Impact Factor:	ISRA (India) = 1.344	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 0.829	РИНЦ (Russia) = 0.179	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 1.042	
	JIF = 1.500	SJIF (Morocco) = 2.031	

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2015 **Issue:** 11 **Volume:** 31

Published: 30.11.2015 **http://T-Science.org**

SECTION 7. Mechanics and machine construction.

Denis Alexandrovich Chemezov
Master of Engineering and Technology,
Corresponding member of International Academy of Theoretical and Applied Sciences,
Lecturer of Vladimir Industrial College,
Russian Federation
chemezov-da@yandex.ru

Vasily Sergeevich Seliverstov
Student of
Vladimir Industrial College, Russian Federation

Andrey Sergeevich Komisar
Student of
Vladimir Industrial College, Russian Federation

Natalia Andreevna Zezina
Student of
Vladimir Industrial College, Russian Federation

Svetlana Ivanovna Tyurina
Lecturer of
Vladimir Industrial College, Russian Federation
scorpion13.60@mail.ru

STAMPING OF THE PLATE STOCK WITH BLANK HOLDER: THE CHARACTER OF THE MATERIAL DEFORMATION AND CALCULATION OF THE COEFFICIENT OF ELONGATION

Abstract: *The article was made the analysis of the degree of plastic strain of the plate stock with a thickness of 3 mm when the depth of draw up to 20 mm. The character of the stresses of the material of the plate stock at different area was specified. The results of calculation of stress-strain state of the material during shallow drawing of plate stock of different thickness were represented.*

Key words: *a plate stock, a die, a deformation, a punch, a blank holder, a coefficient of elongation.*

Language: *Russian English*

Citation: Chemezov DA, Seliverstov VS, Komisar AS, Zezina NA, Tyurina SI (2015) STAMPING OF THE PLATE STOCK WITH BLANK HOLDER: THE CHARACTER OF THE MATERIAL DEFORMATION AND CALCULATION OF THE COEFFICIENT OF ELONGATION. ISJ Theoretical & Applied Science 11 (31): 101-107.

Soi: http://s-o-i.org/1.1/TAS-11-31-16 ***Doi***: crossref http://dx.doi.org/10.15863/TAS.2015.11.31.16

Introduction

Stamping includes separating and shaping technological operations of the processing of metallic alloys and non-metallic materials. Shaping operations of the stamping are the flanging (forming flanges along the outer contour of the plate stock or around a pre-punched holes), the bending process (giving a curved shape to a flat workpiece), the reduction (the narrowing of the end part hollow or three-dimensional details), the forming (local change of form while retaining the configuration of the outer contour of the detail) and the drawing (the conversion of a flat workpiece into a hollow spatial detail) [1].

The drawing of the plate stock carries out in the dies. Wavelike folds are formed when forcing through of the material by the punch in the die hole, on a flange of the plate stock of small thickness [2]. The folds are eliminated when the blank holder is using – the plate with a through central hole (profile of the hole of the blank holder conforms the profile of the working part of the punch). The blank holder is pressed with a certain force to the flange, thereby it is restricting the movement of the plate stock in the vertical direction.

During the drawing, the material of the plate stock is subjected to intense tension and compression on different areas of the outer and inner contours of the hollow detail. Special attention should be given to the research of the value of the stress and strain of

the material of the plate stock at the following areas forming tools: radius chamfer in the die hole and the working part of the punch, directly forming the bottom and inner contour of the side wall of the hollow detail. The maximum permissible value of stress of the material can cause a partial rupture of the side wall or the bottom of the hollow detail.

The calculation of stress-strain state of the material and subsequent careful selection of the optimal mode of drawing (the force value is exerted on the punch) take into account sizes of the plate stock and of the forming tools, will allow to minimize possible production defects of the detail.

Materials and methods

The stages of preparation and implementation of the computer research of the process of drawing of the plate stock were made in software environments: KOMPAS-3D → Ansys Workbench (module of Explicit Dynamics) → LS-DYNA [3].

