UDC 621.771

P.B. Abhari
D.O. Solianov
D.S. Oliinyk

NUMERICAL ANALYSIS OF RADIAL-FORWARD EXTRUSION USING FINITE ELEMENT METHOD

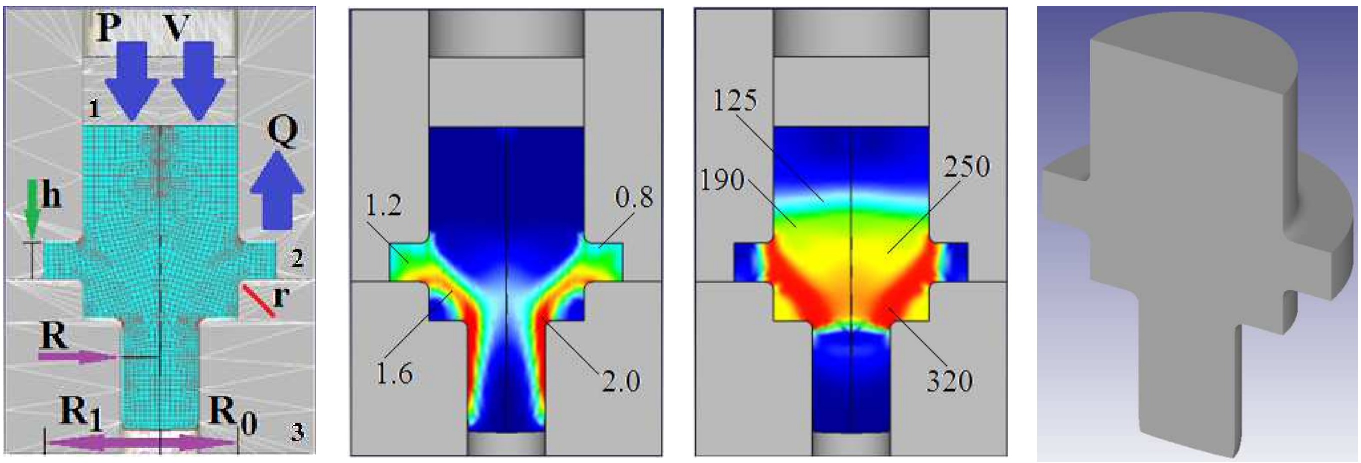
Donbas State Engineering Academy, Kramatorsk – Ternopil, Ukraine

Abstract: *This paper investigates the radial–forward extrusion process at room temperature through numerical analysis. The simulation was conducted using the rigid-plastic finite element software, Deform 2D. The study considered multiple parameters such as die configurations, die geometry, axisymmetric billet dimensions, and power mode settings to analyze key forming characteristics. These include the distribution of effective strain and stress, as well as the punch and die disclosure load–stroke curves throughout the process.*
Keywords: *extrusion, finite element method, strain, stress, punch load, die disclosure load*

Extrusion, encompassing cold, warm, and hot forming, is a key metal forming method used to produce complex shapes. Modeling in extrusion predicts material flow, stress, and strain, aiding in tool force evaluation and failure analysis. Cold extrusion, performed at room temperature, offers advantages such as superior surface finish, mechanical strength, and precision making it increasingly favored in cost-conscious industries. Types include forward, backward, radial, and combined extrusion, where a billet is compressed into a die cavity to form a desired shape. Finite Element Method (FEM), especially via tools like Deform 2D, is vital in simulating extrusion, optimizing parameters, and enhancing design accuracy in computer-aided engineering [1].

This study employs finite element simulations to elucidate the effective strain and stress distributions during radial–forward extrusion, using AA 6060 aluminum alloy as the workpiece material. The simulation also generates corresponding punch load–stroke and upper die disclosure load–stroke curves.

Detailed specifications for the die geometry, billet dimensions, and power mode parameters are provided below (Fig. 1): R_0 – the radius of billet (R_0=20mm), R_1 – the flange radius (R_1=30mm), R – the radius of the axial branch (R=10mm), the billet height (70mm), h – the flange height (h=10mm), r – the die fillet (r=2mm), V – punch velocity (V=1mm/s), P – punch load, Q – upper die disclosure load and the friction factors between the billet and tools are constant (Zibel's law, μ=0.08).



a) b) c) d)

1 – punch, 2 – upper die, 3 – under die

Figure 1. The radial–forward extrusion process with gridlines distortion (a), effective strain distributions (b), effective stress distributions, MPa (c) and final formed part (d)

The analysis reveals a uniform distribution of effective strain and stress within the billet, indicating a symmetrical deformation pattern. In the radial–forward extrusion process, the maximum effective strain and stress are calculated as $\varepsilon_{max} = 2.0$, $\sigma_{max} = 320$MPa, respectively (Fig. 1).

Figure 2 presents the variations of punch and upper die disclosure loads with punch displacement (stroke). The curves reveal a progressive increase in loads throughout the punch stroke, emphasizing the impact of tool geometry on the overall performance of the Radial–forward extrusion process.

