Analysis of change in surface roughness of samples printed using screen printing with variable mesh type

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Abstract: *This paper presents results of experiment conducted in order to determine influence of mesh density on surface roughness of textile materials printed with screen printing technology. Experiment was conducted to prove hypothesis that printing with different mesh density of the screen will cause changes in surface roughness parameters. Density of the screen mesh is usually used for determining volume of the ink transfer to the substrate. Volume of the transfer ink has a significant influence on changes in surface roughness of substrates. Surface structures of the textile substrates are filled with ink thus causing changes in surface roughness. For these experiment three different types of screen printing mesh were used with variable mesh density, 46, 54, as well as 90 threads per centimeter. Printing substrates used in the experiment was textile material composed of 100 % cotton. Inks used for printing were cyan, magenta, yellow, black, and green. All together 15 samples were made and their surface roughness was measured using TR 200 measuring unit. Mean value of 10 measurements is presented and further analyzed. The results showed a correlation between the type of screen printing mesh used and changes in surface roughness.*

Keywords: *screen printing, type of mesh, surface roughness*

1. Theoretical part

The most used printing techniques for textile printing in today's market are screen and digital printing. The advantages of screen printing are simple printing process, equipment price, and speed [1, 2]. Screen printing is a printing technique that uses a mesh to support an ink blocking stencil. The attached stencil forms open areas of mesh that transfer ink or other printable materials, which can be pressed through the mesh as a sharp-edged image onto substrate. A fill blade or squeegee is moved across the screen stencil, forcing or pumping ink into the mesh openings for transfer by capillary action during the squeegee stroke [3].

Besides ink viscosity, substrate surface, position, and hardness of the squeegee and other factors, mesh openings and mesh thickness have a decisive influence on the quality of the printing results [4]. Density of the screen mesh is usually used for determining volume of the ink transfer to the substrate. A typical fabric classification system uses the number of threads per cm (mesh) measured in both the warp and weft directions. The fabric meshes are usually classified as coarse, medium, as well as fine. Coarse meshes run in mesh counts of 43 threads per cm and finer up to 95 threads per cm. Medium mesh counts fall in the 120–140 threads per cm range. Fine meshes have a mesh count from 153–185 threads per cm and higher [5]. The higher the mesh count, the finer the threads, and holes are in the screen. The size of the mesh has a lot to do with how detailed your image is and how thick the ink you are using is. If you have an image with extremely high details, the fine mesh should be used. Otherwise, the fine lines or dots in the image will simply fall through the holes in the mesh not giving you a correct representation of what your image should be. In addition, if you are using a thinner ink, the ink will also flood through the larger holes and soak the substrate, making your image blurry as the ink bleeds. On the other hand, if you are trying to print a thicker ink (such as white) through to high of a mesh screen, barely any ink will print through the mesh [6].

All textile materials have distinctive properties, which differ from that of other materials, and their surface it is not absolutely flat. They have a certain roughness. At the very roughness affects both the mode of production, and their processing [7, 8], you can say that with the processing of raw materials of textile fiber surface roughness decreases [8] and that fibers of different origins have different roughness. On textile materials, printing can be done with digital or screen printing techniques, but as in the first [9] in the second case also [10], color application will result in changes in surface roughness.

This paper presents results of experiment conducted in order to determine influence of mesh density on surface roughness of textile materials printed with screen printing technology. Experiment was conducted to prove hypothesis that printing with different mesh density of the screen will cause changes in surface roughness parameters.

2. Experimental part

In this experiment, we investigated changes in surface roughness of printed samples. Material used in experiment was one of the most used types of materials in textile printing. Test chart was printed with screen printing with variable mesh type.

2.1. Methods and materials

The experiment included the measurement and determination of the relevant data necessary to accurately define the impact of mesh type on the printed samples. For this experiment three different types of screen printing mesh were used variating in density, 46, 54 as well as 90 threads per centimeter. Test chart was printed on the material by screen printing technique using M&R Chameleon with Classic Plastisol inks (cyan – OP215, magenta – OP135, yellow – OP058, black – OP001 as well as green – PANTONE 361 C). The textile material with 100 % cotton was taken as the sample, whose properties are following (table 1):

Table 1: Characteristics of material used in testing

Tests	Methods	Unit of measure	Values
Weight	SRPS F. S2.016	g/m^2	130
Material composition	SRPS F. S3.112	%	100 (cotton)

After printing process, we determined surface roughness for 15 samples. Basic parameters for measuring surface roughness are as follows:

- Ra – arithmetic average of the absolute values of deviations of the profile inside the reference run,
- Rz – the arithmetic average of the deepest single file roughness measuring several adjacent tracks,
- Rt – total height profile,
- Rp – maximum height profile,
- Rv – deepest valley [11].