Simulation of the process of drawing was carried out by means oriented in spatial three-dimensional models of the forming tools, of the blank holder and of the plate stocks various thickness.

5 experiments was performed to determine the stress-strain state of the model of the plate stock with thickness of 1, 2, 3, 4, 5 mm and outer diameter 120, 128, 136, 144, 150 mm subjected to the process of drawing, at change of the dimensions of the forming surfaces of the models of die and punch.

The size of the diameter of the die hole – 60, 64, 68, 72 and 76 mm, outer diameter of the punch – 57.9, 59.9, 61.9, 63.9 and 65.9 mm. The length of the punch and the depth of the die hole were taken the size of 50 mm. A through cylindrical hole of the model of blank holder is increased by 4 mm (the range of the diameters of 62 to 78 mm).

As a material of the plate stock aluminium alloy 2024 is selected, forming tools and blank holder – tool steel X165CrMoV12 [4, 5].

All models were divided into finite elements. Automatic smoothing of finite elements allowed us to obtain high mesh quality and consequently the accuracy of the calculation results [6].

The values of the technological forces during the drawing (the force perceived by the punch and the pressing force of the flange plate stock) for each experiment are presented in table 1.

Table 1

Technological force during the drawing of the plate stock.

The number of the experiment	1	2	3	4	5
Punch					
The force value, kN	15	30	45	60	75
Blank holder					
The force value, kN	5	10	15	20	25

Models of the punch, of the blank holder and of the die according to the test were the rigid bodies, the model of the plate stock – plastic material.

Results and discussion

The results of calculation of stress-strain state of the material of the plate stock were processed through two programs: LS-DYNA and MS Excel.

The values plastic deformation of the material [7] at different depths of the draw are presented as colored contours on the three-dimensional model of the plate stock with a thickness of 3 mm (Fig. 1).

Diagram of the process of drawing of the plate stock, and also the geometry of the chamfers in the die hole and on the working part of the punch are showed in Fig. 1, *A*.

The movement of the punch towards the die hole is leads to bend plate stock. Plastic strain of the material when the depth of draw – 2.2 mm is observed (Fig. 1, *B*) on the areas immediate pressure of the forming tool, as well as on the radius chamfers (the maximum value of the coefficient is 0.024) in the die hole (the formation of the inner contour of the hollow detail) and the working part of the punch (the formation of the outer contour of the hollow detail).

Further drawing of the plate stock at a depth of 8.1 mm (Fig. 1, *C*) is characterized by an increase in the intensity of plastic strain of material on areas of radius chamfers (highlighted by contours of the red and orange colors). The outer diameter of the plate stock is reduced. The bottom of hollow detail is subjected slight plastic strain.

Process of the deformation of the flange plate stock (the displacement and movement of the material) is observed when the depth of draw of 14.1 mm (Fig. 1, *D*). The value of this deformation is minimal, due to the pressing of the flange plate stock. The value of the plastic strain of the material of the plate stock is increased to 1.5 times in the area radius chamfers of the forming tools. On the model we can see that the distribution of the largest plastic strain occurs at a small depth of the surface layer of the material.

The formation of cylindrical form of the hollow detail is occurred when the depth of draw equal to 16 mm (Fig. 1, *E*). There is an increasing the intensity of plastic strain of the bottom hollow detail and the material at the area of the radius chamfer (is made in the die hole). The surface of the side wall detail, contacting with the surface of the die hole, is deformed uniformly.

Further forcing through of the plate stock into the die hole to a depth of 18.4 mm (Fig. 1, *F*) is characterized by increasing values of the coefficient of plastic strain of the material in the local areas.

Maximum values of plastic strain of the material of the plate stock of different thickness: 1 mm – 0.203, 2 mm – 0.18, 3 mm – 0.206, 4 mm – 0.207, 5 mm – 0.227.

The dependencies of the effective stress of the material [8] in different areas from time of drawing of the plate stock are presented in Fig. 2. The dependencies of the pressure on the material [9] (diagrams of tension and compression at different areas) from time of process of drawing of the plate stock are presented in Fig. 3.

