THE APPLICATION OF THREE-DIMENSIONAL COMPUTER SIMULATION WHEN DEVELOPING DIES FOR EXTRUSION OF ALUMINIUM SHAPES

The automated system of three-dimensional computer simulation with use of FEM is developed. The model is based on the Euler approach. The function of Markov variation principle is used for derivating. The connected task of thermo-viscous-plasticity is solved. The flat die is designed for extrusion of the thin-walled shape from a soft aluminium alloy 6060.

Key words: three-dimensional simulation, finite element method (FEM), aluminium, extrusion, shape, die


Ključne riječi: trodimenzionalna simulacija, metoda konačnog elementa (FEM), aluminij, ekstruzija, profil, matrica

INTRODUCTION

The existing practice of aluminium shapes production for construction consists in extrusion of aluminium through direct dies without use of lubricant. For uniform and rectangular outflow of metal from die aperture usually are applied pockets (prechambers) of the complicated cross-section, which make the passage from the container to die aperture more smooth. Except assigning pocket sizes, metal flow smoothing realizes with the help of working pocket, making their length and angle variable on a perimeter of the aperture [1]. The modern techniques of the definition of these parameters have a brightly expressed empirical character and are based on realisation of numerous experiments.

The intensive development of aluminium extrusion branch in Ukraine and abroad has led to arising a great number of mini-factories for production of aluminium shapes. For such a production the realisation of a lot of experiments for implementation of a new shape reduces competitiveness of a firm. Thereby a problem of extrusion process computer simulation with the complex considering of three-dimensionality of flow, real rheological properties of metal, friction and thermal processes in the deformation zone is actual.

MATHEMATICAL MODELLING

In studies [2, 3] the development and the testing of a mathematical model based on a solution of the three-dimensional task of flow of nonlinearly viscous incompressible medium during shapes extrusion is carried out with the help of a finite element method.

Except some modifications concerning free surfaces, the model is based on the Euler approach. For obtaining solution of the function of a Markov variable principle [4] is used

\[
J = \frac{1}{2} \int_{V} \mu H^2 \, dV + \int_{V} \sigma_{ij} \, dV - \int_{S} \tau_{ij} \, dV;
\]

where \( \mu \) - conditional viscosity of metal, determined under the formula:

\[
\mu = T(H, \Lambda, \Theta)/H;
\]
**THE USE OF THE SYSTEM FOR EXTRUSION DIES DESIGN**

Let us consider application of an automated system of three-dimensional computer simulation for the task of die design for extrusion the shape of window-door system TECNO produced by YOUNGCHERMET (Ukraine, Dnipropetrovsk). The drawing of the shape is shown at Figure 1.

Disposition and form of the aperture and pocket are shown at Figure 2. The definition of these parameters is carried out on a basis of computer simulation of a series of trial variants. The conditions of simulation corresponded to the production conditions of these shapes by YOUNGCHERMET: velocity of extrusion - 4 mm/s, temperature of heating of billet and die 450 °C, factor of friction by
results of precomputations is taken as 0.8 (extrusion is carried on without greasing). The diameter of the container is 159 mm. The variant represented at Figure 2. was accepted as basic.

Outcomes of metal flow simulation for the given disposition of aperture is shown at Figure 3.. The depth of a pocket was 15 mm, bearing length was constant along a perimeter of the aperture and was 5 mm. By results of simulation the bending of the shape was 8.6 mm/m and torsion 192.9 °/m.

A further correcting of the die was fulfilled by modification of distribution of bearing lengths along a perimeter of the shape and metal flow simulation for the taken form of the die. The outcomes of metal flow computations for variant of the die, which was recognised final, are shown at Figure 4.. As a result the bending of the shape was 0.4 mm/m and it torsion was 16.2 °/m. The distribution of bearing lengths, corresponding to the given computation variant is shown at Figure 5.

Figure 4. The result of metal flow simulation (final variant)
Slika 4. Rezultati simulacije tečenja metala (završna varijanta)

Figure 5. The distribution of bearing lengths
Slika 5. Raspored nosivih dužina

CONCLUSION

The opportunity of use of the developed mathematical model of three-dimensional metal flow is shown for designing of extrusion dies. The mathematical model based on a finite element method, is realised as software ready for use at the enterprises.

REFERENCES