

Numerical simulation of blanking process

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Abstract. This paper presents numerical simulation of blanking process for cold-rolled steel sheet metal. The problem was modeled using axial symmetry in commercial finite element software ADINA. Data obtained by experimental measurement were used to create multi-linear plastic material model for simulation. History of blanking force vs. tool displacement was obtained.

Keywords: blanking, plasticity, axial symmetry, rupture, contact, nonlinear static analysis

1 Introduction

Blanking is the most widely used forming operation. It is used both for the preparation of semi-finished products and cutting of metal parts either for final use or as preparation for other technological operations [1, 2]. Simple analytical calculations are usually used during preparation of serial manufacturing [3, 4]. These analytical calculations are sufficient for determining basic parameters of blanking process such as maximal blanking force, however when problems occur during the manufacturing process the solution is often complicated and can be calculated only by using advanced numerical methods [5]. This paper presents a comparison of blanking process for a steel washer with and without v-ring indenter using finite element method. Use of v-ring indenter improves quality of resulting surface and also decreases the necessary blanking force.

2 Material data and model

Material data are one of the most important inputs in numerical simulation [6-8]. Precise results can be obtained only when precise material data in combination with proper material model are used [9-11]. Material data used for the presented simulations were obtained by tensile test using sheet metal samples of 1 mm thickness [12, 13]. The sheet metal samples were made from structural steel S235J.

The data obtained from tensile test were used to create multi-linear elastic-plastic material with isotropic hardening. Young's modulus $E = 210000$ MPa, Poisson's ratio $\mu = 0.3$. The stress-strain data in true stress representation were used. Rupture of elements

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Reviewers: Jozef Bocko, Tomasz Domański

occurred at the last stress-strain point. The material model in true stress representation can be seen on Fig. 1.

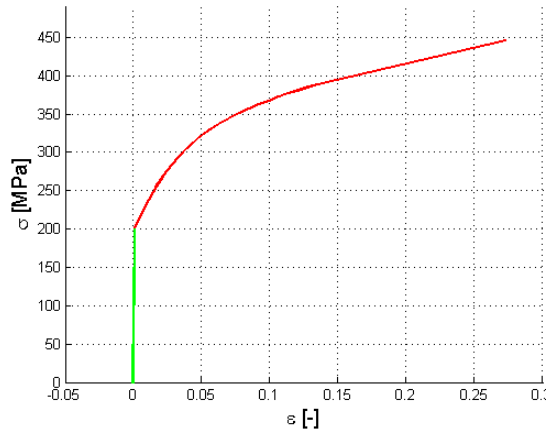


Fig. 1. Stress-strain curve for multi-linear material model in true stress representation

3 FEM model

The problem was modelled using axial symmetry in commercial FEM software ADINA. The punch, blank holders, v-ring indenter and die were modelled as rigid bodies [14]. Rigid target contact was used for contact of punch blank holders and die with sheet metal [15-17]. Friction coefficient of 0.2 was used for all contacts. The sheet metal was meshed using 2D 4 node elements, with very fine mesh in the area near punch.

In the first phase the sheet metal was pressed by blank holders using force of 62400 N. The second stage involved displacement of punch, which was prescribed by time function. The punch moved 5 mm downward and then 6 mm upward. In the model with v-ring indenter, the indentation operation was performed prior to all other operations. The thickness of sheet was 2 mm and depth of dent created by v-ring indenter was 0.5 mm.

The FEM model with boundary conditions for blanking without v-ring indenter can be seen on Fig. 2:

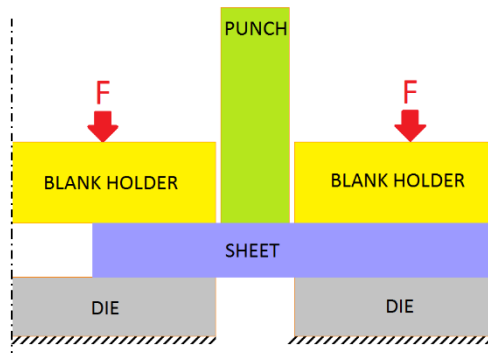


Fig. 2. FEM model without v-ring indenter

The FEM model with boundary conditions for blanking with v-ring indenter can be seen on Fig. 3.

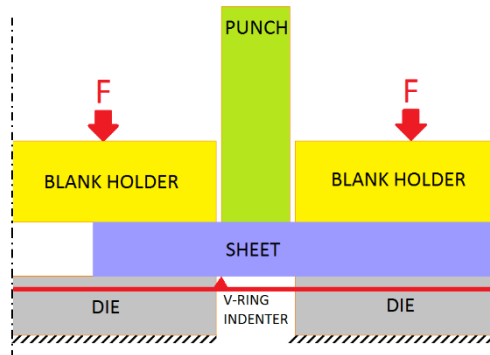


Fig. 3. FEM model with v-ring indenter

4 Results of numerical simulation

The results of FEM simulation can be seen on the following Figs. 4-6:

