SIMULATION OF FULLERING TECHNOLOGY AS A PLASTIC DEFORMATION METHOD FOR HIGH QUALITY FORGINGS PRODUCTION

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Abstract

During recent years, deformation technologies based on the severe plastic deformation (SPD) developed extensively. SPD methods are effective for refining microstructures of different materials, which lead to a significant improvement in strength properties. In this case, the researchers had the important task of improving the quality of workpieces with minimal material and energy costs. During a deformation process, carried out with the aim of structure refinement, large macroscopic deformation has a great influence. Currently, we are actively developing innovative ways of forging based on large macroscopic deformation, which can intensify the strain imposed into inner layers of an ingot. The work is aimed at solving the problem of improving quality of preforms produced by fullering with the implementation of severe plastic deformation. Carry out computer simulation of fullering technology and studied stress-strain state metal by deformation.

Keywords: Fullering technology, Computer simulation, Stress-strain state, Severe plastic deformation

1. INTRODUCTION

In recent years intensively developed methods metal forming, based on severe plastic deformation (SPD). Methods of severe plastic deformation effective for refining of microstructures of different materials, which leads to a significant improvement in strength properties under sufficient plastic level [1-3]. Improving the mechanical properties of workpieces with improved metal structure causes high adaptability of its further processing, which reduces costs and increases the cost of the demand for this type of product from manufacturers, thus ensuring greater competitiveness in a market economy. Improving the complex of mechanical properties of workpieces in reducing its cost in mass production allows you to create a new high-tech products, including those used to create a variety of new types of hardware [4-5]. In [6] on the basis of numerous works of local and foreign researchers analyzed the factors influencing the parameters of the forging of large forgings. It was revealed that the quality of forgings has a great influence of the stress-strain state (SSS). All factors affecting SSS workpiece during forging can be divided into three groups: the shape factor, which includes the shape of the tool and the workpiece, and kinematic factor temperature factor. When the deformation of the metal with the aim of crushing the structural components has a great influence makroshift deformation. Macroshift positive role in the elaboration of the deformation structure is the appearance microlines slip (microshears) in a large number of grains with different crystallographic orientation, for which the grain boundaries are not an obstacle. Such changes in the metal microstructure promote grain refinement and positively affect the level of mechanical properties may be achieved by utilizing new forging device, providing a high level of shear deformation in the workpiece. Currently, there is an active development of innovative methods of processing forming, which can intensify the elaborate preparations, and the main ones are related to the implementation of the shear deformation of the workpiece material [7-11].

