Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 55
ISSUE 2
December
2012

Application of the Finite Element Method for computer simulation of aluminum stamping process

W. Kwaśny, R. Dziwis
Institute of Engineering Materials and Biomaterials, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland
* Corresponding e-mail address: waldemar.kwasny@polsl.pl

Received 27.10.2012; published in revised form 01.12.2012

Analysis and modelling

ABSTRACT

Purpose: The goal of the paper is study the influence of the falling stamp speed on the material in the aluminum stamping process. The simulation was performed on several samples and the time of the falling stamp was changing.
Design/methodology/approach: The article presents using of the finite elements method for simulation of aluminum stamping process in dependence of the time of falling stamp. The simulation of stresses and deformation obtained in the result of stamping process was carries with the help of the finite elements method in ANSYS.
Findings: One of the major factor that has influence of the quality of a drawpiece is speed of the falling stamp. Too fast falling of the stamp causes huge stresses, which lead to destruction of the material.
Research limitations/implications: In order to estimate the application of the drawing aluminum elements, additional computer simulation should be concentrated on determination of other properties, for example- the distribution of temperature.
Originality/value: Presently the computer simulation is very popular and it is based on the finite element method, which allows to better understand the interdependence between parameters of process and choosing optimal solution. The possibility of application faster and faster calculation machines and coming into being many software make possible the creation of more precise models and more adequate ones to reality
Keywords: Computer simulation; Finite Element Method; Process of stamping; Aluminum

Reference to this paper should be given in the following way:
W. Kwaśny, R. Dziwis, Application of the Finite Element Method for computer simulation of aluminum stamping process, Journal of Achievements in Materials and Manufacturing Engineering 55/2 (2012) 551-555.

1. Introduction

Aluminum is presently the second metal in the word in the respect of application frequency and systematically gaining popularity. Density of this silvery white and light metal is three times lower than the density of iron. Aluminum's valuable properties are: oxidation resistance, water resistance, nitric compound action resistance and many organic acids action resistance. Systematically is growing the demand for aluminum products, which find an application as a raw material, semi-finished product and ready product in different fields of economy and in industries such as: automotive, building, chemical, electronic, metallurgical and packaging. One of many connected elements made with aluminum are sections, which are used with clean aluminum. They are presently used very frequently in building industry , for example to suspension ceiling framing or walls made with gypsum cardboard. Moreover these sections are applied in: interior equipment, electronic, sport, household equipment, mechanical devices, armaments industry, automotive industry and also in many others fields [1-3].

Application of the finite elements method contains many fields of contemporary industry and also modern technologies supported by computers [5-10]. This method is presently the most popular and the fastest developing numerical methods which are used in aircraft, ballistic rocket, automotive, shipbuilding, machine and electrotechnics industry and also contains such field of science as biomechanical, medicine, mechatronic, and in materials technology. Computer methods using in design processes serves mainly to optimization of these processes [11-14].

The finite elements method is also used in plastic forming and thanks to its application it is possible to perform simulation of aluminum press forming by selection of appropriate forming parameters for given material such as pressure force and falling speed of punch on material [4].

During drawing occurs conversion of flat product into a drawpiece, which is unable to change into a plane. As the result of punch action the material undergoes plastified and gradually relocates into interior of a die block. During the process of press forming the dimension of flange and unbounded surface decrease, whereas increase the area of contact zone between a material and a stamp.

The purpose of this thesis is studying the influence of falling speed of punch on material during the process of aluminum press forming.

2. Materials

Tested roller is made with aluminum EN AW-1050A marked according to ISO standard: AL 99.5. This aluminum is not alloy and is susceptible to cold forming. For poor properties of resistance the aluminum is not suitable for machining process. Aluminum is applied in energetic, building, chemical and comestible industry, in production of utensils, containers, pots for comestibles and chemical products, house holding equipments and packages.

Chemical composition and properties of material are presented in Tables 1, 2. A scheme of process of stamping together with dimension of the die block, the stamp and the roller are presented in Fig. 1.

