USE OF EQUAL-CHANNEL ANGULAR PRESSING FOR RECEIVING FINISHED PRODUCTS FROM ALLOYS OF THE TITAN BASIS

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Abstract

At equal-channel angular pressing (ECAP) there is an essential study of metal without change of a form and the dimension of billet. It billet use for the follow production of quality details. In this work the way of receiving finished products cogwheels types by combination of ECAP with forming of billet in one technological operation is studied. Thus decrease in costs of production of products will be reached. Researches are conducted in the program complex DEFORM 3D. By simulation the step matrix output channel had a form of the cross section corresponding to contours of the received cogwheel was used. Transition from a cylindrical form to the final is executed smoothly, diameter of initial billet has to correspond to the external diameter of a cogwheel. When forming a cogwheel in the output channel back-pressure due to changes of a form is created. After receiving billet with the issued contours, it is cut at lengths corresponding to cogwheel thickness. The analysis of the obtained results shows that equal channel angle extrusion of alloys on titanium base favours the improvement of metal quality.

Keywords: Titanium alloy, simulation, deformation.

1. INTRODUCTION

Research methods of severe plastic deformation carried out by scientists all over the world in recent years. However, their relevance is increasingly growing. To implement the methods of severe plastic deformation using traditional methods, such as torsion under high pressure, screw extrusion, equal channel angular pressing, and others, as well as new: twist angular pressing, equal channel angular pressing with back pressure from portsialnym pressure [1-4]. The main advantage of the above methods is the nature of the distribution of stresses and strains on the cross-section of the workpiece, grinding structural components, healing pores and defects, improving the physical and mechanical characteristics. Currently, increased requirements to the quality of products, with an emphasis on obtaining a complex of physical and mechanical properties without significantly changing the shape and size of deformable workpieces. To carry out this type of treatment allows the use of severe plastic deformation, in particular, equal channel angular pressing. During ECAP there is a deformation of the total volume of metal with virtually no change in the shape and size of the workpiece. The thus obtained preform used for further manufacturing of various parts with high quality. But the sequence of process steps in the approach described above leads to increased costs in the manufacture. In order to reduce costs for obtaining a predetermined shape of the product was an attempt to reconcile with the ECAP forming the workpiece. Given that the classic way of pressing for the production of various profiles, this experience has been applied to the equal channel angular pressing. Using a combination of strengthening operations through the implementation of the shear deformation at ECAP and possibly forming flat in terms of products, such as gears. The present work is devoted to assessing the use of equal-channel angular pressing to produce finished products from titanium alloys.

