PARAMETERS AFFECTING SPRINGBACK FOR VEHICLE BODY PART 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.Springback is the geometric change made to a part at the end of the forming process when the part has been released from the forces of the forming tool. Upon completion of sheet metal forming, deep-drawn and stretch-drawn parts spring back and thereby affect the dimensional accuracy of a finished part. The final form of a part is changed by springback, which makes it difficult to produce the part. As a result, the manufacturing industry is faced with some practical problems: Firstly, prediction of the final part geometry after springback and secondly, appropriate tools must be designed to compensate for these effects. In this study, the amount of springback was tried to be reduced by the application of the strainer bar 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.

Keywords – Spring Back, Spring Back Compensation Algorithm, Finite Element Analysis, Deep Drawing Proces, Elasticity Module, Material Thickness, Drawbeads

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. DEEP DRAWING PROCESS

The deep drawing process

Deep drawing is one of the most widely used processes in sheet metal forming. Apart from its use in many other sectors, it is applied in the automotive industry for the manufacturing of car body parts.

Process definition:

The deep drawing process is a forming process which occurs under a combination of tensile and compressive conditions. A flat sheet metal blank is formed into a hollow body open on one side or a hollow body is formed into a hollow body with a smaller cross-section.

Deep drawing processes are divided into three types:
Deep drawing with tools
Deep drawing with active means
Deep drawing with active energy

In the automotive industry, deep drawing is usually carried out using rigid tools

The figure illustrates the deep drawing process. Therigidtoolsconsist of a punch, dieandbinder. Indeepdrawing, theplateholderclosesafterthe metal sheetblank has beeninserted.

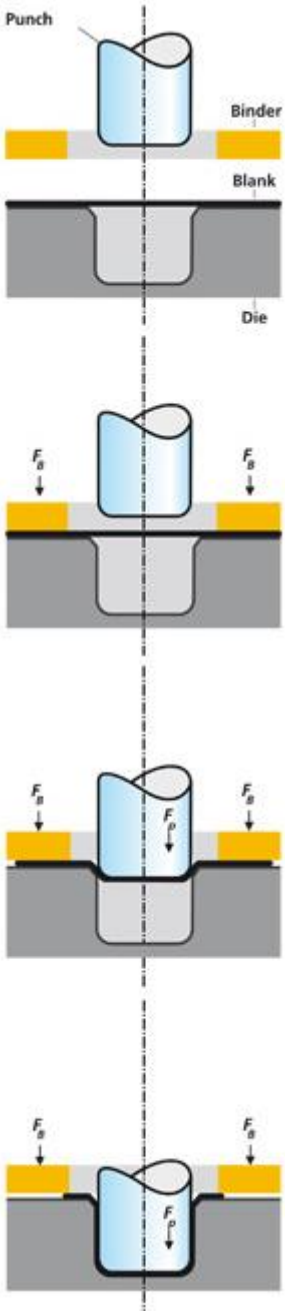

Figure 1Illustration of the deep drawing process

Next the sheet is clamped between the die and the binder. This process slows down the flow of the sheet while it is being drawn and there by prevents wrinkles from formingunder the binder. The punch stretches the sheet over the dieradiusandforms it in thedie. Theamount of punchforcenecessaryforforming is here by continually increased upto the lowerdead center of thepunch.

Whereas in puredeepdrawingthere is noreduction of sheet metal thickness, forming is achieved in stretchformingpurely as a result of a decrease in sheet metal thickness. Stretchforming is extensivelyusedfortheforming of onlyslightlycurvedpartswithlowdepth of draw (e.g. roofs, doors).

Whendrawingcomplex car body parts in practice, there is usually a combination of stretchanddeepdrawinginvolved. It is necessarythatthesheet metal is stretched as well as possiblewithoutreachingthematerial'slimits

III. DRAWBEADS IN SHEET METAL FORMING

In some sheet metal bending operations, the pressure plate forcerequiredto be applied to the sheet is much higher than the presscapacity, or the sheet is damaged in high force applications. In order to avoid suchsituations, draw beads is widelyused. In the draw beads, the sheet is compressed regionally under theforce of thelow pressure plate and thebackspring is intendedto be reduced

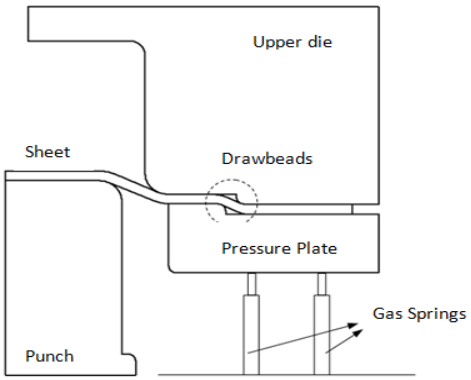

Figure 5 Schematic view of the die using the drawbeads

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 0.8 mm and a tensile strength of 270 MPa. Thispart is producedwith 4 differentdies.Theprocesses of thediesaredeepdrawing, cuttingandbending.