The following areas of material of the plate stock (profile of the hollow detail in the longitudinal section) subjected to deformation on the whole time range of the process of drawing: the side wall of detail (1' – 1"), the bend with *r*5 (2' – 2"), the flange of the plate stock (3' – 3"), the bottom of detail (4' – 4") and bend with *r*3 (5' – 5") were considered. The simulation time of the process of drawing of the plate stock amounted to 1.4 s.

The effective stress of flange of the plate stock is increased to 100 N/mm^2 during the drawing of material to a specified depth. The inner and outer surfaces of the bottom hollow detail are subjected the same effective stress. Thus, it is noted that in 1.2 s of the process of drawing decreases the value of stress of the material. The inner surface of the side wall of the hollow detail is experiencing more effective stress (at least 50 N/mm^2) than the outer surface. The maximum values of the effective stress on inner (over 250 N/mm^2) and outer (235 N/mm^2) of the surfaces of the detail are identified on the bend with *r*5 and with *r*3, respectively.

The flange of the plate stock is subjected to compression (in this case positive values of pressure) while the bottom hollow detail is subjected to tension (negative values of pressure). The ratio of the pressures of is 1:3. The area (point 2") on the inner side of bend of the plate stock is compressed to a maximum value in a short period of time of process of the drawing. The area on the opposite side of the bend is stretched, but with less intensity. The area is exposed of maximum tension (point 5") and not significant compression (point 5'). The area of material with the points 1' – 1" is compressed (the inner surface of the side wall of detail) and is stretched (the outer surface of the side wall of detail). The deformation of the material at area 1' – 1" has of a transitional character as forcing through of the plate stock into the die hole: until the formation of the inner/outer surfaces of the side wall is observed tension/compression, in the formation of the inner/outer surfaces of the side wall – compression/tension.

The dependencies of change of the coefficient of elongation from a depth of draw of the material of the plate stock of different thickness are presented in Fig. 4.

The coefficient of elongation is calculated as the ratio of the outer diameter of the hollow detail to the outer diameter of the plate stock [10].

Let us consider the dependencies *1* and *2*. When the thickness of the plate stock 1 mm and 2 mm there is no sharp changes in the increasing coefficient of elongation of the material, this means that the speed of movement of the punch remains constant on the whole time range of the process of drawing. Because when the depth of draw equal to 14 – 16 mm occurs a sharp increasing in the value of the coefficient of elongation (dependence *3*), it can be assumed that in this area, perhaps, there will be a partial destruction of a deformable material. Similar changes occurs during the drawing of the plate stock with a thickness 4 mm and 5 mm (the dependencies of *4* and *5*) when the depth of draw equal to 16.3 – 16.5 mm and 18 – 18.2 mm, respectively.

Conclusion

Based on the results of calculation of stress-strain state of the material of the plate stock and subsequent analysis of the dependencies the parameters of the process of drawing can draw the following conclusions:

1. The largest deformation is subjected of the material of the plate stock on the bend, formed by radius chamfer in the die hole. The decreasing in the degree of deformation will occur when the change of the size or geometric shape of the radial chamfer.

2. As forcing through the plate stock into the die hole, on different areas of the outer and inner contours of the hollow detail (from flange to bottom), the compressive and tensile stresses in the material are alternating.

3. The least destructive stress of the material occurs during the drawing of the plate stock with a thickness of 5 mm to the depth of draw – 18 mm. The drawing of the plate stock with a thickness of 1 mm is characterized by a smooth increasing of the value of the coefficient of elongation, this means that the operating stresses does not lead to the destruction of the material.

