Modeling of the Braille Font Elements Creation Process Using Regression Analysis

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Abstract
Braille is widely used in almost all countries of the world, which confirms the perspective of technology research for the creation of information space for people with vision impairments. The improvement of technological processes, materials, and equipment for the product manufacture for people with vision impairments was carried out through the years of Braille system usage. Based on the analysis of scientific works, patent documentation, and Braille printing technologies, it was concluded that a large thickness of the print layer can be achieved in the stencil printing method. Therefore, it is one of the most promising methods from the perspective of tactile communicative media manufacturing for people with visual impairments. For the standardization of the stencil printing process, it is important to describe mathematically the influence of the main parameters of the stencil printing form and the process of printing relief-dotted images to ensure the necessary height of Braille font elements.

Keywords 1
Modeling, regression analysis, correlation analysis, Braille, people with visual impairments, spreading coefficient, absorption coefficient, element height

1. Introduction

In 2015, there were approximately 253 million people with visual impairments worldwide. This quantity included 36 million of blind persons, and another 217 million persons had medium and high level of visual impairment [1, 2]. In 2020, there were approximately 295 million of visually impaired people worldwide. This number included 43.3 million of blind persons, and another 251.7 million had medium and high level of visual impairments [3, 4]. In total, by 2050, there may be approximately 703 million people who will be blind or have medium and high level of visual impairment [1].

For almost two centuries, people with vision impairments all over the world have been using dot-relief writing, which was invented by the blind French pedagogue Louis Braille in 1824 [5]. Much attention is paid to the implementation of the Braille font for the manufacture of various types of products used by people with vision impairments in the European Union, the United States, Canada, Japan and many other countries. Now the Braille information space is being created, that includes the production of Braille publications, the development of electronic devices, the application of tactile signs and Braille on label and packaging products, the production of information plates, mnemonics, marking elevator buttons, door handles, etc. [6, 7]. Due to Braille people with vision impairments successfully get an education, join world culture, and expand their information space.

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Since the beginning of the 20th century a systematic analysis of the usage/literacy level of Braille among people with vision impairments has been carried out in the USA [8, 9], as the connection between reading Braille and well-being (higher life satisfaction, self-esteem and employment level) of adults with vision problems was clearly proved [10].

Regulatory documents (for example, Braille on folding cartons, European Carton Makers Association, 2005), research works dedicated to the perception of the Braille font [11, 12], tactile graphics [13, 14], resistance of the Braille font to loads [15], electronic systems [16, 17] contain the definition that the reliability of reading information by people with vision impairments depends on the height of the Braille font element.

Lots of different technologies are applied for the printing with Braille [18], but one of the most promising technologies is the stencil printing method, which allows to receive thick image layers.

2. Related Works

As the stencil printing method is a complex process that is influenced by a significant number of factors, it is important to determine the importance of these factors, mathematical modeling and the use of statistical analysis methods in the research of the influence of individual technological factors on the quality of the print.

In the study [19], the quality of stencil printing prints was evaluated using the mathematical statistics methods, a mathematical model of the process of erasing the ink layer on film materials was created. In the study [20], the stencil printing parameters that most affect the resistance of the ink layer to abrasion and the image resolution are determined using statistical methods of experimental data processing. The study [21] proves a tight correlation between the state of powder dispersion in silver pastes and the characteristics of thick films for stencil printing. In the study [22], the stencil printing process was optimized for functional printing.

The final goal of any experimental data processing is to propose hypotheses about the class and structure of the mathematical model of the object or process under study, determine the composition and volume of additional dimensions, choose possible methods of further statistical processing, and analyze the execution of the main process prerequisites. To achieve the final goal, it is necessary to solve some partial tasks, for example, to identify statistical relationships and the mutual influence of various measurable factors and resulting variables. The solution of this problem makes it possible to select those variables that have the strongest influence on the resulting characteristic. The selected factors are used for further processing, in particular, with regression analysis methods. The analysis of correlations makes it possible to propose hypotheses about the structure of the interrelationship of variables and, as a result, about the structure of the object model of research.

3. Modeling of the relief and dot images elements creating process

3.1. Research methods

The STATISTICA package is a computer analytical tool for quantitative analysis studying. It is a universal integrated system designed for statistical analysis and data visualization, database management and development of custom applications, containing a wide set of analysis procedures for usage in scientific research, engineering, business, as well as special methods for data acquisition.

When we are dealing with phenomena and processes with a complex structure, the analysis of their inherent relationships between different features is a difficult task. If the features and properties of the studied objects can be measured and expressed quantitatively, then the analysis of relationships can be conducted on the basis of the mathematical methods application. The usage of these methods allows to test the hypothesis about the presence or absence of relationships, which is based on the meaningful analysis. Further, only with the help of mathematical methods it is possible to establish the tightness and nature of relationships or to reveal the strength (degree) of influence of various factors on the result.

