The study of the screen printing quality depending on the surface to be printed

Viorica Cazac[1,*], *Jana* Cîrja[1], *Emilia* Balan[2] and *Cristina* Mohora[2]

[1] Technical University of Moldova, Design and Printing Technologies Department, MD-2004, 168, Stefan cel Mare Blvd., Chisinau, Republic of Moldova
[2] Politehnica University of Bucharest, Machines and Production Systems Department, RO-060042, Splaiul Independentei no. 313, district 6, Bucharest, Romania

Abstract. This paper presents the study results regarding the analysis of the screen printing quality on different types of materials. The quality of the screen printing is determined by several particularities of the screen printing process such as: the type of mesh, screen ruling, ink viscosity, raster spacing, etc. The material which is supposed to be printed is as important as the particularities of the screen printing process itself. The composition, structure and features of the printed items as well as the composition, viscosity and other ink properties, all together determine the quality of the screen printed matter.

1 Introduction

Screen printing is used to print on different types of items, such as technical textiles, textiles for clothing and footwear, leather goods, furnishing, household and decorative textiles. At the same time, textiles used in the fields of aeronautics, medical, electronics, automotive, etc. have to be taken into consideration. Moreover, the printed surface can be made of paper, cardboard, polymeric materials, wood, metal, leather and non-woven substitutes.

The variety of printed surfaces that can be used in the screen printing by helps to increase the fields where the screen printing can be applied. However, the multitude of these fields requires extensive studies to analyze and evaluate the quality of the screen printing and adhesion characteristics of screen printing inks on different printed surfaces. In this paper, the quality of the screen printing on textiles is analyzed according to the printing with of water-based screen printing inks.

2 Screen printing classification

The extent of the diversity of screen printing imposes the need to identify the criteria for classification and classification of their own called. The criteria of the screen printing classification are shown in the Figure 1.

* Corresponding author: viorica.cazac@dtp.utm.md

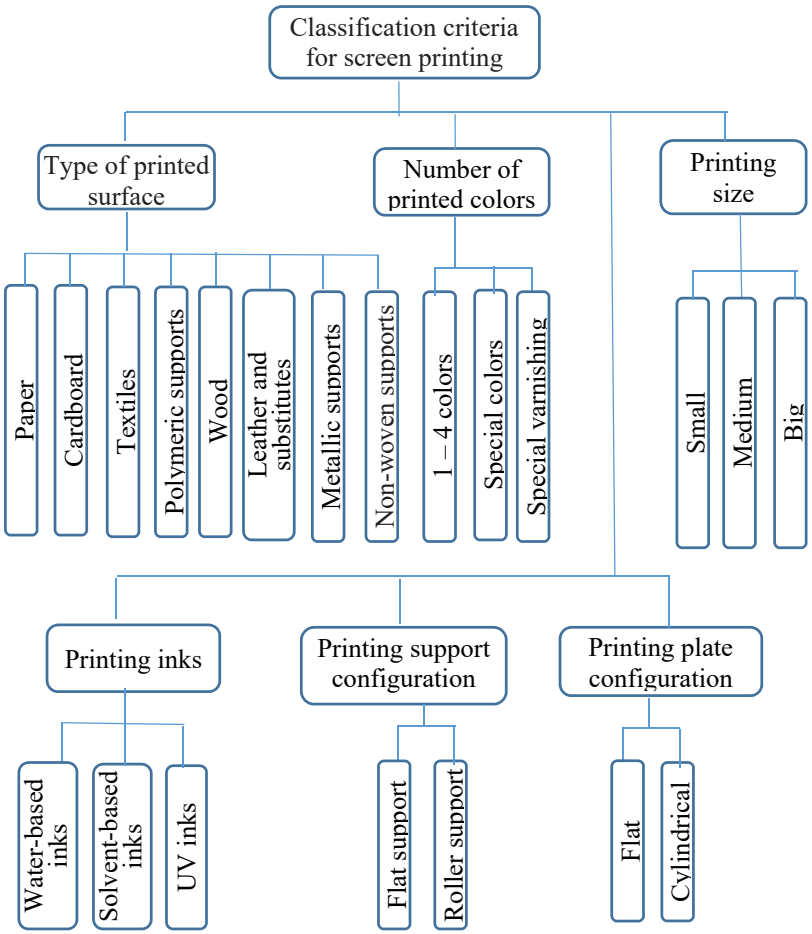

Fig. 1. Classification criteria of screen printing.