2. MATERIALS AND METHODS

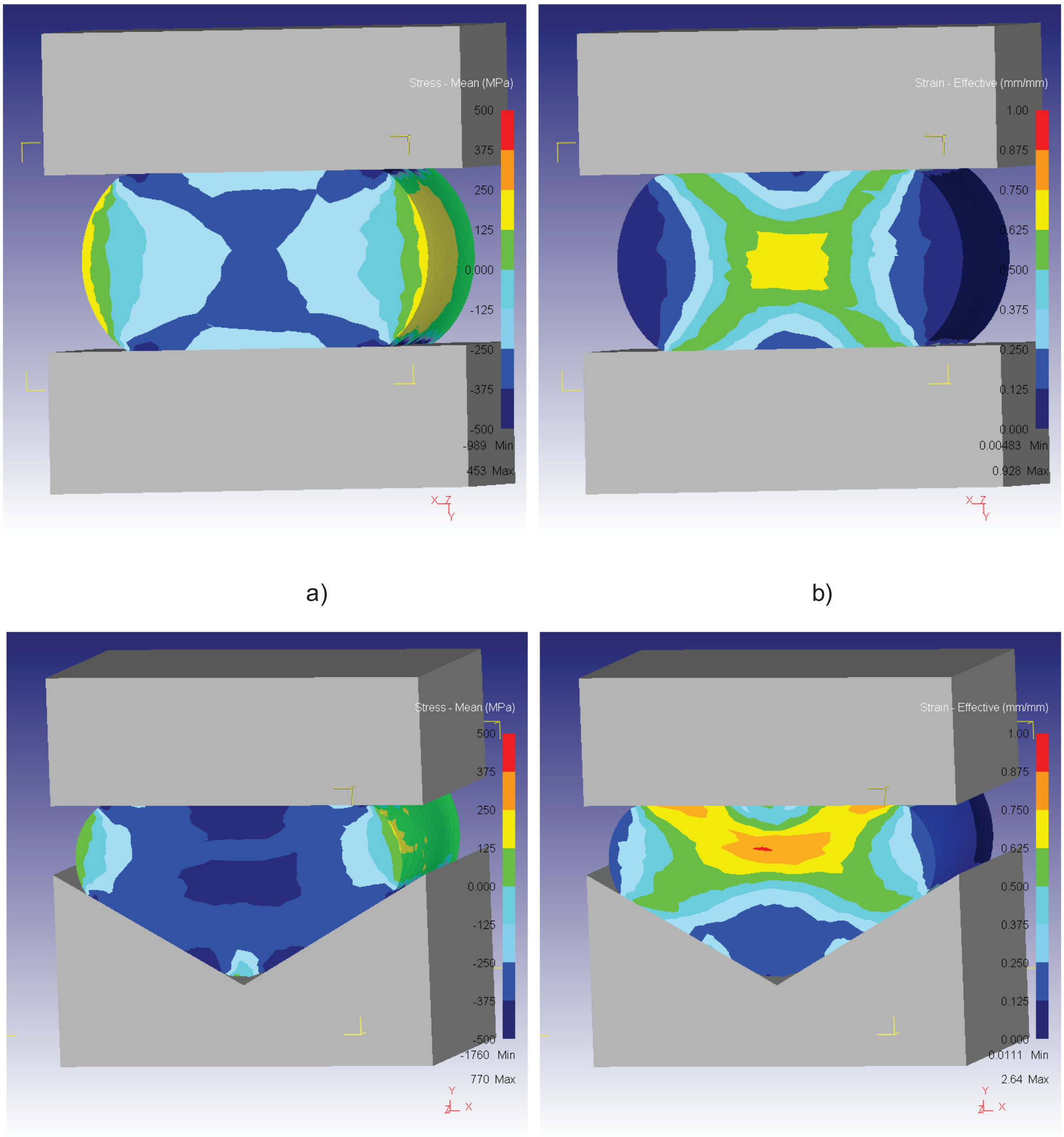
Research fullering of cylindrical workpieces carried by the finite elements method in the environment of software DEFORM 3D, allows the construction of three-dimensional models that have the properties of objects, modeling that is done. To create models of the workpiece and device used software KOMPAS 3D. Creating models was carried out taking into account the geometric similarity with the scale factor = 1. After building models imported to the software DEFORM 3D. One of the main parameters that characterize the accuracy of the calculation, a finite element mesh. Deformable body models was determined in the tetragonal grid finite elements distributed in the bulk of the preform. The total number of finite elements is chosen to be 50000, which allows the calculation with a sufficient precision. Device of model has the properties of a rigid body. The mechanical behavior of a deformable body in plastic deformation of the described model of behavior. Device and workpiece material is given a choice of database software. For device used tool steel. As a model of the material used for construction steel AISI 1035. The simulation was carried out taking into account the heat exchange (heat transfer) between the workpiece, tooling and the environment under normal conditions (ambient temperature shall be equal to 20 °C). For tool selected room temperature. The temperature of the workpiece was set in accordance with the forging interval and chosen equal 900 °C. Terms of friction at the interface largely determine the course of the process of deformation and, accordingly, power settings, and the stress-strain state in the deformation zone. In this study, the coefficient of friction of 0.3 is selected on the basis of previous studies [9-11]. When all the conditions set deformation process of calculating the total number of steps with step by relating to the time or movement, then the model is defined by the calculation. In this paper it was investigated fullering cylindrical workpieces flat dies, dies combined (top die flat bottom engraved), as well as having a movable work surface to optimize the stress-strain state. In the study made an assumption that the length of the workpiece is equal to the width of the pins, tight ends were not considered. He was considered a single stroke tool, workpiece dimensions ∅ 20 x 60 mm.

