentioned ink types often used in ink jet printing (6). The additional advantage of the digital printing techniques for instance ink jet printing is the possibility of printing on large number of different substrates. One of the most frequently used materials in digital printing of textiles is polyester and because of its properties its use is increasing constantly. Consequently, it is widely used in flag printing. Materials used in flag printing are often exposed to influence of environmental factors such as heat, UV light, moist, rain and etc. One of the most influential processes applied to flags in everyday use is the heat treatment or the ironing process, since the excessive heat influences both the printed inks and fibres in the printed substrate. Finally, there is the occurrence of colour changes on the prints and structural changes in textile substrates (7). Heat treatment by ironing transfers the heat through the textile materials in three ways: conduction, convection and electromagnetic radiation (8, 9, 10), all of which can lead to structural changes of the fibres (11). The variation in ink quantity and coloration can decrease the influence of this negative effect on the quality of printed material. The effect of ironing heat on the changes of the material characteristics can be tested by several different standards such as ISO 105-X11, where the influence of the ironing heat is measured at the temperatures of 110°C, 150°C, and 200°C. Following the heat treatment, colourfastness and staining tests are applied to cotton by using the standard gray scale test with the 1 to 5 grading, where grade 5 represents the best colourfastness to ironing, as well as the quality of staining transfer. Another very important factor for the quality and long term usability of a product is the light fastness or the stability in relation to light. Exposure to light and other environmental factors can induce changes in colours, which is a problem primarily because it is difficult to anticipate the final product appearance (12). It has been found earlier that the influence of light and weather can lead to colour change between the prints as well to the changes in the structure of the tested material (13).

This study aims to prove the enhancement of properties in digitally printed textiles by application of multiple ink layers, whereby the focus is set on heat, light and weathering conditions.

2. MATERIALS AND METHODS

In this research three types of textile materials were used, all printed with Mimaki JV22 – 160 digital ink jet printer and J-Eco Subly nano inks. Polyester textile materials were chosen as they are well known for their strong fastness and durability (14) and due to their properties, are widely used in flag printing. All materials were characterized by following parameters: fabric weight using standard ISO 3801, thread count (ISO 7211-2) and material composition (ISO 1833). These properties are presented in Table 1.

For the analysis of influence of the ironing (heat treatment) and light fastness, a 150 x 10 cm sized test form was prepared (Figure 1.). The test form consisted four patches sized 35 x 10 cm with 100% tone value of all four process colours (cyan, magenta, yellow, black).

To apply different amounts of ink, the ability of Mimaki JV 22-160 ink jet printer was used to print multiple layers (amounts of applied ink) and variations of 1 to 5 ink layers were printed. The samples were tested in terms of applied ink quantity colourfastness and colour difference induced by accelerated ageing and heat. Based on the printing system, it was assumed that the larger ink quantity (more printing steps) would improve the durability and colourfastness of the samples during longer use and exposure to environmental factors. For colorimetric measurements of the reflection properties of prints was used a spherical Datacolor Spectraflash SF 600® PLUS – CT spectrophotometer. d/8 measurement geometry was used with 16 mm aperture, with D65 standard illuminant and 100 standard observers. Using these parameters, the colour strength was determined by Kubelka Munk analysis. The colour strength (K/S value) of dyed or printed fabrics is a measure of dye or pigment concentration in the fabric. It is calculated by measuring the K/S values of the dyed or printed fabrics with a spectrophotometer under a reflectance mode. This method was defined by Vickerstaff as the “Direct Colourimetric Estimation”. The principle is based on Kubelka-Munk theory which gives the relationship between the K/S and R (reflectance) (15). In the present study, the colour strength of the printed samples was calculated consistent with the Kubelka-Munk equation:

Table 1. Characteristics of material used in testing

Tests	Material composition (%)	Fabric weight (g/m^2)	Thread count p/10cm	
			Warp	Weft
Material 1	Polyester 100 %	110,6	170	120
Material 2	Polyester 100 %	101,5	160	100
Material 3	Polyester 100 %	141,3	260	120
Methods	ISO 1833	ISO 3801	ISO 7211-2	

Figure 1. Test form

$K/S = (1 - R)^2/2R$ (1)

Where R – is the reflectance of an incident light from the material, K – is the absorption coefficient, and S – is the scattering coefficient.

All the K/S values in the presented study were determined at the maximum absorption wavelength (λmax) at which the reflectance value is the lowest.

