Creation of anisotropic friction conditions during the process of hot forging

To cite this article: D L Pankratov and R I Valiev 2014 IOP Conf. Ser.: Mater. Sci. Eng. 69 012034

View the article online for updates and enhancements.

Related content
- Improvement of the cold forming technology of the parts such as longeron
  L R Kashapova, D L Pankratov and A A Bilyalova
- Automation System Goals for the Creation and Operation of the Tool
  R M Khisamutdinov and M R Khisamutdinov
- The determining of the coefficient of safety of bearing ability of anisotropic bars in the general case of their complex resistance
  K E Sibgatullin and E S Sibgatullin

Recent citations
- Research of influence of geometrical parameters of a stamp engraving of setting transitions at setting of semi-finished pipe products to receiving defect-free products
  D L Pankratov et al
- Improvements in the process of boss bar upset forging into a horizontal forging machine with the aim of joint knuckle forging quality improvement
  D L Pankratov et al
Creation of anisotropic friction conditions during the process of hot forging

D L Pankratov, R I Valiev
Kazan Federal University,
423800, 68/19 Mira avenue, Naberezhnye Chelny, Russia
E-mail: chelny@kpfu.ru

Abstract. The features of changing the form of ring samples during the upsetting depending on the billet and the tool surface friction conditions are considered.

1. Introduction
In all the laws, describing the boundary conditions during the process of plastic deformation in one form or another, there is a concept of friction coefficient, which is defined only by isotropic friction conditions on the surface of contact of the stamp and a deformable workpiece [1; 2; 3; 4]. However, in real conditions, it is necessary to distinguish roughness along the machining marks - longitudinal and across them - transverse [5; 6]. That is why the coefficient of friction, which is largely dependent on the surface roughness of the tool during the plastic deformation in two mutually perpendicular directions, has different values. Therefore, it would be more precisely to use two friction coefficients in the description of boundary conditions - parallel and perpendicular to the machining marks of the tool surface. In this regard, the shape of the workpiece after deformation may vary depending on the values of the friction coefficient and anisotropy [7].

2. Basic part
This is especially relevant during the process of upsetting of the ring billets.
Figure 1 - Curves for determining the friction coefficient using the method of ring upsetting [8; 9; 10, 11, 12].

Based on the analysis of methodology for determining the friction coefficient (Figure 1) proposed by Cockcroft MG, it is possible to distinguish the following options of form changes of the ring samples during the process of upsetting depending on the obtained coefficient of anisotropy I:

- When I = 1 (isotropic friction) and the friction coefficient is equal to 0 the flow of metal goes to the radial direction from the axis of symmetry of the ring (Fig. 2a). Such character of form changing is observed in the range of $0 < \mu < 0.055$. In this case, the area of flow division in contrast to the ideal state, when the area of flow division was at the point, represents a circle which diameter is smaller than the internal diameter of the ring sample (Fig. 2b). When $\mu = 0.055$, the area of flow division reaches the internal diameter of the sample that leads to the increase only of the external diameter of the ring at the constant internal diameter (Fig. 2c). Increasing $\mu > 0.055$ leads to the movement of the area of flow division inside the ring sample. In this case, two types of plug flows are observed (Q1 - of the center and Q2 towards the center of the ring sample) (Fig. 2d). To get the flow of metal Q2 during the upsetting of the ring samples to the axis of symmetry of the ring, it is necessary to provide the imposition of external restrictions on the side surface of the ring sample when there are large \( \mu \) values (Fig. 2e).

Section 1.01

Figure 2 - Schemes of the egress of metal during the process of upsetting of the ring samples for different values of contact friction

When I < 1 (anisotropic friction), the appearance of the ring samples in the form of ellipsoid during the upsetting can be observed. There are four possible variants differ from each other by the
scheme of the flow of metal. In the case, when the friction coefficients along and across the machining marks are more than $0 < \mu_{\parallel} < \mu_{\perp} < 0.055$ the form change is observed, when the flow of metal move of the center of the sample, which leads to the increase in both external and internal diameter of the ring. As friction forces act on the contact surfaces, being slightly different in absolute value, it results in a small ellipse of the external and internal surfaces of the sample in the direction of the machining marks of the tool surface (Fig. 3a). The area of the flow division in this case is less than the internal diameter of the ring, but in contrast to the isotropic conditions it takes the form of the ellipsoid character.