Table 1.
Chemical analysis of aluminum

Al	Fe	Si	Zn	Ti	Mg	Mn	Cu	other
%								
99.5	0.4	0.25	0.07	0.05	0.05	0.05	0.05	0.03

3. Computer simulation

Computer simulation of aluminum press forming was performed in ANSYS programme in LS-DYNA module. Influence of falling speed of punch on material during the process of aluminum press forming was also simulated. The simulation was done in several trails. In every trial a roller relocates 13 mm, but also the time of falling was been changing. Trails are presented in Table 3.

Table 2.
Properties of aluminum

Young's modulus	Poisson ratio	Rm	Re
GPa		MPa	MPa
69	0.33	85	65

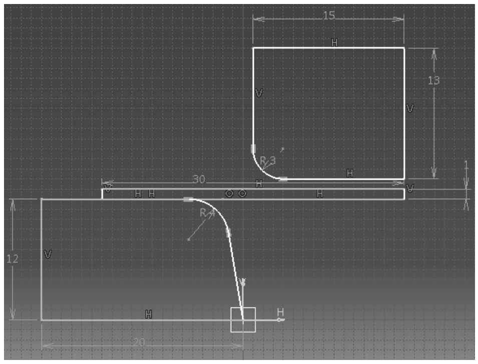


Fig. 1. Scheme of process of stamping together with dimensions of the die block, the stamp and the roller

Table 3.
Numbers of trials and time of the falling stamp

No. Trial	Time [s]
1	0.1
2	1
3	5
4	10
5	13
6	26

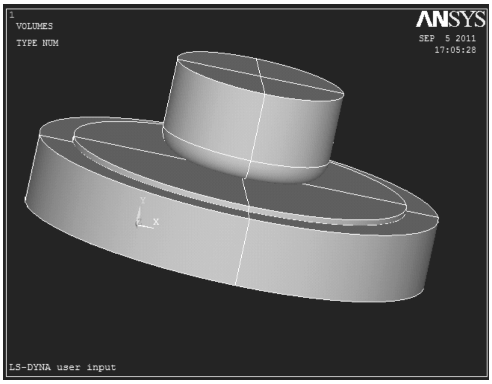


Fig. 2. Real model

Geometrical model (Fig. 2) was digitized (Fig. 3) by PLANE 42 element. The element of this type serves to simulation of space structure with the help of plane element (2-d) of solid body. It can be also used for simulation of structures described by the use of symmetry axis. In the analysis of press forming was used also the description of symmetry axis. In order to avoid an error in calculations of inner stresses in surfaces were applied variable quantity of the finite elements. In places where higher stresses gradients were expected, the mesh is more condensed than in places in which stresses should have had similar values.

Because of symmetrical model, the computer simulation was carried out on quarter of the total model what in substantial degree cut down the time of analysis and did not an influence of final result.

The die block is stiff located, so was deprived of all possibilities to displace and rotation. The stamp moves only vertically, so there is not the possibility of rotation and dislocation along the axis X and Z, however there is possibility of dislocation along axis Y.

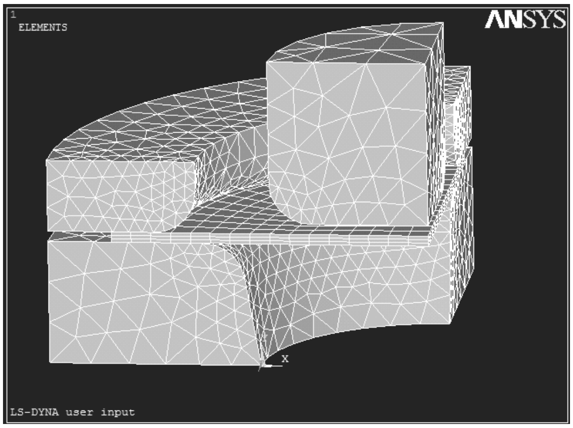


Fig. 3. One quarter of meshed model with pressure

Because tested model what is a quarter of the whole model in the roller was also blocked possibility for dislocation the central parts along the axis X and Z, in order to avoid dislocation of the model behind the tested zone.

Next the contact between the stamp and the roller was defined and also between the die block and the roller. I n this case the roller was "the target" Fig. 4, because the roller is the deformable element.

