Technical science and innovation

Volume 2023 | Issue 4 Article 1

1-10-2024

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Recommended Citation

Babakhanova, Khalima Abishevna; Khasanova, Mukhlisa Ergashevna; Soadatov, Aziz Azimjonovich; and Sadriddinova, Nigora Junaydullaevna (2024) "INFLUENCE OF FOIL STAMPING PARAMETERS ON IMAGE QUALITY," *Technical science and innovation*: Vol. 2023: Iss. 4, Article 1.
DOI: https://doi.org/10.59048/2181-0400
E-ISSN: 2181-1180
.1529
Available at: https://btstu.researchcommons.org/journal/vol2023/iss4/1

UDC 658.5

INFLUENCE OF FOIL STAMPING PARAMETERS ON IMAGE QUALITY

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Received: December 03, 2023; Accepted: January 10, 2024; Online: January 16, 2024.

Abstract: *The paper evaluates the influence of technological process parameters, namely die temperature and pressure force, on the quality of foil stamping, which is one of the types of finishing having a wide range of applications due to giving unique decorative and protective elements to printed products. When evaluating the influence of process parameters on the linearity and coverability of the image, it was found that the pressure force has less influence on the result than the temperature. According to the data of the study, it can be concluded that the maximum percentage of completeness of covering is achieved at a die temperature of 120^0 C and pressure force of 13±1MPa. Consequently, it can be concluded that the optimal embossing parameters for specific conditions of the technological process have been determined to achieve a qualitative result.*

Keywords: *foil, plate temperature, pressure force, lineature, image quality, embossing, finishing.*

Annotatsiya: *Qog'oz texnologik jarayon parametrlarining, ya'ni shtamp harorati va bosim kuchining folgada bosishda sifatiga ta'sirini baholaydi, bu bosma mahsulotlarga noyob dekorativ va himoya elementlarini berish tufayli keng ko'lamli ilovalarga ega bo'lgan pardozlash turlaridan biridir. Jarayon parametrlarining tasvirning chiziqliligi va qoplanishiga ta'sirini baholashda bosim kuchi natijaga haroratga qaraganda kamroq ta'sir qilishi aniqlandi. Tadqiqot ma'lumotlariga ko'ra, qoplamaning to'liqligining maksimal foiziga 120^0 C haroratda va 13±1 MPa bosim kuchida erishiladi degan xulosaga kelish mumkin. Binobarin, sifatli natijaga erishish uchun texnologik jarayonning o'ziga xos shartlari uchun maqbul bo'rttirma parametrlari aniqlangan degan xulosaga kelish mumkin.*

Tayanch so'zlar: *folga, qolip harorati, bosim kuchi, lineratura, tasvir sifati, bo'rtma, ishlov berish.*

Аннотация: *В статье оценено влияние параметров технологического процесса, а именно температуры штампа и силы давления, на качество тиснения фольгой, которое является одним из видов отделки, имеющим широкий спектр применения за счет придания напечатанным изображениям уникальных декоративных и защитных элементов. продукты. При оценке влияния параметров процесса на линейность и покрываемость изображения установлено, что сила давления оказывает меньшее влияние на результат, чем температура. По данным исследования можно сделать вывод, что максимальный процент полноты покрытия достигается при температуре матрицы 120^0С и силе давления 13±1 МПа. Следовательно, можно сделать вывод, что определены оптимальные параметры тиснения для конкретных условий технологического процесса, обеспечивающие достижение качественного результата.*

Ключевые слова*: фольга, температура штампа, сила давления, линеатура, качество изображения, тиснение, отделка.*

Introduction

Printing foil stamping, which is one of the types of finishing, has a wide range of applications due to the imparting of unique decorative and protective elements to printed products. Uniqueness is ensured due to the high reflectivity of particles of fine metal foil than that of metallized paints, as well

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as the formation of a convex or concave relief, which cannot be achieved with other finishing methods [1].