When the friction coefficients along and across the machining marks are more than $0 < \mu_{\parallel} < \mu_{\perp} = 0.055$ the form change is observed, at which the flow of metal move of the center of the sample, like in the first case. However, the internal diameter of the ring pattern in the direction that is perpendicular to the machining marks remains constant and increases along the machining marks. The external diameter of the ring increases both along and across the machining marks.

Herewith, the change in diameter along the machining marks is more significant than across. As a result, the ellipsoid character of both internal and external surfaces of the upsetting ring in the direction of the machining marks is increasing (Fig. 3b) as compared with the case in Figure 3, a.

![Diagram](Image)

Figure 3 – Scheme of the flow of metal during the process of upsetting of the ring samples in terms of anisotropy friction (dashed line indicates the contour of the ring sample before deformation).
When the friction coefficient along the machining marks $\mu_{//}<0.055$, and across the traces of processing $\mu_{\perp}>0.055$, the area of the flow division is partially within the sample, and partly in the hole of the ring (Fig. 3c). This leads to the appearance of oppositely directed plug flows of metal towards the external ($Q_{\perp1}$) and internal ($Q_{\perp2}$) surface of the sample in the direction that is perpendicular to the machining marks of the tool contact surface. Displaced flow ($Q_{//1}$) can be observed along the machining marks of the tool surface. This leads to a further increase of ellipse of both internal and external surfaces of the ring, as compared with the case shown in Fig. 3 b.

In the fourth case, when a friction coefficient along and across the machining marks is described as $\mu_{\perp}>\mu_{//}>0.055$, the surface of the flow division is within the sample, and its section has the form of ellipse (Fig. 3d). Differently directed plug flows take place throughout the ring sample of the surface of the flow division towards the external and internal surfaces of the ring. This leads to the reduction of internal and external diameters of the sample. The magnitude of ellipse in this case depends on the ratio of the friction coefficients along and across the machining marks of the tool surface, but in any case, this magnitude is smaller than for the scheme in Fig. 3, c.

Suggested hypothesis about the flow of metal during the process of upsetting of the ring samples are in good agreement with the experimental results and allow by means of application of the oriented roughness on engraving of the stamp to get the desired direction of the displacement of metal during the upsetting. The obtained results also can be used to restore worn parts with plastic deformation using the operation of upsetting, stamp dressing, in the case of the defect in the form of insufficient feeling of the stream during the pressure forming. Therefore, to create the zones of hindered flow, it is necessary to direct the machining marks on the engraving of the tool perpendicular to the flow of metal during the plastic deformation. Deformation should occur without the application of technological greasing. The appearance of the slip zones is possible if the machining marks on the engraving of the stamp are directed parallel to the flow of metal during the plastic deformation. The process should be accompanied by the use of technological greasing.

3. References
[1] Storojev M V, Popov E A 1977 Theory of metal forming: Textbook for universities. - 4th ed., rev. and add. - M.: Mechanical Engineering 423 p
[2] Kolmogorov V L 1986 Mechanics of metal forming: Textbook for universities. - Moscow: Metallurgy 688 p
[3] Contact friction in metal forming processes Levanov A N, Kolmogorov V L, S P Burkin, B R Kartak, Ashpur Y V, Spassky Y I – Moscow: "Metallurgy", 1976, 416 p
[4] Severdenko V P, Theory of metal forming. - Minsk: High school, 1966. – 233 p
[5] Poloukhinc, V Tiourinc, P Davidkov, D Vitanov. 1987 Traite ment des metaux par deformation. – Mir 318 p
[6] Matalin A A 1985 Engineering Technology: Textbook for engineering universities for specialty "Technology of mechanical engineering, machine tools and instruments." - Mechanical engineering, Leningrad Branch 496 p
[7] Schuster L S 1994 Basics of triboengineering. – Ufa: Ufa State Aviation Technical University 107 p
[8] Cockroft M G. Greases and lubricating materials: Greases in metal forming processes: Trans. from English. - Moscow: Metallurgy, 1970. - 111 p.
[9] Male A T, Cockroft M G 1966 Journal of the Institute of Metals vol. 93 P 38-46
[10] Grudev A P and others. 1982 Friction and lubrication in metal forming: Moscow: Metallurgy 312 p
[11] Abdullin I Sh, Kashapov N F and Kudinov V V 2001 Fizika i Khimiya Obrabotki Materialov 6 69-75
[12] Abdullin I Sh, Kashapov N F and Kudinov V V 2000 Fizika i Khimiya Obrabotki Materialov 3 35-38.