Influence of Ink Layers on the Colour Fastness to Rubbing of Printed Textile Materials

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Abstract: Textile materials printed with screen or digital printing during the exploitation can be under the influence of various environmental elements and treatments. This paper presents research regarding influence of rubbing treatment on changes of printed textile material characteristics which are obtained by inkjet printing technique. Research was done on textile materials composed of 100 % polyester on which the test chart was printed. Test chart consisted of four colour fields each 100% of one of process colours (CMYK). Printing machine Mimaki JV22-160 with J-eco Subly nano inks was used. Variable factor was number of ink layers applied, textile materials ware printed with one, two, three, four and five layers of ink. With increasing number of ink layers, we also increase K/S values. The analysis of rubbing treatment influence on prints was done according to ISO 105-x 12 standards. Total of 20 samples were analyzed. Resistance of colour to rubbing treatment (dry and wet staining) was determined by usage of the grey scale.

1. Introduction

Screen and digital printing processes are mostly used for printing on textile substrates. Currently the most dominant printing technique for textiles is screen printing (90 % in 2000) [1], but it should be noted that digital ink jet printing is rapidly expanding in the textile markets because the ink jet printing process can achieve better flexibility, creativity, speed and environmental protection [2-3]. The great progress is made in the field of textile materials. Materials have different characteristics; those characteristics can be influential factors in the printing process, because characteristics of the materials correlate with ability of colour reproduction in printing process. Generally, textile materials may by describe with fabric weight, thread count and material composition. Characteristics of material could be improved with changing some basic characteristic or with some pre-treatment [4]. One of the important characteristics of textile ink jet printing process is that print formats are not limited in length; this is particularly suitable for designers in the pursuit of new ideas [5]. The amount of colour that is applied to the material in printing process could be determined with K/S value. The colour strength (K/S value) of dyed or printed fabrics is a measure of dye or pigment concentration in the fabric. This value is very important and we can find a lot of researchers who investigated K/S values [6 - 12]. 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 Vicker staff as the “Direct Colourimetric Estimation”. The principle is based on Kubelka-Munk theory which gives the relationship between the K/S and R (reflectance) [13]. In the present study, the colour strength of the printed samples was calculated using the Kubelka-Munk equation:

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

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

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.

Textile materials printed with screen or digital printing during the exploitation can be under the influence of various treatments such as washing, heat, light, rubbing etc. Colour fastness to rubbing is very often a topic of research [14 - 22]. Standard ISO 105-X12 can be used to examine influence of rubbing treatment on changes in printed material [14 - 22]. After rubbing treatment the colour resistance to dry and wet staining is judged. Gray scales are taken as a reference (*figure 1*). Judgment on the scale from 1 to 5 is taken as characteristics of materials examined, 1 being worst and 5 best.

The aim of this research is to determine influence of quantity of ink layers on the colour fastness to rubbing of printed textile materials.

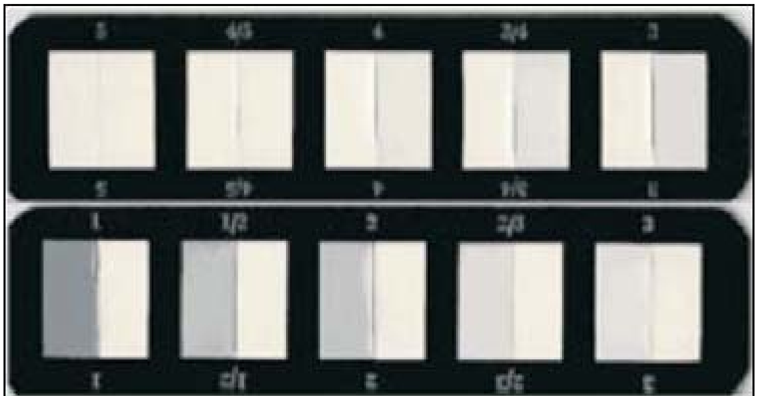

Fig 1- Grey Scale

2. Experimental

In the experiment the material composed of 100% polyester (determined using standard SRPS F.S3.112) was examined. It is characterized by following parameters: fabric weight (g/m2) – 120, 6 (determined using standard SRPS F.S2.016) and thread count (p/10 cm) – warp: 200, weft: 140 (determined using standard SRPS F.S2.013).