All the materials were processed with heat through ironing in line with the ISO 105-X11 standard. In compliance with the raw material composition, the recommended temperature was 110 °C, while the accelerated ageing process conformed to method 2. To ensure the exact temperature during the ironing the P65 IR thermo vision camera by FLIR was used to obtain pictures and temperature distribution in the heating element. The camera operates on the IR (Infra Red) basis, where the measurement procedure does not interfere with surface temperature and has a high degree of accuracy (10, 16, 17 and 18). Owing to the qualities mentioned, it is often used in research, with the following measurement procedure:

- The temperature of the measurement area is recorded (19),
- Through suitable application, the thermal picture of the object can be obtained for later processing (20),
- The value of the measured temperature can be expressed as a function of 5 parameters (13, 21, 22):

$Tob = f(\varepsilon_{ob}, T_{atm}, T_0, \omega, d), (K)$ (2)

where: ε_{ob} – is surface emission, T_{atm} – is atmosphere temperature, T_o – is temperature of the measured surface, ω – is relative humidity, d – is the distance of thermo IR camera.

The ironing experiment was conducted and the results were evaluated through visual gray scale test for colourfastness and staining upon testing the surface of the heated element. In all, 60 samples were tested, 20 for each material type.

Second part of the testing was performed with the purpose of evaluation of the environmental factors on flags during their outdoor display.

Testing the influence of light and other environmental factors can be conducted according to standards ISO 105 – B02, ISO 105-B01-1999 ISO 105-B03 -1997, ISO 105-B04-1997, ISO 105-B05-1996, ISO 105-B06-1999, ISO 105-B07:2009, and ISO 105-B08:1999, where the induced changes of two materials are accessed visually using blue wool reference strip and graded 1 to 8; grade 1 denominates poor fastness while 8 indicates a very good colourfastness to artificial ageing process.

Printed samples were placed in Xeno Test chamber Alpha from Atlas which simulated the environmental factors so as to obtain results of light and environmental factor influence on colourfastness. The exposure and other process parameters (temperature, relative humidity, irradiance), used to provide data for printed materials behaviour under simulated accelerated ageing, were kept constant and programmed according to the standard values for these types of tests. The accelerated ageing and weathering tests were followed by visual and instrumental evaluations with the aim to determine the colourfastness. While the visual part was conducted with blue wool scale, the instrumental measurement was conducted with Spectro Dens directional $0^o/45^o$ measurement geometry, D50 standard illuminant and 2^o standard observer. Spectral curves were established using the spectrophotometer before and after ironing, as well before and after weathering and ageing, both on the original and reference materials used for staining control.

Scanning electron microscope (SEM) grants quality microscopic views of the fibres (23), and further investigation of possible causes of colourfastness changes. SEM imaging was performed on JEOL 646O LV electron microscope where the coloured surfaces were treated separately after the ironing and ageing process. All the results were classified by the initial patch colour for easier determination of the changes in colorimetric values.

3. RESULTS AND DISCUSSION

3.1. Determination of the Colour Strength (K/S value) Using the Kubelka Munk Analysis

The Kubelka Munk analysis was used for assessment of colour strength (K/S value) prior to conducting the ironing and ageing tests. On all samples 10 repeated measurements were performed and their mean value was used for further calculation. The K/S value for the material 1 is presented in Figure 2. It can be seen that with every additional printing layer (ink quantity) the K/S value rises, while a linear correlation was detected between the ink quantity and K/S value, with high degrees of determination factor R^2, from 0,974 for magenta, to 0,997 for the yellow ink.

Similar to material 1, material 2 exhibited linear correlation between the ink layers and measured K/S value. The determination factors R^2 are also high for these samples and are above 0.9 except for magenta colour samples where R^2=0.891 value was calculated. Black colour samples have the highest R^2 = 0.974. The measured values are presented in Figure 3.

