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Calculation of the importance of quality factors in braille application process on labels by screen UV-varnishes

ABSTRACT

Oriented graph has been drawn in the article according to fixed factors of the quality of applying Braille screen printing on the label by screen UV-varnishes. Using hierarchical representation of relationships between factors in the form of oriented graphs we have ranked the factors of the screen printing process of Braille elements by UV-varnishes and calculated their corresponding coefficients. We have found that the most ranked are such factors as the surface energy of the printing material, the printing speed, the temperature of UV-varnish and its viscosity. Received results of ranking will enable to synthesize the model of the process' priority factors and to reveal the possibilities of regulations of geometrical parameters of the tactile font elements.

KEY WORDS
screen printing, UV-varnish, hierarchy model, tactile fonts

Vyacheslav Repeta,
Vsevolod Senkivsky,
Sergiy Piknevych

*Ukrainian Academy of Printing,
Faculty of Publishing, Printing and
Information Technologies,
Lviv, Ukraine*

*Corresponding author:
Vyacheslav Repeta
e-mail: uad-pmc@yandex.ru*

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Introduction

In Europe, in accordance with the Directive (Directive 2004/27/EC, 2004), they carry out labelling of pharmaceutical products and products that have potential dangers with tactile fonts and symbols that allows people with visual impairments to get information about a specific type of a product or danger. The actual content of information on the products packaging depends on labelling drawbacks or its lack, in the case of drugs it can be dangerous for life and health of a consumer, and in the case of dangerous substances – for the society as a whole.

According to current standards (ISO 17351, 2003), the labelling is performed with the help of Braille fonts, which is based on a combination of six points (elements) with the relevant geometrical parameters. Reproduction of Braille elements and tactile warning signs of danger is made in many ways, including: congreve stamping, screen printing technique (rotary, flat), digital inkjet printing technique. Screen and digital inkjet techniques of tactile fonts application owe their development to UV-varnishes design that are capable to form solid polymer structure at irradiation by actinic UV-emission. The applied UV-varnish elements are characterized by high resistance to abrasion and to aggressive environments influence. Market of polygraphic materials is provided with a wide assortment of relief UV-varnishes: UVLB1, UVRS 912, UVLB2, UVLG 7 (Marabu GmbH & Co), UVD 01120, Braille Maker Varnish 1,0A (Flint Group), RS 250 (Pulse Roll Label Products Ltd), UV 747 (N.V. UNICO), UVivid Screen CN622, UVivid Rotary Screen RN 622 (Fujifilm-Sericol), Excure 90356 Screen (Schmid Rhyner AG), Sicura Screen LM № 85-600579-8 (Siegwerk Switzerland AG). For this purpose printing forms with mesh of low lineature with a big number of applied copying emulsion are used in screen printing . In order to big reliefs by the help of UV-varnishes of rotation screen printing, companies Gallus Screeny, Stork Prints B.V. (Gudilin, 2007), Kocher+Beck GmbH (Etiketen-Labels, 2011), Seasky Rotary Screen CO., LTD produce metal mesh, with the provisionally applied emulsion layer for single usage and mesh for multiple usage.

This work is devoted to detection of quality factors priority of Braille screen printing process by UV-varnishes.

Methods

It is known that the method of hierarchies' analysis has gained the widespread use for the research of operations and technological processes (Saaty, 1980; Pich and Senkivskyy, 2013). The method is a systematic procedure for hierarchical representation of the elements or factors that determine the nature of a system. Solving the matrix range and pair wise comparison of factors that form the system we can calculate the value of their priority. Built upon the graph the distance matrix contains both direct impacts and dependencies between factors as well as indirect or consequential, that is, those which pass through another factor. Both types of impacts are identified in the matrix in the same way, there is no different between them. Consequently, this leads to the fact that the analysis and processing of binary elements of the distance matrix using iterative tables leads to placing of two factors at the same level of hierarchy that have the same values regarding the number of impacts and dependencies, though according to the original graph, one of these factors affects another, which leads to some inadequacy of the hierarchical model.

