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ASPECTS REGARDING THE INFLUENCE OF EXTERNAL FRICTION CONDITIONS ON MATERIALS FORMABILITY

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ABSTRACT *The aim of the paper is to present the influence of friction conditions on the flow of material in the processes of plastic formation of metals. Insufficient knowledge of the interface between the material and the forming tools is a factor for which the phenomenon of friction is not fully known. Due to friction the deformation of the material occurs unevenly. The non-uniformity of the deformation is greater the more the friction is accentuated. In order to determine the influence of the friction state on the material flow, experiments were performed for: the determination by the ring method of the friction coefficients in the case of three types of friction states; determination of the influence of the deformation energy on the formability of the material depending on the coefficient of friction at the surface of the sample-tools.*

KEYWORDS: *friction, ring compression, metal forming, strain*

1.INTRODUCTION

In the plastic deformation processes on the contact surfaces are frictional forces that oppose the flow of the material. The stresses that result from frictional forces influence the stresses and deformations, the mode of distribution and the size of the resistance to deformation, the temperature of the semi-finished product, the wear and durability of the tools, etc.

In the processing by plastic deformation the friction has negative influences on the product and on the tools. Also the friction leads to an increase in the forces and deformation energy required for processing.

The aspects that are related to the friction are: deformation forces that depend on the coefficient of friction between the deformed material and the deformation tools; the surface quality of the deformed product that depends on the type of lubricant used. By using a suitable lubricant the deformation forces and the wear of the deformation tools can be reduced. In figure 1 is presented the friction influence on upsetting of a cylindrical sample.

Under conditions without friction, the sample deforms uniformly, the normal stress, as is seen in the figure is evenly distributed in diameter. If the friction stress is present on the surface the product deformation is not uniform . In this case the normal stress increases from the outside to the center of the sample. The force required for deformation is greater than in the case of deformation without the presence of friction. [1].

Insufficient knowledge of the material / tool deformation interface means that the phenomenon of friction in plastic deformation is not fully known.

The friction models of Coulomb and Tresca are the most common used in plastic deformation processes [2].

Some empirical friction models were also developed. These models were based on the experimental results [3,4,5].

Coefficient of friction depends on the film thickness of lubricant as shown Tabor and Bowden [6]. Bay ,Wanheim and Wilson and Sheu demonstrated that the real contact area can be responsible for the friction [7,8].

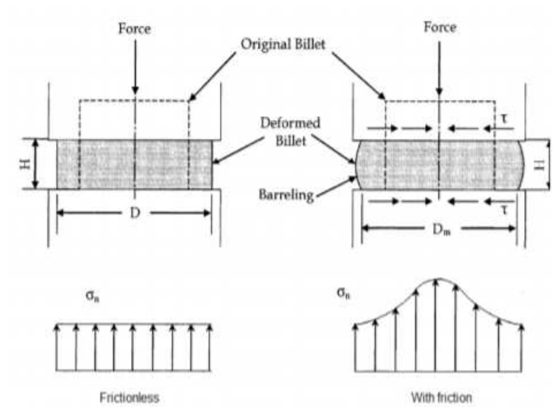


Fig.1 Upsetting of a cylindrical sample[1]

The surface of real contact depends on asperity flattening and is influenced by plastic strains. Some models for the calculation of contacts between single asperity and multi asperity are presented by Adams and Nosonovsky [9].

Friction in plastic deformation processes with simple models of friction are presented by B.-A. Behrens et al [10].

2. **RING COMPRESSION TEST**

In plastic deformation, friction is a very important factor that makes a deformation process to be viable from economic point of view.The most used method for determining the coefficient of friction in plastic deformation is the ring compresion method. The test was first developed by Kunogi in 1956 [11], and later by Male and Cockcroft [12].

In the test, a ring-shape specimen is compressed to a specified reduction (Fig. 2). Modification of the ring diameters depends on the size of the friction on the tool / blank contact surface. At zero friction the ring will deform evenly. At very low friction condition, inner and outer diameters increase. If the friction is higher, the inner diameter decreases and outer diameter increases [11].

