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INFLUENCE OF DRAW BEAD UPON SIMULATION RESULTS OF DRAWING PROCESS OF UNSYMMETRIC SHAPE STAMPING IN THE DYNAFORM 5.2 SOFTWARE

VLIV BRZDICÍHO ŽEBRA NA VÝSLEDKY SIMULACE PROCESU TAŽENÍ NESYMETRICKÉHO VÝTAŽKU V PROGRAMU DYNAFORM 5.2

Abstract

The contribution treats of usability of draw beads application in drawing process and influence of draw bead upon simulation results of drawing process of chosen shape stamping. The utilisation of draw beads bears many advantages and its takes away many uncomfortable effects which guide drawing process. The utilisation of draw beads is analysed in the contribution, advised forms, proportions and location of draw beads in blankholder are described. The possibilities of order character of draw bead in Dynaform 5.2 software evolved by American company Engineering Technology Associates, Inc. (ETA) are described. In contribution the usability of application draw bead is solved for one of the representatives of intricate shape stampings from thin deep-drawing sheet-metal DC04 – the left cover of ventilator for truck Tatra 815. In contribution the analysis is carried out on blank model determined by maximum shear stress trajectories method which is optimal for drawing of this unsymmetric shape stamping.

Abstrakt

Článek pojednává o vhodnosti užití brzdicích žeber při plošném tváření a vlivu brzdicího žebra na výsledky simulace plošného tváření vybraného výtažku. Užití brzdicích žeber přináší spoustu výhod a odstraňuje řadu nepříjemných jevů provázejících plošné tváření plechů. V článku je rozebráno užití brzdicích žeber, jsou popsány doporučené tvary, rozměry a umístění brzdicích žeber v přidržovači. Jsou popsány možnosti v zadávání vlastností brzdicího žebra v programu Dynaform 5.2, vyvinutém americkou společností Engineering Technology Associates, Inc. (ETA). Vhodnost užití brzdicího žebra je v článku řešena pro jeden z představitelů výtažků nepravidelného tvaru z tenkého hlubokotažného plechu DC04 – levého krytu ventilátoru pro nákladní automobil Tatra 815. Analýza je provedena na modelu přístřihu stanoveného metodou využívající trajektorií maximálních smykových napětí, který je pro tažení tohoto výtažku optimální.

1 INTRODUCTION

The shape stamping of the left cover of ventilator belongs between asymmetric intricate shape stampings where the drawing conditions are complicated. The blank surface below blankholder is often small while drawing intricate shape stampings, in comparing with the whole surface of the shape stamping. Plastic strain runs in whole area of drawing blank. Working parts of the punch, the die and the blankholder are often intricate and curved surfaces. Drawing of intricate shape stampings is more difficult than drawing the shapely shape stampings. During the drawing process of the intricate shape stamping, the unwished effects can appear like loss of the plastic deformation process stability, the presence of the various states of the stress in drawing material is typical.

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Local braking of the sheet-metal is necessary for uniform shaping and rigidity of the stamping. Various intensity of the braking is possible to get thanks to various technological inroads, which allow change a conditions about drawing-in the sheet-metal to die area. One of these possibilities is usement of draw beads with selected proportions, shapes, number and way of location in blankholder area along perimeter of the stamping. While drawing the left cover of ventilator it is suitable to use the draw bead in planar part of the stamping where the material moves with maximum velocity.

Suitable selection of locating, length and geometry of draw bead is question of many attempts. Utilisation of simulation software is useful in ahead-productive phase of production. Many programmes exist on base of finite elements method. For flat forming of the sheet-metal the software Dynaform 5.2 is it for example. Absolute advantage of the simulation is the fact that various shapes and proportions of the draw beads and its location in blankholder can be set and test without requirement of making expensive prototype of drawing apparatus parts.

2 STAMPING OF THE LEFT COVER OF VENTILATOR

The left cover of ventilator is intricate shape stamping made from deep-drawing sheet-metal DC04 (Fig. 1 and 2). This stamping is a part of air line system of truck Tatra 815. The stamping is produced in firm Tawesco, Ltd., which is a daughter company of joint-stock company TATRA, Kopřivnice. During shape drawing operation at stampings often defects arises – secondary wrinkling and crack in critical place of stamping. Both introduced defects make the cover of ventilator impossible for its correct function. These defects in production representative scrap which as high as 10 %.

