UTILIZATION OF “DYNAFORM“ SIMULATION SOFTWARE TO VERIFICATION OF MATERIAL APPROPRIATE FOR COMPONETS PRODUCED BY DRAWING

Peter KOVÁČ, Viktor TITTEL

Authors: ***MSc. Peter Kováč, Assoc. Prof. Viktor Tittel, PhD.***
Workplace: ***Department of Forming, Institute of Production Technologies, Faculty of Material Science and Technology in Trnava, Slovak University of Technology***
Address: ***J. Bottu 23, 917 24 Trnava, Slovak Republic***
Phone: ***+421 918646051***
Email: ***peter.kovac@stuba.sk, viktor.tittel@stuba.sk***

Abstract

The contribution deals with the analysis of sheets appropriate for deep-drawing. There were worked out some experiments with chosen kind of material DC 01 (0.1 wt. %. C, 0.45 wt. % Mn, 0.03 wt. % P, 0.03 wt. % S) of material by two methods: experiment in real condition; experiment by computer simulation. A computer simulation is very important during series production in present days. The goal of the experiments was verification of chosen material appropriation for deep-drawing and compares the results by both methods.

Key words

drawing, deep-draw, sheet, simulation

Introduction

Due to it is shape, sheet metal is appropriate for forming process. There are many requirements on technological methods of forming to produce a semi-product by simplest, quickest and the cheapest way [1].

In stamping is very important speed of realization of designed products by shortest time and with minimum costs. At the present time, computer simulation is necessary in series production. We use computer simulation for shortening the preparation stage of production from drawing product to production tools, as well as better use of the material properties or detect errors in the process of forming.

Deep-drawing is one of the technological processes of the flat forming often used in practice. Deep-drawing is process defined by changeling blank to a hollow object with requiring shape and parameters [1, 2].

Materials (sheets) used for production of various products are characterized by deep-drawing, what generally means the ability of the sheet metal to plastic deformation without breaking the cohesion or more precisely without local deformation [3].

Experiments

There was used an experimental material for that work - sheet steel DC 01 EN 10130-91, thickness s = 1 mm, cold rolled from low-carbon plain steel of ductile quality. Specifications of material chemistry and mechanical properties are shown on Tab. 1 and Tab. 2 [4].

CHEMISTRY OF EXPERIMENTAL MATERIAL Table 1

Steel quality	**C** [max wt. %]	**Mn** [max wt. %]	**P** [max wt. %]	**S** [max wt. %]
DC 01	0.10	0.45	0.030	0.030

MECHANICAL PROPERTIES OF EXPERIMENTAL MATERIAL Table 2

Steel quality	**S_y [max MPa]**	**S_u [MPa]**	**A_{80} [min %]**	**Cupping by Erichsen h [mm]**
DC 01	240	280 ÷ 390	29	6.6 ÷ 12.0

Drawing in laboratory

There was applied the real process of forming for the blank of low-carbon material with dimensions Ø110 x 1mm (Fig. 1a). Work device was LEXN 100 C with diameter of draw punch d = 58,5 mm and draw die D = 61,5 mm (Fig. 1b).

a) b)

Fig. 1. *Drawing in laboratory*
a) experimental material – blank; b) experimental tool – draw punch, draw die

Simulation of deep-drawing process

There was used a simulation software Dynaform. Using this software it's possible to see the process of drawing before production of tools starts ⇒ the risk decreases as well as the costs of design and development of tools by using predictions problems of forming. [5]

- *Creation of tool active surfaces*

  There was used CAD software Catia for creation of active surfaces of tool and for receiving of needed data for deep-drawing process realization. Single surfaces of press tool objects and also blank have to be re-transforming from CAD model to the net final element.

