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# EXAMINATION OF THE SPRINGBACK PARAMETERS FOR AUTOMOTIVE BODYPART WITH FINITE ELEMENT SIMULATION

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**Abstract**- It is very important in terms of cost and time to correctly estimate and compensate for the springback during sheet metal forming. Experimental and analytical studies are available in the literature for the prediction of springback propagation. The multiplicity and diversity of the parameters that cause springback makes it difficult to analytical modeling of the springback. On the other hand, the development of finite element method package programs over the years has made the end-of-line method indispensable for industrial and academic work. However, the results obtained using the finite element simulation method should be verified by experimental results. In this study, the amount of springback was tried to be reduced by the application of the draw beads which is used in sheet metal die industry in the process of deep drawing of the vehicle body part having a tensile strength value of 270 MPa. Finite element simulation results and the results obtained in the real environment has been validated. In addition to the work done, the effects of material thickness and modulus of elasticity on the amount of springback were investigated.

**Index terms**- Springback, springback compensation algorithm, finite element analysis, deep drawing proces, elasticity module, material thickness, draw beads

## I. INTRODUCTION

Many products in the automotive industry are produced with the deep drawing process. When the tools are released after the forming stage, the product springs back due to the action of internal stresses. Because the geometric tolerances can be tight for sheet metal products, this shape deviation can be unacceptable. In many cases springback compensation is needed: the tools of the deep drawing process are changed so, that the product becomes geometrically accurate.

Even when the product design has been optimised, and the deep drawing process has been set up carefully, springback compensation has to be carried out to improve the geometrical accuracy of many products. To speed up the manual springback compensation process, the use of finite elements calculations instead of real prototype tools is currently tested in the industry. Several completely automatic springback compensation algorithms have been reported and tested in scientific literature.

Deep drawing is one of the most common manufacturing processes in the automotive industry. Most deep drawn products are structural parts of the car body, such as door panels, engine hoods and side impact protection bars. For these products, the geometrical tolerances are tight, and the tools are expensive. Therefore, accurate process planning is essential.

There have been major improvements in deep drawing simulations, and we are now able to predict the shape of the final product, its internal stresses and process forces. Upon unloading after the forming stage, the product springs back due to internal stresses. For car body panels, these springback deformations can be large, up to several millimetres.

## II. EVALUATION OF SPRINGBACK IN THE DEEP DRAWING PROCESS

### The deep drawing process

In the deep drawing process, shown in picture 1, a product is formed from a flat sheet, the blank, by pressing it into a die. The punch reflects the desired shape of the product, the die cavity shape is pressing it into a die. The punch reflects the desired shape of the product, the die cavity shape is produced by ‘offsetting’ the punch surface. The sheet pressed onto the die by the blankholder

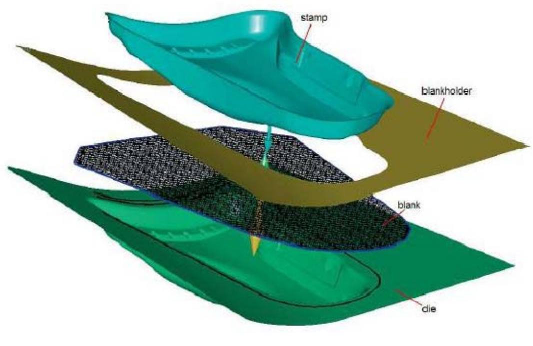


**Figure 1. The deep drawing process**

This blankholder is essential for controlling the manufacturing process. The force on the blankholder affects the way the blank slides into the die, and consequently, how the product is stretched. When the affects the way the blank slides into the die, and consequently, how the product is stretched. When the blankholder is pressed too hard, the blank will not flow into the cavity and the metal is stretched only. That can cause the blank to tear apart. When the blankholder-force is too small, the product will be formed mainly by bending. As a result, springback effects will be larger and the product could even be wrinkled. Lubrication and drawbeads in the blankholder are also used to control the material flow into the die. Modelling the friction between the sheet, die, punch and blankholder is a vital part of a simulation. When the product is finally taken out of the die, it will springback because of internal stresses.