Correlation and regression analysis methods are the most fully developed in mathematical statistics. The analysis of the statistical connection includes the detection of the connection form, as well as the assessment of the connection tightness. The first task is solved with methods of regression analysis, the second one is solved with methods of correlation analysis. Regression analysis encompasses the description of a statistical connection using the corresponding functional dependence. Correlation analysis allows to evaluate the connection tightness using special indicators, and their choice depends on the type of functional dependence suitable for an adequate description of the considered statistical connection.

The most common in the study of relationships is the hypothesis of linear dependence. Correlation and regression analysis methods are corresponding to it and most fully investigated in mathematical statistics.

Linear dependence is the simplest and, in a certain way, universal form of connection in many phenomena. Its universality means the fact that more complex dependencies can often be considered as linear "in the first approximation".

As a result of the regression analysis, an analytical expression for the straight regression line is received with the determination of the quantitative values of the regression equation coefficients, as well as the image of the data and the regression line in the form of a graph. The least squares method (LSM) is widely used when finding regression parameters. It is based on the fact the regression line through the set of points should pass in such a way that the distances of all points from it are the smallest. The quality of the regression dependence is evaluated using the coefficient of determination R2, which determines the part of the scatter of the data that is taken into calculation with the regression. If this coefficient is closer to 1 (one), the constructed regression describes the data under study better.

3.2. The results of research

Stencil printing forms with a minimum thickness of the copying layer and with an increased thickness of the copying layer above the grid at 100 and 200 μm were used in the research.

Prints with relief dot images created with a stencil grid with a minimum thickness of the copying layer ensure readability for people with vision impairments if the ink capacity value of such a grid is estimated in the range of 125,4-294 cm3/m2, with a copying layer that exceeds the grid thickness by 100 microns, part of the ink capacity in the range of 125.4-343 cm3/m2; with a copying layer that reaches a thickness of 200 microns, the range of painting is 125.4-392 cm3/m2.

The thickness of the raw ink layer is influenced by the ink capacity of the printing form and the ink transfer coefficient, which quantitatively characterizes the share of ink transferred to the print. While research conducting, it was determined that the color transfer coefficient is within 0.3-0.8.

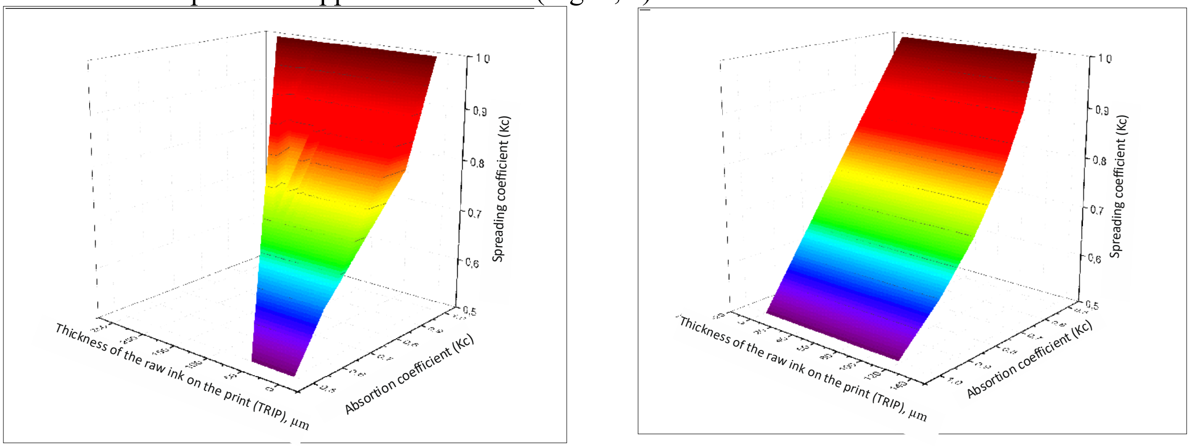
To ensure the necessary range of ink capacity of the stencil grid, the theoretical thickness of raw ink should be equal to 100-235,2 microns, and the color transfer coefficient should be equal to 0,4-0,8. For a stencil grid with a copying layer that exceeds the thickness of the grid by 100 microns, the theoretical thickness of the raw ink should be equal to 100.85-274.4 microns, and the color transfer coefficient should be within the range of 0.3-0.8. For the stencil grid with a copying layer that exceeds the thickness of the grid by 200 μm, the theoretical thickness of the raw ink should be equal to 100.32-313.6 μm, and the ink transfer coefficient should be within the range of 0.3-0.8.

The thickness of the raw ink on the print depends on the coefficient of the ink spreading, which is equal to 0,5-1,0, and on the coefficient of absorption, which is equal to 0,5-1,0. The thickness of the raw ink on the print is calculated in two ways: when the coefficients coincide in ascending order, and when they are placed in opposite directions (Fig. 1-3).

