Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 1, rok 2008, ročník LIV, řada strojní
článek č. 1581

Radek ČADA[*], **Miloš KIJONKA**[**]

INFLUENCE OF INPUT VALUES CHANGES ON THE SIMULATION RESULTS IN THE DYNAFORM 5.2 SOFTWARE

VLIV ZMĚN VSTUPNÍCH HODNOT NA VÝSLEDKY SIMULACE V PROGRAMU DYNAFORM 5.2

Abstract

The paper concerns testing of the influence of input values (normal plastic anisotropy ratio, the strain-hardening exponent and the friction coefficient) changes on the main logarithmic strain values obtained by simulation of stamping drawing. With the use of Dynaform 5.2 software the drawing of cylindrical stamping with the bottom radius $R_d = 23{,}5$ mm (a hemisphere shape) was simulated partly for the drawing coefficient $M = 0{,}57$, partly for experimentally determined limit drawing coefficient $M_m = 0{,}445$. Some conditions were established which provide information about importance of the influence and when the influence can change the decision about drawability of a given component.

Abstrakt

Článek se týká zjišťování vlivu změn zadaných vstupních hodnot (součinitele plastické plastické anizotropie, exponentu deformačního zpevnění a součinitele smykového tření) na velikost hlavních logaritmických deformací získaných simulací tažení výtažku. S využitím programu Dynaform 5.2 bylo simulováno tažení válcového výtažku s poloměrem zaoblení dna $R_d = 23{,}5$ mm (ve tvaru polokoule) a to jednak se součinitelem tažení $M = 0{,}57$, jednak s mezním, experimentálně stanoveným součinitelem tažení $M_m = 0{,}445$. Byly určeny podmínky, za kterých je vliv zadaných vstupních hodnot podstatný a může změnit rozhodnutí o vyrobitelnosti dané součásti.

INTRODUCTION

The methods of modelling of technological processes using computer programs are of great help also in optimization of stamping processes. Nowadays, the stamping quality requirements increase, as well as rate quality standards of the technological preparations of production. Using of the most modern devices is, therefore, necessary at present days. The possibility of verifying the rightness of the material and the tools design by computations before its production is very important.

The conditions for using methods of forming processes modeling are not only efficient computers but also the knowledge of the process parameters which are used as input values. Parameters describing the properties of the material which influence the results of the simulation are meant in the main. The influence of every single material value and the accuracy requirements are to be known. The results are also affected by main force and friction conditions choices. The comparison of the simulation results with experimental values leads to correction of input values requirements and to choice of more suitable mathematical descriptions of the material behavior.

1 SOFTWARE DYNAFORM 5.2

Dynaform is the complete die system simulation software. Utilization of it allows the organization to entirely bypass soft tooling, reducing overall tryout time, lowering costs, increasing produc-

[*] prof. Ing. CSc., VŠB – Technical University of Ostrava, Faculty of Mechanical Engineering, Department of Mechanical Technology, 17. listopadu 15, 708 33 Ostrava – Poruba, Czech Republic, tel.: +420 59 7323289, fax: +420 59 6916490, e-mail: radek.cada@vsb.cz

[**] Ing., Ph.D., Secondary Technical School in Karviná, Žižkova 1818/1a, 733 01 Karviná, tel.: +420 59 6348161, e-mail: KijonkaM@seznam.cz

tivity and providing complete confidence in die system design. It also allows evaluation of alternative and unconventional designs and materials for an optimal solution. The most cost-effective and accurate solution available, software Dynaform is the clear choice among progressive organizations seeking to streamline the die analysis system.

Software Dynaform 5.2 has additional modules:

a) ***Blank Size Engineering (BSE) module*** – it is a complete solution for accurate blank size estimation, nesting to maximize material utilization, piece price and scrap calculation. BSE is based on a one-step algorithm for rapid calculation. Potential forming failure due to excessive blank thinning is detected through an inverse method. BSE also creates a forming limit diagram (FLD) map for feasibility review.

b) ***Die Face Engineering (DFE) module*** – based on the product design of a panel, the DFE module offers capabilities of both CAD surface and CAE meshing tools. DFE interactively generates binder surfaces, addendum profiles/surfaces, PO lines and layout drawbeads with full associativity between FEA mesh and surfaces. A preliminary die face is created for further formability studies with an iterative process until die face validation is achieved.

c) ***Formability Simulation (FS) module*** – it is a complete incremental die simulation program for quickly generating formability results at a very early stage of the product design cycle. It is suited for design feasibility analysis and verification. Stress, strain and thickening results are plotted and a complete forming limit diagram (FLD) is generated. It is a proven tool for uncovering hidden problem areas.

d) ***Die System Analysis (DSA) module*** – it offers an LS-DYNA based FEA solution to analyze die system operations including scrap shedding/removal, die structural integrity and sheet metal transferring/handling. Further development will include trimming, flanging and hemming operations.