Taking this into account, for the analysis of the process factors we have used the method (Senkivskyy et al, 2013), which takes into account not only the number of impacts or dependencies between factors, but also distinguishes their types by giving different weights to each of them.

The works (Piknevych and Repeta, 2013-2014) presents the analysis of the technological process of screen printing application of UV-varnishes images, tactile fonts, symbols and identifies the factors that affect the quality geometric parameters of their elements. The combination of these factors makes some set F={f_1, f_2,..., f_n}.

The most significant among them are:

f_1 – Surface energy of a printing material (SE);
f_2 – Surface tension of UV-varnish composition (ST);
f_3 – Viscosity of UV-varnish composition (VV);
f_4 – Characteristics of a screen printing plate (PS);
f_5 – Absorbing ability of a printing material (AD);
f_6 – Temperature of UV-varnish composition (TV);
f_7 – Spreading of UV-varnish composition (SV);
f_8 – Parameters of a printing contact (TP);
f_9 – Speed of printing (SP).

The subset of selected factors and possible interactions between them are given in the form of the oriented graph (Figure 1). It points to the dependence of one factor of the process of selective screen printing UV-varnishing on the other.

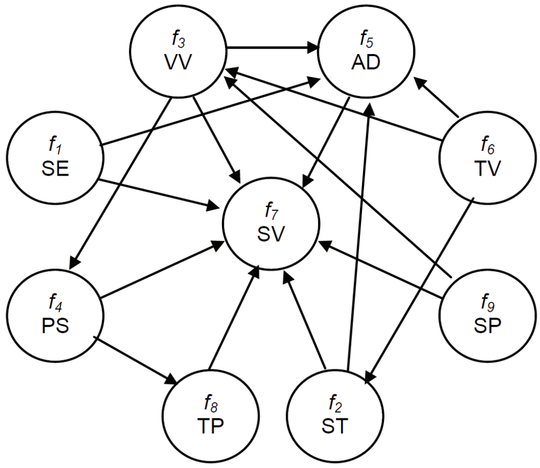

Figure 1: *The graph of relationships between the factors*

Based on the graph in Figure 1 for each factor we build hierarchical trees of their relationships with other factors, including the impacts of both types – direct and consequential, that are indirect, which pass through another factor.

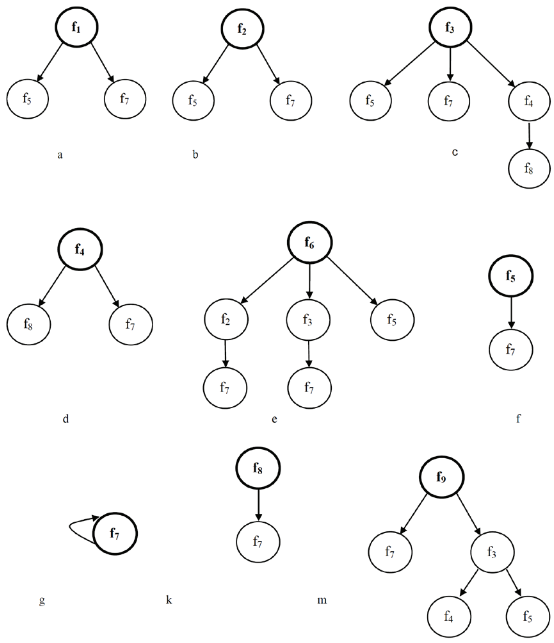

Figure 2: *The graphs of multilevel hierarchical relationships for the factors of selective screen UV-varnishing process (a – m)*

After analyzing the graphs (Figure 1 and 2), we make a separate division of the factors showing the number of direct impacts of each factor and the ways of its dependence on other factors (Figure 3).