The friction coefficient can be determine from the diagram presented in figure 3 where the decrease of inner diameter is function of reduction of height [12].

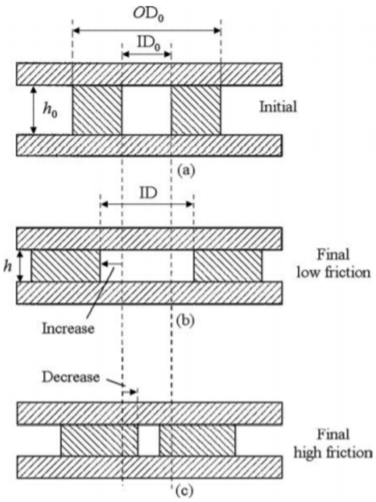


Fig.2 Ring compression: (a) initial ring (b)low friction (c) high friction.

3. THE INFLUENCE OF EXTERNAL FRICTION CONDITIONS ON MATERIAL FORMABILITY

The friction conditions between the blank and the deformation tools strongly influence the formability of the material, by increasing the deformation efforts and by accentuating the non-uniformity of the local deformations that favor the fracture. In the processes of plastic deformation, the friction conditions negatively influences the deformation by increasing the energy required to carry out the process. The friction positively influences the deformation processes; in the rolling process could not developed without the friction between the rolling cylinders and the product.

From the formability point of view if higher the friction, the formability is lower and if reduced friction the formability of the material increases.

Figure 4 shows the shape of the flow lines during the direct extrusion process. The shape of flow lines is dependent on the friction between the billet-container-die-punch.

The shape of the flow lines presented in figure a characterizes the most uniform flow of the material in the container. In the case of extrusion with lubrication, therefore a very low friction between the semi-finished product and the container, the shape of the flow lines is the one shown in figure 4 b. Figure 4.c shows the shape of the flow lines in case of the presence of a high friction between the semi-finished product-container-die. Figure 4.d presents the flow lines in the billet in the case of the direct extrusion process without any lubrication. This shape of the flow lines is specific to the hot extrusion of aluminum. [13].

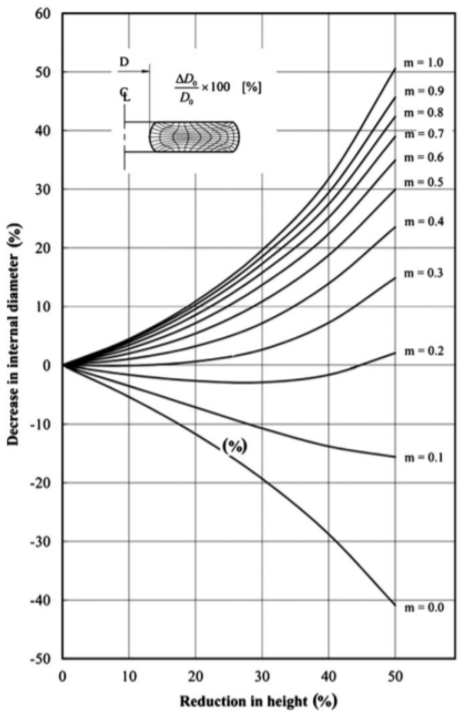
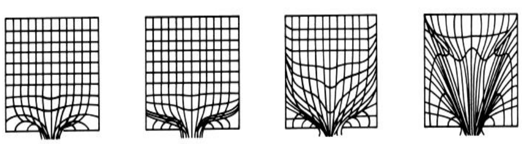


Fig.3 Curves for ring compression tests



a. b. c. d.

Fig.4 Flow patterns in the direct extrusion

4. EXPERIMENTAL DETAILS

In order to determine the influence of friction condition on material flow, the following experiments were performed for: determination by the ring method of the friction coefficients in the case of three types of lubricants; determining the influence of the deformation energy on the formability of the material depending on the friction coefficient on the sample-tool surface.