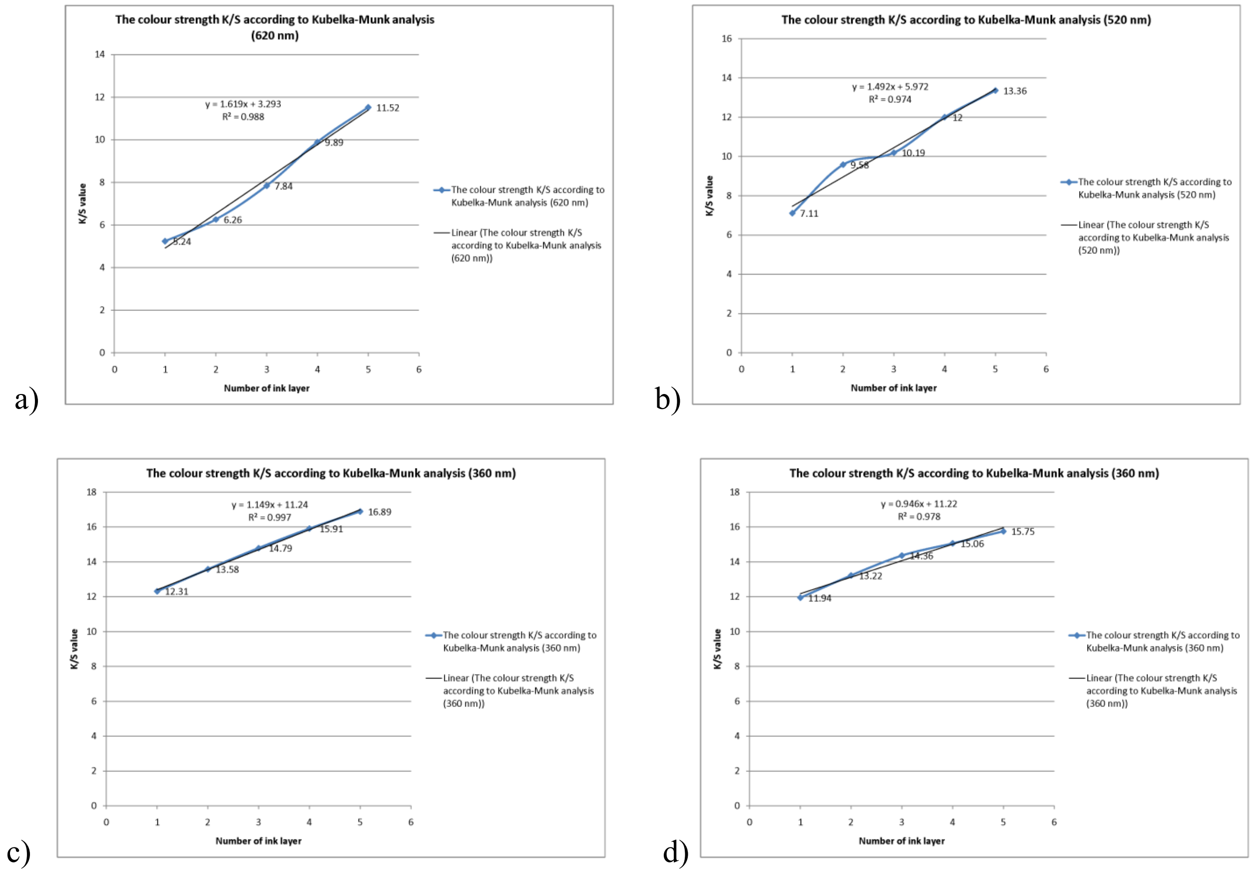


Figure 2. Colour strength K/S according to Kubelka-Munk analysis (material 1) a) cyan, b) magenta, c) yellow, d) black