Software Dynaform creates a die design methodology, capturing the development process. Tool development is moved from a individual skill to a corporate resource. Dynaform reveals the physics controlling the forming process. This insight provides the reassurance to deliver innovative tooling capable of forming unconventional materials or geometry – a true competitive advantage. Dynaform facilitates a faster, lower cost production forming capability providing a level of agility and flexibility beyond the competition.

2 INPUT VALUES FOR THE SIMULATION

Simulations in software Dynaform 5.2 were executed using a cylindrical stamping (Fig. 1 and Fig. 2) with the inside diameter $d_1 = 47$ mm and the bottom radius $R_d = 23{,}5$ mm (a hemisphere shape).

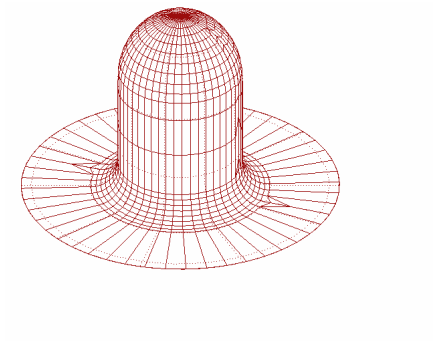

Fig. 1 Network of stamping for construction of models of punch, die and blankholder

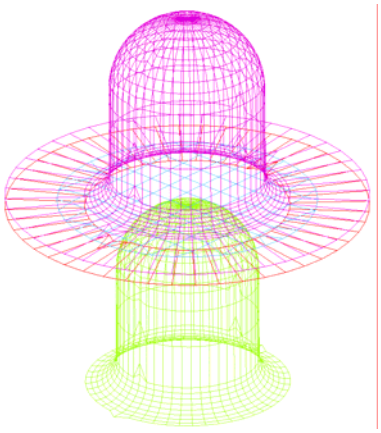

Fig. 2 Models of punch, die, blankholder and blank before simulation of drawing

For simulation the traditional setting was used, which has better possibility of modification to given drawing conditions in comparison to quick setting. For inputing the values determined by practical tests, values from technical literature and constants recommended by producer of programm mentioned like pre-set values were used. For simulation of sheet-metal drawing the material with properties according to material model of type 36 was chosen. This material model uses the Barlat – Lian plasticity condition. Strain hardness curve can be in this model used like linear (in this case material yield point is inputed), exponential (it was used for computing), or insert its distribution by inputing of curve points.

Values inputed to material table in programm:

- material density ρ = 7850 kg/m^3,
- modulus of elasticity E = 208 GPa,
- Poisson constant v = 0,3 (-),
- number of strain hardness curve equation = 2 (exponential),
- constant controlled the shape of plasticity surface M = 6 (for body-centred cubic lattice),
- another values for tested material DC04 (11 305.21) are listed below.

For creation of fine and superior elements network on blank the value „radii“ = 3 was chosen.

Values of holding forces were inputed in accordance with experiments according to table 13.1. Holding force at drawing of disunion stamping F_p = 53 325 N.

Another parameters of setting were left on recommended pre-set values (analysis parameters: time step = 1,2 · 10^{-6} s, degree of network re-creation = 3).

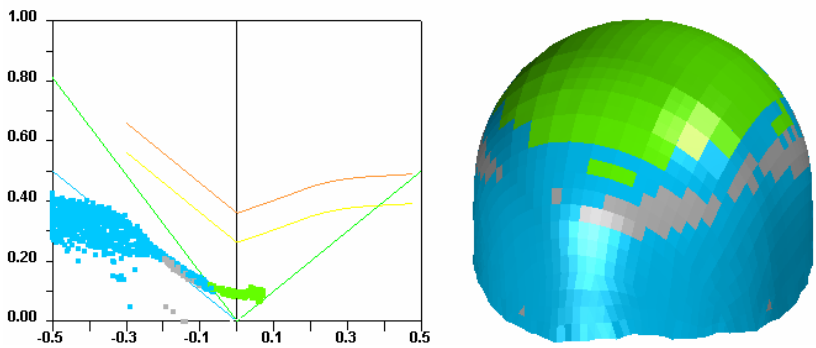

Fig. 3 Result of drawing simulation of cylindrical stamping with a hemisphere shape bottom and forming limit diagram with its deformations

The examined parameters, obtained by measurment of 2 mm thick material DC04 (11 305.21), were changed within the range ±20 %.