To ensure the necessary range of theoretical raw ink thickness for the stencil grid with a minimum thickness of the copying layer, the raw ink thickness on the print should be 100-235,2 μm with a spreading coefficient of 0,8-1,0 and an absorption coefficient of 0,8-1,0, if the corresponding coefficients coincide in ascending order (Fig. 1, a) and 100-131,71 μm with a spreading coefficient of 0,8-1,0 and an absorption coefficient of 0,5-0,7, and if the coefficients are placed in opposite directions (Fig. 1, b).

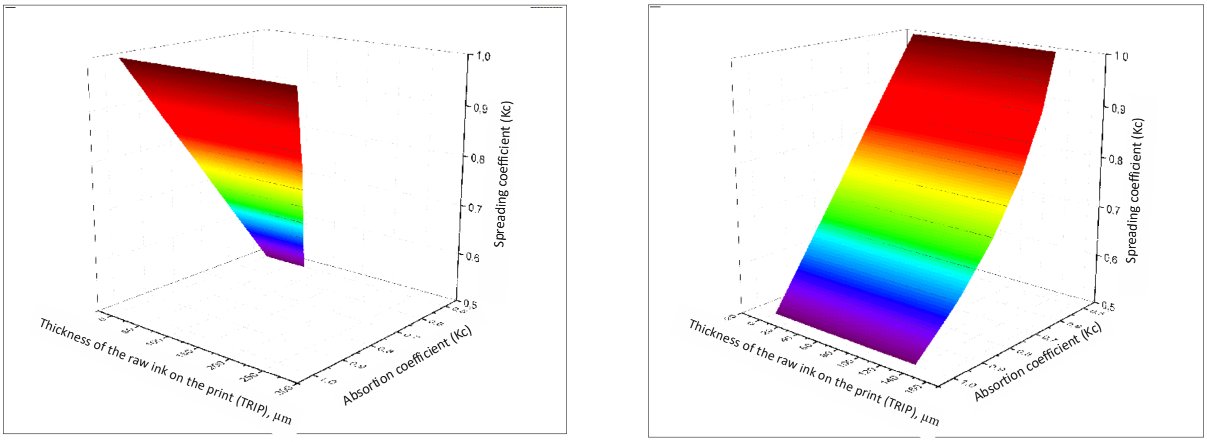
To provide the necessary range of theoretical raw ink thickness for a stencil grid with a copying layer that exceeds the grid thickness by 100 μm, the raw ink thickness on the print should be equal to 100.85-274.4 μm with a spreading coefficient equal to 0.8-1.0 and absorption coefficient equal to 0.8-1.0, if the corresponding coefficients are placed in the ascending order (Fig. 2, a) and 100.35-153.66

µm with the spreading coefficient of 0.7-1.0 and the absorption coefficient equal to 0.5-0, 8, if the coefficients are placed in opposite directions (Fig. 2, b).



a) b)

Figure 1: The dependence of the thickness of the raw ink on the print (the stencil form with the minimal thickness of the copying layer) from the spreading coefficient and the absorption coefficient: a – the coefficients coincide in magnitude; b – coefficients are placed in opposite directions



a) b)

Figure 2: The dependence of the thickness of the raw ink on the print (the stencil form with a copying layer that exceeds the thickness of the grid by 100 µm) from the spreading coefficient and the absorption coefficient: a – the coefficients coincide in magnitude; b – coefficients are placed in opposite directions

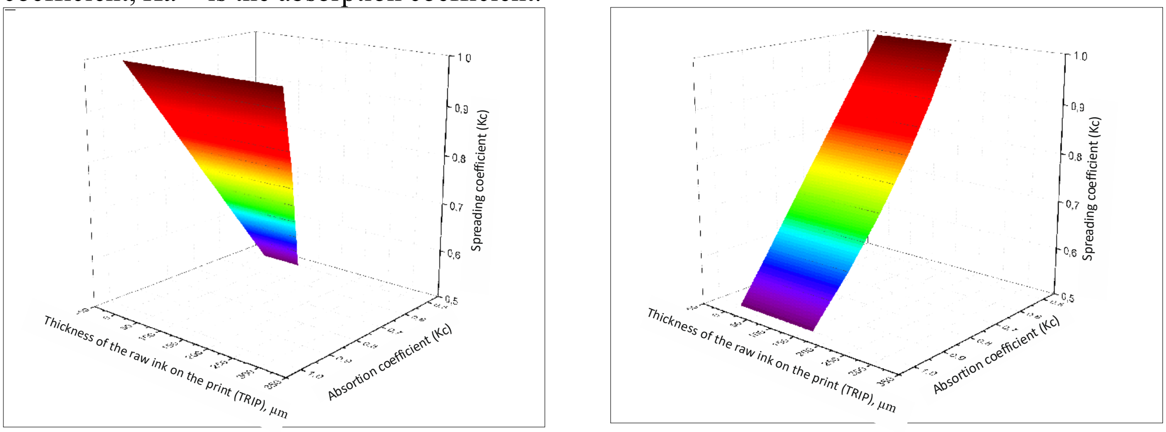
To provide the required range of the theoretical thickness of raw ink for a stencil grid with a copy layer that exceeds the thickness of the grid by 200 µm, the thickness of the raw ink on the print should be equal to 100.32-313.6 µm with a spreading coefficient of 0.7-1.0 and an absorption coefficient of. 0.7-1.0, if the corresponding coefficients coincide in the growth order (Fig. 3, a) and 102.4-175.62 µm with a spreading coefficient of 0.6-1.0 and an absorption coefficient of 0.5-0.9 , if the values of the coefficients are opposite (Fig. 3, b).