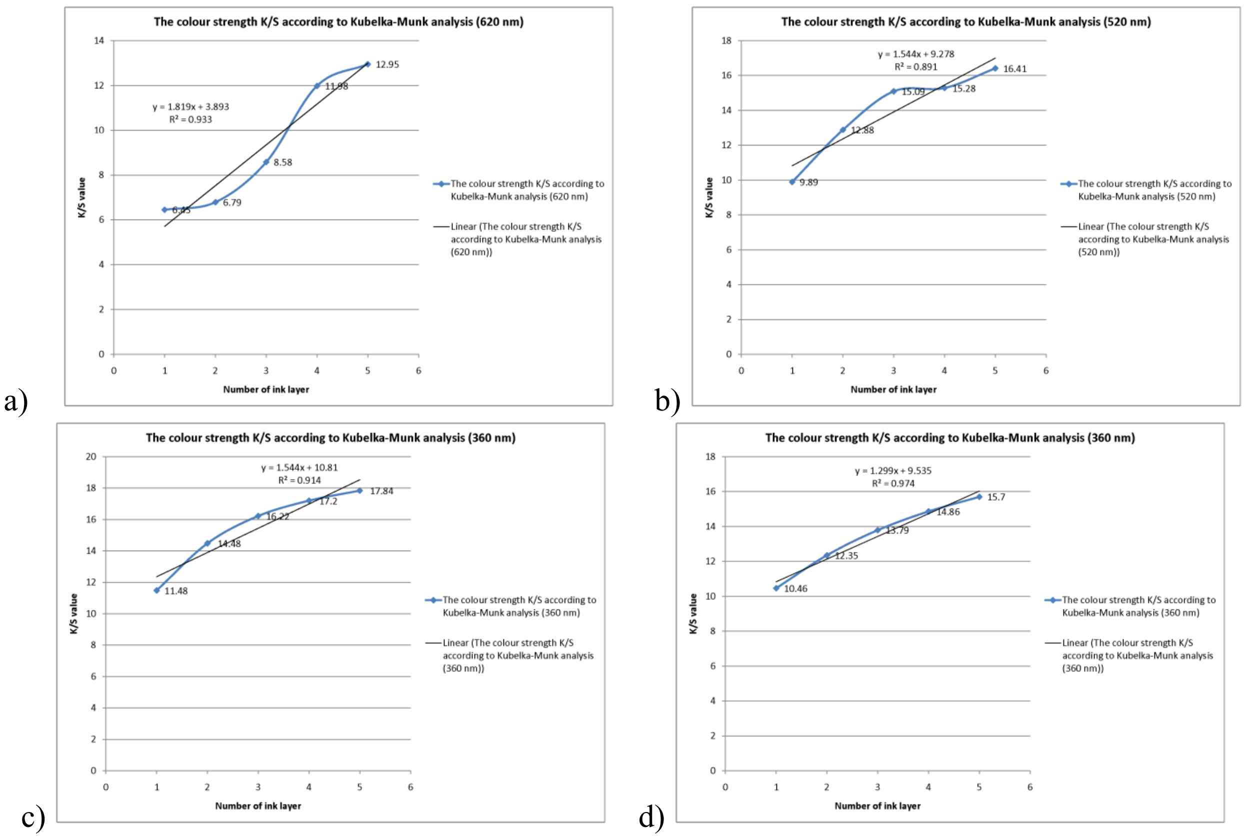
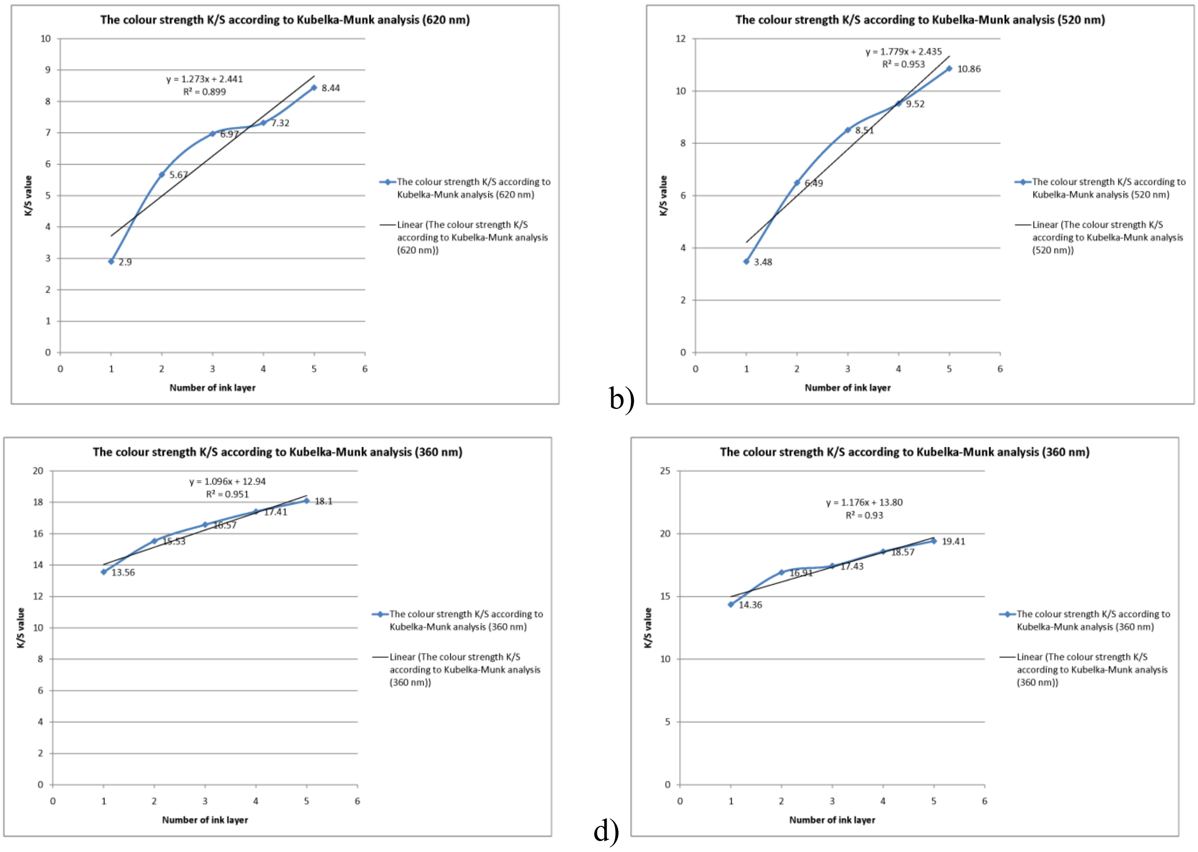


