The International Journal of Engineering and Science (IJES)
|| Volume || 7 || Issue || 11 Ver.I || Pages || PP 31-35 || 2018 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

Springback Prediction Of Formed Tailor Welded Blanks

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ABSTRACT

Springback prediction is necessary when applying tailor welded blanks to automotive parts. The accuracy of springback prediction depends on the material model, which describes the deformation behavior of steel sheets. In each sheet metal forming process, the steels, in this case tailor welded blanks exhibit springback effect, which is governed by strain recovery of material after load removal. In this work, numerical simulation of a U-shape forming was performed on tailor welded steel strips. Two steels with different strengths were taken into account. High strength steels exhibit more distinct springback effect than steels used for deep drawing. This is mainly due to their higher values of Yield strength. Springback is related to many parameters like forming conditions, tool geometry and material properties such as sheet thickness, yield stress, work hardening, strain rate sensitivity and elasticity modulus.

In this contribution, springback effect of U - shaped part made of tailor welded strip was investigated. Two materials were used to make tailor welded strip in numerical simulation – double phase DP1200 steel and deep drawing quality DC04 steel.

KEYWORDS *–tailor welded blank, springback prediction, sheet metal forming, numerical simulation*

Date of Submission: 05-11-2018 Date of acceptance: 19-11-2018

I. INTRODUCTION

Recently, in the automotive industry many companies are trying to form the body panels in a single stamping operation while keeping material costs and the scrap down by using tailor-welded blanks (Fig.1). A tailor-welded blank consists of two or more sheets that have been welded together in a single plane prior to forming. And the sheets joined by welding can be identical, or they can have different thickness, mechanical properties or surface coatings. Various welding processes, i.e. laser welding, mash welding, electron-beam welding or induction welding, can join them. [1]

Many studies presented a wide range of information about the formability and failure patterns of welded blanks. A wide range of information about the formability and failure patterns of tailor-welded blanks and the springback of non-welded sheet metal parts has been presented. However, the springback characteristics of tailor-welded blanks have hardly been found [2-5]

Springback involves small strains, similar in magnitude to other elastic deformation of metals. As such, it was formerly considered a simple phenomenon relative to the large-strain deformation required for forming. Nonetheless, appreciation for the subtleties of springback in two areas has grown dramatically. In particular, high precision is needed for the large strain plastic response that directly affects the stresses in the body before removal of external forces. The unloading, while nominally linear elastic for most cases, it can show remarkable departures from an ideal linear law. [6-9]

A common countermeasure against springback is to design forming dies that anticipate springback compensation, but the compensation amount is a difficult question even for experienced die designers, and field practice is largely based on trial and error. Nowadays it is possible to use finite element analysis for more accurate prediction of springback. [9-12]

Springback phenomenon is influenced by process conditions (friction coefficient, forming speed, etc.), geometry (punch, die, blank geometry, etc.), used material (Yield Strength, anisotropy, strain, hardening, etc.) and numerical variables (type, size and number of elements, yield surface model, hardening model, etc.).

Fig. 1 Tailor welded blank with formed door panel

In this contribution, springback effect on tailor welded blanks was investigated. Two process variables, blank holder force (BHF) and friction coefficient and their effect on the springback of U- shaped part was evaluated. Used tool and tailor welded blank in numerical forming simulation of U- shaped part are shown in Fig. 2. Mild steel DC04 and double phase steel DP1200 were used in the sheet metal forming simulation. Mechanical properties of the investigated steels were obtained from the material library of the FEA simulation software.