The regression analysis (Fig. 4), according to the information from the stencil form with the minimum thickness of the copying layer (part I), shows that the dependence of the theoretical thickness of the raw ink on the print (TRIP) on the thickness of the raw ink (TRI) and coefficients of spreading (Ks) and absorption (Ka) can be considered linear since the coefficient of determination $R^2 = 0,86$ is high (> 0,7).

The corresponding regression dependence (Fi g. 5) will be calculated in the following formula (1):

$$TRIP_{form1\ (p.I)} = -51,9330 + 0,6037 \cdot TRI + 48,3664 \cdot Ks + 19,7900 \cdot Ka \pm 11,867 \qquad (1)$$

where *TRIP* $_{form1\ (p.I)}$ – is the stencil form with the a minimum thickness of the copying layer, if the spreading and absorption coefficients coincide; *TRI* – the thickness of the raw ink; *Ks* –is the spreading coefficient; *Ka* – is the absorption coefficient.



a) b)

Figure 3: The dependence of the thickness of the raw ink on the print (the stencil form with a copying layer that exceeds the thickness of the grid by 200 µm) from the spreading coefficient and the absorption coefficient: a – the coefficients coincide in magnitude; b – coefficients are placed in opposite directions

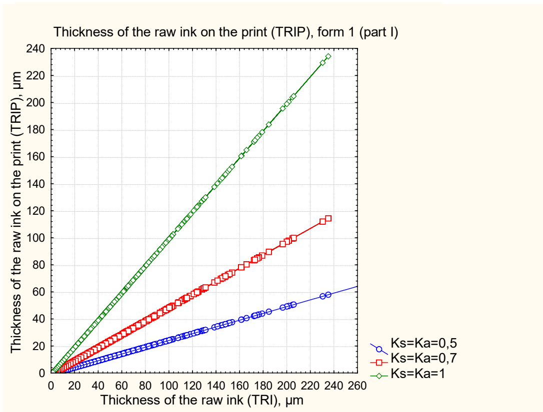


Figure 4: Regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (the stencil form with a minimum thickness of the copying layer), if the spreading and absorption coefficients coincide

N=3096	Regression Summary for Dependent Variable: The thickness of the raw ink on the print (TRIP), µm R= ,92891290 R?= ,86274613 F=(3,3092)=6485,8 p<0,0000 Std.Error of estimate: 11,867								
	Beta	Std.Err Of Beta	B	Std.Err Of B	t(3092)	p-level			
Intercep			-51,4142	0,984237	-52,2376	0,000000			
The thickness of the raw ink (TRI), µm	0,853454	0,006659	0,6037	0,004710	128,1587	0,000000			
Spreading coefficient (Ks)	0,257916	0,035708	48,3664	6,696258	7,2229	0,000000			
Absorption coefficient (Ka)	0,110178	0,035708	19,7900	6,413852	3,0855	0,002050			

Figure 5: The screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption coincide)

The correlation analysis (Fig. 6), according to the information from the stencil form with the minimum thickness of the copying layer (part I), indicates the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0,92), but not from spreading coefficient (partial correlation coefficient r = 0,13) and absorption (partial correlation coefficient r = 0,05). At the same time, TRIP is more significantly affected by TRI (0,85) and less by spreading coefficient (0,26) and absorption coefficient (0.11).

Variable	Variables currently in the Equation; DV: The thickness of the raw ink on the print (TRI), µm							
	Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	T(3092)	p-level	
The thickness of the raw ink (TRI), µm	0,853454	0,917372	0,853454	1,000000	0,000000	128,1587	0,000000	

Spreading coefficient (Ks)	0,257916	0,128813	0,048100	0,034780	0,965220	7,2229	0,000000	
Absorption coefficient (Ka)	0,110178	0,055404	0,020547	0,034780	0,965220	3,0855	0,002050	

Figure 6: The screenshot of the program for determining correlation coefficients (the coefficients of spreading and absorption coincide)

The regression analysis (Fig. 7), according to the information from the stencil form with the minimum thickness of the copying layer (part II), did not reveal a linear dependence of TRIP from the coefficients of spreading and absorption, but only the dependence of TRIP from the thickness of the raw ink (TRI), the coefficient of determination R2 = 0,99 is very high (> 0,7).