The measured values were the following:

- the strain-hardening exponent n_m = 0,220 (-),
- normal plastic anisotropy ratios r_0 = 1,77 (-), r_{45} = 1,29 (-), r_{90} = 2,08 (-),
- the friction coefficient μ_1 = 0,150 (-),
- the hardening coefficient C = 494 MPa.

The testing was executed for the drawing coefficient M = 0,57 and for experimentally determined limit drawing coefficient M_m = 0,445. Only one parameter was changed during one testing, leaving the others set to the values mentioned above. The holding power values were entered in accordance with experiments for the holding pressure 1 MPa. The tool velocity was set to v_n = 100 mm.s^{-1}. The other parameters were left on recommended pre-set values.

The variable parameters were set as follows:

a) the friction coefficients μ = 0,125; 0,150 and 0,180 – the same for any surface,

b) the medium strain-hardening exponent values n_m = 0,180; 0,220 and 0,250,

c) the normal plastic anisotropy ratio values r_0 = 1,77, r_{45} = 1,29, r_{90} = 2,08 ($\bar{r}$ = 1,61); r_0 = 1,50, r_{45} = 1,10, r_{90} = 1,70 ($\bar{r}$ = 1,35); r_0 = 2,10, r_{45} = 1,50, r_{90} = 2,50 ($\bar{r}$ = 1,90).

The results of the simulations can be seen in Fig. 4 to Fig. 9.

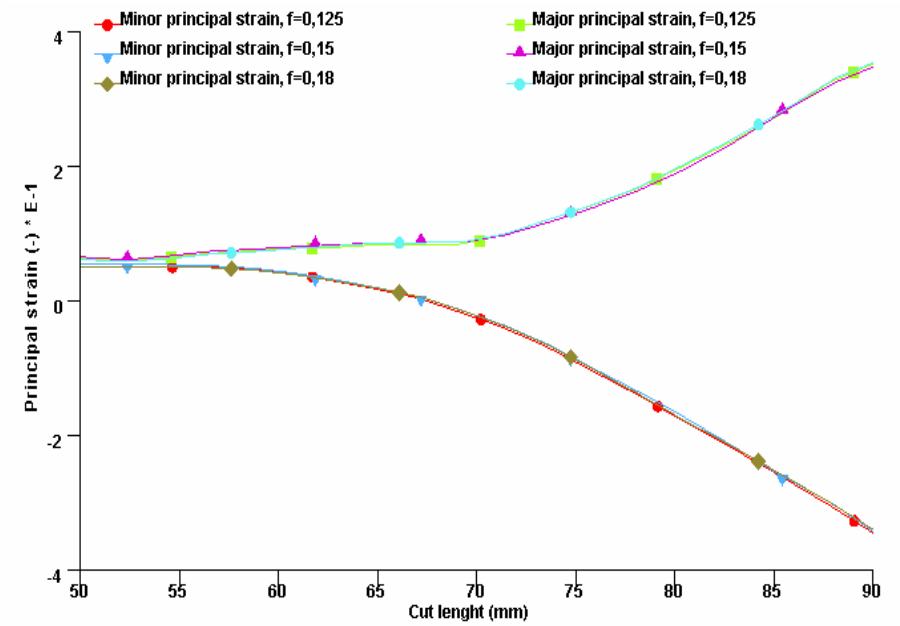

Fig. 4 Diagram „principal strain – cut length“ for D_p = 86 mm and three values of the friction coefficient (μ = 0,125; 0,150 and 0,180)