The analysis of roughness parameters was conducted using Ra, which in relation to the Rz gives a better correlation between subjective and measurement results, and that is reason why this unit was adopted as a principal in determining the surface roughness [11], Rp, because it is interesting to watch how the thermal effects influence to the maximum height profile as well Rt. Analyze Rt parameter were interesting because, that parameter represent total height profile.

The device used for measuring the roughness of TR 200, with settings shown in table 2.

Table 2: Set up TR 200

Cutoff	0.25 mm
Access	5L
Standard	ISO
Range	+/- 80 μm
Filter	RC
Unit	metric

3. Results and discussion

The results of roughness measurements showed changes of Ra parameter (figure 1). In case of samples printed with cyan values for Ra were 4.321 μm (46 threads /cm), 6.457 μm (54 threads/cm) as well as 8.907 μm (90 threads /cm). The lowest value for Ra in case when we printed magenta ink was 5.374 μm (46 threads /cm). The biggest value was 7.383 μm (90 threads / cm). When we printed with 54 threads/cm mesh value for Ra was 6.549 μm. Samples printed with yellow ink had values 5.565 μm (46 threads/cm), 6.445 μm (54 threads/cm) and 7.472 μm (90 threads/cm). Ra values for samples printed with black ink were 3.730 μm (46 threads/cm), 5.428 μm (54 threads/cm) and 6.805 μm (90 threads/cm). The lowest value for Ra we determined when we had analyzed for samples printed with green inks. Values were 2.191 μm (46 threads/cm), 2.231 μm (54 threads/cm) and 2.919 μm (90 threads/cm). When all the samples were analyzed, it can be concluded that with bigger mash thread count, values for Ra were bigger.

The second analysis of printed samples was analysis of Rp (figure 2). Similar to measurement Ra parameters results for Rp parameter showed that samples printed with bigger mash threads per cm, had bigger values for Rp. Samples printed with cyan ink had values 8.096 μm (46 threads/cm), 12.891 μm (54 threads/cm) as well as 16.686 μm (90 threads/cm). Values for other inks were: magenta: 10.284 μm (46 threads/cm), 14.054 μm (54 threads/cm) and 24.491 μm (90 threads/cm); yellow: 9.453 μm (46 threads/cm), 11.955 μm (54 threads/cm) and 13.696 μm (90 threads/cm); black: 8.196 μm (46 threads/cm), 10.354 μm (54 threads/cm) and 12.525 μm (90 threads/cm); green: 4.788 μm (46 threads/cm), 4.919 μm (54 threads/cm) and 6.723 μm (90 threads/cm).