3 The technological particularities of screen printing

The surface to be by screen printing interacts with inks using a screen that can be flat/plane or cylindrical (Figs. 2-3) and is prepared using mesh. The factors that determine the quality of the screen printing process are [2-6]:

- mesh type (PET, PA);
- mesh color;
- thread diameter;
- mesh density (counted thread/cm);
- mesh stretching angle;
- raster density;
- raster angle;
- ink viscosity;
- print speed;
- squeegee angle;
- take of distance.

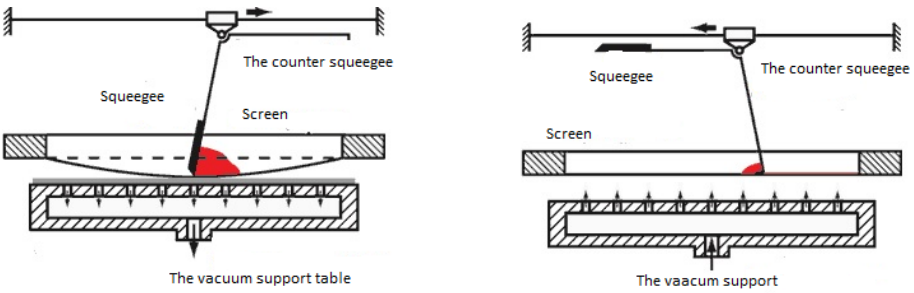

Fig. 2. The functional model of flat screen printing press.

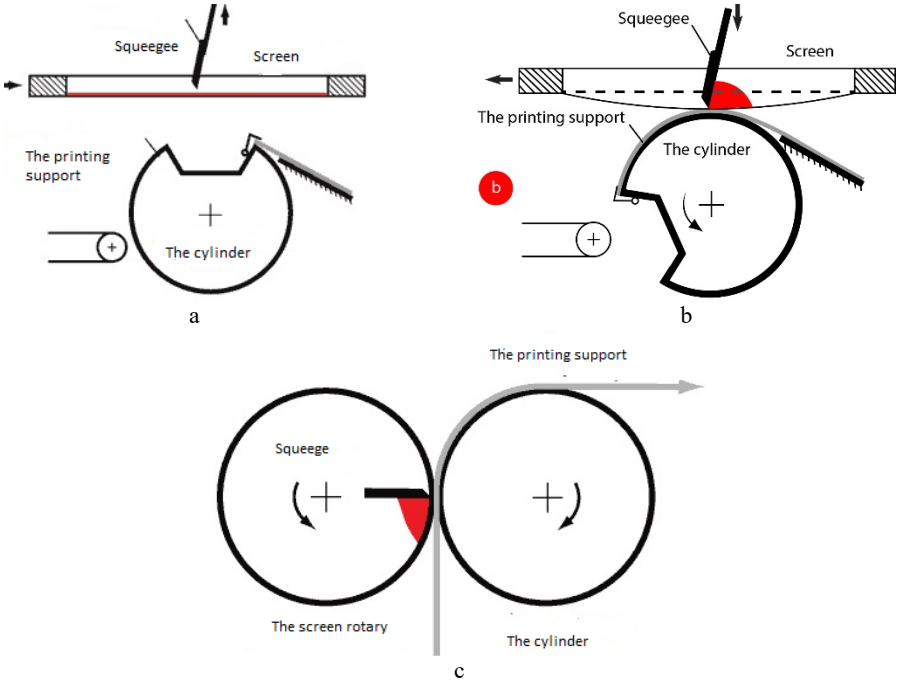

Fig. 3. The functional model of screen printing press: a, b – flat screen printing press; c – cylindrical screen printing press.

4 Case studies

By considering the current trends in the safety of printing, the study was focused on the analysis of the screen print quality by assessing the adherence of water based inks on paper, textile and materials.

Characteristics of the materials included in the study are presented in Table 1.

Representative quality characteristics for screen printing include the adherence of inks to the surface, washing resistance, chromatic resistance, friction resistance, resistance to climatic factors.

The properties of the printed film ink are influenced by the composition of the inks and the nature and the structure of the printed surface as well. Thus, the substrates with good absorption properties will provide a good quality printed image avoiding the occurrence of

inconsistent scattering of the inks on the surface, linearity of the reproduced contours, soiling of the surfaces, good registration.

Based on the above, it has been decided to evaluate the hydrophilicity and vaporous permeability of the surface to be printed to evaluate their absorption properties.

The vaporous permeability evaluation was carried out by using the HERFELD glass method; the hydrophilicity assessment used the capillary aspiration velocity method, the friction wear resistance - by mass loss after a certain number of friction cycles by using the WAARTESTER apparatus [1]. The friction dye resistance - by the degree of color loss using the PILLTESTER machine, the inking of the inks on the supports was evaluated by the rapid test using the ink transfer from the printed surface to the adhesive tape, the ink resistance - by the inks' color loss compared to the standard samples.