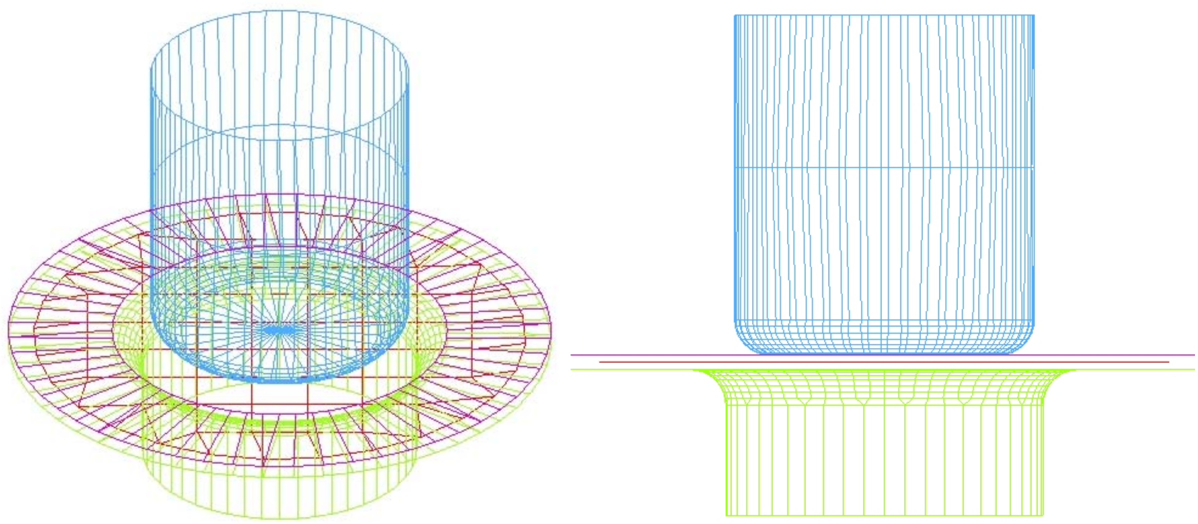

Fig. 2. *Model of technical shape of tool – draw die [5]*

Drawing punch — *Draw die* — *Blank holder* — Semi-product

- *Complex analysis of stamping process*

  Complex analysis was applied on simple deal from deep-drawing material DC 01 by EN 10130/91 (11 321.21) – semi-product parameters Ø110 x 1 mm. Correct calculations need to enter relative positions and movement of press tools. In our case, there was used single pressing with movement of drawing-punch. This drawing-punch draws pressed material into the fixed draw-die with defined depth of draw (in our case 40 mm). Size of holding force was specified by holding press on F_p = 10 073.5 [N].

By this software, there is also possibility to check the appropriation of steel for stamping and we can find out it by forming limit diagrams according to Keeller (area pull – pull) and Goodwin (area pull – press) shown on Fig. 3 [2].

The principle of construction of forming limit diagrams is to apply deformation net on the blank. By this deformation net we can quantitative evaluate deformations φ_1 and φ_2 in plane sheet. There are shown maximum logarithmic deformations in the plane sheet on the vertical axis, which can be just positive during the drawing. On the horizontal axis, there is shown a minimal deformation in the plane sheet, which is always measuring across the 1. This deformation can obtain positive or negative values. Allowable deformations are in the area below the curve and bad deformations are in the area above the curve [1, 6].

$\varphi_1 = \varphi_2$ – balanced two-axis draw

$\varphi_2 = 0$ – sheet elongate just to the prejudice of thickness reduction, without width change

$\varphi_1 = -2\varphi_2$ – uni-axial draw for isotropy material

$\varphi_1 = -\varphi_2$ – flat state of deformation without change of sheet width ($\varphi_3 = 0$)

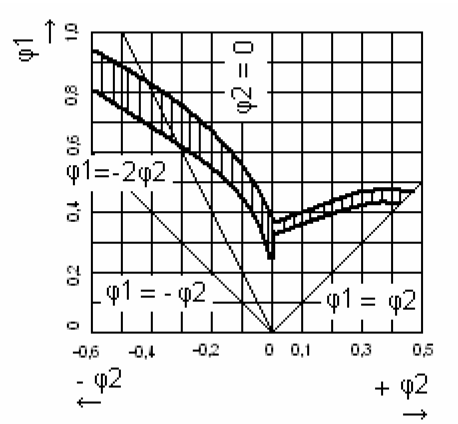

Fig. 3. *Keller-Goodwin diagram [4]*

Experiment results

Drawing in laboratory

Product produced by drawing from semi-product of Ø110 x 1mm dimensions and material of 11.321.21 is shown on Fig. 4. Wrinkle of flange is considerable and available height of product is h = 35 mm and outside diameter of product is D = 61,5 mm.

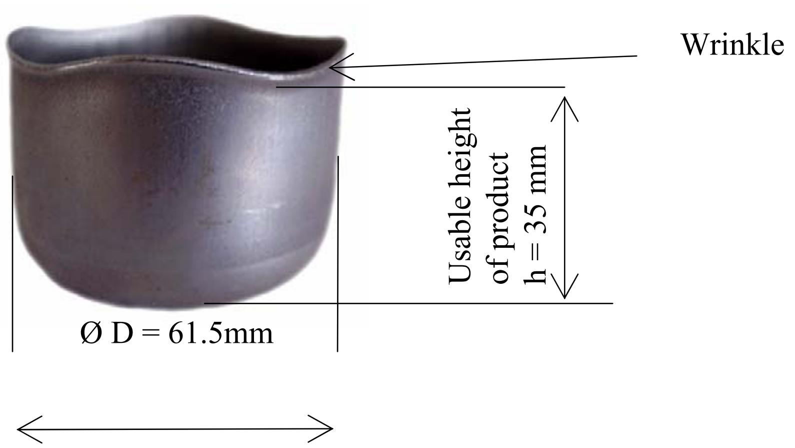

Fig. 4. *Product of experiment*

Simulation of drawing process

Product and his net model created by simulation software Dynaform are shown on Fig. 5. More detailed results of simulation, where we can see the condition of product are shown on Fig. 6