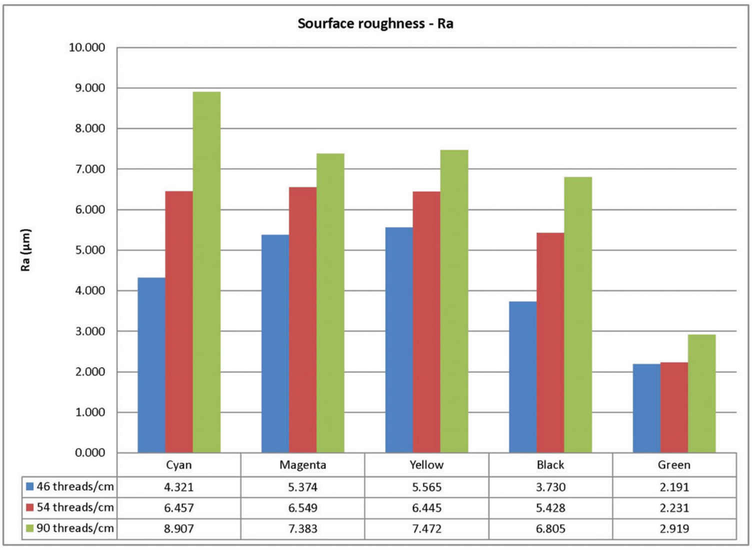

Figure 1: Change the parameter Ra

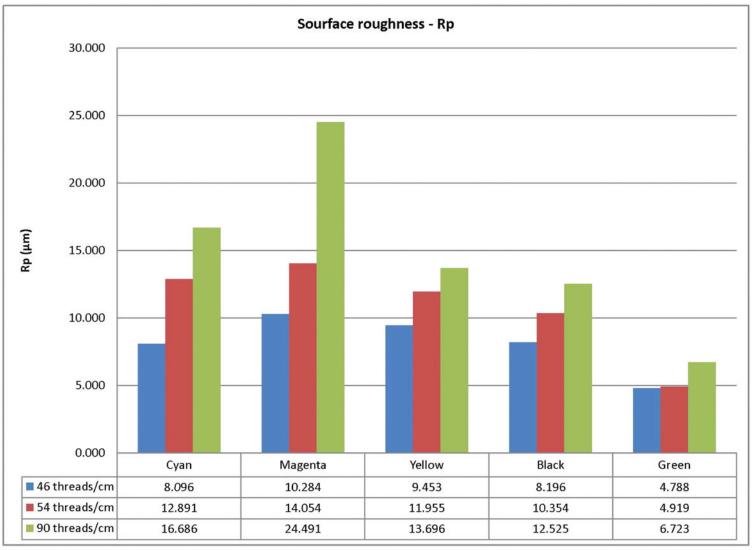

Figure 2: Change the parameter Rp

The last analyze was analysis of Rt (figure 3). In case of samples printed with cyan values of Rt were 29.942 µm (46 threads /cm), 41.536 µm (54 threads /cm) as well as 43.804 µm (90 threads/cm). The lowest value of Rt in case when we printed magenta ink was 32.868 µm (46 threads /cm). The biggest value was 43.914 µm (90 threads /cm). When we printed with 54 threads/cm mesh value of Ra was 38.708 µm. Samples printed with yellow and black inks had values: yellow: 33.178 µm (46 threads/cm), 41.156 µm (54 threads/cm) and 44.264 µm (90 threads/cm); black: 31.140 µm (46 threads/cm), 32.166 µm (54 threads/cm) and 45.098 µm (90 threads/cm). Like in previous analyze, the lowest value of Rt was determined in case of samples printed with green inks. Values were 14.454 µm (46 threads/cm), 16.808 µm (54 threads/cm) and 22.456 µm (90 threads/cm). Results showed that with bigger mash thread count, values of Rt were bigger.

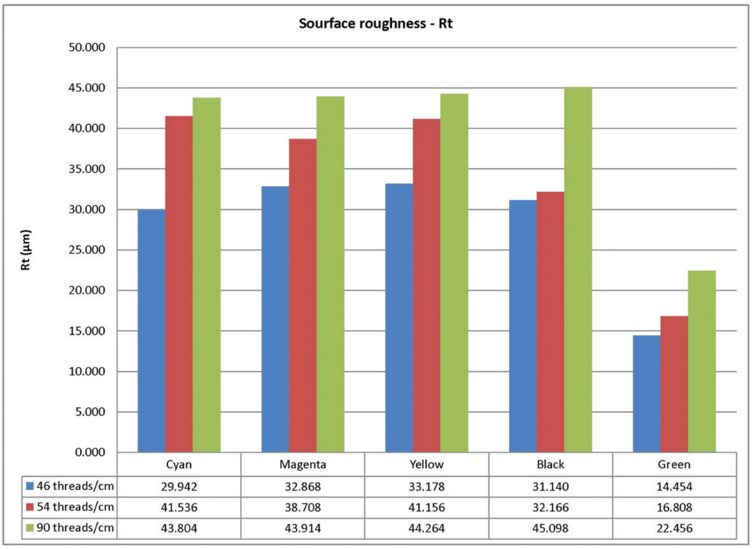

Figure 3: Change the parameter Rt

4. Conclusion

The results in the experiment showed a significant dependence of surface roughness parameters on screen printing mesh characteristics. For all printed samples, no matter which ink was used, variations of mesh thread count are reflected in changes of surface roughness of materials i.e. changes in the arithmetic mean of the absolute value of deviation profile inside the reference run (Ra), maximum height of the profile (Rp) as well as total height profile (Rt). Increase in mesh thread count causes increase in all the analyzed parameters of surface roughness. The reason is that ink in printing process fills textile material structure. With lower density of mesh, ink volume on the substrate surface was higher and it filled structure of the material causing lower values for Ra, Rp and Rt parameters.

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6. References

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