3. RESULTS AND DISCUSSION

A specific feature of forging cylindrical workpieces is the stress-strain state in the deformation process. When forging cylindrical workpieces is very dangerous intensification of tensions in the central part of the workpiece. Typically, the line of action of maximum shear stress in a cross shape disposed at an angle to each other 90° and 45° to the axis of load application. The appearance of the forging cross can cause loosening and cracking of the workpiece in the central part. In addition, when the fullering cylindrical workpieces in cross section a large gradient stresses and strains. Further, compared to the stress-strain state in the fullering cylindrical workpieces flat and combined dies (top die flat bottom engraved). To use the angle cutout pin cut-out equal 120°.

Fig. 1 shows the average hydrostatic pressure, i.e. mean stresses acting in the cross-sectional samples in during fullering by flat dies and combined dies. There is significant run values for a flat die forging and forging a combined dies. Shown is significant heterogeneity of stress and strain states. The conditions in which the peripheral layers of metal are fundamentally different from those for the central layer, it follows unevenness deformation of metal over the cross section of the sample different layers of billet from the center to the periphery.

Similar changes are also characteristic of the workpiece deformed in combined dies. When forming a cone and the displacement of the metal layers in the cutout dies average stress goes to tensile stress, which is unfavorable. Stress gradient is high in both cases. The consequence of this is the high strain effective of the deformation gradient in both cases. For deformation by flat die strain effective gradient is 0.5. The use of one of the die engraved shape gradient is 0.68.

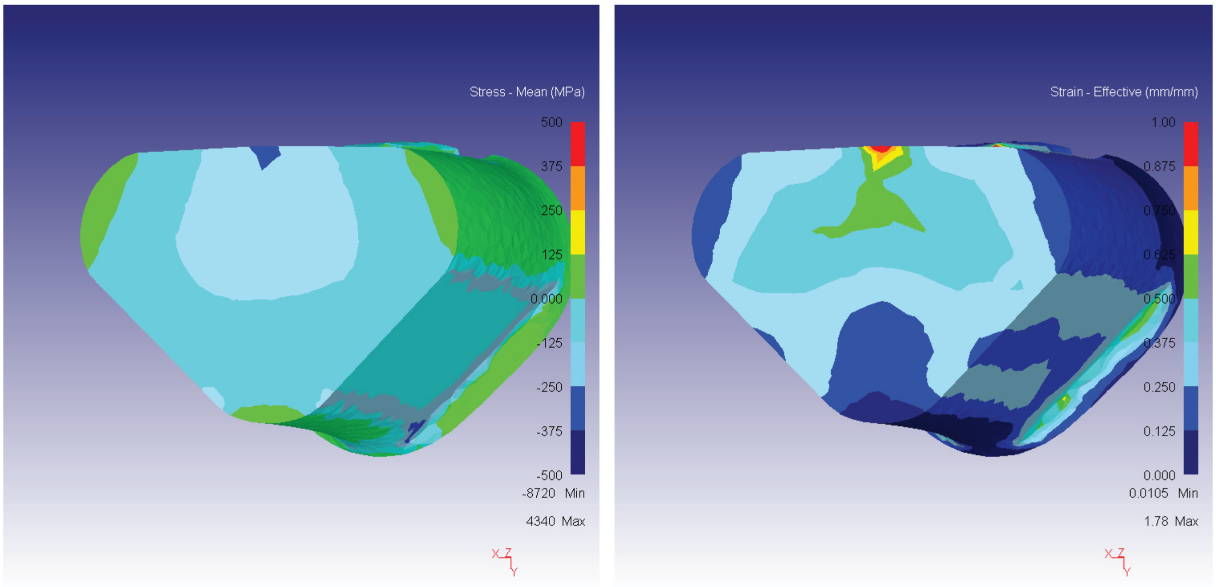


a) b)

c) d)

Fig. 1 Distribution stress mean (a, c) and strain effective (b, d) by cross section during fullering in flat dies (a, b) and combined dies (c, d)

To solve the problem of heterogeneity of the stress-strain state decided to replace one of the dies (flat) on the die moving to constituents. The device is configured so that at the initial time camber components equal to the angle of the engraved die, as motion of the die towards each other of the composite angle of the die gradually increases and the end motion becomes 180°, i.e. its shape becomes similar to the shape of a flat die. In **Fig. 2** shown distribution stress mean and strain effective by cross section during fullering in new dies



a) b)

Fig. 2 Distribution stress mean (a) and strain effective (b) by cross section during fullering in new dies