The Autoform finite elements deep drawing simulation

A deep drawing simulation consists of 4 basic steps:
-Conversion of CAD data into a FE mesh and creation of punch, die, blankholder and blank meshes
-Setting up the stamping process
-Performing the nonlinear FE calculation
-Evaluation

Generation of the tool meshes

The geometry of the product is described in a CAD file. Most sheet-formed products are modelled with surface representation. The geometry is then represented as a set of connected complex surfaces. For a FE calculation, the surfaces need to be approximated by a set of (shell) elements. The geometry module can automatically generate a product mesh. To construct a punch, the geometry needs to be extended, as shown in picture 2 below. The product is fixed to a surface with curves. An algorithm calculates a surface in between those curves, the ‘die-addendum’

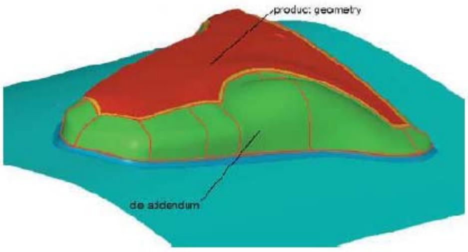

**Figure 2 Construction of a punch**

### Setting up the stamping process

Here, the definition is given of the interaction between the tools and the blank. Normally the stamping process is split up in phases. First the blank is positioned on the die: the blankholder moves down, pressing the blank onto the die, as shown below (die in green, blankholder in blue and blank translucent white) In the second phase the punch moves down and forms the product. Finally the blankholder, punch and die are taken away, allowing the product to spring back (phase 3)

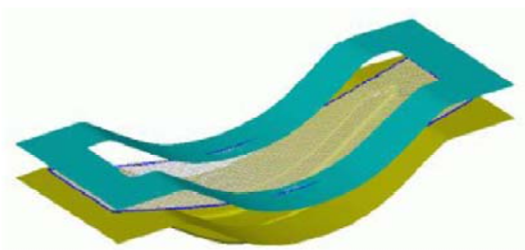

**Figure 3 First process step: closing of the blankholder**

### Performing the calculation

The deep drawing process is simulated using a nonlinear FE solver. PAM-stamp has an explicit solver for the blankholder closing and deep drawing phases, and switches to implicit for the springback calculation. The calculation is generally very expensive, so advanced algorithms are used to speed up the process.

### Evaluation

The results of the FE calculation can be stored in any time step during the process, but for the springback compensation, the last two steps are most important: the deformed blank with the tools closed, and the blank after the springback calculation. The two blanks are shown for an example product below. The green mesh is the deep drawn blank. The green mesh springback compensation, the last two steps are most important: the deformed blank with the tools closed, and the blank after the springback calculation. The two blanks are shown for an example product below. The green mesh is the deep drawn blank (reference) and the red mesh is the deep drawn blank after springback.

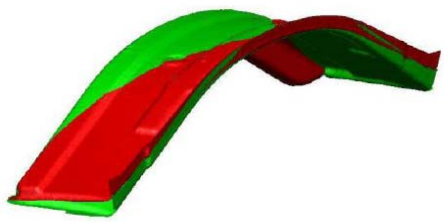

**Figure 4 The blank mesh before (green) and after (red) springback**

## III. DRAWBEADS IN SHEET METAL FORMING

Insomesheet metal bendingoperations, thepressureplateforcerequiredto be appliedtothesheet is muchhigherthanthepresscapacity, orthesheet is damaged in highforceapplications. Inordertoavoidsuchsituations, drawbeads is widelyused. Inthedrawbeads, thesheet is compressedregionallyundertheforce of thelowpressureplateandthebackspring is intendedto be reduced