The authors of works [2-8] explain the widespread use of hot stamping by the presence and combination of different textures and types of foil, which provides wide visual possibilities. In addition, embossing is an environmentally friendly process that does not involve the use of volatile organic substances [9-10]. But there are also disadvantages, the main one of which is the selection of embossing modes on new types of materials and new series of foil. In [11], the optimal embossing mode, namely the die temperature, was determined for hot stamping of metallized foil. In addition, as a result of scientific research, recommendations have been developed to improve the quality of printing foil stamping on papers with a high roughness parameter. The optimal embossing modes for foil with a thin adhesive layer (1 micron) are: temperature - from 100° to 130° C, embossing force - 17-18 kN; and for foil with a thick adhesive layer (1.6 microns): temperature - from 100° to 130° C, stamping force - 13-15 kN. It was determined that with increasing drying time, hiding power increases from 65.4% to 100% and the clarity of prints improves. The optimal drying time for the primer layer to obtain a high-quality print was 6 seconds. On paper with an adhesive layer weight of 33-40 g/m^2, high-quality prints are obtained with 100% coverage and an acceptable amount of foil protrusion beyond the printing elements. The optimal glue viscosity is 160 SP. However, these parameters cannot be universal, since when embossing, equipment with varying degrees of wear and materials with different properties are used. To determine the optimal values and parameters of embossing, experiments are required with constant adjustment of technological process parameters to achieve a high-quality result.

Research Methods and the Received Results

A study was conducted to evaluate the influence of process parameters and material properties on the quality of embossing.

The purpose of the study is to determine the optimal technological modes when stamping with metallized foil on papers of various densities and to study the influence of process parameters, namely temperature and pressure force on the quality of embossing.

To achieve the goal, the following tasks were set:

- study the influence of temperature and pressure on the lineature and hiding power of the foil on the print;
- determine the resolution of embossing by reproducing small details with complex configurations, separated by small spaces, positive (negative) texts;
- evaluate the quality of foil stamping on papers of various densities.

For the study, we used a magnesium stamp (5 mm) measuring 70x120 mm, which contains an image of a six-field test object, a die, objects with complex configurations, negative and positive texts, made using the Corel Draw 17 version. The thickness of the lines of the test object to determine the clarity of the foil print: 1 - 1.5 mm; 2 - 1.0 mm; 3 - 0.5 mm; 4 - 0.4 mm; 5 - 0.3 mm; 6 - 0.2 mm. The size of the printed image is 65x114 mm. The developed test object will allow a comprehensive and objective assessment of the hiding power and sharpness of the embossing [12-13].

The cliche was prepared at the ENGRAVER TECHNOLOGY LLC enterprise on a multifunctional CNC milling machine Mikoni 430P/540P [14].

At the polygraphic enterprise “Micross” Ltd. a stamp was glued to the heating plate of a semi-automatic crucible press, a dressing was made to equalise the pressure, the temperature was adjusted and impressions were obtained on coated paper with a density of 270 and 290 g/m^2 (Dobrush paper factory, Belarus) and with a density of 270 g/m^2 produced by “Zenit”. For stamping we used universal foil designed for a wide range of paper and cardboard surfaces. The temperature of the stamp was varied in the range from 11^0 to 120^{0}C, at a pressure of 12±1 MPa.

Table 1

Paper characteristics

Manufacturer	Dobrush paper factory	“Zenit” Paper Mill
Application	For box, packaging products	
Country	Belarus	Russia
Surface	matte	
Coating	one-sided	
Thickness, µm	235	205
Gloss (TAPPI 75%)	40	35
Parker roughness, µm	2.5	3.2
Moisture, %	3.8	5.3
Absorbency (Cobb 60), g/m^2	70	58

Lineatures were evaluated according to the six-point system by the number of clearly reproduced groups of lines of the six-field test-object, the data are presented in Table 2. Diagrams were plotted in Microsoft Excel for complex analysis (Fig. 2).