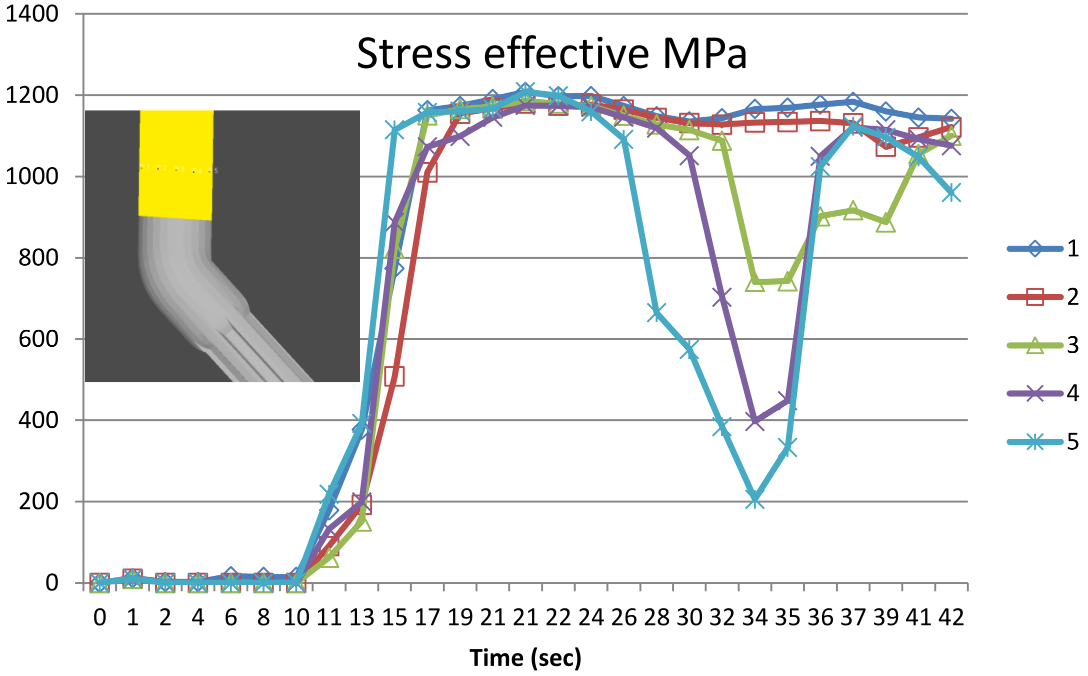
2. MATERIALS AND METHODS

In this paper we studied a method for producing finished products such as gears combining ECAP forming a workpiece in a single operation. The analysis was performed using the software DEFORM 3D. Previously we created model device and the workpies. As a material selected deformable workpies alloy Ti-6Al-4V, which is used in the aerospace industry and mechanical engineering. In the simulation, the boundary conditions have been set on the basis of the results obtained in the works [5, 6]. The friction coefficient is selected for deformation conditions using lubricants. With the implementation of the finite element method with the size of the workpiece ø20x60 mm was divided into 150,000 finite element octahedral shape. Type of object device is the hard, workpies -plastic. The task was given to the possibility of non-isothermal type accounting heat dissipation from the workpiece to tooling and the surrounding atmosphere. When the initial deformation temperature of the preform the ambient temperature is 20°C. Device design was performed so that the formation of the profile of a gear wheel carried directly into the outlet channel of the instrument. The input channel and the first zone corresponds to the geometry of the deformation of the matrix presented in [2]. The angle of the channel selected to be 135° rounded junction channel instrument. The radius of curvature equal to the diameter of the channel and up to 20 mm. At 0.5 the diameter of the input channel from the beginning of the inclined channel done smooth transition to the profile of a gear wheel. The transition from the cylindrical shape to the gear formed smoothly so that the outer diameter of the gear wheel corresponds to the diameter of the initial workpies. Inlet and oblique channels are equal. In the formation of the toothed wheel in the outlet backpressure created by changing the shape, which also has a positive effect on the quality of the products. After receiving the workpiece contouring sample is cut into lengths corresponding to the desired thickness of the toothed wheel.