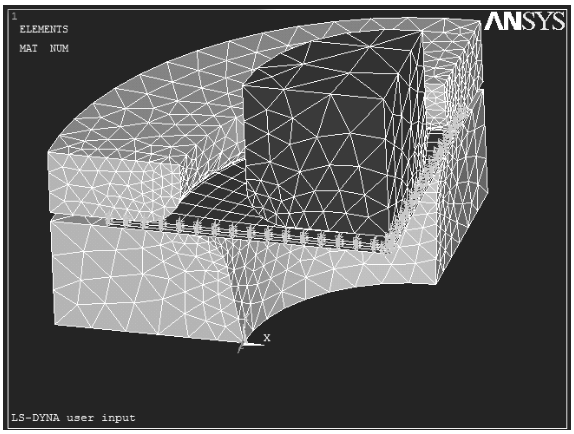


Fig. 4. Meshing model with determined contact surface between the stamp and the roller and between the die block and the roller

a)
b)
c)
d)

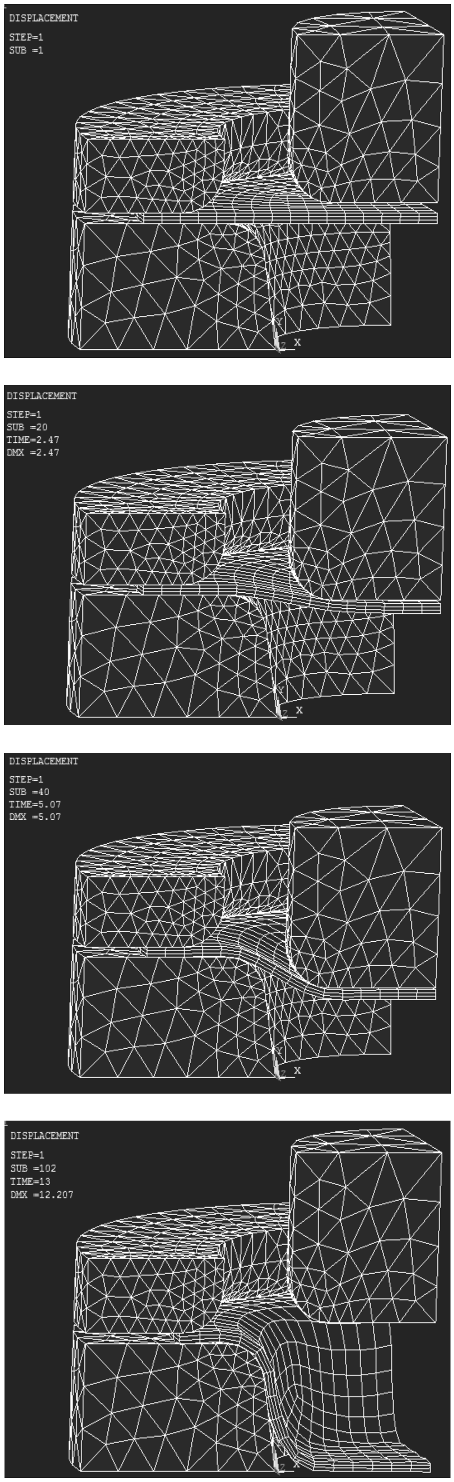


Fig. 5. Drawing of the roller In trial 5 (13 seconds of the stamp halling): a) the roller in the initial location b) preliminary deformation after 2.5 seconds c) deformation after 5 seconds d) a ready diestamping, the stamp in initial location

4. Results

The results of initial simulation was presented in Fig. 6, where is show that the roller was corrugated as the result of the stamp pressure and the planed collar was not preserved.

For the purpose of prevention of undesirable effects that is corrugation of the roller, clamping element was added to prevent this effect. Additional task of clamping is preservation of the collar in upper part of the diestamping.

Hobbing stages of stamp into the roller were presented in Fig. 5. The result is presented in selected stages. Presented results are for trails 5, where dislocation of the stamp from initial location to final location is 13 mm and takes 13 seconds.

In the first trial the stamp dislocated to final position in 0.1 second, what caused distraction of the roller in bottom part of the diestamping, what is presented in Fig. 7.It appeared as the result of using too strong force when the stamp hit the roller. Stresses considerable crossed stretching resistance limit in the result of huge pressure and force was caused the roller tearing.

In the Figs. 8, 9, 10 were presented the distribution of stresses and plastic deformation for successive trails of the stamp falling in time of 1, 10 and 13 seconds.