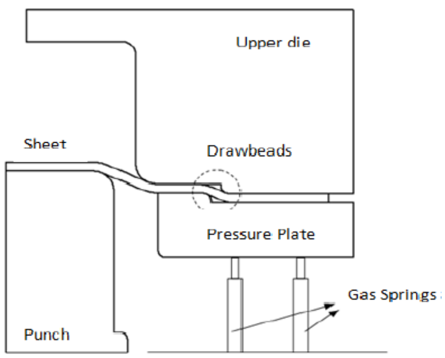


**Figure 5 Schematic view of the die using the drawbeads**

The drawbeads extends along the die surface perpendicular to the material axis. Sheet is pressed using drawbeads.Tensile stress occurs along the sheet axis and springback is reduced.

## IV. VEHICLE BODY PART

Thevehicle body part has a materialthickness of 0.5 mm and a tensile strength of 270 MPa. Thispart is producedwith 6differentdies.Theprocesses of thediesaredeepdrawing, cuttingandpierce, flange ,pierce , cam pierce-pierce, cam flange.

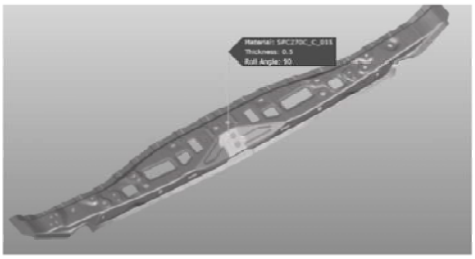

**Figure 6The vehicle body part**

SPC270C_C_055 steel material was used in the experiments. The sheet is 230 mm wide and 1300 mm long.

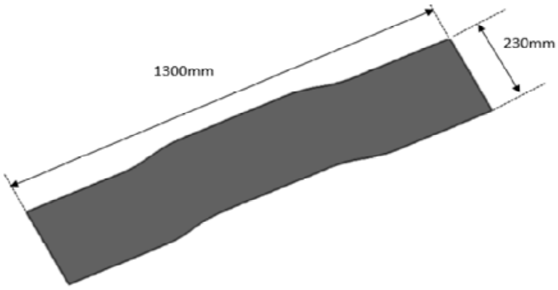


**Figure 7 Material size**

**Table 1 Sheet material properties**

| g/cm3 | E(Mpa) | v | G0(Mpa) | $R_m$(Mpa) |
|---|---|---|---|---|
| 7.8 | 206000 | 0.3 | 190 | 340.3 |

With the help of partial Cad data, in the Catia V5 program; punch,part blankholder and fixed upper die surfaces were formed for the deep drawing process. The created surfaces were imported in the Autoform program and simulated.

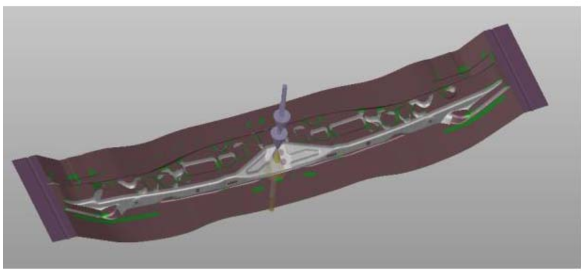

**Figure 8 Deep drawing process simulation**

In the deep drawing process, a highly used drawbead is used in the sector in order to control material flow and springback appropriately

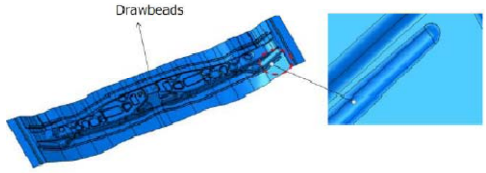


**Figure 9 Drawbeads**

Simulation studies after using with finite element simulation without drawbeads are shown in the following images.3 different drawbeads radius are used.Drawbeads radius are designed as 3, 4 and 7 respectively.