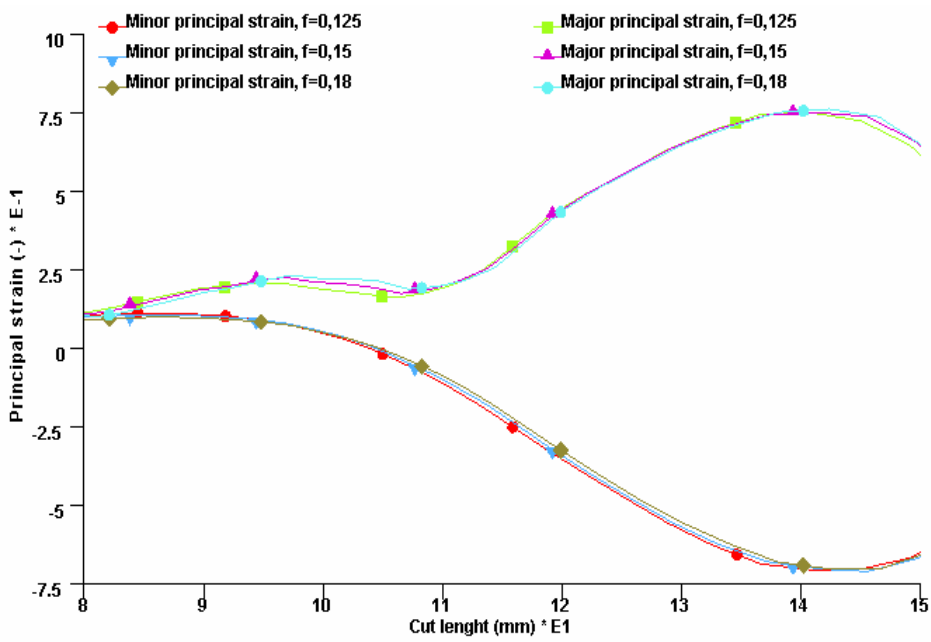

Fig. 5 Diagram „principal strain – cut length“ for D_p = 110 mm and three values of the friction coefficient (μ = 0,125; 0,150 and 0,180)

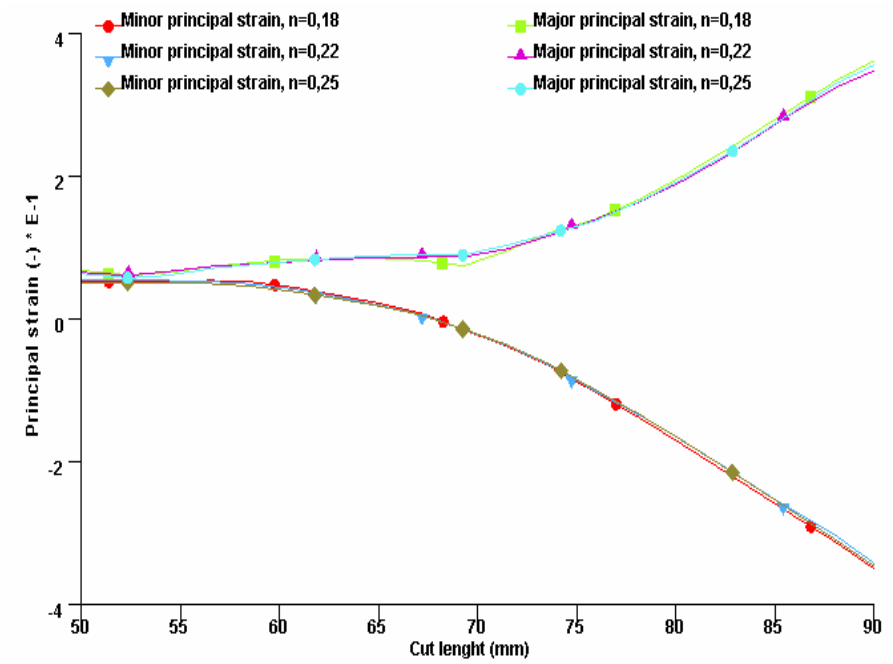

Fig. 6 Diagram „principal strain – cut length“ for D_p = 86 mm and three values of the strain-hardening exponent (n_m = 0,180; 0,220 and 0,250)

