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ANALYSIS OF THE TEMPERATURE FACTOR INFLUENCE ON THE TITANIUM ALLOYS DEFORMATION CHARACTER DURING EXTRUSION

The paper determines the effect of deformation temperature on the stress-strain state and structural transformations of titanium alloys. Based on the calculation of the process by the finite element method (QForm) and experimental studies of structural transformations, the correlation between the stress-strain state and the state of the workpiece after deformation is shown.

The nature of the metal flow during hot extrusion largely depends on the following simultaneously acting factors: the intensity of the friction forces at the interface between the metal and the tool and the degree of inhomogeneity of the strength characteristics in the volume of the deformed workpiece. Depending on the action of these factors, different patterns of metal flow are observed, of which three main types can be distinguished (according to S.I. Gubkin):

- uniform flow, when the deformation zone is localized near the matrix;
- uneven flow with the spread of the deformation zone to the entire workpiece;
- even more uneven flow with pinching of the workpiece inner layers by the outer ones.

When titanium and its alloys are extruded, these factors manifest themselves most of all in comparison with other materials. The deformation of titanium alloys, as a rule, is characterized by a high friction coefficient between the metal and the tool, and often by seizure with the latter. At the same time, the low thermal conductivity of titanium contributes to the formation of a sharply inhomogeneous temperature field of the workpiece, which cools down due to contact with the tool. As a result, the deformation resistance of the central zone of the workpiece is much lower than in the annular zone adjacent to the container and the die, which, in turn, leads to an uneven metal flow.

As a calculation model, an extrusion stamp was chosen, shown in Fig. 1. The angle of entry of the matrix is 60 degrees, the ratio of the workpiece diameter to the extruded part is D:d=1.75.

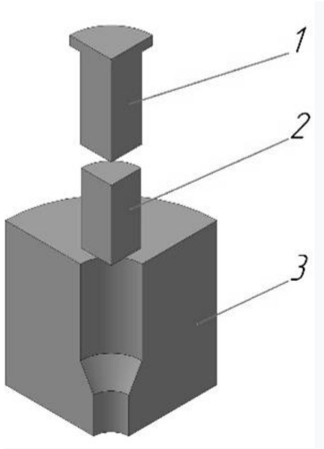
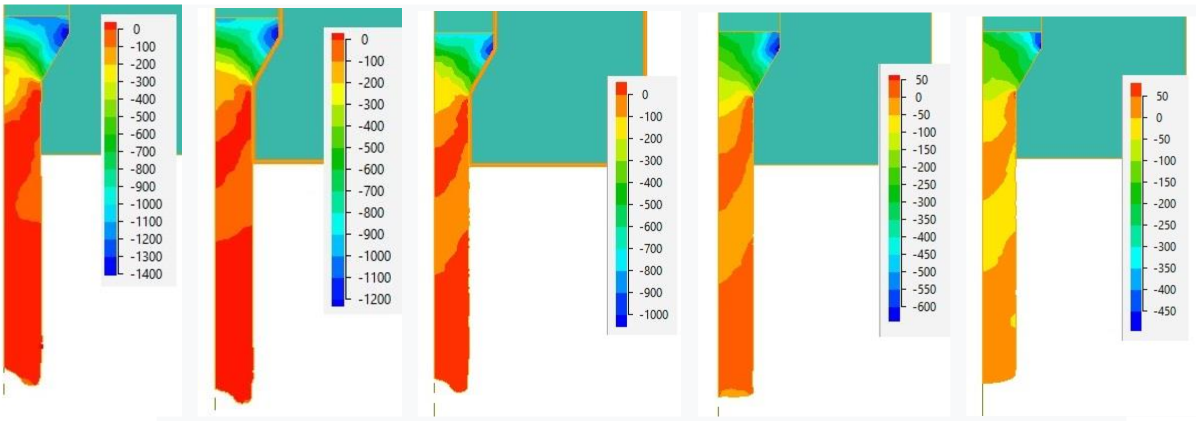


Fig. 1 – Stamp for extrusion: 1 – punch; 2 – blank; 3 – matrix

On Fig. 2 shows the characteristic distribution of the average stress on the workpiece depending on the initial heating temperature. At deformation temperatures of 600°C, 700°C, and 800°C, only compressive stresses are observed, which are explained by the presence of negative values on the scale. These stresses are most intense in the zone of contact with the punch and in the corner of the die. As the workpiece metal moves towards the matrix cell, the stresses decrease and at the exit the metal flow is pulsating in nature - from free flow to flow with low values of compressive stresses.

At a deformation temperature of 900°C and 1000°C, the stresses on the workpiece change their sign; therefore, tensile stress is present in the zone of metal outflow from the matrix cell. It is this nature of the deformation that is favorable for the extrusion process. It should be noted that the average stresses at the indicated deformation temperatures are twice as low, and the metal flow also has a pulsating character.



a) b) c) d) e)

Fig. 2 – Average stresses in the workpiece a– 600°C, b – 700°C, c – 800°C, d – 900°C, e – 1000°C

Studies have shown that titanium has sufficient plasticity at temperatures of 800...900°C, and VT5D alloy - at temperatures of 850...1000°C. In practice, these are the temperature intervals for pressing titanium and its alloys. However, the pressing temperature range should take into account not only the ductility of the metal, but also the phase transformations occurring in it and affecting the mechanical properties of the pressed product. Titanium alloys having an α+β structure have a lower comparative elongation if they are pressed in the β-phase region. Therefore, the pressing of these alloys must be completed at a temperature below the phase transition α+β→β.

Thus, the increase in the uniformity of the flow of titanium and its alloys during hot extrusion should be facilitated by:

- lowering the heating temperature of the workpiece before extrusion and, on the contrary, increasing the heating temperature of the tool;
- the use of an effective lubricant that reduces the coefficient of contact friction between the metal and the tool and has sufficient thermal insulation properties;
- an increase in the speed of pressing, that is, a reduction in the contact time of the workpiece with the tool.

Reducing the extrusion temperature of titanium alloys improves the structure and properties of the product, and also provides a more uniform metal flow. This increases the tool life and improves the surface quality of the profile.

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