Fig. 1 The left cover of ventilator

Fig. 2 The left cover of ventilator with crack in critical place

For production of ventilator left cover the steel DC04 (11 305.21) is used. The material is killed, non ageing, with very good properties for deep drawing. During its working the anisotropy of mechanical properties must be taken into account. Sheet-metal from steel DC04 is usually delivered recrystallizationaly annealed and additionally light cold re-rolled (marking .21 after numerical steel symbol).

Like initial blank the thin sheet-metal in plates with dimensions (0,9 × 1000 – 2000) mm ČSN 42 6312.32 from steel DC04 is used. Drawing of this stamping is carried out at crank presses PKZZ I 315 of German firm ERFURT, or at drawing crank presses LKT 250-A (firm Šmeral, Czech Republic). Anually about 2500 pieces are produced, correct number depends at number of ordered trucks.

3 ADVANTAGES OF DRAW BEADS UTILISATION

The way of braking by the draw beads belongs between most effective ways, how braking and escalate radial tension stress in needed range can be regulated. Draw bead is actually protrusion made in the blankholder for purpose of shaping material braking. It locals only on places, where escalation an intensity of sheet-metal braking is desirable.

Utilisation of draw beads allows:

- to magnify the gripping of the flange of the formed sheet-metal and by that to heighten the braking of material flow during sheet-metal drawing,
- to heighten the acceptable range of the blankholder pressure,
- to regulate the displacing of sheet-metal drawing in curve and in straight parts of the die drawing edge,
- to magnify purposely braking of displaced material on particular places by more draw beads,
- in some events to reduce the quality of surface finishing of the die and the blankholder of the drawing tool,
- to stabilize the big intricate stampings drawing and to take away arising of secondary wrinkling,
- to reduce the tools wear (of the blankholder and the die).

4 Draw beads shapes, dimensions and location of in blankholder

Suitable location of the draw beads in the blankholder is a question of experiences. The literature mentions the distance of the draw beads 20 mm to 30 mm from die drawing edge, in the event of larger number of the draw beads in sequence, a distance 25 mm to 35 mm preserves [2]. Optimal location of draw beads is in straight part of the contour of the drawing edge. Draw beads use to be 5 mm to 10 mm wide and 1,2 mm to 5 mm high according to the size and shape of the stamping and thickness of the drawn sheet-metal [3].

For the most effective result of draw beads utilisation, the most suitable geometrical profile and proportion is cecessary to be found. The intensity of sheet-metal braking in blankholder depends on many parameters like:

- radius of the draw bead, radius between vertical side of the draw bead and die too,
- total angle of wrap (draw bead radius, radius between vertical side of the draw bead and die, radius of drawing edge), everything in dependence on draw bead height,
- thickness and mechanical properties of drawn material,
- number of the draw beads.

At unsuitable choice of draw bead profile geometry (radius, height etc.) and draw bead location the stamping drawability gets worse markedly. Tension stresses can heighten suddenly, it evocates cracking of sheet-metal near drawing edge. The draw bead must not be too high, so as the metal not strengthens so much by cold strain. High draw bead during sinking to plane blank can evocate waviness of material, which cannot be additionally cleared off. So utilisation of several low draw beads in sequence is more preferable than one high draw bead.

5 SIMULATION OF DRAWING PROCESS OF THE STAMPING WITH THE AID OF THE DRAW BEAD

5.1 Suitable place for location of draw bead at drawing of the left cover of ventilator

For follow-up the influence of the draw bead upon drawing process of chosen stamping, first this draw bead must be defined on selected part of drawing tool. It was proposed for drawing simulation of the left cover of ventilator, that the draw bead will be situated on upper part of the drawing tool – in the blankholder and it will be located into the area, where drawing-in of material proceeds by maximum velocity (Fig. 3) and it is necessary to brake it, so in the planar part of the stamping. The location of draw bead can be defined by line which can be located on the blankholder model in

CATIA V5 software or directly in Dynaform 5.2 software. This line presents the lengthwise axis of the draw bead.

