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COMPUTER SIMULATION OF THE ALUMINIUM EXTRUSION PROCESS

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The purpose of the work is computer simulation of the aluminium extrusion process using the Finite elements method (FEM). The impact of the speed of a punch falling on the material in the aluminium extrusion process was investigated. It was found that high stresses are created, leading to material destruction, if the punch is falling too fast. The design cycle is significantly reduced in multiple industrial applications if the FEM is applied, which enhances productivity and profits.

Key words: aluminium, extrusion, stress, finite element methot d(FEM), process of computer simulation

INTRODUCTION

Aluminium is a chemical element featuring low density, good thermal conductivity and high chemical activity. It is distinct for very good plasticity and good corrosion resistance. Extrusion is a process of plastic working, usually cold working, applied for manufacturing various types of items utilised in the car, aviation, military and food industry [1-3]. Figure 1 shows an extrusion process

The Finite elements method (FEM) is one of the most popular and most often used numerical methods [4,5]. The FEM is also employed in the plastic working of different engineering materials and the simulation of aluminium extrusion can be performed with the method by selecting appropriate parameters of a given material, such as force of pressure and of punch speed fall [6,7].

MATERIAL AND METHOD

The investigated disc is made of EN AW-1050A aluminium, which is non-alloy aluminium susceptible to cold plastic working. This material, due to its poor strength properties, is not suitable for machining; however, it is employed in power industry, in construction, in chemical and food sector, for production of utensils, containers, pots, household items and packages.

In extrusion, a flat product is turned into a drawpiece which cannot be unfolded in the plane. The material becomes plasticised as a result of the acting punch and is gradually displaced deep inside the die. The dimensions of the collar and free surface are reduced in the extrusion process, and the contact area of the material and the punch is increasing [10]. The constituents of the stress in the free area and in the collar fulfil the condition 1:

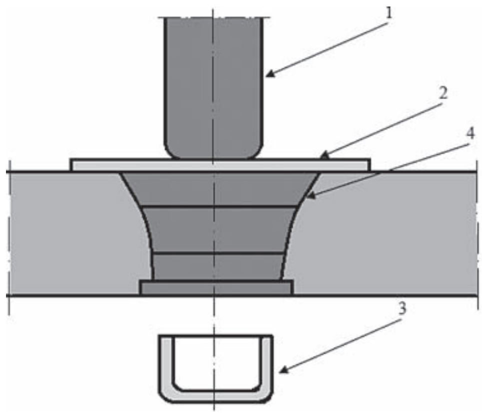

Figure 1 Stamping process diagram: 1- a punch, 2- a material, 3- a drawpiece 4- a die [8,9].

$$\sigma_{rr}\ \sigma_{\Theta\Theta} \leq 0 \quad (1)$$

where:

- District stresses e $\sigma_{\Theta\Theta} \leq 0$
- Radial stresses $\sigma_{rr} \geq 0$

If the condition 1 takes place, then axial symmetry in the flat state of stress (Tresca yield criterion) is (2) :

$$\sigma_p = \sigma_{rr} - \sigma_{\Theta\Theta} \quad (2)$$

The condition which must be met for the correct progress of extrusion is that a wall of the drawpiece being formed is able to transmit the necessary loads at any time during the process. This is limited by a degree of deformation expressed with the so-called extrusion ratio (3):

$$m_1 = \frac{d_1}{D_0} \quad (3)$$

where:

- m_1 – stamping process coefficient
- d_1 – punch inner diameter
- D_0 – Initial material diameter

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The condition 4 must be fulfilled for the process to have correct progress:

$$m_{1obl} = m_{gr} \quad (4)$$

gdzie: where:

- m_{1obl} – computional coefficient
- m_{gr} – Boundary value of stamp processing coefficient

If condition is not fulfilled, it happens that occurs strong wall rub and material cracks in hazardous sectional view (close to punch rounding).

Coefficient m_1 can not posses free values, and its boundary values (m_1)gr result from condition equivalence of highest force of stamp processing Fmax and rip force Fzr. If the stamp processing force reach value Fzr, at that time it is equivalent with district separation of a die stamping close to rounded value of a punch.