Use the new design of dies provides a macroshift in the volume of the workpies. In addition, the area of occurrence of maximum stress is constantly changing in the process of crimping by changing the angle of the compound of the die, which excludes areas undergoing shear tensile stresses. Considering that one of the die is its engraved, part of the metal workpiece as well as during the deformation under the combined dies is under tensile hydrostatic pressure, but its numerical values are minimal and do not exceed 30 MPa. Stress are more homogeneous as compared to the above configuration both dies. More intensively worked out the blank area, located close to the engraved die. Using the new design of dies allowed to completely eliminate tensile stresses in the central layers of the workpies. The area is experiencing tensile stresses, leaving only the area shifted to the corner engraved die. Span values of strain effective decreased by 15 % compared to conventional combined dies. Maximum damage for the section under consideration amounted to 0.07, which effectively eliminates the loosening of the workpiece during the deformation.

4. CONCLUSIONS

During carrying out researches the following main results were received:

1) Carry out simulation fullering process.
2) Revealed significant heterogeneity in the fullering in flat dies and combined dies.
3) Study stress-strain state by fullering in new dies.
4) Span values of strain effective decreased by 15% compared to conventional combined dies. Maximum damage for the section under consideration amounted to 0.07, which effectively eliminates the loosening of the workpiece during the deformation.

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REFERENCES

[1] NAIZABEKOV, A.B., ANDREYACHSHENKO, V.A. Evaluation of possible mechanical property improvement for alloy of the Al-Fe-Si-Mn system by equal-channel angular pressing. *Metallurgist*, 2013, year 57, p 364-364.

[2] NAIZABEKOV, A.B., ANDREYACHSHENKO, V.A., KOCICH, Radim. Study of deformation behavior, structure and mechanical properties of the AlSiMnFe alloy during ECAP-PBP. *Micron*, 2013, year 44, p. 210-217.

[3] KOCICH, R., MACHACKOVA, A., ANDREYACHSHENKO, V.A., A study of plastic deformation behaviour of Ti alloy during equal channel angular pressing with partial back pressure. *Computational Materials Science*, 2015, year 101, pp. 233-241.

[4] LUKAC, P., KOCICH, R., GREGER, M., PADALKA, O., SZARAZ, Z., Microstructure of AZ31 and AZ61 Mg alloys prepared by rolling and ECAP. *Kovove Materialy,* 2007, year 45, pp. 115-120.

[5] KOCICH, R., MACHACKOVA, A., KUNCICKA, L., FOJTÍK, F. Fabrication and characterization of cold-swaged multilayered Al-Cu clad composites. *Materials & Design*, 2015, year 71, pp. 36-47.

[6] ALIEV, I.S., GBANKOV, Ya.G., PERIG, A.V. Factors influencing the parameters of the forging of large forgings. *Bulletin PNIPU "Machinery, Materials"*, year 15, No. 1. pp.27-44.

[7] NAIZABEKOV, A.B., ANDREYACHSHENKO, V.A., KLIBER, Jiri, KOCICH, Radim. Tool for realization several plastic deformation. In: *Metal 2013*, Conference proceedings. Ostrava: Tanger Ltd, Brno, Czech Republic, 2013, p. 45.

[8] KOCICH, R., KURSA, M., MACHACKOVA, A., FEA of Plastic Flow in AZ63 Alloy during ECAP Process. *Acta Physica Polonica A*, 2012, year 122, pp. 581-587.

[9] KOCICH, R., GREGER, M., MACHACKOVA, A., Finite element investigation of influence of selected factors on ECAP proces. In: *Metal 2010*, Conference proceedings. Ostrava: Tanger Ltd, Roznov Pod Radhostem, Czech Republic, 2010, pp. 166-171.

[10] KOCICH, R., KUNCICKA, L., MIHOLA, M., Numerical and experimental analysis of twist channel angular pressing (TCAP) as a SPD proces. *Materials Science and Engineering A,* 2013, year 563, pp. 86-94.

[11] KUNCICKA, L.; KOCICH, R.; DRAPALA, J.; et al. FEM simulations and comparison of the ECAP and ECAP-PBP influence on Ti6Al4V alloy's deformation behavior. In: *Metal 2013*, Conference proceedings. Ostrava: Tanger Ltd, Brno, Czech Republic, 2013, pp. 391-396.