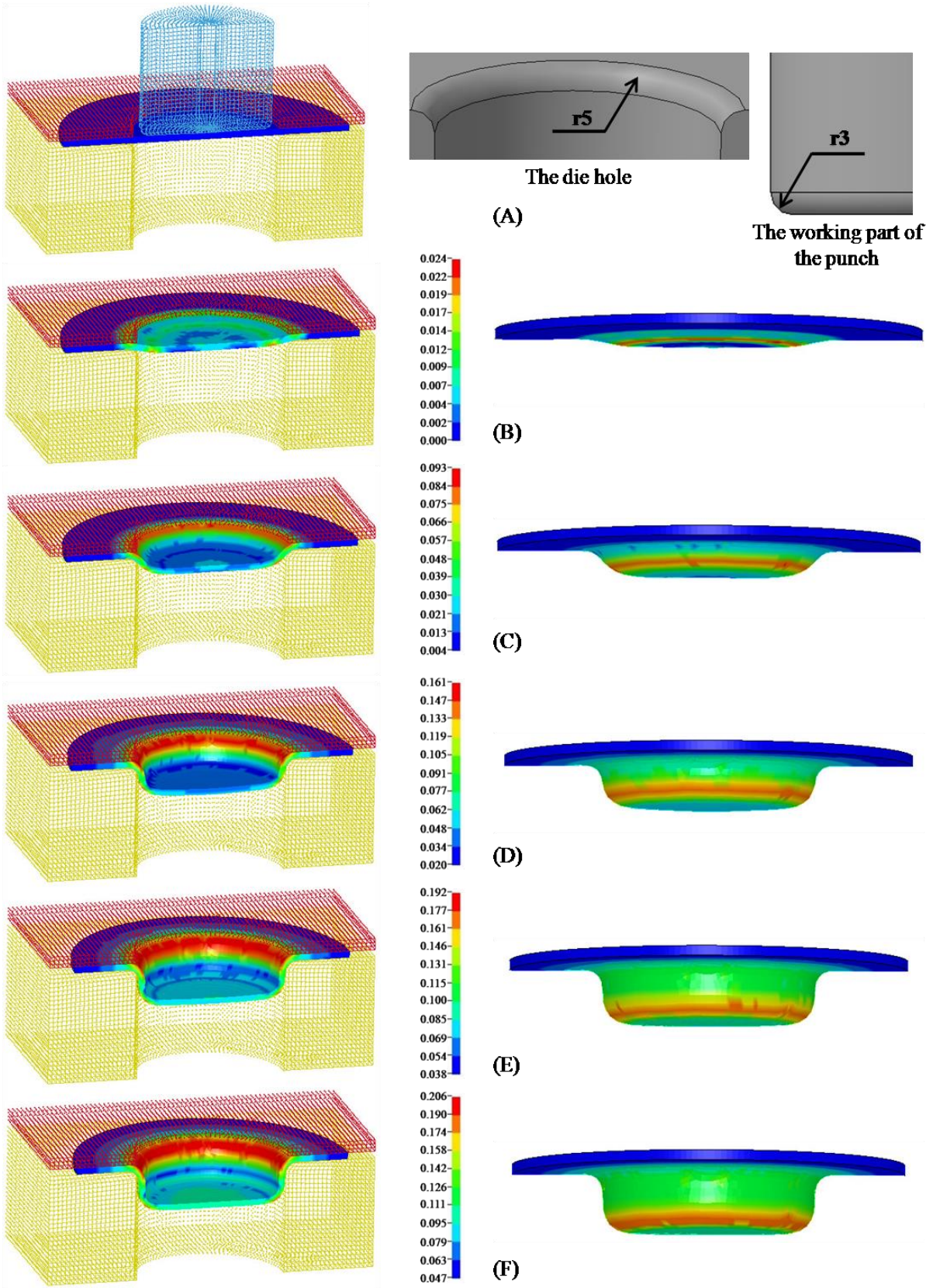

Figure 1 – The plastic strain of the plate stock in forming the contour of the hollow detail. *A* – Orientation of the models of the punch, of the blank holder, of the plate stock and of the die (on the left); Removal elements: the size of the radius of the chamfer in the die hole and on the working part of the punch (on the right). *B*, *C*, *D*, *E*, *F* – A view of the inner and outer contours of the deformable of the plate stock when the depth of draw 2.2, 8.1, 14.1, 16.5, 18.4 mm (on the left and on the right, respectively).