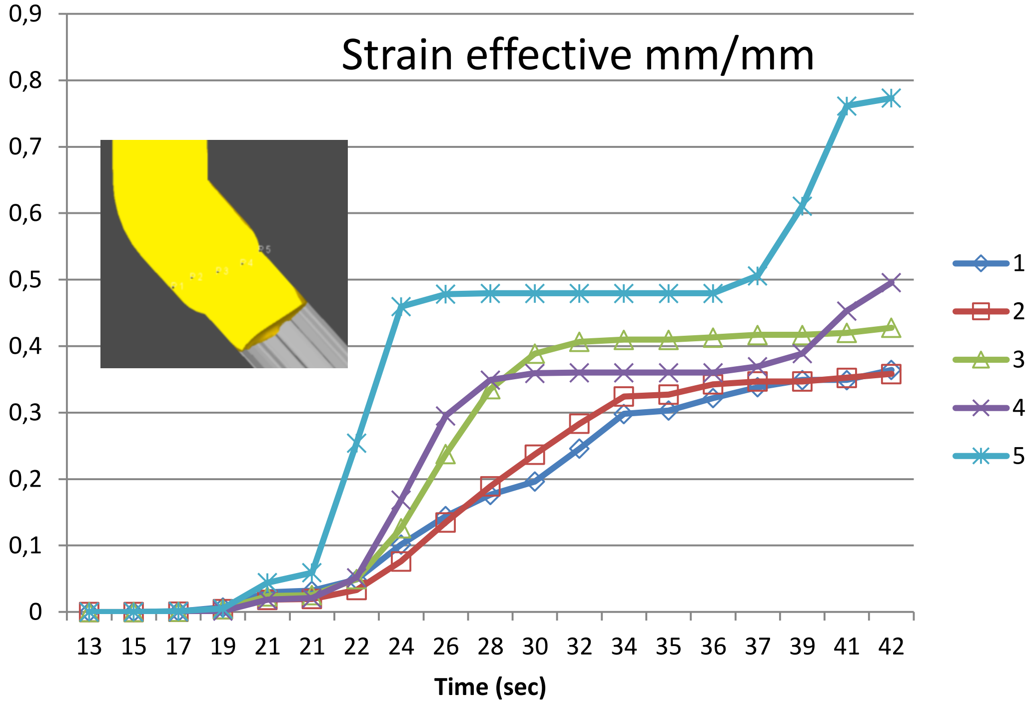
3. RESULTS AND DISCUSSION

The simulation results showed the possibility of the deformation to the combined operations of hardening through equal channel angular pressing and shaping the profile of the finished product. When implementing this process forms two roll gap: the first as well as during normal angular extrusion at the junction of the channel and a second tool in the zone of the profile in the outlet channel. With the passage of the workpiece zone interface channel instrument it is formed mostly condition of hydrostatic compression. The flow of metal has characteristics, such as increased flow velocity layers of metal located at the outer radius of the tool. At the time of passage of the metal particles instrument channels junction area on each particle a force of compression against the punch and shear deformation, moreover, surface and subsurface of the particle exposed workpiece contact friction forces. When metal exit from the main deformation area, which is hardened by the action of shear deformations at the inner radius of the tool there are tensile stresses. The appearance of tensile stresses caused by the lack of contact with the tool, as well as the change in shape of the front end of the workpiece due to a partial transition to the side end surface of the metal particles located at the outer radius of the workpiece.

Analysis of the data showed that during the passage of the workpiece through the instrument each next volume of the metal along the length of the workpiece is experiencing the same name of the stress-strain state of the previous one. However, in the lateral direction of the stress-strain state is not homogeneous. To evaluate the characteristics of the intensity distribution of stresses and strains in the intensity of the transverse direction of the blank data were examined for five feature points **(Fig. 1)**, arranged uniformly over the cross section of the preform. The first point is located in the surface layers of the metal in the outer radius of the workpiece, the second point is placed at the same distance from the edge and the center of the workpiece. The third point is placed at the center, the fourth at an equal distance from the center to the opposite edge and the fifth in the surface layers at the inner radius of the tool. Points were placed at a distance of 20 mm from the front end of the workpiece (as shown in the inset to **Fig. 1**) in order to eliminate the influence of the end volume of metal, which is different from distortion deformation bulk metal.



a)



b)

Fig. 1. Stress efffective (a) and strain effective (б) for characteristic point of cross

Schedule changes in the stress effective for each of the 5 points considered is shown in **Fig. 2**. When passing the instrument channel interface zone stress state is homogeneous for the entire cross section of the workpies, the stress effective at all points is in the range of 1150-200 MPa. Upon further movement of the workpiece metal particles are at the inner radius of the tool is not in contact with the walls of the channel matrix, the chart can be seen from the sharp decline of the stress points "4" and "5". At point "3" which is located in the center of the workpiece, and a decrease in the stress effective, but less dramatically. Points "1" and "2" are to strain until reaching output channel with tooth form. As a result, through deformation of the tool joint channels workpiece material reaches a strain effective in the range of 0.4-0.5, which is comparable with literature data [1-4]. With the passage of the workpiece through the area under consideration sloping channel, the force deformation **(Fig. 3)** is consumed only to overcome the resistance to the forces of contact friction, increasing the strain effective occurs. After hitting metal in forming the output channel peripheral metal layers take the form of a gear wheel, which is connected with their extra strain and strain effective of contact layers correspond to the values of 0.76-0.78. As seen from these graphs (**Fig. 1 b**) for forming the profile of the gear, the deformation not only of the surface layers, but also penetrates into the deformation of the workpiece so that the point "4" located at ¼ depth preform deformation observed intensity is equal to 0.5. At the moment when the metal particles in the points "1" and "2" is reached forming the output channel, they will also experience deformation during the forming of the preform. As described in horizontal line formed by the points 1-5 by treatment in an angular array due to the action of shear deformation becomes inclined at an angle corresponding to the angle of shear. To overcome the workpiece interface channel instrument need to force 284 kN deformation, the formation of the toothed shape is necessary to expend effort to 430-450 kN. Thus, the presence forming outlet causes an increase in force at 30%.