Table 1. Characteristics of the materials included in the study.

The trade mark	Coding	Fibrous composition	Thickness, (mm)	Density, (g/m^2)	Density (yarns/10cm)		Type of link material	Width (cm)
					U	B		
110	**B 1.1**	100% C_0	0.21	101.59	290	260	Textile, cloth	152±2
190	**B 1.2**	100% C_0	0.27	141.87	290	250	Textile, cloth	152±2
750	**B 1.3**	100% C_0	0.22	118.73	260	220	Textile, cloth	152±2
350	**B 1.4**	100% C_0	0.245	132.93	290	250	Non-woven	152±2
230	**B 1.5**	100% C_0	0.23	129.67	280	250	Non-woven	152±2
550	**B 2.1**	98% C_0 2% LY	0.99	305.75	300	280	Textile, cloth	152±2
650	**B 2.2**	98% C_0 2% LY	0.85	287.32	280	280	Textile, cloth	152±2
1149/329	**B 3.1**	98% C_0 2% ES	0.61	264.20	400	160	Textile, cloth	152±2
1149/331	**B 3.2**	98% C_0 2% ES	0.31	124.50	380	140	Glat knit	152±2
932/257	**B 4.1**	70% C_0 30% PES	0.4	241.96	270	250	Glat knit	152±2

The structural analysis of the surface to be printed by using the organoleptic method with the Dino Lite digital microscope with magnification capacity z = 230x is shown in Figs. 4-7.

In order to evaluate the adhesion of the screen printing inks, the 10 types of materials presented in Table 1, 3 samples for the same type of material (Figures 5-7) were printed.

The screen used (Figure 4) was prepared using mesh with the following identity features: surface density 120f /cm, yellow mesh.

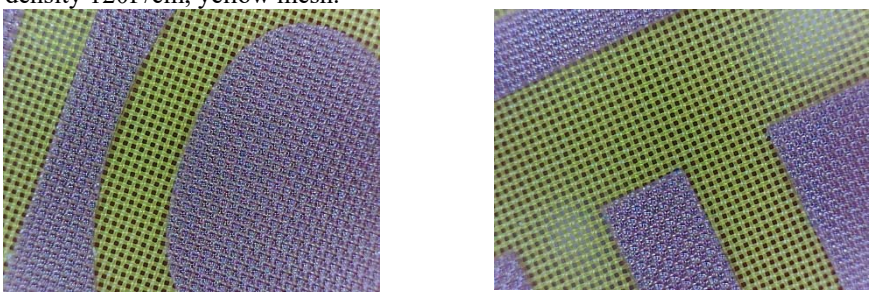

Fig. 4. Screen used in screen printing process, z = 150x.

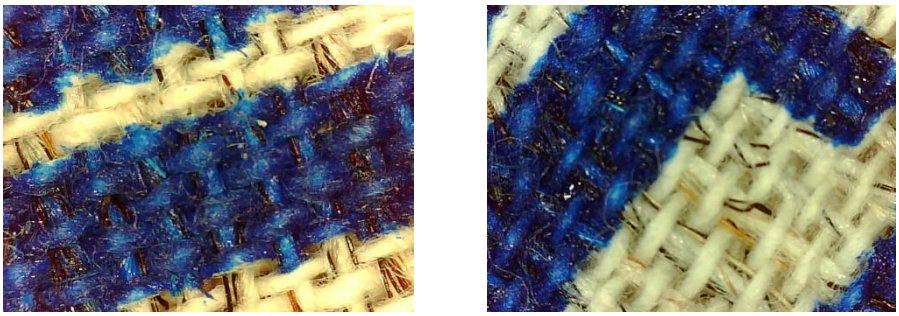

Fig. 5. Printed samples on textile surfaces, z = 200x.

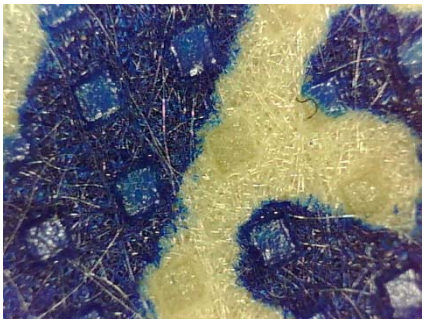

Fig. 6. Microscopic appearance of non-woven surface printed by using screen printing method, z = 200x.