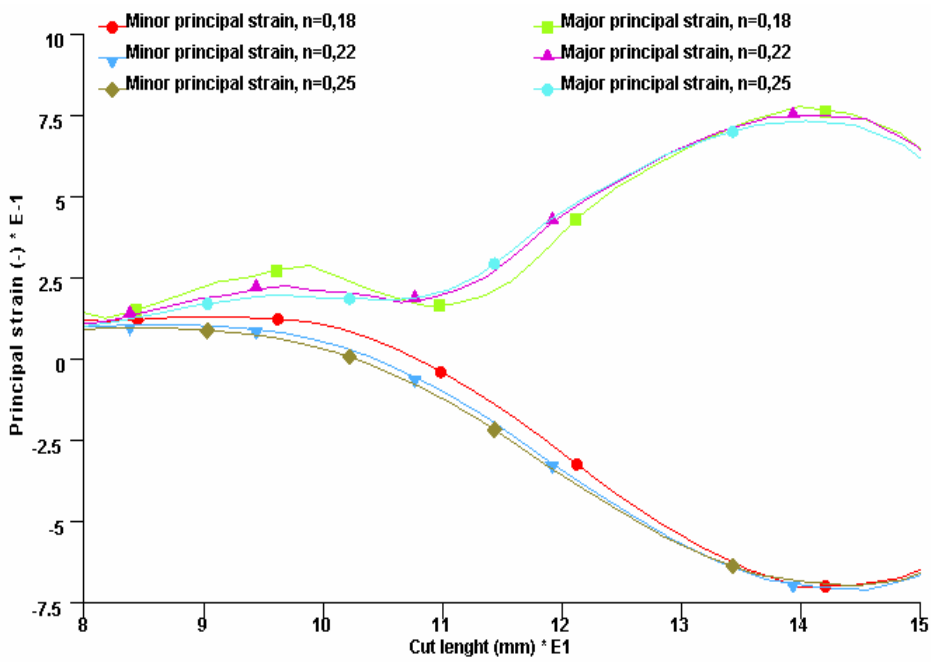

Fig. 7 Diagram „principal strain – cut length“ for D_p = 110 mm and three values of the strain-hardening exponent (n_m = 0,180; 0,220 and 0,250)

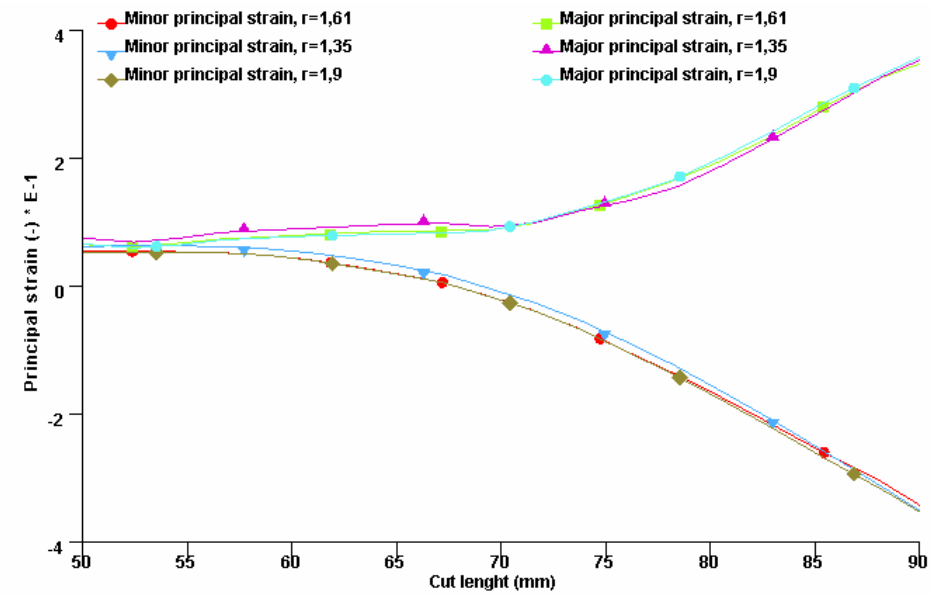

Fig. 8 Diagram „principal strain – cut length“ for D_p = 86 mm and three values of the mean normal plastic anisotropy ratio ($\bar{r} = 1{,}61$, 1,35 and 1,90)