Figure 3. Colour strength K/S according to Kubelka-Munk analysis (material 2) a) cyan, b) magenta, c) yellow, d) black

Material 3 also exhibited linear correlation between the applied ink layers and K/S value where the smallest R^2=0.899 was calculated for the cyan colour sample and the highest for magenta samples R^2 = 0.953. The calculated values are presented in Figure 4.



a) b) c) d)

Figure 4. Colour strength K/S according to Kubelka-Munk analysis (material 3) a) cyan, b) magenta, c) yellow, d) black

Besides the fact that materials were with different thread counts and fabric weights, it is also interesting that the highest K/S values for cyan and magenta samples were measured on material 2 (lowest fabric weight and thread count), while for material 3 - with the highest fabric weight and thread count - these values were measured on yellow and black samples. Moreover, material 1 proved better than material 3 in terms of printing cyan and magenta; material 2 for printing the black ink, which implies that quality and reproduction of the prepress material can be enhanced by choosing the appropriate substrate.

3.2. Thermal Influence Analysis

All the samples were treated with ironing process in compliance with ISO 105-X11 standard, at 110 °C. Using thermal IC camera the exact temperature was determined on the iron surface.

Figure 5 shows the thermo vision picture of sample patches heat distribution with minimum and maximum temperature values. As can be observed, minimal offset implies that the heat applied to the printed surface was evenly distributed and of the right temperature.

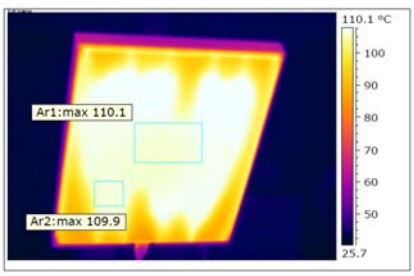


Figure 5. Thermo vision analysis of heat element at 110 °C

Standard ISO 105-X11 requires the gray scale method for evaluating the colourfastness and staining of cotton and the visual rating of the changes.

Table 2. shows that all colours printed on material 1 proved to have good colourfastness after ironing.

Experienced panel of judges assessed colourfastness and rated the basic colour changes in all 20 samples with 4, proving their fastness to be independent of number of printed ink layers. Staining was observed on the reference cotton fabric and shown that the highest values were obtained for cyan and black colour samples with just a single ink layer applied. Furthermore, the highest values 4-5 for yellow samples were obtained on prints with one and two ink layers. All other samples, beside cyan and black, printed with one layer and yellow printed with one and two layers, reported value 4. Final observation was on how different ink layers influence the staining of cotton fabric.

In Table 2 the analysis of material 2 is presented showing that a slightly smaller degree of cotton staining was measured on this material, which is accentuated in the samples with larger number of ink layers cyan (four and five) where the samples were rated 3. Except for this colour, lower staining values were also recorded for colours magenta (five layers) and black (five layers), which were nevertheless higher than values for cyan rated 3-4. The yellow colour samples had the smallest offsets and its recorded value for the cotton staining was 4. It must be noted that the colourfastness to ironing for all colours was ranked 4.

In Table 2 are presented results of the last series of analyses performed on material 3, showing the same value for gray scale change of all ink quantities, while for staining ranking the values varied. In comparison with the two other, this material had larger number of lower ratings, where cyan was the least durable and its values ranged from 3 to 4. Values of 4 for the magenta samples are higher for samples with two printed ink layers, while the values for additional printed layers have decreased to 3-4. Whilst yellow colour proved to be most colourfast with the constant value of 4, black and cyan had lower values ranging from 3 to 4. Value 4 was recorded in the black sample with one ink layer. In all other cases the values were around 3-4.

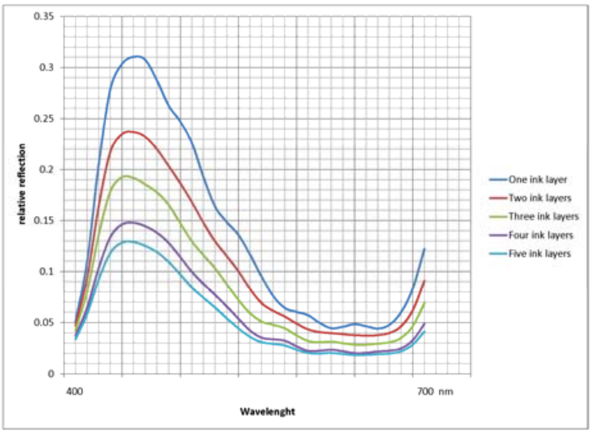
Table 2. Colourfastness to ironing at 110 °C (values of gray scale degrees)