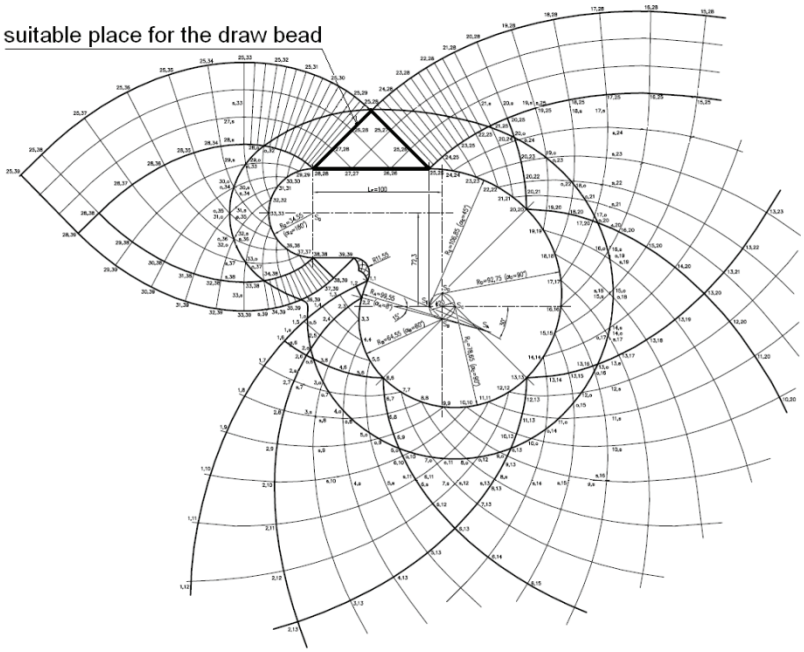

Fig. 3 Network of the maximum shear stress trajectories with marked place of the fastest flow of material into the die

5.2 Preparation of the stamping drawing process simulation with the use of the draw bead

It is necessary to create the element network (it is needed for analysis) on the blankholder model by meshing form „Tool Mesh, Connected“. The size of the elements of the blankholder (and other tools – punch and die) affects the final shape of the stamping, but accuracy of the analysis the size does not affect. For this case, the elements size was chosen 10. Than it is useful to check the mesh, firstly check of the normals direction of separate model elements („Auto Plate Normal“, „Plate Normal“), which must have the same direction on all elements, check of continuity of model boundary line („Boundary Display“) and check of double and overlap model elements („Overlap Element“). Then the blankholder model with the draw bead axis is complete and it is possible to work with it.

On blankholder model prepared like this the draw bead can be defined. In main offer „Tools“, the other offer „Draw Bead“ is chosen. In displayed table the name of draw bead and its colour can be chosen. Because no draw bead is here defined yet, work on the new draw bead starts by choosing the button „New“. „Draw Bead Properties“ table allows to set up other properties of the draw bead – static friction coefficient, dynamic friction coefficient, draw bead depth, start and finish of the draw bead action in drawing process etc.

The selection of the draw bead on blankholder model can be carried out with the use of line („line“) or points and nodes („point/node“). As soon as the selection of prepared line is done by one of these two alternatives and the selection confirms (OK), the selected area will be marked by such colour, what was chosen at the beginning. The final draw bead on blankholder model is seen on Fig. 4.

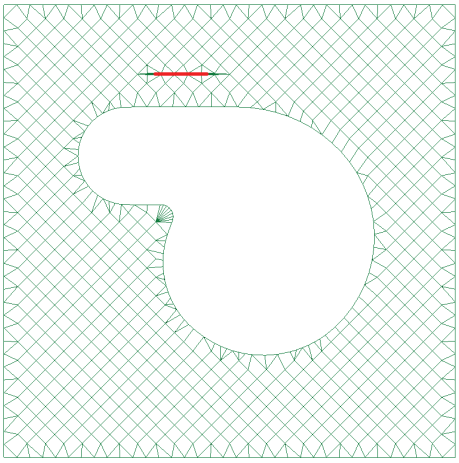

Fig. 4 Defined draw bead at the blankholder model with elements network

Then the geometry of the draw bead must be selected. The right selection of the geometry is very important and difficult act, everything is question of many attempts. That draw bead, which would be suitable for braking the stamping, misses find out at first mostly. Many calculations and analyses must be done, then an optimal draw bead for existing stamping will be chosen.

After selection the offer „Drawbead Force“ it is possible to choose the offer „Auto Load Curve“, where in „Draw Bead Force Prediction“ table the type and parameters of draw bead („Draw Bead Type and Parameters“), sheet parameters („Sheet Parameters“), material parameters („Material Parameters“) and others miscellaneous parameters („Miscellaneous Parameters“) can be chosen.