Fig. 7. Microscopic appearance of the knit printed surface by using screen printing process, z = 200x.

The results of the tests carried from the tests carried out on different types of surfaces are presented in Table 2.

Table 2. Results of the quality evaluation of screen printing.

Sample	Vapor permeability, P_v, mg/m^{2}s	Hydrophilicity, Va, cm/min	Resistance to rubbing wear, μ	Resistance at dyeing, points, Rv, pt	Inks' adherence to surface Ac, pt	Ink resistance after 0 wash
110	28.4686	14.86613	1.14	5	5	5
190	18.4942	16.12808	1.12	5	5	5
750	3.07544	15.95084	0.24	4	4	5
350	23.3775	20.77735	1.02	5	5	5
230	21.2995	15.56216	1.3	4	4	5
550	2.2858	18.61218	1.48	4	4	4
650	3.3248	16.60412	1.4	3	4	4
1149/329	3.34558	18.16195	1.66	4	4	5
1149/331	4.9872	17.39671	1.6	4	4	5
932/257	5.21578	14.02253	0.08	5	5	4

In Figure 8 there is the graphical interpretation that demonstrates the variation of the permeability of the materials subjected to different pressures, as well as their hydrophilic properties (Figure 9).

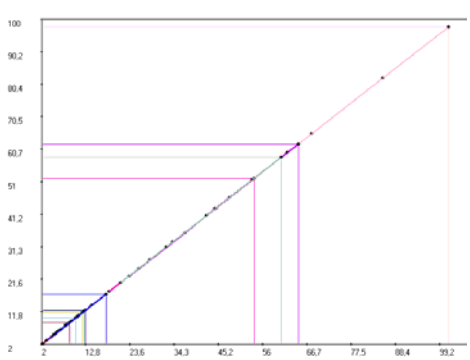

Fig. 8. Permeability of materials to air at 10, 20, 30, 40, 50 N/m^2 - pressure difference.

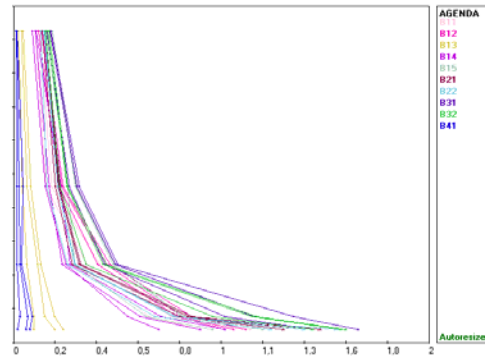

Fig. 9. Hydrophilic materials in the longitudinal, transverse direction and under 45^0.

5 Conclusions

The analysis of the quality of the screen printing on various types of surfaces has denoted the importance of the properties is influenced by the nature of the raw material from which they are made: of natural or chemical origin. Surfaces of natural origin have good hydrophilic characteristics as compared to those in mixture B1.1-B1.4. All surfaces have good hydrophilic properties in the transverse and oblique direction during the first 10 minutes of exposure. After 10 minutes of loading and saturation of the supports, the capillary ascent rate is reduced relatively to the onset phase. Supports of natural origin have good ink adhesion properties. Depending on the types of surfaces to be printed, the best adhesion of the inks was presented by the cellulosic supports. In the same context, due to their structural constitution, the cellular supports have the best absorption characteristics, which explain the low drying time and the fixing of the inks on the surface. Moreover, the textile and knitted surfaces require drying with specially designed methods. Good wear resistance present the textile materials included in the study in relation to cellulose materials. Thus, screen printed cellulosic materials can be further on treated by lacquering or plasticizing in the post-press process to improve their wear resistance.

The organoleptic analysis of screen printing shows good impregnation of water-based screen printing inks in the surface structure without any ink scattering effects, linear contour irregularities, large transferable volume of ink, etc.

References

1. AGIR. *The textile engineer's manual*, vol. III, 1586 p. ISBN: 973-8466-10-5 (2004) (in Romanian)
2. D. Gudilin, *Screen Printing equipment*. (in Russian) [http://compuart.ru/article/8809]
3. FESPA. *The future of screen printing.* [https://www.fespa.com/en/news-media/industry/the-future-of-screen-printing]
4. T. Klosowski, *A simple guide to screen printing your own shirts*. [https://lifehacker.com/5886483/simple-guide-to-screen-printing-your-own-shirts]
5. *Handbook of print media: technologies and production methods* p. 1180 (Heidelberg, Springer, 2001)
6. SEFAR. *Screen printing*. Electronic Design and Consulting Group. Bucharest (2005)