Sample	Material 1		Material 2		Material 3	
	Ironing fastness	Degree of staining	Ironing fastness	Degree of staining	Ironing fastness	Degree of staining
Cyan 1	4	4-5	4	4	4	3-4
Cyan 2	4	4	4	4	4	3-4
Cyan 3	4	4	4	4	4	3-4
Cyan 4	4	4	4	3	4	3
Cyan 5	4	4	4	3	4	3
Magenta 1	4	4	4	4	4	4
Magenta 2	4	4	4	4	4	4
Magenta 3	4	4	4	4	4	3-4
Magenta 4	4	4	4	4	4	3-4
Magenta 5	4	4	4	3-4	4	3-4
Yellow 1	4	4-5	4	4	4	4
Yellow 2	4	4-5	4	4	4	4
Yellow 3	4	4	4	4	4	4
Yellow 4	4	4	4	4	4	4
Yellow 5	4	4	4	4	4	4
Black 1	4	4-5	4	4	4	4
Black 2	4	4	4	4	4	3-4
Black 3	4	4	4	4	4	3-4
Black 4	4	4	4	4	4	3-4
Black 5	4	4	4	3-4	4	3-4
Note: The number following colour name indicates number of ink layers printed on the substrate						

The previous analysis had shown that after the heat treatment (ironing) the colour changes were ranked with value of 4. Consequently, the increase of the applied ink quantity does not increase the resistance to changes during ironing. Although, staining of the cotton varied from material to material, the best results were recorded in material 1, with the fabric weight higher than in material 2, and thread count as in material 3. The lowest value was recorded with the material with the highest fabric weight (material 3). Finally, the application of additional ink layers decreases the transfer of staining.

3.2.1. Spectrophotometric measurements

Parallel to the usual visual ranking a series of spectrophotometric measurements were conducted using the reflection spectrophotometer Spectro Dens. Spectral data were collected from all samples before and after heat treatment, but because of large data set one representative sample shall be presented (cyan on material 1 with one ink layer) in Figure 6a and 6b. Figure 6a shows that with the application of ink layers its reflectance is decreasing and the largest values of reflection for this colour is in the blue region of the spectrum. With the application of heat during ironing a change in the spectral data can be observed, where the heat treated samples showed larger reflectance which is characterized with larger lightness values. Note that all samples on all materials showed a similar trend, where the application of additional ink caused smaller reflectance, but after ironing all the samples had higher reflectance than the untreated samples. The explanation of this effect most probably could be that the heat induced the evaporation of some part of the ink, what caused smaller light absorption and larger reflection.

a) 

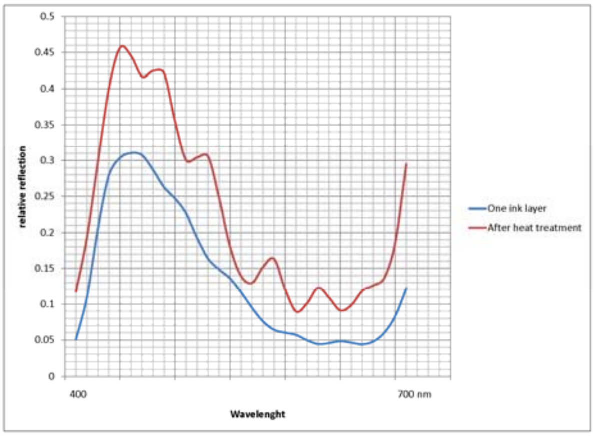
b) 

Figure 6. Spectral curves for one layer of cyan (material 1) a) after printing b) after heat treatment

K/S factor is in direct connection with reported behaviour of the samples. The higher K/S factor, the smaller sample reflectance, due to the smaller amount of light which passes through into the void between threads (more and more threads are bound together), for a large number of pigment particles which absorb light on the surface. Because the heat processing increases the samples reflectance, it could be concluded that the heat applied during the ironing removed some of the ink from the surface.

3.3. Analysis of the light and environmental factors on the colourfastness

For the purpose of the analysis of light and weathering colourfastness, all samples were tested according to the ISO 105-B02 (method 2). Values for light fastness are presented in Table 3. If the samples of material 1 printed with cyan ink were observed, it could be detected that all the samples, regardless of the quantity of ink applied, had the ranking value of 4. Samples of material 1 printed with magenta ink report the increase of colour fastness. Samples printed with one, two and three ink layers had value 4. Samples printed with four ink layers had colour fastness value 5 and value 6 was given to samples printed with five layers of ink, which means better colour fastness.