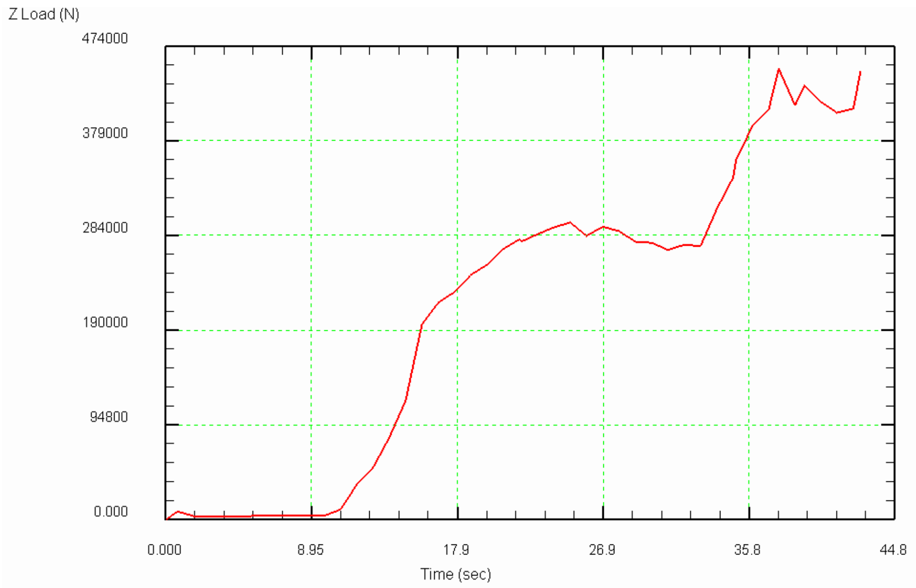


Fig.2. Load deformation

Fig. 3 shows a cross-sectional view of the workpiece in the output channel of the instrument. It can be seen that the profile of the gear is fully formed. Harvesting uniformly filled cavity channel instrument. Complete filling is ensured that the diameter of the inclined channel is equal to the outer diameter of the gear. Smooth transition to the projecting portions of the output channel forming profile precludes the formation of cracks in the finished product. A cross section of the blank formed in the profile **(Fig. 3)** visible to the heterogeneity of the hydrostatic pressure, however, in all cross-sectional areas are only compressive stresses in a small area of the tensile stress in the peripheral portions of individual teeth. In the central region of the blank is slightly smaller than the average stress of zero. This is due to the intense deformation of peripheral portions of the workpiece during the formation of the profile of the teeth. Values medium stress range from -100 to -300 MPa, in some areas reaching values of -500 MPa. Moreover, the intensity distribution of stress over the cross section of the preform is more uniform. 60% of the value of the stress intensity harvesting up 1000-1100 MPa. The lower intensity of stresses corresponds to the workpiece disposed on the part of small radius tool. Here, the intensity of stress may have values above 500MPa. In this same region decrease at a strain effective of 0.1 units. Remedy this possible by using as the initial preform, after one cycle of the ECAP and tilting it to 180° around the longitudinal axis. At the base of the teeth have higher values of strain effective **(Fig. 3c)** - up to 0.9, which corresponds to the best study of the area and its more hardening, which is necessary for performance of the resulting gear. In the direction toward the center of the workpiece strain effective gradually decreases to a value of 0.4-0.5.