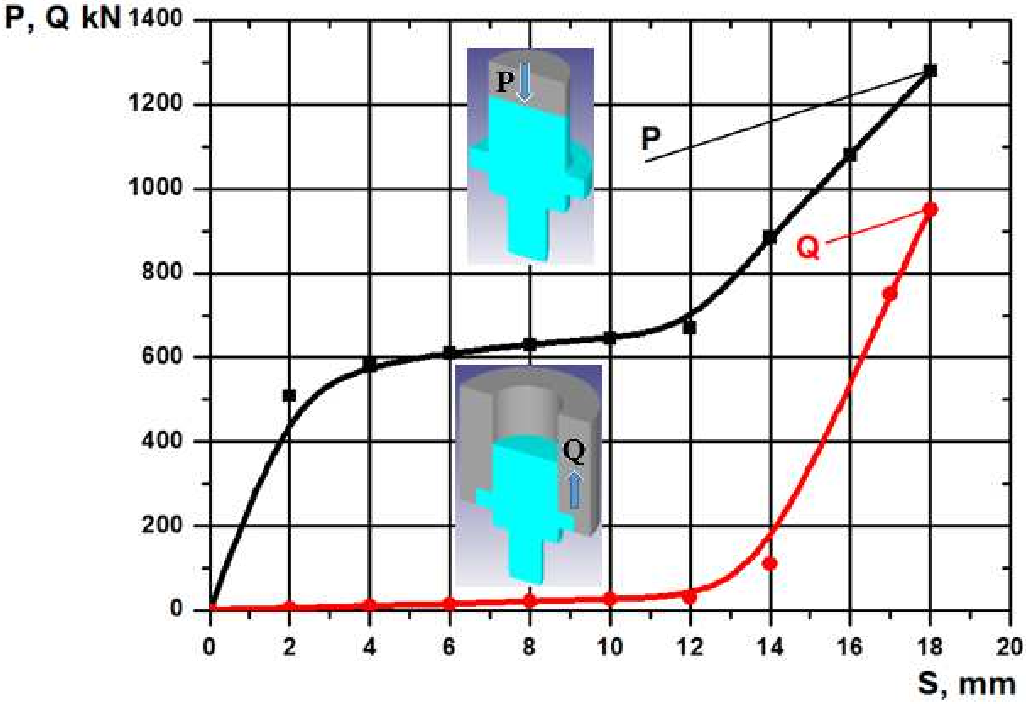


Figure 2. The punch load (P) and upper die disclosure load (Q) vs. the punch stroke (S)

REFERENCE

1. Abhari Payman. Investigation of load on the tools in precision radial extrusion process with multiple ram /Payman Abhari // XVII International scientific conference «New technologies and achievements in metallurgy, material engineering and production engineering»: Series: Monographs. – Nr 56. – Częstochowa, 2016 – P. 330–333.

Abhari Payman Bakhmanovich, Dr.Sc. (Eng.), Full Professor, Professor in Department of Metal Forming, Donbas State Engineering Academy, Kramatorsk – Ternopil, Ukraine, E-mail: payharies@gmail.com

Solianov Denis Olexandrovich, PhD student, Department of Metal Forming, Donbas State Engineering Academy, Kramatorsk – Ternopil, Ukraine, E-mail: annasolyanovaas@gmail.com

Oliinyk Dmytro Serhiyovich, master's student, Department of Metal Forming, Donbas State Engineering Academy, Kramatorsk – Ternopil, Ukraine, E-mail: dragon75gd46@gmail.com

ЧИСЛОВИЙ АНАЛІЗ РАДІАЛЬНО-ПОЗДОВЖНЬОГО ВИДАВЛЮВАННЯ З ВИКОРИСТАННЯМ МЕТОДУ СКІНЧЕННИХ ЕЛЕМЕНТІВ

Анотація: *У роботі чисельно досліджено процес радіально-поздовжнього видавлювання за кімнатної температури методом скінчених елементів у Deform 2D із жорстко-пластичною моделлю. Аналізувалися впливи конфігурації штампів, геометрії заготовки та режимів навантаження на характеристики формоутворення: розподіл деформацій, напружень і криві «навантаження–хід».*

Ключові слова: *видавлювання, метод скінчених елементів, деформація, напруження, навантаження*

Абхарі Пейман Бахменович– д.т.н., професор, професор кафедри обробки металів тиском, Донбаська державна машинобудівна академія, Краматорськ – Тернопіль, E-mail: payharies@gmail.com

Солянов Денис Олександрович, Аспірант кафедри обробки металів тиском, Донбаська державна машинобудівна академія, Краматорськ – Тернопіль, E-mail: annasolyanovaas@gmail.com

Олійник Дмитро Сергійович, Магістрант кафедри обробки металів тиском, Донбаська державна машинобудівна академія, Краматорськ – Тернопіль, E-mail: dragon75gd46@gmail.com