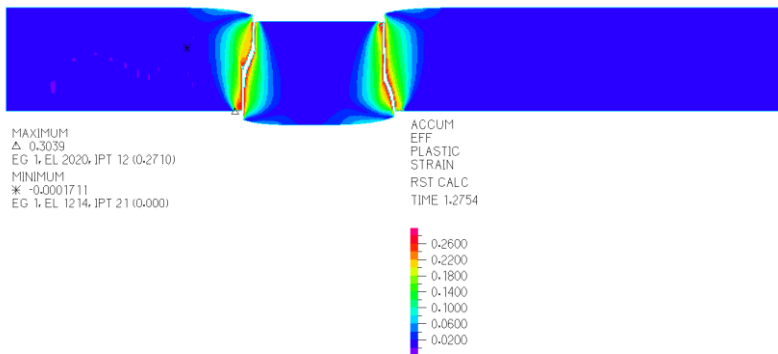


Fig. 4. Accumulated effective plastic strain – model without v-ring indenter

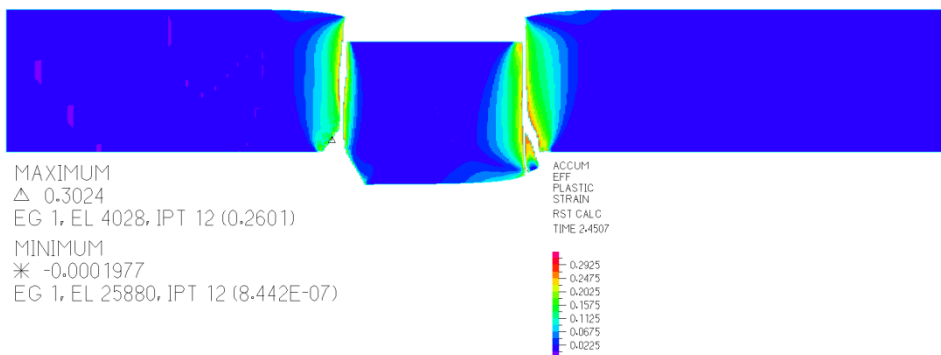


Fig. 5. Accumulated effective plastic strain – model with v-ring indenter

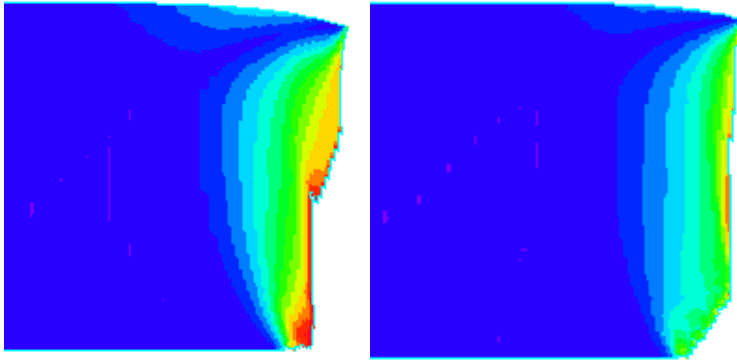


Fig. 6. Comparison of resulting surface – without v-ring indenter (left), with v-ring indenter (right)

The history of applied blanking force can be seen on Figs 7 and 8:

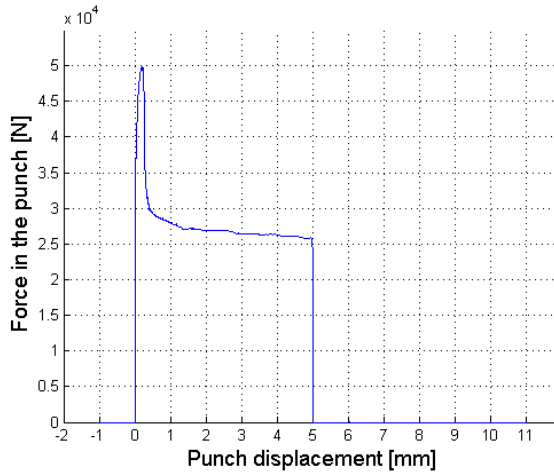


Fig. 7. Blanking force vs. punch displacement – without v-ring indenter

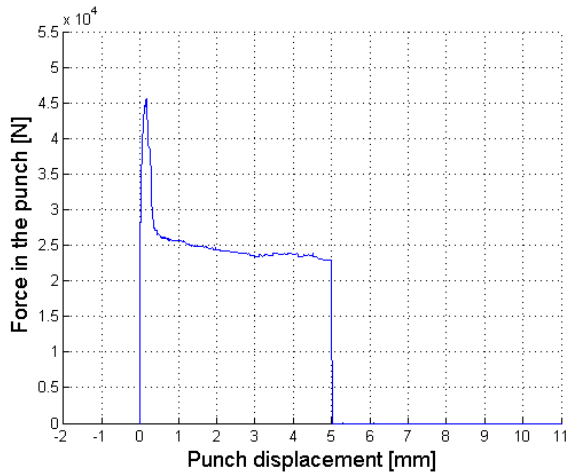


Fig. 8. Blanking force vs. punch displacement – with v-ring indenter

Conclusion

The numerical simulation confirmed that the use of v-ring indenter can benefit the blanking process. The maximum blanking force without v-ring indenter was 49921 N. The maximum blanking force with v-ring indenter was 45668 N. The use of v-ring indenter decreased the required blanking force by 8.5%. The improvement in terms of blanking force was only minor, however the use of v-ring indenter improved the quality of the resulting surface as can be seen on the Fig. 6.

The presented problem required nonlinear finite element solution which is much more complex than simple analytical solution used for calculation of blanking force. On the other hand, the results of FEM solution offer much more than information about maximal blanking force. The results of FEM simulation also include the shape and quality of resulting surface after blanking. Numerical simulation can be used to find optimal parameters for the blanking process and it is also more cost efficient than using physical prototypes.

This work has been supported by KEGA project No. 015ŽU-4/2017.

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