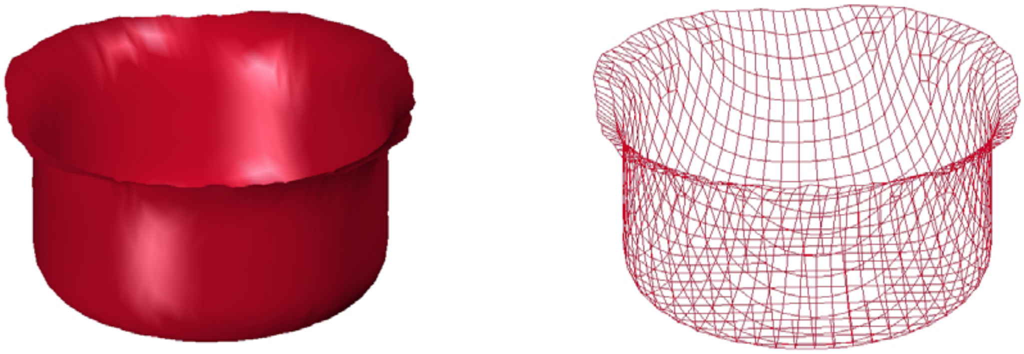

Fig. 5. *Product of simulation [5]*

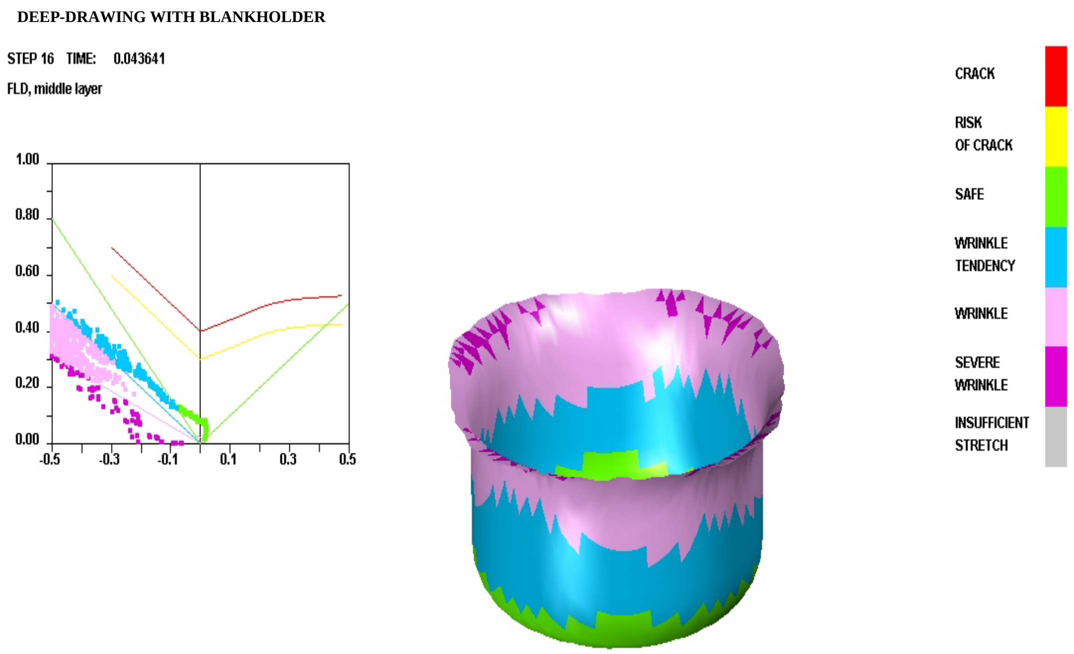

Fig. 6. *Zones determines state of product acquired by simulation [5]*

Limit forming diagram as well as product shown on Fig. 6 are divided into 8 colored areas, which means different states of material: insufficient stretch, severe wrinkle, wrinkle, wrinkle tendency, safe, risk of crack, crack (because of view it isn't displayed). As we can see from the picture, there won't be overload of deformations, there won't be a crack.

Discuss of reached results

In visual aspect, both methods of drawing get us approximately same results. In the case of simulation drawing process, there's no way to crack of material. There were no risk regions, where can be crack happened. The bottom of product was marked as a safety region. Side walls have tendency to wrinkle, while changing the wall to the flange the wrinkle already exists and in the end of flange, there's a several wrinkle. The real deep-drawing is nearly the same as simulation of deep-drawing. It means that simulation of deep-drawing process good describes the process of drawing and that material is appropriate for deep-drawing.

Conclusions

Acquired results (real and simulated) confirm that chosen material is appropriate for products produced by flat forming. On the other hand, results of simulation depend on input conditions such as the mechanical properties of material, used drawing process, technological conditions etc. Some factors, which we can see in the real drawing, are hard describable, therefore we have to know there are always specific mistakes in result of simulation.

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