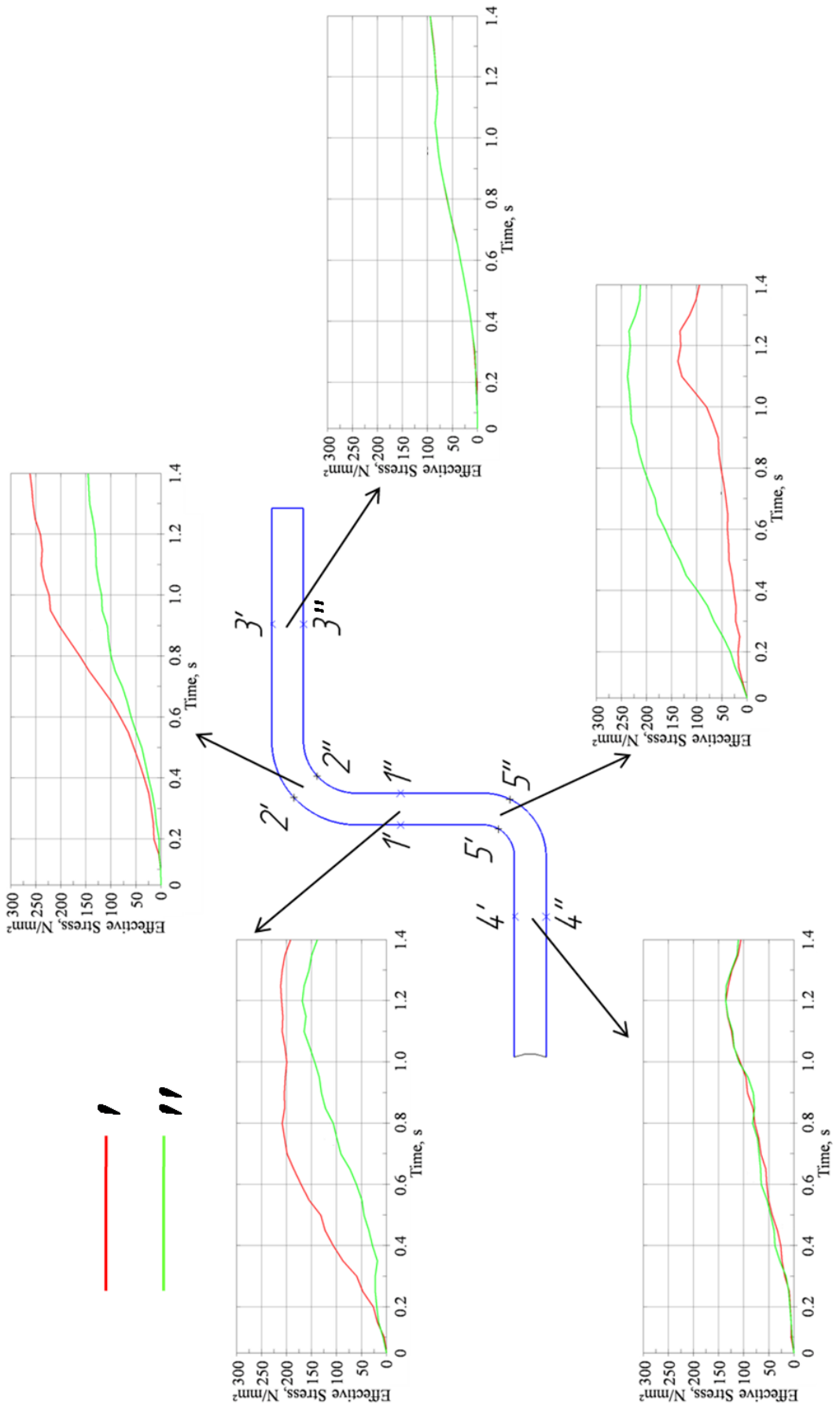

Figure 2 – The dependencies of the effective stress of the material from time of process of the drawing of the plate stock.