Generally, polyester textile materials are well known for their strong fastness and durability [23]. Material was printed by digital inkjet printing machine Mimaki JV22-160. J-eco Subly nano inks based on nano-dot technology were used. The volume of ink transferred to the material was varied; five different ink volumes were applied to material and used in analysis. The fields of 100% coverage for all process colours (CMYK) were printed.

For all samples we determined the colour strength (K/S value) and rubbing fastness.

Colour strength was determined with a spherical Datacolor Spectrafl ash SF 600® PLUS – CT spectrophotometer. Measurement geometry d/8 with 16 mm aperture, with D65 standard illuminant and 100 standard observers was used.

After spectrophotometric analysis we determined colour fastness to rubbing. Colour fastness was determined according to ISO 105-X12 with gray scale.

3. Results and Discussion

In these experiment, we determined the colour strength (K/S values) using the Kubelka Munk analysis. The K/S values for cyan with different volumes of inks are presented in *Figure 2*. We can see that with every additional printing layer the K/S value is raising. There is a linear correlation between number of ink layers and K/S values, with high degrees of determination factor R2 = 0,991.

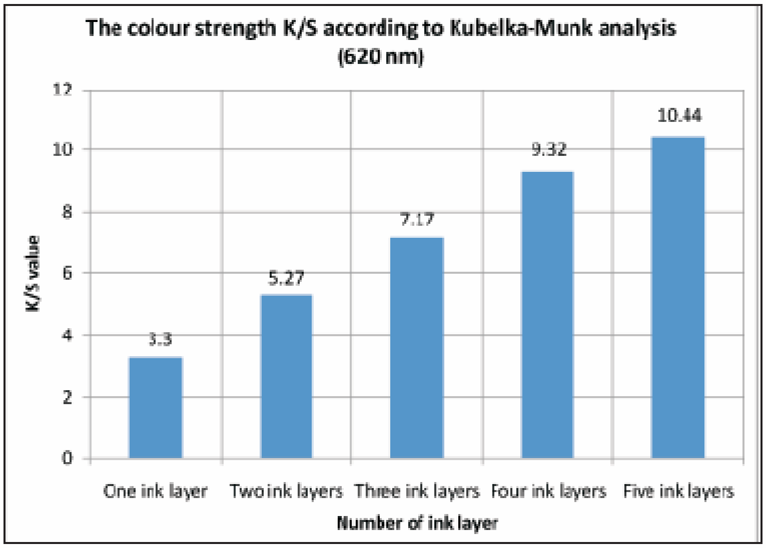

Fig. 2 – *Colour strength according to Kubelka – Munk analysis – cyan in relation to number of ink layers*

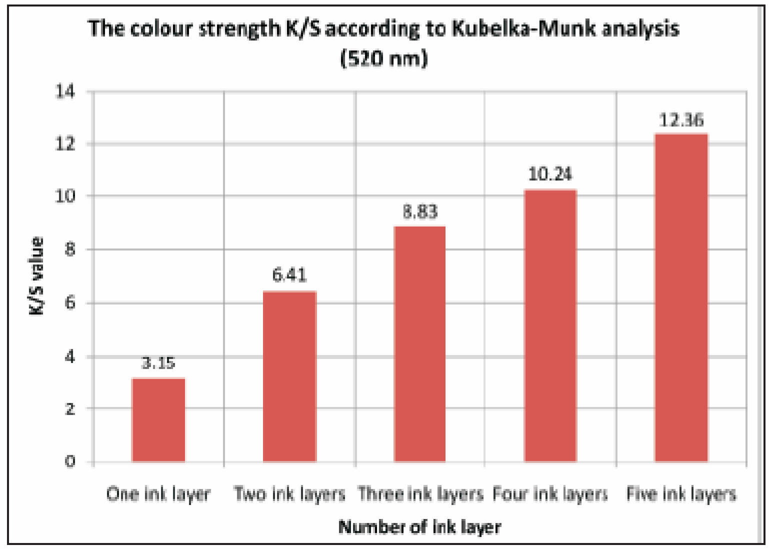

Fig. 3 – *Colour strength according to Kubelka – Munk analysis – magenta in relation to number of ink layers*