Three types of draw beads shapes are for a choice – rectangular („Rectangular“), semi-circular („Semi-circular“) and edge („Edge“). The rectangular shape of the draw bead was chosen, where the various parameters of geometry of the draw bead were gradually chosen, the draw bead default geometry in Dynaform 5.2 software is on Fig. 5.

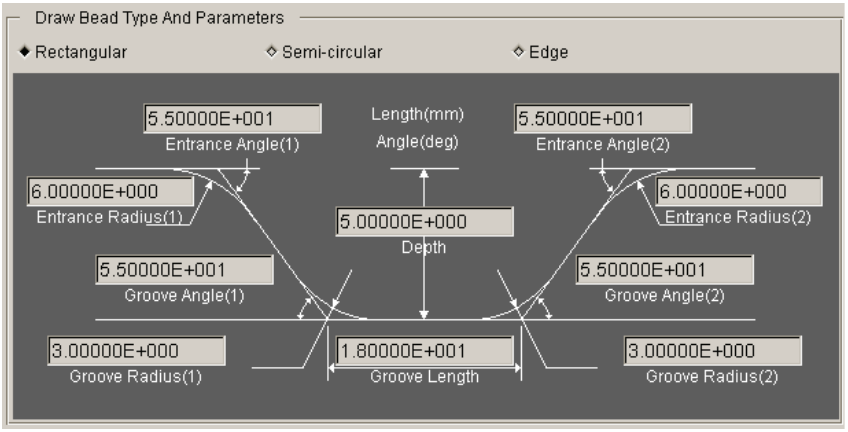

Fig. 5 Draw bead default geometry in Dynaform 5.2 software

After setting all parameters of the draw bead, needed for computation, it is possible to approach to computation and simulation of drawing process of the left cover of ventilator. Simulation of drawing process of this stamping was carried out with the use of Dynaform 5.2 software at the Department of Mechanical Technology of Faculty of Mechanical Engineering of VŠB-Technical University of Ostrava on computer with operation system Windows XP. Saved data were worked up in program LS-DYNA Jobs Submitter 2.2 than, which is part of Dynaform 5.2 software. Simulation

results can be seen in program ETA/Post-Proccessor 1.0, where is possible to play back the whole drawing process simulation like animation or display this simulation separately by steps with all information about drawing simulation course.

6 RESULTS OF DEEP-DRAWING SIMULATION WITHOUT USE OF DRAW BEAD

This chapter with results of deep-drawing simulation of the left cover of ventilator without use of draw bead, is here for a possibility to compare the result with results of deep-drawing simulation with the use of draw bead with various length. The analysis of stamping thickness at stamping drawn from optimal blank from steel DC04 without use of draw bead in drawing process is on Fig. 6.

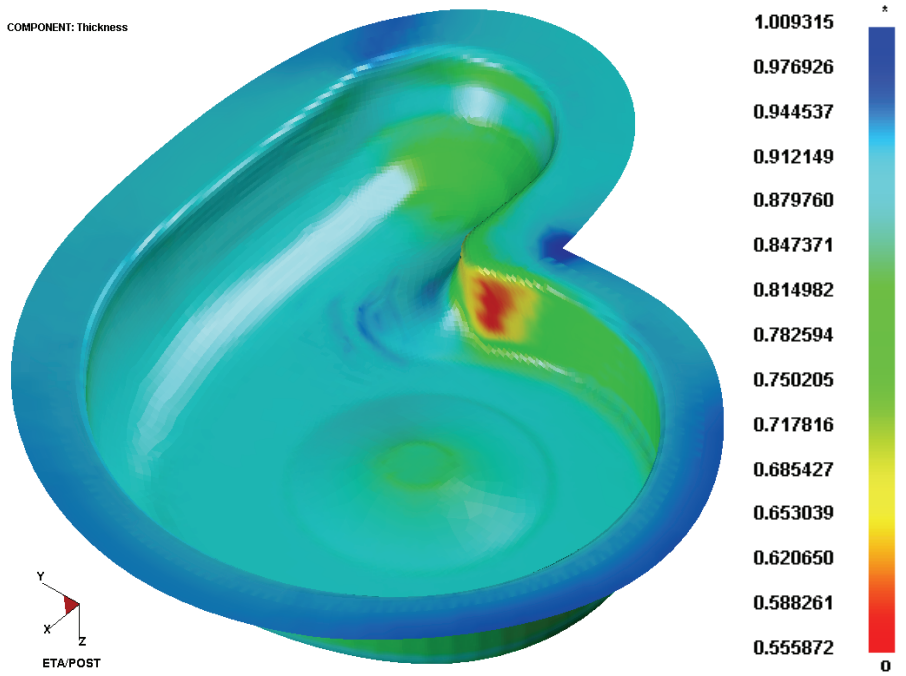

Fig. 6 Analysis of stamping thickness at stamping drawn from optimal blank from steel DC04 without use of draw bead in drawing process