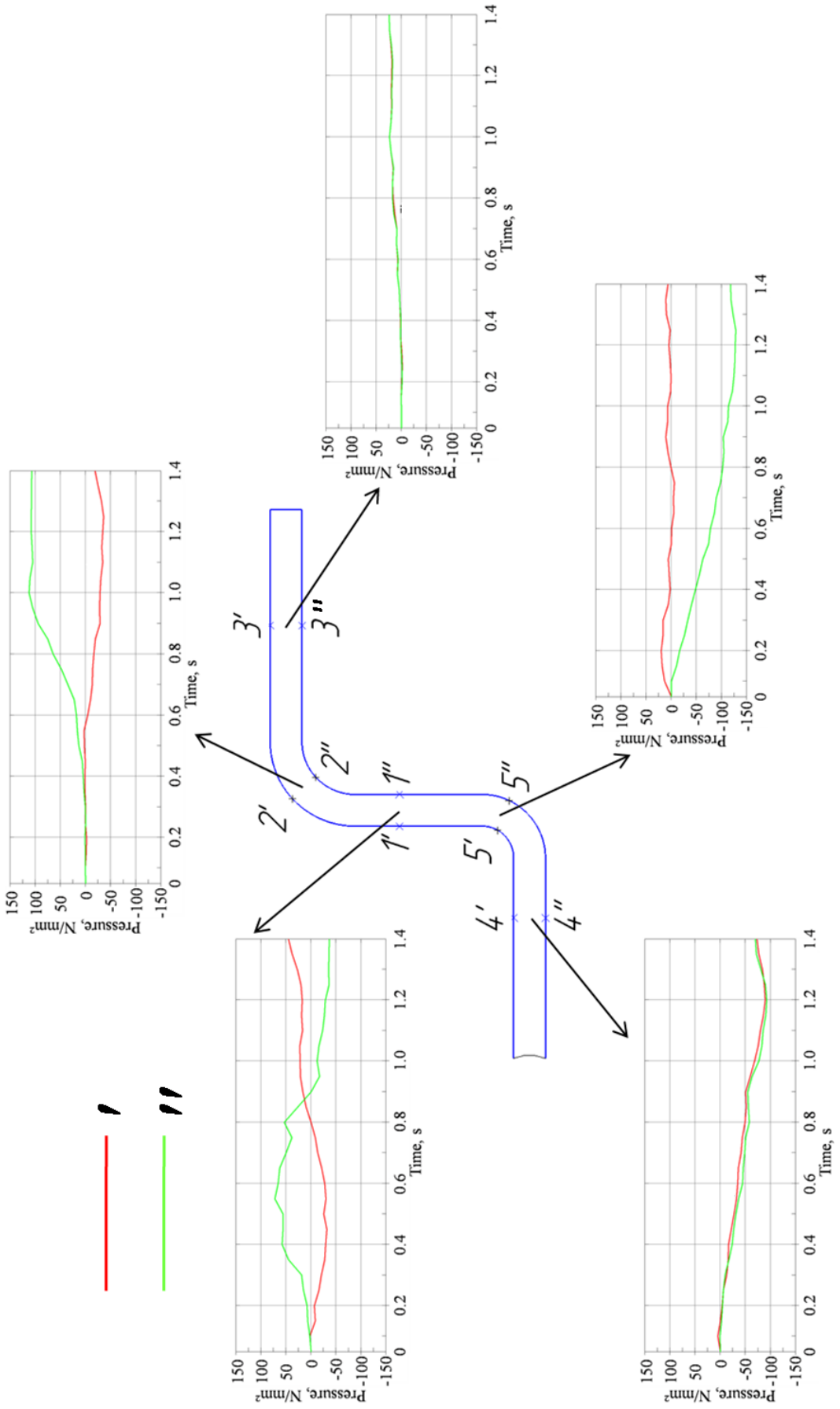

Figure 3 – The dependencies of the pressure into the material from time of process of drawing of the plate stock.