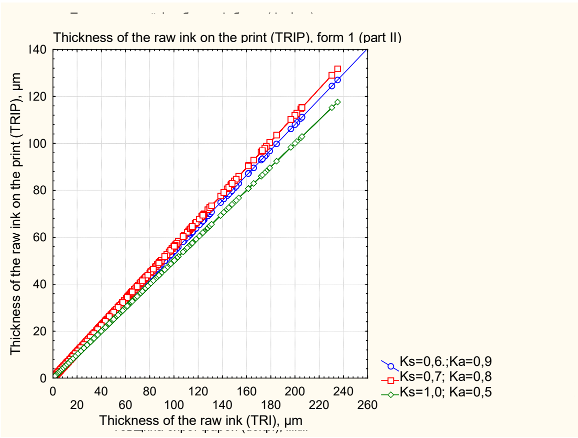


Figure 7: The regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (the stencil form with a minimum thickness of the copying layer), if the spreading and absorption coefficients are located in opposite directions

The corresponding regression dependence (Fig. 8) will be calculated in the following formula (2):

$$TRIP_{form1\ (p.II)} = 0{,}5333 \cdot TRI \pm 1{,}5959 \qquad (2)$$

where $TRIP_{form1\ (p.II)}$ – is the stencil form with the a minimum thickness of the copying layer, if the spreading and absorption coefficients are located in opposite directions.

	Regression Summary for Dependent Variable: The thickness of the raw ink on the print (TRI), µm R= ,99782544 R?= ,99565562 F=(2,3093)=3544E2 p<0,0000 Std.Error of estimate: 1,5959						
N=3096	Beta	Std.Err Of Beta	B	Std.Err Of B	t(3092)	p-level	
Intercept			-0,000000	0,132312	-0,0000	1,000000	
The thickness of the raw ink (TRI), µm	0,997825	0,001185	0,533333	0,000633	841,9388	0,000000	
Spreading coefficient (Ks)	0,000000	0,001185	0,000000	0,167945	0,965220	1,000000	

Figure 8: The screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption are located in opposite directions)

The correlation analysis (Fig. 9), according to the information from the stencil form with the minimum thickness of the copying layer (part II), testifies the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0,998), but no dependence from coefficients of spreading and absorption was found. At the same time, the influence of TRI on TRIP is estimated as 0,998.

	Variables currently in the Equation; DV: The thickness of the raw ink on the print (TRI), µm							
Variable	Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	T(3093)	p-level	
The thickness of the raw ink (TRI), µm	0,997825	0,997825	0,997825	1,000000	0,00	841,9388	0,000000	
Spreading coefficient (Ks)	0,000000	0,000000	0,000000	1,000000	0,00	0,0000	1,000000	

Figure 9: The screenshot of the program for determining correlation coefficients (the coefficients of spreading and absorption are located in opposite directions)

The regression analysis (Fig. 10) based on the data from the stencil form with a copying layer that exceeds the grid thickness by 100 µm (part I) shows that the dependence of the theoretical thickness of the raw ink on the print (TRIP) from the thickness of the raw ink (TRI) and coefficients of spreading and absorption can be considered as linear, since the coefficient of determination R2= 0.86 is high (> 0.7).

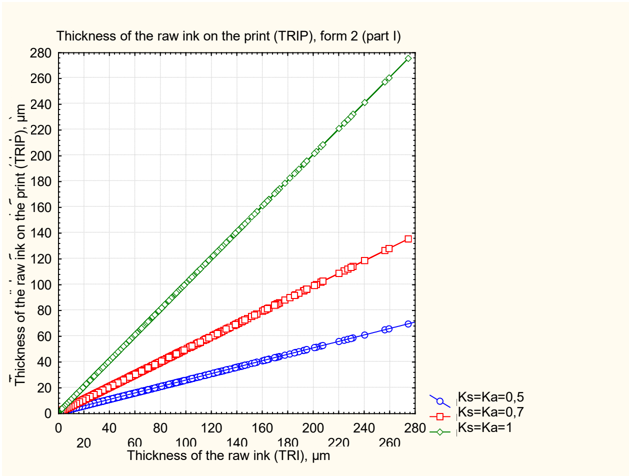


Figure 10: The regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (the stencil form with a copying layer that exceeds the thickness of the grid by 100 µm), if the spreading and absorption coefficients coincide

The corresponding regression dependence (Fig. 11) will be calculated in the following formula (3):

$$TRIP_{form2\ (p.I)} = -66{,}6564 + 0{,}6037 \cdot TRI + 62.7051 \cdot Ks + 25.6569 \cdot Ka \pm 14{,}608 \qquad (3)$$

where $TRIP_{form2\ (p.I)}$ – is the stencil form with the copying layer, that exceeds the thickness of the grid by 100 µm and if the spreading and absorption coefficients coincide.