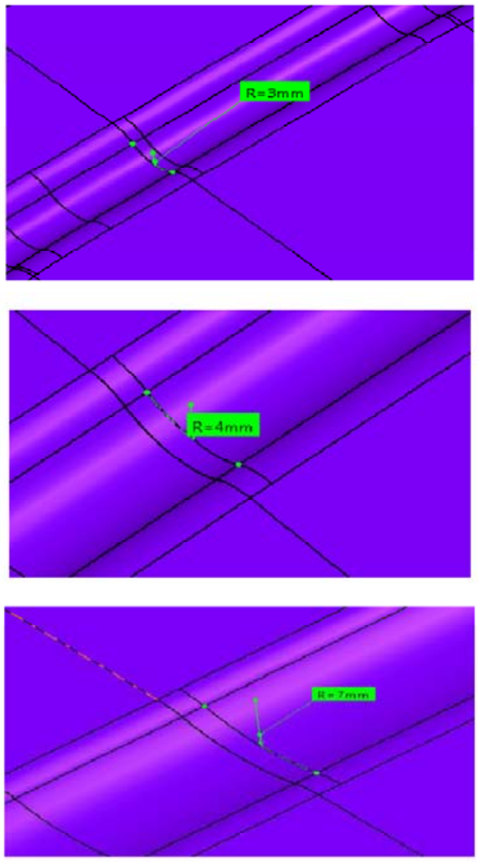


**Figure 10 The radius of the determined drawbeads**

**Table 2 Finite element simulation results**

| | Simulationresults(mm) |
|---|---|
| Withoutdrawbeads | 0.284 |
| Drawbeadsradius(R3) | 0.58 |
| Drawbeadsradius(R4) | 0.3 |
| Drawbeadsradius(R7) | 1.05 |

According to the results of the finite element simulation results, it was decided that the simulation of the drawbeads radius 4 on the die surfaces is suitable for springback. The least springback was obtained without using the drawbeads, but the sheet material was not sufficiently regressed in the deep drawing process.

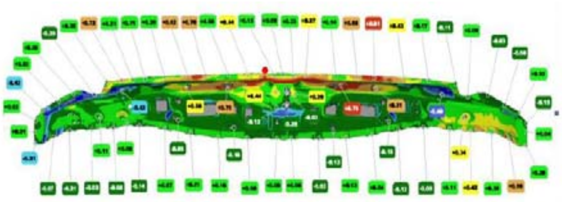

**Figure 11 Part produced in real environment**

**Table 3 Comparison of simulation results with reel results**

| | Simulationresults | Reel results |
|---|---|---|
| Results | 0.3 | 0.2 |

Using the square root mean square root method, the results of the finite element analysis were compared to the experimental results. The approximation of square root mean square root method to zero indicates the consistency of the finite element analysis estimates.

$$\sqrt{\frac{1}{n}\sum_{i}^{n}(x_i - y_i)^2}$$

The square root mean square root method:0.08

## Effect of material thickness on springback behaviour

**Table 4 Effect of material thickness on springback**

| | Material thickness(mm) | | | | |
|---|---|---|---|---|---|
| | t:0.5 | t:0.9 | t:1.3 | t:1.8 | t:2.2 |
| Springback results with finite element simulation | 0.11 | 0.15 | 0.165 | 0.36 | 0.40 |

## Effect of elasticity module on springback behaviour

**Table 5 Effect of elasticity module on springback**

| | Elastisity modüle(Mpa) | | | | |
|---|---|---|---|---|---|
| | 206000 | 210000 | 215000 | 220000 | 225000 |
| Springback results with finite element simulation | 0.11 | 0.09 | 0.09 | 0.1 | 1.7 |

## CONCLUSION

In the finite element analysis for Vehicle Body Part, The least springback was obtained without using the drawbeads, but the sheet material was not sufficiently regressed in the deep drawing process.So it was seen that drawbeads radius is 4 mm and it is suitable for the minimum spring behavior.
When examined the effects of material thickness and elasticity modulus on the springback,It was observed that the amount of springback increased as the material thickness increased. At the same time,as the modulus of elasticity increased, the amount of springback did not change first and then decreased.

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