Table 3: Colourfastness to light and weathering (values of gray scale degrees)

Sample	Light fastness		
	material 1	material 2	material 3
Cyan 1	4	5	4
Cyan 2	4	5	4
Cyan 3	4	5	4
Cyan 4	4	5	4
Cyan 5	4	5	4-5
Magenta 1	4	3	3
Magenta 2	4	4	4
Magenta 3	4	4	4
Magenta 4	5	5	4
Magenta 5	6	6	5
Yellow 1	4	4	4
Yellow 2	4	4	4
Yellow 3	4	4	4
Yellow 4	4	4	4
Yellow 5	5	4	4
Black 1	3	5	3
Black 2	3	5	3
Black 3	4	5	3
Black 4	4	5-6	3
Black 5	4	6	4

Note: The number following colour name indicates number of ink layers printed on the substrate

Yellow colour samples yielded the grade 4 for the first four applied ink layers, while at the fifth layer the value was 5, which proves that the increase of layers can to some extent increase the colourfastness. The black colour samples showed the smallest colourfastness to light because the first two applied layers have value 3, while the samples printed with more layers have value 4.

The cyan samples printed on material 2 had the value 5 and this value was not dependent on number of applied ink layers. The samples with one layer of magenta ink had the smallest value of 3, while the samples printed with two and three ink layers exhibited larger colourfastness and have value 4, while the samples printed with four and five ink layers had value 5 and 6, respectively. The samples printed with yellow ink were constant and have value 4. The black samples were more colourfast than the yellow ones. The lowest value was 5 and it was observed at the first three ink layers. Increased colourfastness value 5-6 was recorded in the sample with four layers, while the samples printed with five ink layers were graded 6.

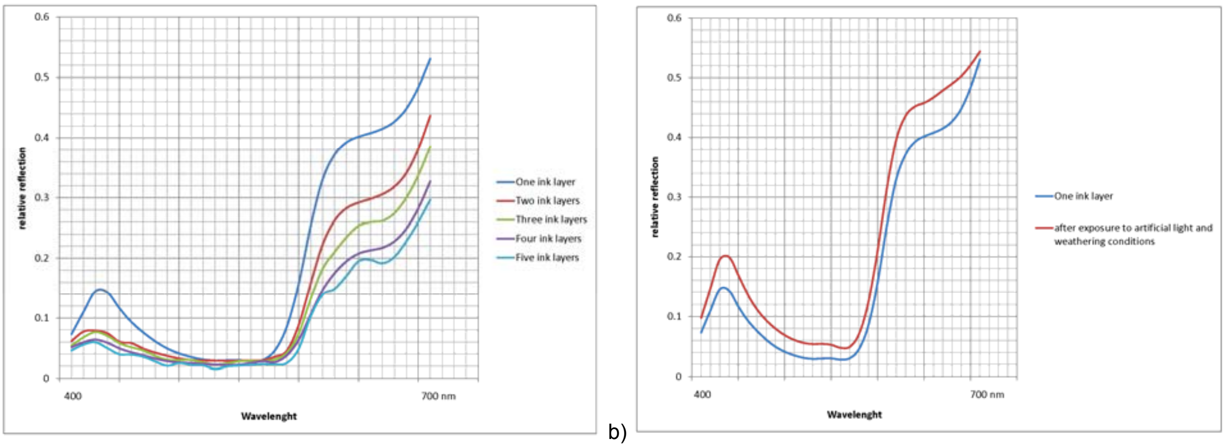
The analysis of the cyan colour samples on material 3 showed average colourfastness, so the samples printed with one to four ink layers have value 4. On the other hand, the sample with five layers had a somewhat larger value of 4-5. The analysis of magenta samples showed that the sample with just one printed layer had the smallest value of colourfastness, the samples with two; three and four ink layers reported higher colourfastness value 4. The sample with five layers which was ranked with grade 5 had the highest colourfastness. The yellow samples, similarly to the samples on material 2, exhibited changes which did not depend on the number of applied ink layers and their value was constantly 4. The black colour samples with one to four applied ink layers had value 3, while the samples with five layers had value 4.

3.2.1. Spectrophotometric Measurements

As in previous analysis of the samples treated with heat through ironing and the samples artificially aged with Xenotest and weathering, spectral curves before and after testing were generated. Magenta with one layer (material 2) is presented as a typical example. From Figure 7a it can be observed that with the increase of ink layers, reflectance decreases while being highest in the red region of the spectrum. After exposure to artificial light and weathering conditions, spectral curve changes occur, which results with higher reflectance for the aged samples in comparison to the printed samples not artificially aged (Figure 7b). This effect is typical for all samples and can most probably be attributed to the same effects observed during the ironing.