	Regression Summary for Dependent Variable: The thickness of the raw ink on the print (TRI), µm R= ,92994082 R?= ,86478992 Adjusted R?= ,86465873 F=(3,3092)=6592,0 p<0,0000 Std.Error of estimate: 14,608						
N=3096	Beta	Std.Err Of Beta	B	Std.Err Of B	t(3092)	p-level	
Intercept			-66,6564	1,214697	-54,8749	0,000000	
The thickness of the raw ink (TRI), µm	0,847164	0,006613	0,6037	0,004712	128,1099	0,000000	
Spreading coefficient (Ks)	0,269734	0,035458	62,7051	8,243038	7,6070	0,000000	
Absorption coefficient (Ka)	0,115226	0,035458	25,6569	7,895399	3,2496	0,001168	

Figure 11: The screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption coincide)

The correlation analysis (Fig. 12), according to the information from the stencil form with the minimum thickness of the copying layer (part I), indicates the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0,92), but not from spreading coefficient (partial correlation coefficient r = 0,13) and absorption (partial correlation coefficient r = 0,06). At the same time, TRIP is more significantly affected by TRI (0,85) and less by spreading coefficient (0,27) and absorption coefficient (0.11).

	Variables currently in the Equation; DV: The thickness of the raw ink on the print (TRI), µm							
Variable	Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	T(3092)	p-level	
The thickness of the raw ink (TRI), µm	0,847164	0,917316	0,847164	1,000000	0,000000	128,1099	0,000000	
Spreading coefficient (Ks)	0,269734	0,135541	0,050304	0,034780	0,965220	7,6070	0,000000	
Absorption coefficient (Ka)	0,115226	0,058340	0,021489	0,034780	0,965220	3,2496	0,001168	

Figure 12: The screenshot of the program for determining the correlation coefficients (the coefficients of spreading and absorption coincide)

The regression analysis (Fig. 13) based on the data from the stencil form with a copying layer that exceeds the grid thickness by 100 µm (part II) did not show any linear dependence of the theoretical thickness of the raw ink on the print (TRIP) from the coefficients of spreading and absorption, but only the dependence of TRIP from the thickness of the raw ink (TRI), the coefficient of determination R2= 0.99 is very high (> 0.7).

The corresponding regression dependence (Fig. 14) will be calculated in the following formula (4):

$$TRIP_{form2\ (p.II)} = 0{,}5333 \cdot TRI \pm 2{,}017 \qquad (4)$$

where $TRIP_{form2\ (p.II)}$ – is the stencil form with the copying layer, that exceeds the thickness of the grid by 100 µm and if the spreading and absorption coefficients are located in opposite directions.

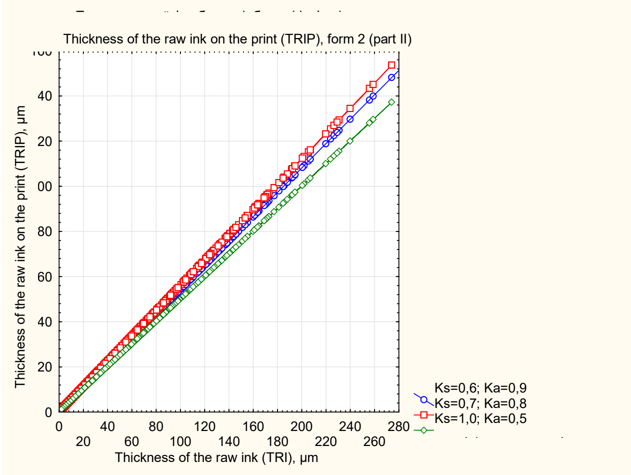


Figure 13: The regression dependence of the thickness of the raw ink on the p rint from the thickness of the raw ink (the stencil form with a copying layer that exceeds the grid thickness by 100 µm), if the coefficients of spreading and absorption are located in opposite directions

	Regression Summary for Dependent Variable: The thickness of the raw ink on the print (TRI), µm R= ,99770653 R?= ,99541832 Adjusted R?= ,99541536 F=(2,3093)=3360E2 p<0,0000 Std.Error of estimate: 2,0170						
N=3096	Beta	Std.Err Of Beta	B	Std.Err Of B	t(3092)	p-level	
Intercept			0,000000	1,167650	0,0000	1,000000	
The thickness of the raw ink (TRI), µm	0,997707	0,006613	0,6037	0,000651	819,7482	0,000000	
Spreading coefficient (Ks)	0,000000	0,035458	62,7051	0,212254	0,0000	1,000000	

Figure 14: The screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption are located in opposite directions)

The correlation analysis (Fig. 15), according to the information from the stencil form with the copying layer that exceeds the grid thickness by 100 µm (part II), indicates the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0,998), but not from spreading and absorption coefficients. At the same time, the influence of TRI on TRIP is estimated equal to 0,998.