The ring samples were made of lead and their initial dimensions are shown in the figure 5. The deformation of the samples took place on a hydraulic laboratory press with a 100 kN maximum force. Using the empirical relation of Crackfort and Male, the value of the coefficient of friction is calculated [12]:

$$\mu = 0{,}055\ e^{\left(\frac{\Delta d}{d_0}\right)m} \quad (1)$$

$$\frac{\Delta d}{d_0} = \frac{d_0 - d_1}{d_0} 100\ ,\ [\%] \quad (2)$$

$$m = e^{(0{,}044_{\varepsilon} + 1{,}006)} \quad (3)$$

$$\varepsilon = \frac{h_0 - h_1}{h_0} 100\ ,\ [\%] \quad (4)$$

The values obtained for the friction coefficients in the three situations are:0,1377 for unlubricated surfaces; 0,101 for soap and 0,0789 for mineral oil.

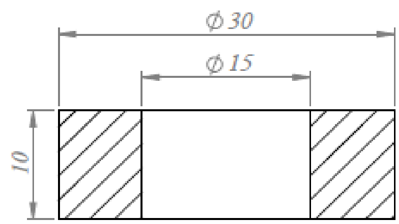


Fig. 5 Initial dimensions of the samples

The appearance of the samples obtained after the deformation is presented in the figure 6.

a b c d

Fig.6 Ring samples subjected to compression under certain conditions

a)Initial sample; b) non-lubricated sample; c) sample lubricated with powder; d) sample lubricated with mineral oil.

In order to determine the influence of the deformation energy on the formability of the material depending on the friction coefficient on the sample-tool surface a number of twelve samples with dimensions of 20 mm in diameter and 30 mm in height was prepared, having the same degree of processing of the base surfaces. From these samples are formed three series of samples, which will be deformed at the laboratory sonnet with different deformation energies.

In the case of each series of samples, in order to ensure different friction conditions, one sample was deformed between the surfaces greased with soap, another sample between the degreased surfaces, and the third between the surfaces. greased with mineral oil. After compression, the height, maximum diameter and minimum diameter of each sample was measured.

The deformed samples are shown in the figures below.

a b c d e

Fig.7 Deformed cylindrical samples on laboratory sonnet at different impact energies (unubricated) a) initial sample; b) 48000 daN mm; c) 32000 daN mm; d) 24000 daN mm; e) 16000 daN mm

a b c d e

Fig.8 Deformed cylindrical samples on laboratory sonnet at different impact energies (lubricated with soap) a) initial sample; b) 48000 daN mm; c) 32000 daN mm; d) 24000 daN mm; e)16000 daN mm.

a b c d e

Fig.9 Deformed cylindrical samples on laboratory sonnet at different impact energies (lubricated with mineral oil) a)initial sample; b)48000 daNmm;c) 32000 daN mm; d) 24000 daN mm; e) 16000 daN mm.

Based on the obtained results , the curves of variation of the engineering strains are drawn function of friction coefficient for different deformation energies (Fig.10). From the intersection points, the corresponding values of the friction coefficients for a constant engineering strain achieved with different deformation energies can be determined from the diagram.

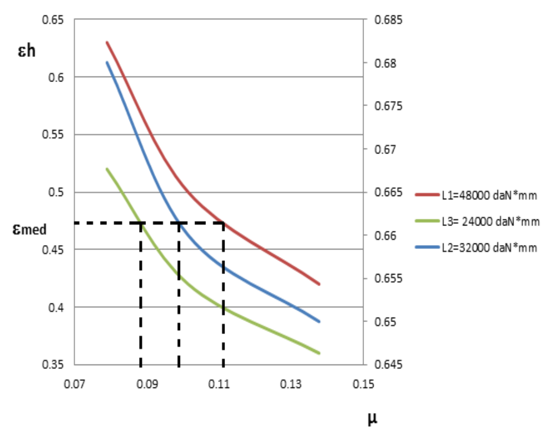


Fig.10 Variation of engineering strain depending on the friction coefficient

It can be seen that by increase of the friction coefficient for the same deformation energy, the engineering strain decreases. Also, the increase of the deformation energy leads to the increase of strain for the same value of the friction coefficient.

Fig.11 shown variation of diameter d_1 depending on the coefficient of friction and various strains.

