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NUMERICAL SIMULATION IN RADIAL-FORWARD EXTRUSION PROCESS TO ANALYZE FORMING CHARACTERISTICS

ЧИСЕЛЬНЕ МОДЕЛЮВАННЯ ПРОЦЕСУ РАДІАЛЬНО-ПРЯМОГО ВИДАВЛЮВАННЯ ДЛЯ АНАЛІЗУ ХАРАКТЕРИСТИК ФОРМОУТВОРЕННЯ

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Extrusion is a highly efficient metal-forming technique used in a wide range of applications. It offers significant economic advantages compared to other production methods due to its high-speed capabilities. There are five primary types of extrusion: forward, backward, radial, lateral, and combined. This research focuses on analyzing the strain-stress state and change of loads on die parts during combined extrusion with material flow in both radial and forward directions. Numerical simulation using the rigid-plastic finite element method (FEM) in Deform 2D was conducted to investigate the radial-forward extrusion process [1].

The die geometry and power mode (as shown in Figure 1) are as follows: R_0 – the radius of billet (R_0=18mm), t = R_1-R – the thickness of branch in forward direction (t=4.5mm), h – the flange height (h=9mm), r – the radius of fillet (r=2mm), V – punch velocity (V=1mm/s), The friction factors between the billet and tools are constant (Zibel's law, μ=0.08), and also the material used for the simulation is AA 6060 aluminium alloy.

In radial-forward extrusion with an axisymmetric billet, a rigid punch forces the material through a die cavity. The billet is modeled as rigid-plastic, while the punch and other tools are rigid. All components are initially at room temperature.

Deformation patterns (gridlines distortion), distributions of effective strain and stress for this extrusion process are shown in figure 1. Based on the figure, the maximum effective strain and stress values reached are 2.0 and 220 MPa, respectively [2].

The variations of punch load and disclosure load of the upper die with punch displacement (stroke) have been shown in the figure 2.

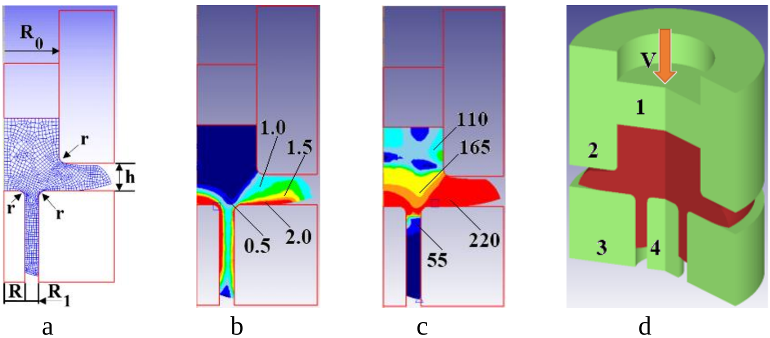

Fig. 1. Single-ended radial-forward extrusion process: deformation patterns (gridlines distortion) (a), effective strain distributions (b), effective stress distributions (c) and die scheme to design radial-forward extrusion process (d).
1 – punch, 2 – upper die, 3 – lower die 4 – mandrel

The figure 2a demonstrates that the forming loads increased rapidly and steadily with the punch stroke at all stages of the deformation. In the figure 2b shows three distinct stages in the disclosure load: an initial increase, followed by a decrease, and finally, a sharp rise in forming loads as the punch stroke continues. Changing the flow material will have a significant impact on load changes [3].

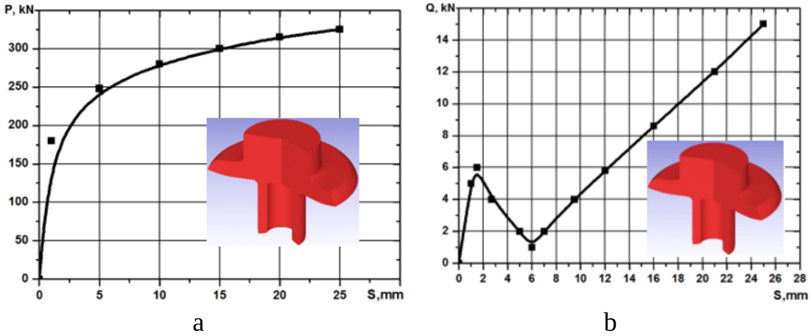

Fig. 2. The punch load vs. the punch stroke (a) and the disclosure load of the upper die vs. the punch stroke (b) in single-ended radial-forward extrusion process

Conclusions:

1. This paper presents a numerical simulation of the radial-forward extrusion process, which provides insights into the strain-stress state and load variations on die components during deformation.

2. The results demonstrate that the maximum effective strain and stress values reached were 2.0 and 220 MPa, respectively, which are crucial for understanding material behavior under specific extrusion conditions.

3. The study concludes that changes in material flow significantly impact the load distribution, offering potential optimizations for the extrusion process and tool design.

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