The thickness of sheet-metal moves about value 0,9 mm on most of stamping surface. Thinning occurs here and there, for example the bottom of stamping is gently thinned on value of thickness about 0,85 mm. The lowest value of thickness of sheet-metal appears nearly the place with the minimal radius, where the crack appears very often. Thickness of the stamping is 0,556 mm here in critical place, it means, the thinning of sheet-metal is about 38,2 %.

On the surface of the left cover of ventilator the second defect, observed in production, appears – secondary wrinkling. The material crams on value of thickness 0,944 mm here. This defect lowers the quality of the stamping from point of view of look. Expressive wave of sheet-metal can be seen in part of production, which hinders to right function of the ventilator – this defect comes out by rubbing of shovels of the ventilator about wavy cover than.

7 RESULTS OF DEEP-DRAWING SIMULATION WITH THE USE OF DRAW BEAD

For analysis of the usability of the draw bead application in drawing process of the left cover of ventilator the geometry of the draw bead, which is shown in tab. 1, was selected. The distance of lengthwise axis of the draw bead from inside edge of the blankholder was chosen 17 mm for compu-

tation. The length of alone draw bead was gradually shortened in separated computations. The influence of these draw beads with various lengths on thinning of the sheet-metal in critical place and on creation of wrinkles at the stamping bottom was evaluated.

Tab. 1 Draw bead geometry selected at drawing of the left cover of ventilator

Draw bead depth	Entrance angle	Entrance radius	Groove length	Groove angle	Groove radius
5 mm	55 °	6 mm	18 mm	55 °	3 mm

The results of simulation of the left cover of ventilator stamping drawing with the use of draw bead with various lengths are in detail described in chapters 7.1, 7.2 and 7.3 which follows. The analysis of thickness of stamping drawn from optimal blank from steel DC04 in program ETA/Post-Proccessor 1.0 was used for comparison of the draw bead various lengths effect in drawing process on separate stamping models.

7.1 Results of deep-drawing simulation with the use of draw bead with length 52 mm

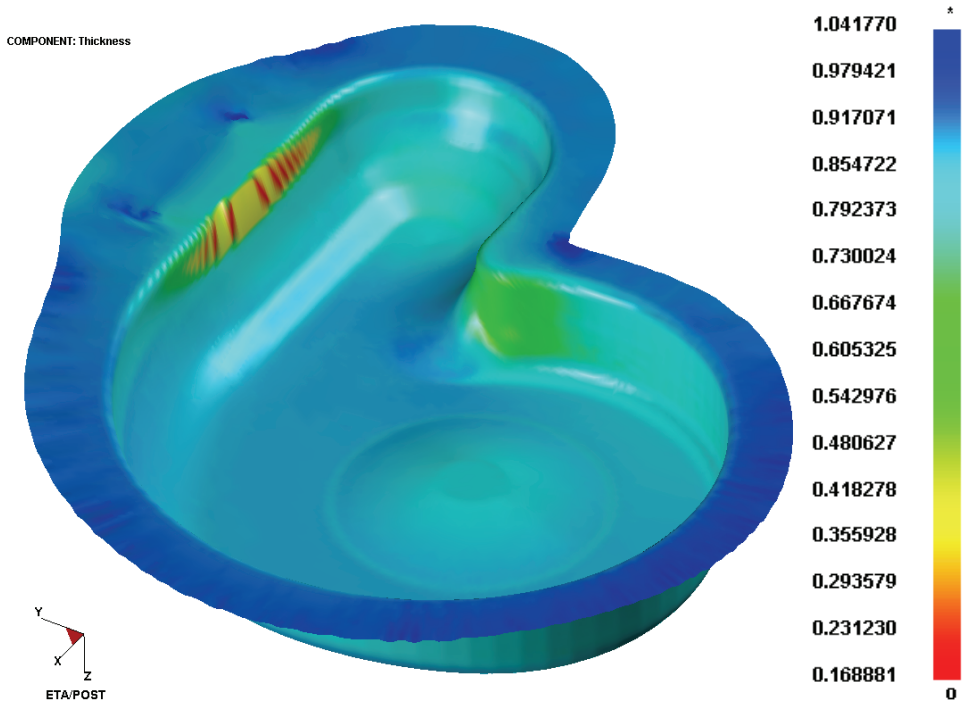

Fig. 7 Analysis of thickness of stamping drawn from optimal blank from steel DC04 with the use of draw bead with length 52 mm at drawing process