Similar to the samples printed with different volumes of cyan ink, we also find linear correlation between number of ink layers and K/S values, when we tested samples printed with magenta, yellow and black. The largest R2 was determined for the black colour and was 0,997 (*figure 5*). R2 was 0,979 where we analyzed magenta (*figure 3*) and 0,996 where we analyzed yellow (*figure 4*).

After measuring K/S values, we exposed samples to rubbing process. Total of 20 samples were analyzed. Resistance of colour to rubbing treatment (dry and wet staining) was determined by using the gray scale (*table 1*).

Results in this table show that samples have higher colour fastness to dry staining in comparing with results to wet staining.

In case of cyan colour change values for dry staining was 3 (samples printed with one and two ink layers), 2-3 (samples printed with three and four ink layers) and 2 (sample printed with five ink layers). Colour change values for wet staining was 2 when samples were printed with one, two, three and four ink layers. The lowest value for wet staining was 1-2 when sample was printed with five ink layers.

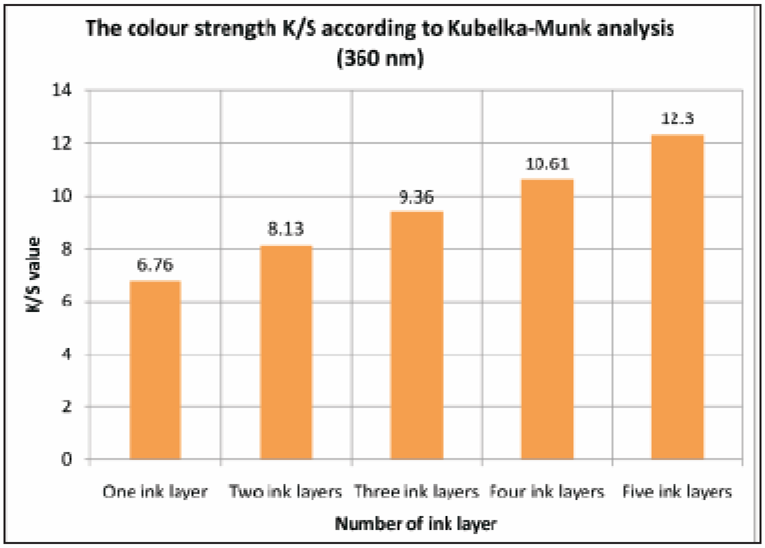

Fig. 4 – *Colour strength according to Kubelka – Munk analysis – yellow in relation to number of ink layers*

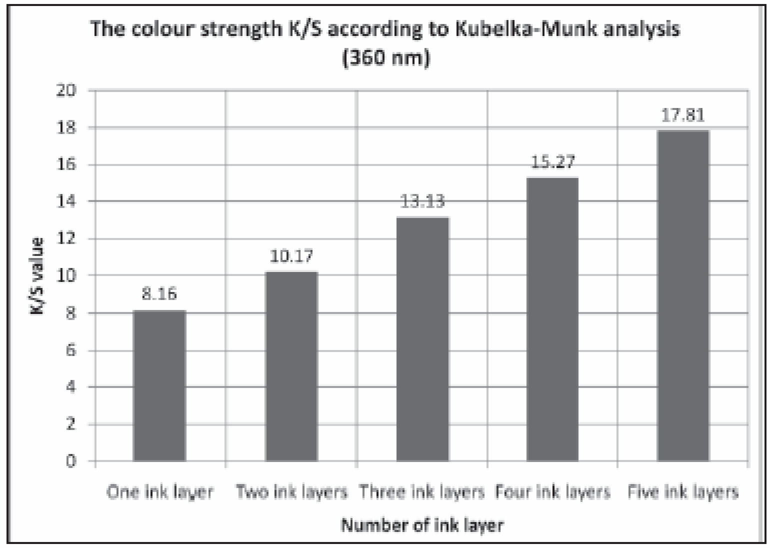

Fig. 5 – *Colour strength according to Kubelka – Munk analysis – black in relation to number of ink layers*

Colour fastness to rubbing was higher when we were printing with magenta ink.