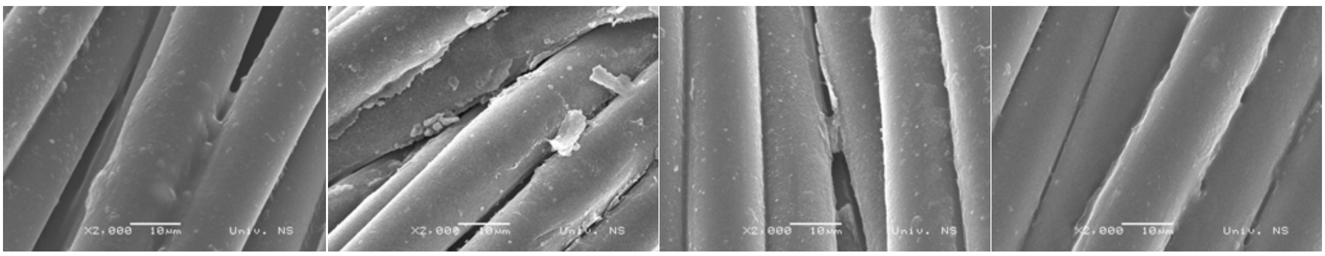
3.4. SEM Microscopic Analysis of Samples

SEM microscope was used on all samples before and after printing as well after ironing, ageing and weathering. One typical sample is presented in figure 8 (cyan colour with 5 layers printed on material 2). Figure 8 represents a) the unprinted and untreated synthetic threads b) printed surface with 5 layers c) results of ironing of the printed surface, and d) results on the surface after exposure to artificial light and weathering conditions.



a) b)

Figure 7. Spectral curves of magenta with one printed layer (material 2) a) after printing b) after exposure to artificial light and weathering conditions



a) b) c) d)

Figure 8. SEM images of material 2 samples, a) before printing, b) after printing, c) after ironing (110 °C), d) after exposure to artificial light and weathering conditions

Figure 8 shows a change in surface topography after printing. The surface of the printed samples is smooth and some particles, printing by-product can be found. Their quantity increases with the additional amount of ink applied, which was confirmed with spectrophotometric measurements. If the surfaces presented in Figure 8c obtained after printing and ironing were observed, it can be seen that some particles were removed by the heat, which led to smoother and more reflective surface. The smaller amount of particles was also noticed upon exposure to artificial light and weathering conditions, what was also confirmed by surface reflectance presented in Figure 7.

4. CONCLUSION

Textile materials used for flag printing are often exposed to various influences during use. All tested materials had different characteristics as well colours and colour quantities applied. The results lead to conclusion that the increase in number of ink layers causes linear increase of K/S value, which was confirmed with high coefficients of determination. Analysis also shows that K/S value is influenced by material characteristics, fabric weight and thread count in particular, but it is as well dependent on the colour of ink. This was also observed on samples printed with black and yellow ink where the K/S value increased with higher fabric weight and thread count, whereas in case of magenta and cyan ink effect was revered. Spectrophotometric measurements show the decrease of relative reflection with increasing number of ink layers printed on material. This effect can be explained by higher amounts of pigments blocking reflected light from the surface of material. The increase of ironing colourfastness with higher amount of applied ink was not registered in this experiment, but one can argue that gray scale test card is not sophisticated enough to register these changes and spectrophotometric measurements are necessary. However, in the same case the resistance to staining is decreasing with higher K/S values, because higher amount of pigments makes it easier for pigment to migrate to cotton fabric used for assessment of staining. After ironing the increase of reflectance was registered as a result of the pigment particles being fused together on the material surface. Ranking grades of light and weathering colourfastness can be improved with larger amounts of applied ink, which can be also related to K/S value, considering that higher K/S values increase colourfastness. These results were partly expected and it is logical to suppose that more ink layers would produce better light and weathering colourfastness. The samples exposed to artificial light and weathering conditions increase surface reflectivity as proven by spectrophotometric measurements. Ink particles were partly removed from surface and fused together, which was confirmed by SEM images (Figure 8.). The increase of printed ink layers will lead to a better final product in terms of resistance to various environment influences. In the production and reproduction process it is important to anticipate and properly simulate the behaviour of final product during exploitation period. This research offers insight in the influence of one parameter in textile materials printing process on longevity of flag products, but it can also be applied to any product produced by ink jet printing on polyester material.

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