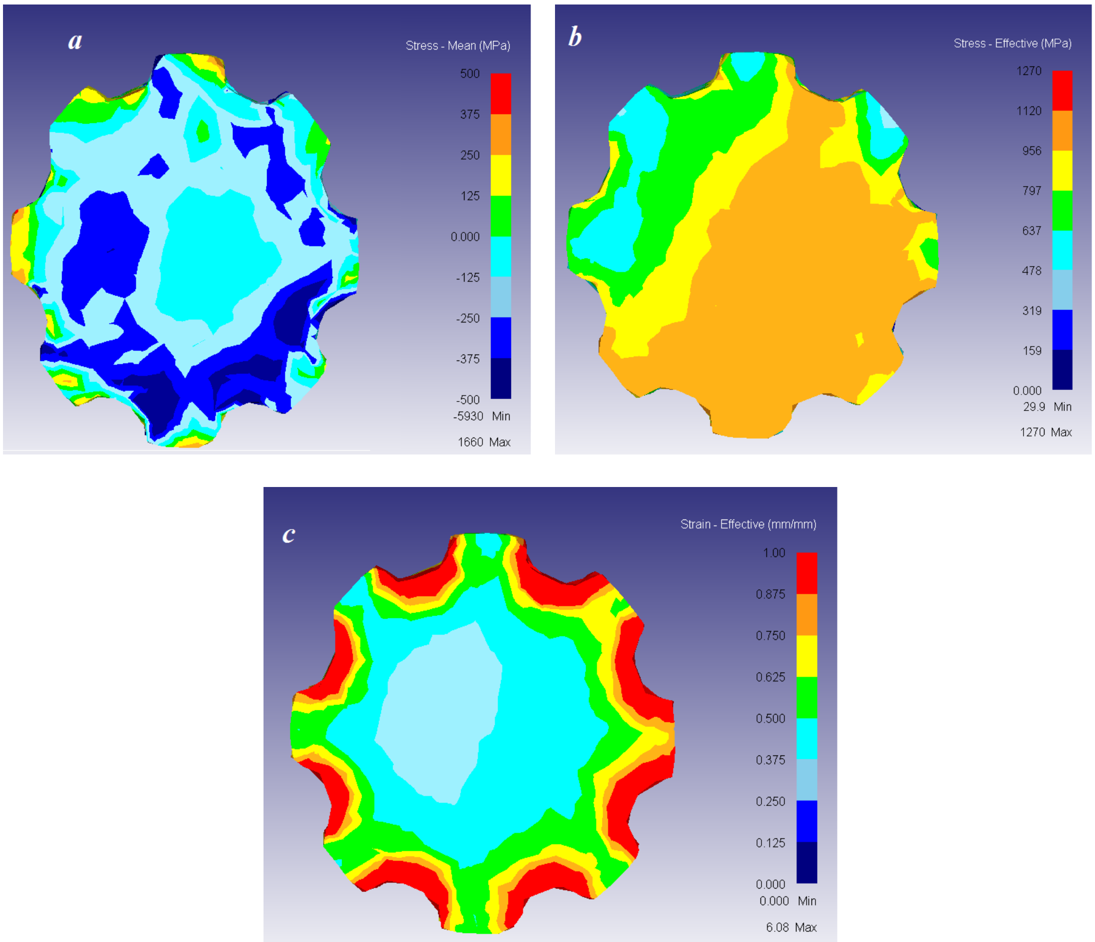


Fig.. 3. Hydrostatic pressure distribution (a), the stress effective (b) and the strain effective (c) the cross section of the sample with the profile of the gear

The advantage of the considered method for producing gears is also a characteristic arrangement of metal layers. If the gear is obtained cutting the required profile of the teeth, the metal layers are disturbed, which can cause premature failure of the finished gear during operation. Gearwheel obtained on the considered method does not have this disadvantage, that it will provide greater operational reliability.

CONCLUSIONS:

During carrying out researches the following main results were received:

1. The possibility of combining the hardening of the workpiece through the ECAP and obtain the desired profile of the product in a single operation.

2. The total force required to produce products such as gears ECAP force exceeds 30% and is 430-450 kN.

3. In the formation of the profile of the gear in the output channel instrument prevail compressive stresses, contributes to a better elaboration of the workpiece.

ACKNOWLEDGEMENTS

Work is performed with support of a grant of Committee of science of the Ministry of Education and Science of the Republic of Kazakhstan topic: «Research of fullering technology and its development as a plastic deformation method for high quality forgings production» (agreement N120 from 12.02.2015).

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