	Variables currently in the Equation; DV: The thickness of the raw ink on the print (TRI), µm							
Variable	Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	T(3093)	p-level	
The thickness of the raw ink (TRI), µm	0,997707	0,997707	0,997707	1,000000	0,00	819,7482	0,000000	
Spreading coefficient (Ks)	0,000000	0,000000	0,000000	1,000000	0,00	0,0000	1,000000	

Figure 15: The screenshot of the program for determining the correlation coefficients (the coefficients of spreading and absorption are located in opposite directions)

The regression analysis (Fig. 16) based on the data from the stencil form with a copying layer that exceeds the grid thickness by 200 µm (part I) shows that the dependence of the theoretical thickness of the raw ink on the print (TRIP) from the thickness of the raw ink (TRI) and coefficients of spreading and absorption can be considered as linear, since the coefficient of determination R2= 0.86 is high (> 0.7).

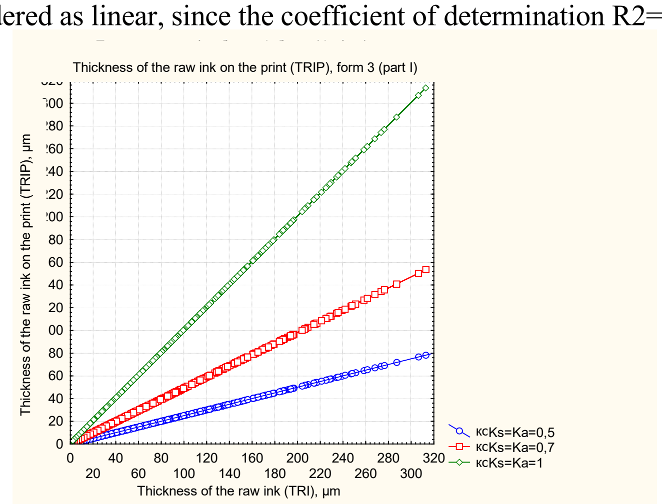


Figure 16: The regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (the stencil form with a copying layer that exceeds the thickness of the grid by 200 µm),

if the spreading and absorption coefficients coincide

The corresponding regression dependence (Fig. 17) will be calculated in the following formula (5):

$$TRIP_{form3\ (p.I)} = -\ 81{,}8993 + 0{,}6037 \cdot TRI + 77.0446 \cdot Ks + 31.5241\ Ka \pm 17{,}60 \quad (5)$$

$TRIP_{form3\ (p.I)}$ – is the stencil form with the copying layer, that exceeds the thickness of the grid by 200 µm and if the spreading and absorption coefficients coincide.

N=3096	Beta	Std.Err Of Beta	B	Std.Err Of B	t(3092)	p-level
	Regression Summary for Dependent Variable: The thickness of the raw ink on the print (TRI), µm R= ,93035013 R?= ,86555136 Adjusted R?= ,86542091 F=(3,3092)=6635,0 p<0,0000 Std.Error of estimate: 17,600					
Intercept			-81,8993	1,465004	-55,9038	0,000000
The thickness of the raw ink (TRI), µm	0,844644	0,006594	0,6037	0,004713	128,0900	0,000000
Spreading coefficient (Ks)	0,274301	0,035358	77,0445	9,931322	7,7577	0,000000
Absorption coefficient (Ka)	0,117177	0,035358	31,5241	9,512481	3,3140	0,001168

Figure 17: The screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption coincide)

The correlation analysis (Fig. 18), according to the information from the stencil form with the copying layer that exceeds the grid thickness by 200 µm (part I), indicates the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0,92), but not from spreading (partial correlation coefficient r = 0,14) and absorption (partial correlation coefficient r = 0,06) coefficients. At the same time, the influence of TRI on TRIP is more significant and equal to 0,84 and the influence of the spreading and absorption coefficients is less significant (0,27 and 0,12 accordingly).

Variable	Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	T(3092)	p-level
	Variables currently in the Equation; DV: The thickness of the raw ink on the print (TRI), µm						
The thickness of the raw ink (TRI), µm	0,844644	0,917294	0,844644	1,000000	-0,000000	128,0900	0,000000
Spreading coefficient (Ks)	0,274301	0,138175	0,051156	0,034780	0,965220	7,7577	0,000000
Absorption coefficient (Ka)	0,117177	0,059492	0,021853	0,034780	0,965220	3,3140	0,000930

Figure 18: The screenshot of the program for determining the correlation coefficients (the coefficients of spreading and absorption coincide)

The regression analysis (Fig. 19) based on the data from the stencil form with a copying layer that exceeds the grid thickness by 200 µm (part II) did not show any linear dependence of the theoretical thickness of the raw ink on the print (TRIP) from the coefficients of spreading and absorption, but only the dependence of TRIP from the thickness of the raw ink (TRI), the coefficient of determination R2= 0.99 is very high (> 0.7).