The condition 5 must take place during extrusion:

$$F^{max} < F^{zr} \quad (5)$$

The maximum extrusion force can be determined from formula 6:

$$F^{max} = \pi \cdot d \cdot g \cdot R_m \cdot k \quad (6)$$

gdzie: where:

- d –a die stamping diameter (calculated in the middle of walls thickness)
- g – initial thickness of sweet metal plate
- rm – tensile strength of forming metal plate
- k – ratio coefficient F^{max} i F^{zr}

If this condition is not satisfied, the wall is strongly thinned and the material cracks in a so-called dangerous section (near the punch rounding).

The coefficient cannot assume any value, and its limit value results from the condition of equivalence of the highest extrusion force and breaking force. If extrusion force reaches the value, then it is equivalent to the peripheral separation of the drawpiece near the rounded punch value.

The simulation of the impact of the speed of a punch falling on the material in the aluminium extrusion process was performed in several tests using the FEM for this purpose. The disc was displaced by 13 mm in each test and the punch falling time was changed. The first punch lowering test lasted 0,1 s, then 1 s, 5 s, 10 s and 13 s.

RESULTS AND DISCUSSION

The results of the first tests are presented in Figure 2 showing that a disc became waved as a result of die pressure and that the collar planned was not maintained.

A pressing element to eliminate stability loss was added to prevent undesired effects such as disc waving. An additional task of pressing is to maintain a collar in the upper part of the drawpiece.

The die was moved to the final position in 0.1 s in the first test, which led to disc destruction in the lower part of the drawpiece. This was caused by excessive force of the punch hitting against the disc. The stresses

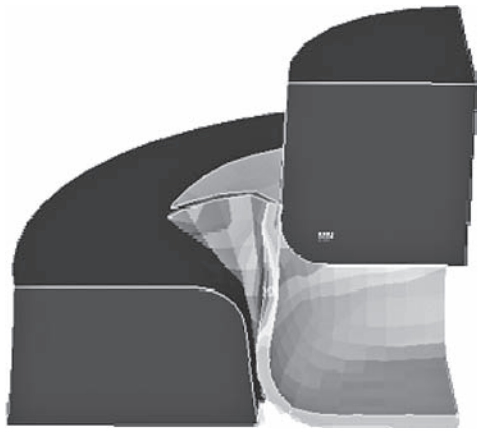

Figure 2 Drawpiece waving (loss of stability)

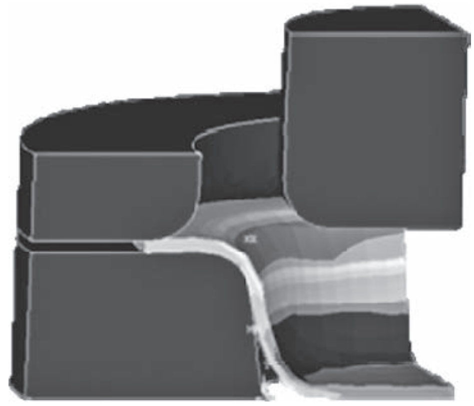

Figure 3 Disc deformation after 13 s of punch lowering.

significantly exceeded the tensile strength limit, leading to disc breaking.

Another test lasted 1 second and the drawpiece was not torn so abruptly, however, the stresses caused by the pressure of the punch still may lead to considerable disc deformations.

Another test lasted 5 s, 10 s and 13 s and the stress value in such cases is comparable and the disc is deformed correctly Figure 3.

CONCLUSIONS

Numerical methods have become more and more widespread in industry by streamlining technological processes at each stage of new product fabrication. The area of plastic working is not exceptional here; analyses are being made starting with designing various products through process analysis to ready product assessment.

Appropriate treatment parameters for a given material can be selected owing to the application of computer simulations. This allows, in particular, to match pressing force and speed of punch lowering on the material.

If pressing is added, material stability loss is prevented, allowing to manufacture products with the desired quality.

Punch falling speed is one of the key drivers affecting the drawpiece quality. High stresses are created, leading to material destruction, if the punch is falling too fast.

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Note: The responsible translator for English language is Michał Lisek
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