Table 2

Data from research results

№	t^0C	Plate	Thickness of lines, mm						Objects of complex configurations			Text	
			1	2	3	4	5	6	7	8	9	positive	negative
			1,5	1,0	0,5	0,4	0,3	0,2					
Paper "Dobrush" 270 g/m²													
1	115	4,0	1	1	1	0,5	0,6	0,5	0,7	0,5	0,8	0,7	0,6
2	112	3,5	0,9	0,9	0,8	0,4	0,5	0,2	0,6	0,4	0,7	0,6	0,4
3	120	4,0	1	1	1	0,7	0,8	0,7	0,7	0,7	0,8	0,8	0,7
4	120	4,0	0,9	1	1	0,9	0,9	0,9	0,9	0,7	0,9	0,8	0,6
5	112	3,5	0,9	0,9	0,9	0,4	0,4	0,4	0,5	0,3	0,6	0,7	0,4
6	120	3,5	0,9	0,8	0,8	0,4	0,4	0,4	0,5	0,5	0,7	0,5	0,4
7	100	0	0	0	0	0	0,1	0,1	0	0	0	0	0
8	120	0	0,3	0,2	0,1	0	0	0	0	0	0,1	0,1	0
9	120	4,5	1	1	1	0,9	0,9	0,9	1	0,7	0,8	1	0,7
10	112	3,5	0,9	0,9	0,8	0,4	0,4	0,4	0,7	0,6	0,8	0,6	0,4
11	120	5	1	1	1	0,8	1	0,7	0,9	0,7	0,9	0,9	0,7
12	115	4,5	1	0,9	1	0,5	0,6	0,6	0,9	0,7	0,9	0,7	0,5
13	120	5	1	1	1	1	1	1	1	1	1	1	1
14	115	4,5	0,9	0,9	0,9	0,4	0,7	0,6	0,7	0,6	0,9	0,6	0,4
Paper "Dobrush" 290 g/m²													
15	120	5	1	1	1	1	1	1	1	1	1	1	1
16	114	4,0	0,9	0,9	0,9	0,8	0,8	0,8	0,7	0,6	0,7	0,7	0,6
17	112	3,0	0,9	0,9	0,8	0,6	0,6	0,5	0,6	0,6	0,7	0,6	0,4
18	120	5	1	1	0,9	0,8	0,8	1	1	0,7	0,8	0,9	0,9
19	120	4,5	1	0,9	0,9	0,9	0,8	0,7	1	0,8	0,9	0,8	0,7
20	120	0,5	0,1	0,1	0,1	0	0	0	0	0	0,1	0,1	0
21	100	0,5	0,1	0,1	0,1	0	0	0	0	0	0	0,1	0
22	120	4,0	0,9	1	0,9	0,7	0,7	0,6	0,8	0,7	0,8	0,7	0,7
23	115	4,5	0,9	0,9	0,9	0,8	0,8	0,7	0,8	0,8	0,8	0,7	0,5
24	110	1,5	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,1
25	120	4,5	1	1	0,9	0,8	0,8	0,9	1	1	1	0,9	0,8
26	120	4,5	1	1	0,9	0,9	0,9	1	1	0,9	1	1	0,9
27	113	3,5	0,6	0,7	0,6	0,3	0,4	0,4	0,7	0,6	0,6	0,5	0,4
Paper "Zenit" 270 g/m²													
28	120	5	1	1	1	0,7	1	1	1	1	1	0,9	0,9
29	120	4,5	1	1	1	0,8	0,9	1	1	0,9	0,9	0,8	0,7
30	112	2,0	0,7	0,7	0,7	0,3	0,3	0,3	0,4	0,3	0,4	0,2	0,1
31	100	0	0,1	0	0	0	0	0	0	0	0	0	0
32	120	5	1	1	0,9	1	1	1	1	1	1	0,9	0,7
33	120	0	0,2	0,1	0,1	0	0	0	0	0	0,1	0,1	0
34	120	2,0	0,8	0,8	0,8	0,6	0,6	0,6	0,7	0,6	0,8	0,4	0,1
35	115	3,0	0,9	0,9	0,8	0,6	0,6	0,6	0,7	0,6	0,7	0,5	0,4
36	120	5	1	1	1	1	1	1	1	1	1	1	1
37	112	2,0	0,7	0,6	0,6	0,4	0,4	0,4	0,2	0,2	0,4	0,2	0,1
38	120	5	1	1	1	0,8	1	1	1	1	1	0,9	0,8
39	115	3,5	1	0,9	0,8	0,4	0,6	0,6	0,8	0,6	0,8	0,4	0,3
40	115	3,5	1	1	0,9	0,4	0,5	0,4	0,8	0,7	0,8	0,4	0,3
41	112	1,5	0,8	0,8	0,7	0,3	0,3	0,3	0,1	0,1	0,1	0,2	0,1
42	112	3,0	0,8	0,8	0,6	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,1
43	120	5	1	1	1	0,7	1	1	1	0,9	1	1	0,7