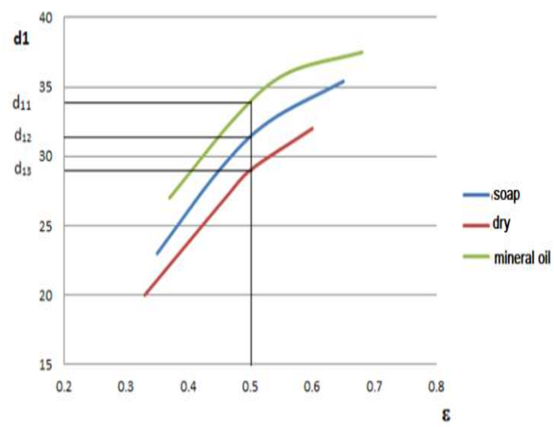


Fig.11 Variation of diameter d_1 vs friction coefficient and engineering strain

$D_1$is the final diameter of the samples after deformation as is presented in figure 12.

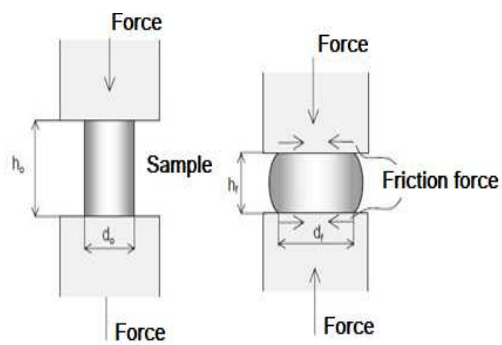


Fig.12 Influence of the friction force on the shape of the deformed sample

As can be seen in figure 11, for the same strain, the diameter d_1 of the deformed sample increases by decreasing the coefficient of friction. This demonstrates that nonuniformity of the strains in the samples decreases.

5. CONCLUSIONS

The experimental study was performed to highlight the importance of the coefficient of friction in plastic deformation processes. The coefficient of friction depends on several factors such as: the degree of processing of the sample and tool surfaces, the tools geometry, the lubrication conditions, the deformation speed.
In the present study, the ring compression test was used in order to determine de friction coefficient in three conditions of lubrication.
The friction coefficient determined by the ring method varies between 0.078 in the case of unlubricated surface, 0.101 in the case of lubrication with soap or 0.137 in the case of mineral oil.
Barreling occurs due to friction between the sample and the die in compression test. Friction reduction can be achieved by using a suitable lubricant.
Uneven deformation of the material is due to friction on the contact surface between the material and the deformation tools. The uniformity of the deformation decreases the higher the friction. In the case of all samples, the presence of friction demonstrated the non-uniformity of the deformations in the volume of the deformed material.The increase of the deformation energy determined the increase of strains in the samples;
The increase of the coefficient of friction determined the decrease of strains in the samples
By decreasing the friction coefficient, the diameter d_1 of the deformed sample increases for same strain. This demonstrates that reducing the friction between the sample and the deformation tool reduces the non-uniformity of the deformations.

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ASPECTE PRIVIND INFLUENȚA CONDIȚIILOR DE FRECARE ASUPRA CURGERII MATERIALULUI IN PROCESELE DE DEFORMARE PLASTICA

REZUMAT Scopul acestei lucrări este de a prezenta influența condiţiilor de frecare asupra curgerii materialului în procesele de deformare plastică a metalelor. O cauză importantă pentru care fenomenul de frecare în procesele de deformare plastică nu este pe deplin cunoscut este cunoașterea insuficientă a interfeței dintre material și sculele de deformare. Frecarea pe suprafața de contact dintre sculă și semifabricat este cauza principală a deformării neuniforme a materialului. Cu cât forțele de frecare sunt mai mari, cu atât este mai mare neuniformitatea deformației. Pentru a determina influența frecării asupra curgerii materialului, s-au efectuat experimente pentru: determinarea prin metoda inelelor a coeficienților de frecare în cazul a trei tipuri de condiții de frecare; determinarea influenței energiei de deformare asupra formabilității materialului în funcție de coeficientul de frecare de pe suprafața probei/scula de deformare.

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