Thickness of sheet-metal after drawing with the use of draw bead moves under value 0,9 mm on most of stamping surface. The thickness of sheet-metal smalls in critical place as far as value 0,501 mm, this value is smaller about 10 % than in case of drawing of stamping without the use of draw bead. So it can be said, that at drawing with the use of draw bead with length 52 mm, the situation in critical place on stamping was not better. In the case of the second observed defect on stamping – secondary wrinkling on a surface of the left cover of ventilator, a little improvement arises, material is not almost wrinkled here, only enlargement of sheet-metal thickness on value 0,916 mm arises.

New is the defect, which did not appear in drawing simulation without the draw bead - creation of crack with length about 77 mm in planar part of the stamping. The stamping thickness lowers as far as on minimal value 0,169 mm here, which presents thinning of material just about 82 %. This large thinning of sheet-metal is non-permissible for stamping. With regard to this defect, the stamping made with draw bead with length 52 mm is unsatisfactory.

7.2 Results of deep-drawing simulation with the use of draw bead with length 31,2 mm

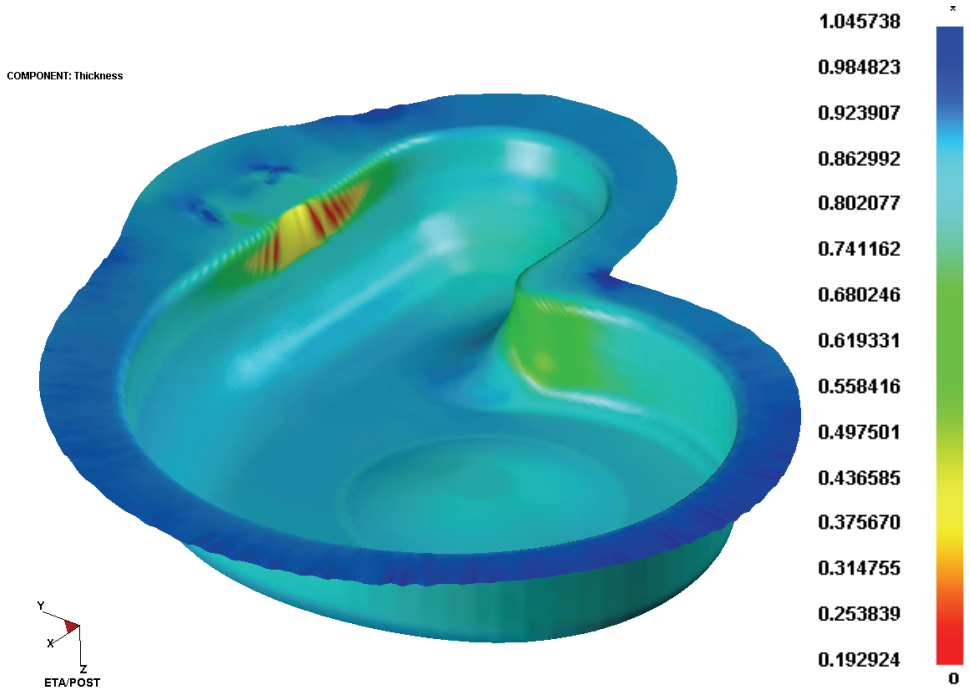

Fig. 8 Analysis of thickness of stamping drawn from optimal blank from steel DC04 with the use of draw bead with length 31,2 mm at drawing process

Drawing simulation of the stamping with the use of draw bead with length 31,2 mm make for similar results like previous case of drawing of the stamping with draw bead with length 52 mm, and it is both in critical place of the stamping, and in place of the wrinkling of sheet-metal on stamping bottom.

The shape of the crack, which appeared by action of draw bead, is similar, minimal value of thickness of sheet-metal moves about 0,193 mm here. Only the crack length is different, it is shorter in this case (about 55 mm). Though that, the thinning is too large in this place and the stamping made by drawing with the use of draw bead with length 31,2 mm is unusable.