In that cases there were not such strong tear of the sample, however stresses caused by the stamp pressure still might cause considerable deformation of the roller.

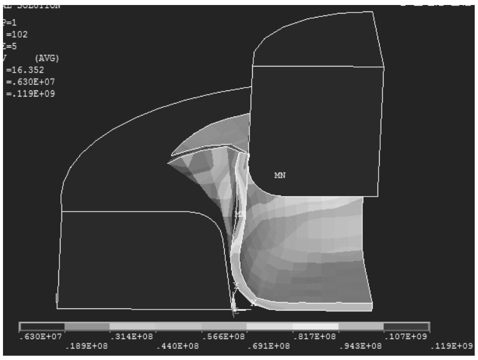


Fig. 6. Corrugation of the roller

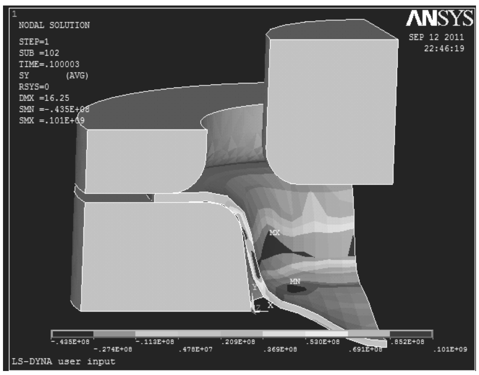


Fig. 7. Distribution of stresses after the stamping process after 0.1 second

a)

b)

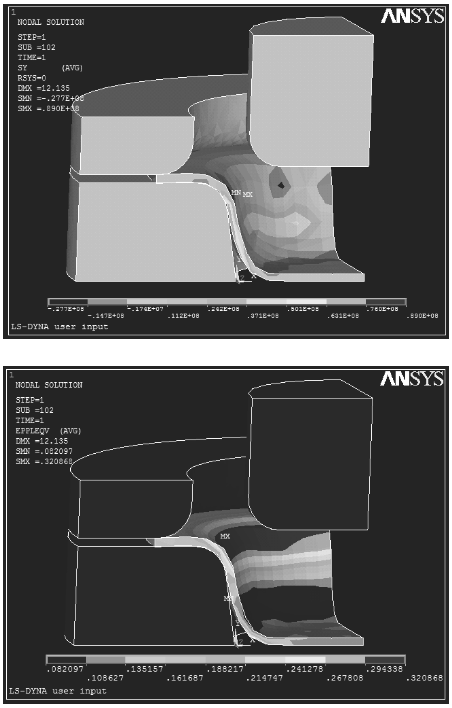


Fig. 8. Results of 2 trials (1 second of the stamp halling) a) distribution of stresses b) plastic deformation

a)

b)

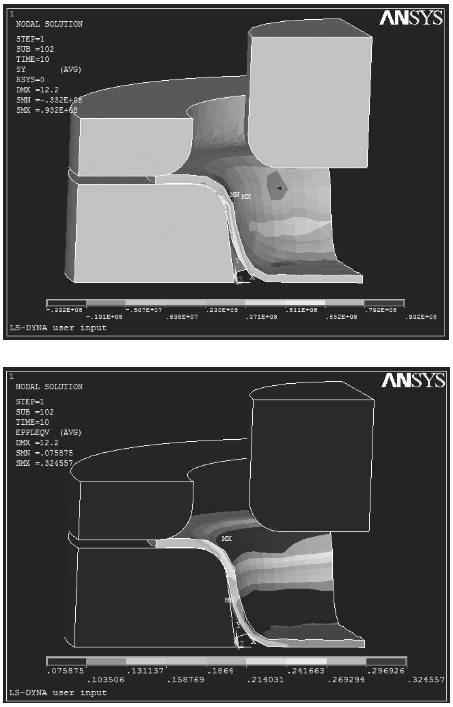
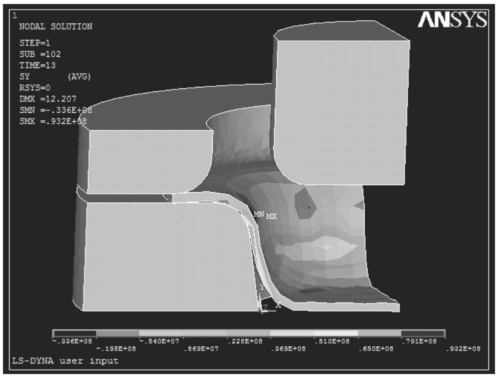