The corresponding regression dependence (Fig. 20) will be calculated in the following formula (6):

$$TRIP_{form3\ (p.II)} = 0{,}5333 \cdot TRI \pm 2{,}4553 \quad (6)$$

$TRIP_{form3\ (p.II)}$ – is the stencil form with the copying layer, that exceeds the thickness of the grid by 200 µm and if the spreading and absorption coefficients are located in opposite directions.

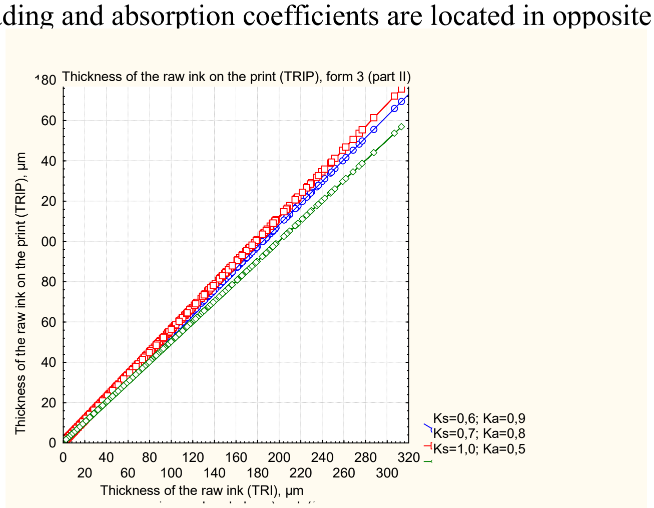


Figure 19: The regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (the stencil form with a copying layer that exceeds the thickness of the grid by 200 µm), if the spreading and absorption coefficients are located in opposite directions

N=3096	Regression Summary for Dependent Variable: The thickness of the raw ink on the print (TRI), µm

	R= ,99765816 R?= ,99532181 Adjusted R?= ,99531878 F=(2,3093)=3290E2 p<0,0000 Std.Error of estimate: 2,4553						
	Beta	Std.Err Of Beta	B	Std.Err Of B	t(3093)	p-level	
Intercept			-0,000000	0,204294	0,0000	1,000000	
The thickness of the raw ink (TRI), µm	0,997658	0,001230	0,533333	0,000657	811,2089	0,000000	
Spreading coefficient (Ks)	0,000000	0,001230	0,000000	0,258378	0,0000	1,000000	

Figure 20: The screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption are located in opposite directions)

The correlation analysis (Fig. 21), according to the information from the stencil form with the copying layer that exceeds the grid thickness by 200 µm (part II), indicates the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0,998), but not from spreading and absorption coefficients. At the same time, the influence of TRI on TRIP is more significant and equal to 0,998.

	Variables currently in the Equation; DV: The thickness of the raw ink on the print (TRI), µm						
Variable	Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	T(3092)	p-level
The thickness of the raw ink (TRI), µm	0,997658	0,997658	0,997658	1,000000	-0,000000	811,2089	0,000000
Spreading coefficient (Ks)	0,000000	0,000000	0,000000	1,000000	0,000000	0,0000	1,000000

Figure 21: The screenshot of the program for determining the correlation coefficients (the coefficients of spreading and absorption are located in opposite directions)

4. Conclusion

According to the information received from all the forms, if the spreading and absorption coefficients coincide, the regression analysis shows that the dependence of the theoretical thickness of the raw ink on the print from the thickness of the raw ink and the spreading and absorption coefficients can be considered linear, as the coefficient of determination R2=0.86 is high (>0.7).

In accordance with the data received from all the forms, if the spreading and absorption coefficients coincide, the correlation analysis indicates the existance of a reliable direct linear dependence of the thickness of the raw ink on the print from the thickness of the raw ink, but not from the coefficients of spreading and absorption.

Based on the information received from all the forms, if the spreading and absorption coefficients are placed in the opposite directions, the regression analysis did not show a linear dependence of the theoretical thickness of the raw ink on the print from the coefficients of spreading and absorption, but only from the thickness of the raw ink, the coefficient of determination R2 = 0.99 is very high (> 0.7).

The last one experiment is that, according to the information received from all the forms, if the spreading and absorption coefficients are placed in the opposite directions, the correlation analysis indicates the existance of a reliable direct linear dependence of the thickness of the raw ink on the print from the thickness of the raw ink (partial correlation coefficient r = 0.998), but not from the spreading and absorption coefficients

On the basis of the conducted regression and correlation analysis, the relationship between the main parameters of the printing form and the printing process was determined, which provides the necessary height in the range of 100 microns and more for the Braille element on the print.

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