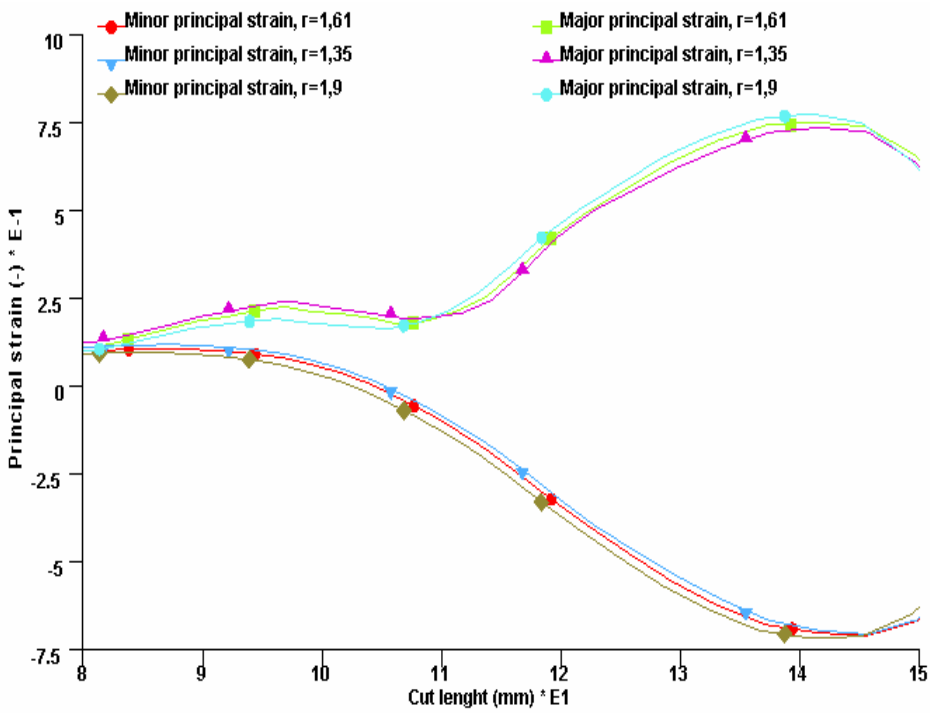

Fig. 9 Diagram „principal strain – cut length“ for D_p = 110 mm and three values of the mean normal plastic anisotropy ratio ($\bar{r} = 1{,}61$, 1,35 and 1,90)

3 EVALUATION OF THE INFLUENCE OF INPUT VALUES CHANGES

The graphs representing the principal strain behaviour in the axial cut conformal with the direction of rolling show, that:

a) When stamping a blank with D_p = 86 mm (M = 0,57) with the principal strain values being in the lower half of the forming limit diagram with plasticity utilization η = 0,3, the changes of the strain-hardening exponent and of the friction coefficient have only a minor impact on the simulation results. The changes of the normal plastic anisotropy ratio (mean values are listed in the diagram) cause a change of the real strain at most $\Delta\varphi$ = 0,02.

b) When stamping a blank with D_p = 110 mm (M = 0,445) with plasticity utilization η = 0,7, the changes of the friction coefficient cause a change of the real strain at most $\Delta\varphi$ = 0,05, the changes of the strain-hardening exponent cause maximal $\Delta\varphi$ = 0,1 and the changes of the normal plastic anisotropy ratio cause maximally $\Delta\varphi$ = 0,05.

4 CONCLUSIONS

From the results follows, that inputing of exact input values (normal plastic anisotropy ratio, the strain-hardening exponent and the friction coefficient) is important mainly when simulating drawing of stamping with higher values of plasticity utilization, when verifying a possibility of drawing of more complicated components produced during a single operation and when drawing close to formability limits. Substantial changes of the results may be caused by a combination of influences of the studied parameters.

REFERENCES

[1] ČADA, R. *Tvářitelnost ocelových plechů : odborná knižní monografie.* Lektorovali: L. Pollák a P. Rumíšek. 1. vyd. Ostrava : REPRONIS, 2001. 346 s. ISBN 80-86122-77-8.

[2] *eta/Dynaform User`s Manual.* Engineering Technology Associates, Inc., 2004. 358 s.

[3] *eta/Post User`s Manual.* Engineering Technology Associates, Inc., 2004. 127 s.

[4] *Ls-dyna keyword user`s manual volume I.* Livermore software technology corporation.

[5] *Ls-dyna keyword user`s manual volume II.* Livermore software technology corporation.

Reviewers:
Ing. Tomáš Vysekal, PRUMLEZ, Ostrava – Poruba
Ing. Michal Synek, výrobní ředitel PEMA METAL, s. r. o., Městec Králové