As can be seen from Table 2, the best results were obtained for samples numbered 32, 38, 9, 26, 28, 28, 29, 43, 11. The analysis revealed that all six groups of lines of the test object, without protrusions and burrs were reproduced relatively clearly on the impressions with a score from 5.9 to 5.5 points at a temperature of 120^0 C regardless of the type and density of paper. While at 115 ± 1^0C the degree of reproduction at six-point evaluation reaches from 5.1 to 4.2, at 112 ± 1^0 C it is from 3.9 to 3.0. The worst results are obtained at a temperature of 100 ± 1^0C.

Coverage was visually evaluated using a five-point system when assessing the degree of sealing of the die on the test object using the same prints as for the evaluation of the linework. As can be seen from Table 2, a qualitative impression or "full covering" is observed on samples 11, 13, 15, 18, 28, 32, 36, 38 and 43, as the colourful foil layer at the embossing temperature 120^0C completely covered the plate impression (Fig. 1).

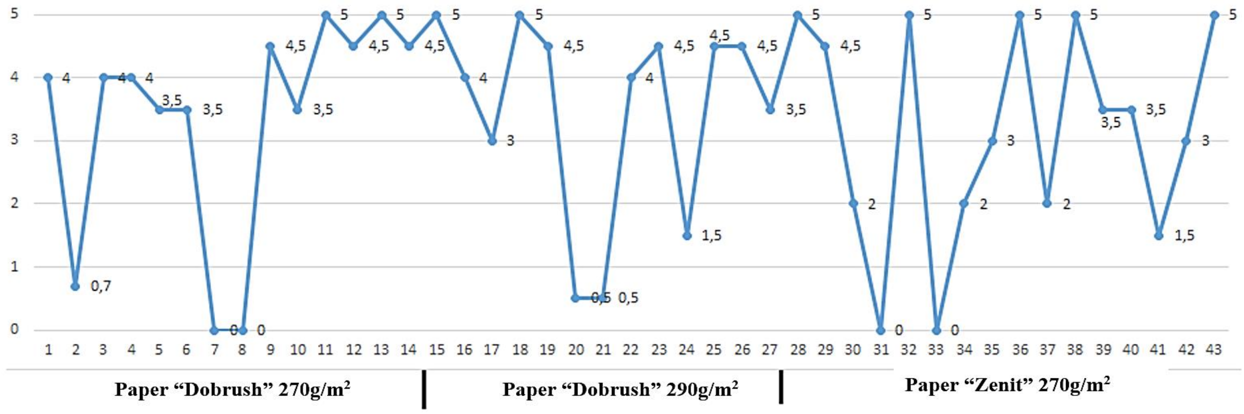

Fig.1. Variation of covering power during foil stamping on papers of different densities according to the five-point system

The resolution of embossing was visually evaluated by reproduction of fine details with complex configurations, separated by small gaps, positive (negative) texts according to a five-point system. The results of the experiment revealed the degree of influence of temperature and embossing force on the graphic accuracy of reproduction of fine strokes.

When using coated paper of density 270 and 290 g/m^2 (Dobrush paper factory, Belarus) and paper of density 270 g/m^2 produced by “Zenit” for achievement of qualitative result the optimal parameters of embossing are stamp temperature 120^0C and pressure force 13 ± 1 MPa.

Conclusions

Printing foil stamping, due to the simplicity of the technological process, is an affordable and widely used type of finishing due to giving unique decorative and protective elements to printed products. When evaluating the influence of process parameters and material properties on embossing quality, it was found that the pressure force has less influence on the result than temperature. According to the data of the study, it can be concluded that the maximum percentage of fullness of covering is achieved at a die temperature of 120^0C and a pressure force of 13 ± 1 MPa. Consequently, we can conclude that the optimal embossing parameters for specific conditions of the technological process have been determined to achieve a qualitative result.

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