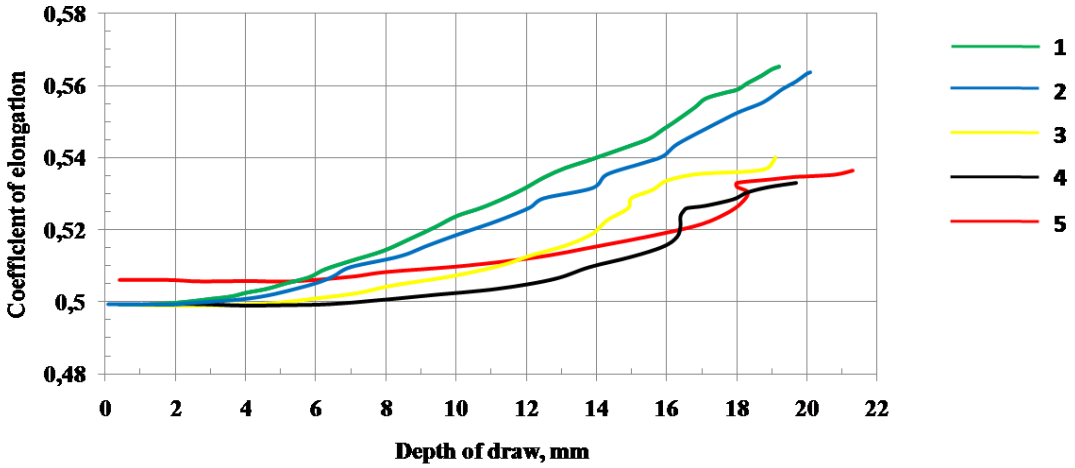

Figure 4 – The dependencies of the change of the coefficients of elongation from a depth of draw of the material of the plate stock: *1* – the plate stock with a thickness of 1 mm, *2* – the plate stock with a thickness of 2 mm, *3* – the plate stock with a thickness of 3 mm, *4* – the plate stock with a thickness of 4 mm, *5* – the plate stock with a thickness of 5 mm.

References:

1. (2015) Listovaya shtampovka. Available: http://cherch.ru/obrabotka_metallov_davleniem/listovaya_shtampovka.html (Accessed: 22.11.2015).
2. Chemezov DA, Seliverstov VS, Kondrakov AA (2015) The process of corrugation on the flange of the deformable of the plate stock. Journal scientific and applied research. №10/2015. – pp. 79 – 81. ISSN 2306-9147.
3. Chemezov DA (2015) The research of the shallow drawing process of the plate stock. ISJ Theoretical & Applied Science 10 (30): 11-15. Soi: http://s-o-i.org/1.1/TAS-10-30-4 Doi: http://dx.doi.org/10.15863/TAS.2015.10.30.4
4. (2015) 2024 aluminium alloy. Available: https://en.wikipedia.org/wiki/2024_aluminium_alloy (Accessed: 22.11.2015).
5. (2015) DIN X165CrMoV12. Available: http://www.ccsteels.com/Tool_steel/611.html (Accessed: 22.11.2015).
6. Andrekayte AA (2010) Variational methods for constructing computational grids for finite element calculations in multiply connected domains. Bulletin of scientific and technical development. №8 (36), 2010. – pp. 1 – 7.
7. (2015) Deformation. Available: http://www.modificator.ru/terms/deformation.html (Accessed: 22.11.2015).
8. (2015) Effective stress. Available: http://www.thefullwiki.org/Effective_stress (Accessed: 22.11.2015).
9. (2015) Mehanicheskie harakteristiki i svoystva materialov. Available: http://edu.dvgups.ru/METDOC/GDTRAN/NTS/DET_MASH/MEHANIKA/METOD/DRIGIN/frame/2_3.htm (Accessed: 22.11.2015).
10. (2015) Tehnologicheskie raschety pri vytyazhke i postroenie tehnologicheskogo protsessa. Available: http://omd.omgtu.ru/wp-content/themes/iGadgets/basetlsh/116-171.htm (Accessed: 22.11.2015).