7.3 Results of deep-drawing simulation with the use of draw bead with length 22,8 mm

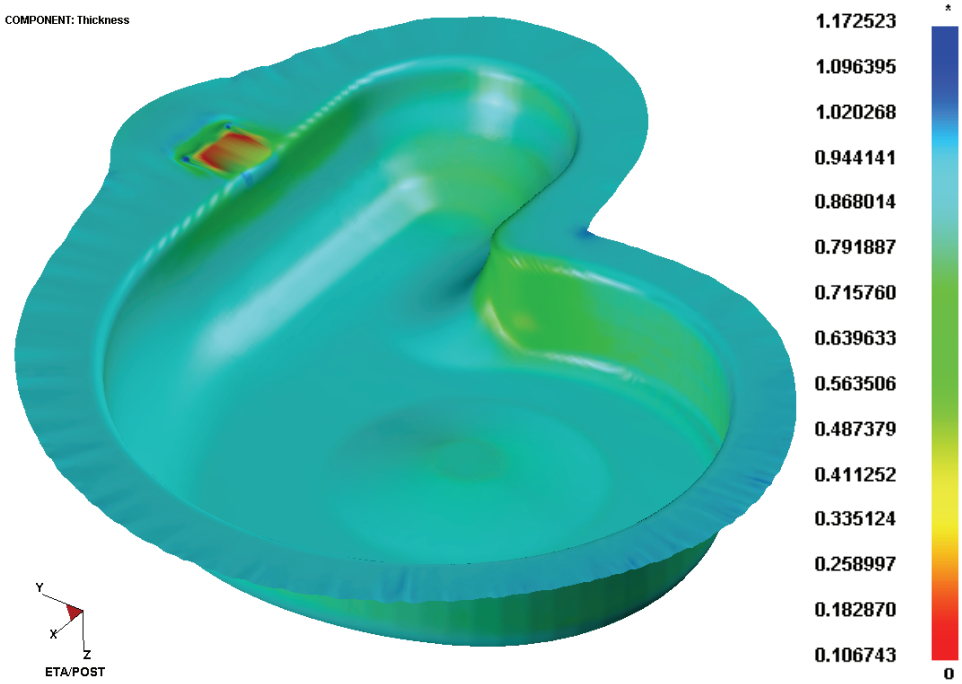

Fig. 9 Analysis of thickness of stamping drawn from optimal blank from steel DC04 with the use of draw bead with length 22,8 mm at drawing process

The drawing simulation of the stamping with the use of draw bead with the length 22,8 mm indicates the similar results like both previous cases of drawing the stamping with the use of draw beads with length 52 mm and 31,2 mm and this is both in critical place of the stamping and in place of the wrinkling of sheet-metal on stamping bottom. The wrinkling on stamping surface is actually vaguest here.

It is evident, in drawing the stamping with the use of draw bead with the length 22,8 mm the situation was better, the crack in planar part of the stamping does not arise like at previous variants (see 7.1 and 7.2). The thickness of sheet-metal moves about value 0,75 mm under an edge in planar part of the stamping. The sheet-metal cracks on flange in area straightly under the draw bead in this case. This defect is unacceptable, because the material for flange is needed in this place, minimal 14 mm from inside edge of the stamping.

8 CONCLUSIONS

From the results of the computer simulation is evident, that many ways exists to final set up of the draw bead for drawing of the stampings. In the case of the stamping of the left cover of ventilator a lot of computations and simulations were carried out, but no one of them does not prove such satisfactory results like the simulation of the drawing of the stamping from optimal blank from steel DC04 without draw bead (see 6).

It is possible to take a note, that in all cases of the results the large lessening of wrinkling on the bottom of the stamping under the critical place arises. The area of critical place is similar in all cases, the variants of the draw bead had only imperceptible influence on drawing process and arising

of the crack. The arising of the crack in planar part of the stamping (see 7.1, 7.2) or in area under the draw bead (see 7.3) is disadvantage.

The arising of the crack in planar part of the stamping is unacceptable effect, which did not appear in drawing of the stamping without the use of the draw bead. In this concrete case, despite of definite advantage in area of lessening wrinkling on the bottom of the stamping, it would be more suitable to produce the stamping by deep-drawing without use of draw bead.

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