Fig. 9. Results of 4 trials (10 second of the stamp halling) a) distribution of stresses b) plastic deformation

a)



b)

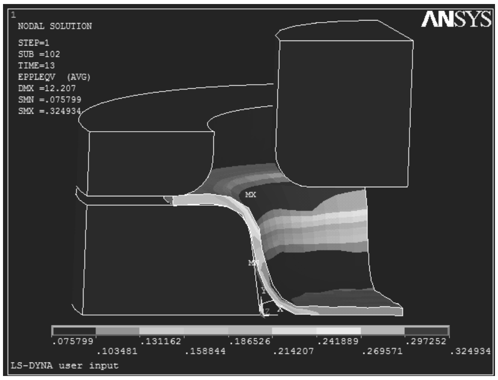


Fig. 10. Results of 5 trials (13 second of the stamp halling) a) distribution of stresses b) plastic deformation

5. Conclusions

- Performer simulation allows to analyse the process of stamping in the initial phrase of designing.
- Addition of pressure blocks stability loss of material, what allows to obtain products of designed quality.
- Once of the main factors which have influence on quality of the diestamping is the speed of the stamp falling. Too fast fall of the stamp causes huge stresses leading to destruction of material.

References

[1] V. Boljanovic, Sheet metal forming processes and die casting, Industrial Press, New York, 2004.

[2] Z. Zimniak, Three-dimensional technology design system of sheet stamping, Research projects in domain of plastic working, physical metarullgist, and sintered technology, Technical University, Wrocław, 1997.

[3] A. Służalec, Theory of metal forming plasticity, Springer, Berlin, 2004.

[4] U. E. Ozturk , G. Anlas, Finite element analysis of expanded polystyrene foam under multiple compressive loading and unloading, Materials and Design 32/2 (2011) 773-780.

[5] W. Walke, Z. Paszenda, Numerical analysis of three-layer vessel stent made from Cr-Ni-Mo steel and tantalum, International Journal of Computational Materials Science and Surface Engineering 1/1 (2007) 129-137.

[6] T. Da SilvaBotelho, E. Bayraktar, Experimental and finite element analysis of spring back in sheet metal forming, International Journal of Computational Materials Science and Surface Engineering 1/2 (2007) 197-213.

[7] A.V. Benin, A.S. Semenov, S.G. Semenov, Modeling of fracture process in concrete reinforced structures under steel corrosion, Journal of Achievements in Materials and Manufacturing Engineering 39/2 (2010) 168-175.

[8] S. Thipprakmas, M. Jin, K. Tomokazu, Y. Katsuhiro, M. Murakawa, Prediction of fine blanked surface characteristics using the finite element method (FEM), Journal of Materials Processing Technology 198 (2008) 391-398.

[9] Y. Kim, S. Yaang, D. Shan, S. Choi, S. Lee, B. You, Three-dimensional rigid-plastic FEM simulation of metal forming processes, Journal of Materials Engineering and Performance 15 (2006) 275-279.

[10] K. Lenik, D. Wójcicka-Migasiuk, FEM applications to the analysis of passive solar wall elements, Journal of Achievements in Materials and Manufacturing Engineering 43/1 (2010) 333-340.

[11] J. Okrajni, W. Essler, Computer models of steam pipeline components in the evaluation of their local strength, Journal of Achievements in Materials and Manufacturing Engineering 39/1 (2010) 71-78.

[12] J. Bouzakis, G. Maliaris, A. Tsouknidas, FEM supported semi-solid high pressure die casting process optimization based on rheological properties by isothermal compression tests at thixo temperatures extracted, Computational Materials Science 59 (2012) 133-139.

[13] B. Regener, C. Krempaszky, E. Werner, M. Stockinger, Modelling the micromorphology of heat treated Ti6Al4V forgings by means of spatial tessellations feasible for FEM analyses of microscale residual stresses, Computational Materials Science 52/1 (2012) 77-81.

[14] Z. Shiping, K. Rooh A. Khurram, G.Habashi, FEM analysis of in-flight ice break-up, Finite Elements in Analysis and Design 57 (2012) 55-66.