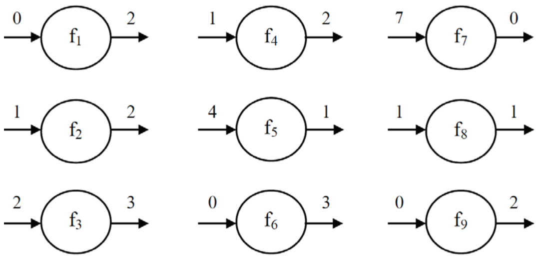

Figure 3: *Directions of impacts and the ways of the factors dependency of screen UV-varnishing process*

We make the calculation of the total weight values of direct and indirect impacts of factors and their integral dependence on other factors. For this we introduce the following symbols. Let k_{ij} be the number of impacts (i=1 – direct, i=2 – indirect) or dependencies (i=3 – direct, i=4 – indirect) for *j* factor (j=1,...,n); w_i – weight of *i*-type. For these calculations we assume such conventional values for the weight coefficients in conventional units: w_1= 10, w_2= 5 , w_3=-10 , w_4=-5 . Total weight values are denoted by S_{ij}. To form a number of impact and dependencies of factors (Figure 3), for each we determine direct impacts, the number of which is fixed by the coefficients k_{1j}. "Ways of dependency" are provided similarly by the coefficients k_{3j} . The combined consideration of indirect impacts or dependencies of the factor (i.e. the impact or dependency through other factors) determines the coefficients k_{2j} and k_{4j}.

For the calculation we use the following formulas:

$$S_{ij} = k_{ij} w_i \ \ (i = 1, 2, 3, 4; \ \ j = 1, ..., n) \tag{1}$$

where n is the number of the factor.

For our oriented graph (Figure 1) taking into account (1) we receive:

$$S_{ij} = \sum_{i=1}^{4} \sum_{j=1}^{9} k_{ij} w_i \tag{2}$$

It is clear that in the absence of some factor of one type of connection its corresponding value in the expression (2) makes zero. The given formula is the basis for obtaining weight values of factors ranging, taking into account different types of relationships between them. It should be noted that S_{3j}< 0 and s_{4j}< 0 , because under the given initial conditions w_3< 0 and w_4< 0. So to bring the factors total weight values to positive values, we transform the formula (2) to the following:

$$S_{Fj} = \sum_{i=1}^{4} \sum_{j=1}^{9} k_{ij} w_i + \max\left|S_{3j}\right| + \max\left|S_{4j}\right| \tag{3}$$

where S_{3j} and S_{4j} is maximum numbers in absolute value.

Results

In accordance to the conducted calculations we form Table 1 to establish factors ranks. As you see from the table, max|S_{3j}|=70 ; max|S_{4j}|=5 . These values are added in each line to the sum of the values in the columns S_{1j}, S_{2j}, and S_{4j}. Finally, we get the resulting factor weight, which is the basis for establishing the factor rank r_j , which is equivalent to prioritize its impact on selective UV varnishing process by screen printing. The factor with the highest value S_{Fj} has the maximum rank.

Table 1
Calculated data of factors ranking of screen UV-varnishing

Number of factors, j	k1J	k2J	k3J	k4J	S1J	S2J	S3J	S4J	SFJ	Factor rank rj
1	2	0	0	0	20	0	0	0	95	7
2	2	0	1	0	20	0	-10	0	85	5
3	3	1	2	0	30	5	-20	0	90	6
4	2	0	1	1	20	0	-10	-5	80	4
5	1	0	4	1	10	0	-40	-5	40	2
6	3	1	0	0	30	5	0	0	110	9
7	0	0	7	1	0	0	-70	-5	0	1
8	1	0	1	1	10	0	-10	-5	70	3
9	2	2	0	0	20	10	0	0	105	8

According to the results, the factors with the highest rank are: f_1 – surface energy of a printing material (SE); f_3 – viscosity UV-varnish compositions (VV); f_6 – temperature of UV- varnish (TV); f_9 –speed of printing (SP). The temperature of UV-varnish has a significant impact on its viscosity. The value of viscosity, the surface energy of the substrate and the speed of the imprint movement to UV-drying unit determine the degree of spreading of the UV-varnish and therefore the geometric parameters of the elements of tactile font.

Conclusion

Thus, as a result of the application of the ranking method we have calculated the factors ranks of the screen application process of tactile fonts on imprints. The results of the factors ranking allow synthesizing the model of the factors impact priority on the process of UV-varnishing that will be the basis for the development of a simulation model of automatic control and regulation of the geometric parameters of tactile font elements.

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