When we analyzed colour fastness to rubbing (dry staining) we can see that sample printed with one ink layer showed good resistance with value 4. With increasing number of ink layers, colour fastness to rubbing was lower. Sample printed with two ink layers had 3-4 values for colour fastness. Values 3 for colour fastness to rubbing were determined for samples printed with three and four ink layers. For sample printed with five ink layers value was 2-3.

Samples exposed to wet staining had lower values to colour fastness. Values were 3 (samples printed with one and two ink layers), 2-3 (samples printed with three and four ink layers) and 2 (sample printed with five ink layers).

Samples printed with yellow ink exposed to rubbing were graded better than samples printed with cyan and magenta inks.

Higher values for colour fastness to rubbing were determined when we tested dry staining. That values were 4-5 (samples printed with one and two ink layers), 4 (samples printed with three and four ink layers) and 3-4 (sample printed with five ink layers).

After exposition to wet staining lower values to colour fastness were noticed.

That values were: 4-5 (sample printed with one ink layer), 4 (sample printed with two ink layers), 3-4 (samples printed with three and four ink layers) and 3 (sample printed with five ink layers).

Table 1- *Colour fastness to rubbing: ISO 105 – X12*		
Sample	**The assessment of dry staining according to grey scale (1-5)**	**The assessment of wet staining according to grey scale (1-5)**
Cyan 1	3	2
Cyan 2	3	2
Cyan 3	2-3	2
Cyan 4	2-3	2
Cyan 5	2	1-2
Magenta 1	4	3
Magenta 2	3-4	3
Magenta 3	3	2-3
Magenta 4	3	2-3
Magenta 5	2-3	2
Yellow 1	4-5	4-5
Yellow 2	4-5	4
Yellow 3	4	3-4
Yellow 4	4	3-4
Yellow 5	3-4	3
Black 1	4-5	4
Black 2	4	3-4
Black 3	3-4	3
Black 4	3	2-3
Black 5	3	2-3

Samples printed with black ink exposed to rubbing were graded better that those for cyan and magenta ink. Values for colour fastness to rubbing were lower in comparison to values for samples printed with yellow ink.

Values for colour fastens to rubbing (dry staining) were: 4-5 (sample printed with one ink layer), 4 (sample printed with two ink layers), 3-4 (sample printed with three ink layers) and 3 (sample printed with four and five ink layers).

Values for colour fastness to rubbing (wet staining) were lower: 4 (sample printed with one ink layer), 3-4 sample printed with two ink layers), 3 (sample printed with three ink layers) i 2-3 (samples printed with four and five ink layers).

4. Conclusion

Based on the results we can see that the increasment of the number of ink layers will increase K/S values. For all process colours, increasing the number of ink layers will linearly increase values for K/S which was confirmed with high coefficients of determination. Based on this information we can conclude that we found the correlation between the number of ink layers and K/S values. The highest values of K/S were noticed in black ink prints and K/S values of prints with different number of ink layers for magenta and yellow inks were smaller than in case of black ink but similar to each other. Samples printed with cyan ink had the smallest K/S values.

Generally, increasing the number of ink layers reduces a colour fastness to rubbing which is shown in *table 1*. In some cases, we determined same values according to gray scale (with different number of ink layers) but based on these results we can conclude that higher K/S value will increase colour fastness to rubbing. Lower values in all samples were determined when the samples were exposed to wet staining.

In the end, we can say that with increasing number of ink layers, we could not improve colour fastness to rubbing, because in the surface of samples will have large amount of inks. When those samples are exposed to rubbing, large amount of inks will be removed.

Acknowledgment

This work was supported by the Serbian Ministry of Science and Technological Development, Grant No.:35027 "The development of software model for improvement of knowledge and production in graphic arts industry"

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"This article was originally published in the Tekstilna Industrija magazine, June, 2012"