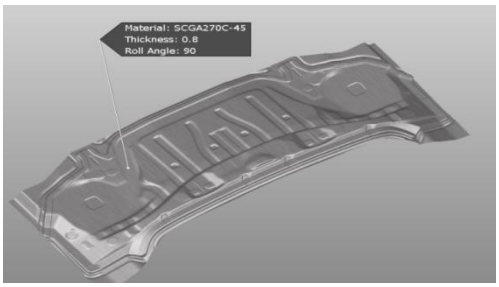

Figure2 The vehicle body part

SCGA270C-45 steel material was used in the experiments. The sheet is 470 mm wide and 1340 mm long.

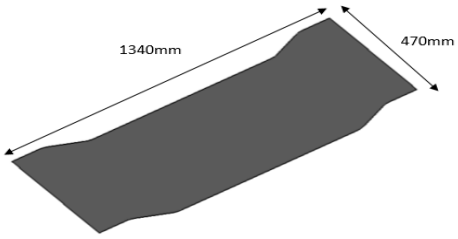

Figure 3 Material size

g/cm3	E(Mpa)	ν	G0(Mpa)	R_m(Mpa)
7,8	210000	0.3	150	271.3

Table 1 Sheet material properties

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.

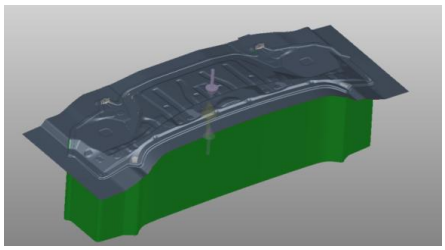

Figure 4 Deep drawing process simulation

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

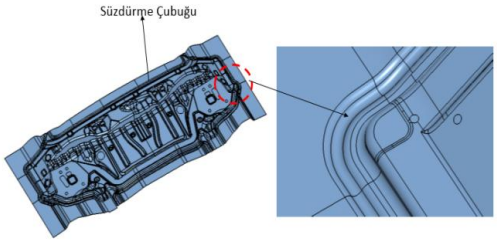

Figure 5 Drawbeads

Simulation studies after using with finite element simulation without drawbeads are shown in the following images.2 different drawbeads radius are used.Drawbeads radius are designed as 4 and 7.5 respectively. The radius of the determined drawbeads are based on the die design experiences.

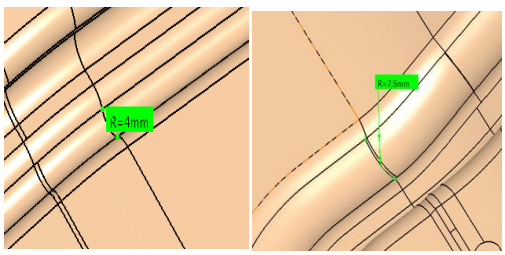

Figure 6 The radius of the determined drawbeads

	Simulation results(mm)
Without drawbeads	0.11
Drawbeads radius(R4)	0.13
Drawbeads radius(R7.5)	0.3

Table 2 Finite element simulation results

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 7 Part produced in real environment

	Simulationresults	Reel results
Results	0.13	0.30

Table 3 Comparison of simulation results with reel results

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:0.11

Effect of material thickness on springback behavior

	Material thickness(mm)				
	t:0.8	t:1.2	t:1.6	t:2.0	t:2.4
Results	0.11	0.17	0.22	0.23	0.27

Table 4 Effect of material thickness on springback

Effect of elasticity module on springback behavior

	Elasticity module (Mpa)				
	210000	215000	220000	225000	230000
Results	0.154	0.154	0.154	0.154	0.18

Table 5 Effect of elasticity module on springback

V. CONCLUSION

In the finite element analysis for Vehicle Body Part, it was seen that drawbeads radius is 3 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.

NOMENCLATURE

E	Elasticity Module
ρ	Density
v	Poission Ratio
G_0	Yield Strength
R_m	Tensile strength
t	Thickness
x_i	Test Result
y_i	Simülation Result
n	total number of measurements

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