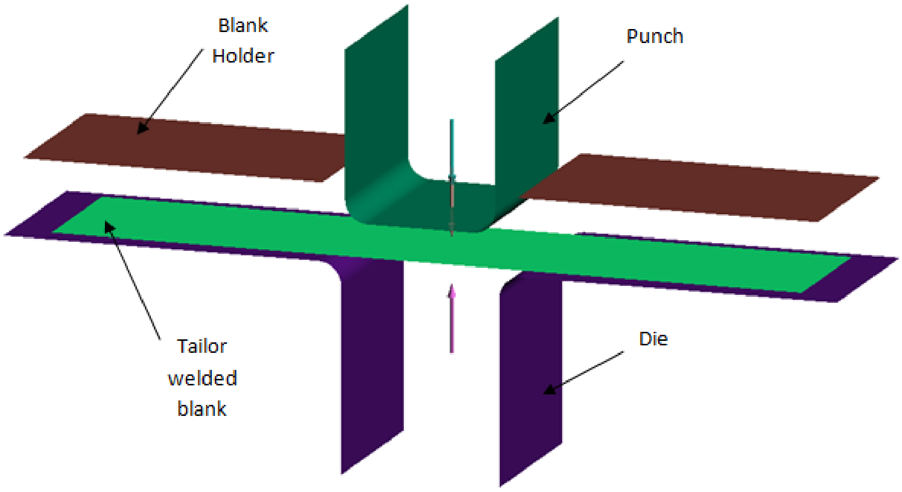
II. PROCESS CONDITIONS, MATERIAL PROPERTIES, GEOMETRY USED IN SIMULATION

In this contribution springback effect of U – Shaped part made of tailor welded blank is evaluated in numerical simulation. In FE analysis it is important to input correct process, geometrical, numerical and material variables. Variables in forming process were Blank holding pressure and coefficient of friction (Tab.1). Two steels - DC04 and DP1200 were examined for springback using CAE software. Sheet thickness for both materials was 1 mm. Material properties of these steels are shown in Table 2. Forming velocity was set to 1 mm/s for the punch. Rectangular shaped tailor welded blank which dimensions are 200 mm by 40 mm was used. One half of blank was made of DC04 steel, second half was made of DP1200 steel. These steels were welded in the middle of the blank.

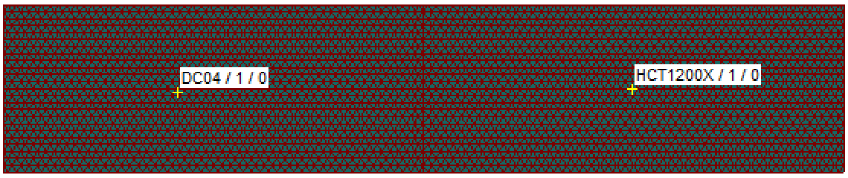
Table 1 Variables in forming process of U – shaped part made of tailor welded blank

Tool	**Coefficient of friction no. 1 [-]**	**Coefficient of friction no. 2 [-]**	**Blank holding pressure no.1 [MPa]**	**Blank holding pressure no.2 [MPa]**
Tool with blank holder	0.05	0.25	1.8	2.8

Tool geometry is also important factor in sheet metal forming. Imported CAD model of tool, used in simulation is shown in Figure 2. Radius used for punch and die was 6 mm. Forming depth was set to 40 mm. Width of the U- shaped part was 40 mm. Forming clearance was 1.2 mm in both forming tools. Accuracy of the numerical simulation was set to fine. With this setting, program automatically generates mesh parameters. Triangle elements were used in simulation. Initial element size was set to 2 mm with max. refinement level of 1. Radius penetration was set to 0.16; number of integration points was set by software to 11.



a) Bending tool with blank holder



b) Tailor welded blank with mesh applied

Fig. 2 CAD model of Tool used in simulation (a), tailor welded blank with mesh (b)

Table 2 Mechanical properties of selected steels

Material	**Yield strength σ_y [MPa]**	**Tensile strength σ_u [MPa]**	**Strain hardening exponent n [-]**	**Planar anisotropy coefficient R [-]**	**Poisson´s ratio V [-]**
DC04	167	303	0.211	1.650	0.3
DP1200 (HCT1200X)	1 173	1 401	0.068	0.940	0.3

III. SPRINGBACK SIMULATION OF FORMED TAILOR WELDED BLANK

In this current study, finite element simulation of forming U – shaped part made of tailor welded blank (Fig.3) was conducted. The Fig. 3 shows part formed in tool with blank holder a) before and b) after springback calculation, tailor welded blank consisted of DC04 (left side) and DP1200 (right side) steels welded in the middle. Blank holder pressure was set to 1.8 MPa, value of coefficient of friction f was 0.25.

For evaluation of the springback of the stamped part, opening angle of arm ß [°] of both sides of tailor welded blank was measured in cross section after springback calculation.

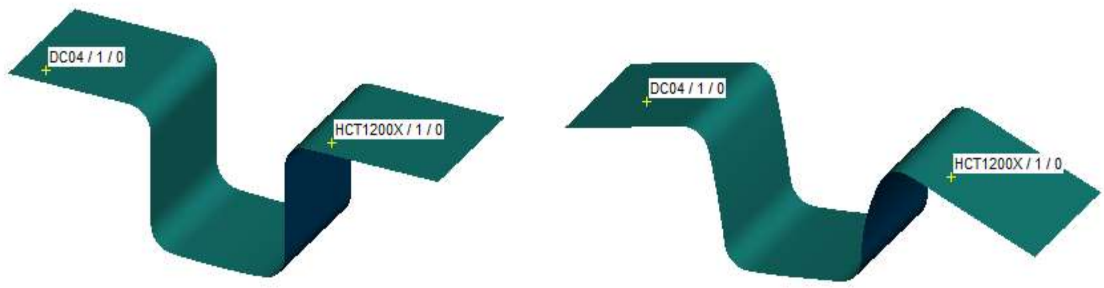


Fig. 3 U shaped part before springback prediction (a), part after springback prediction (b)

Figure 4 shows graphs with obtained values of springback, opening angle ß of the formed tailor welded blank. Different values of blank holding pressure and friction coefficient were used in simulation of forming process. These graphs show that springback, opening angle was in all cases higher for the right side of the blank which was made of DP1200 steel.

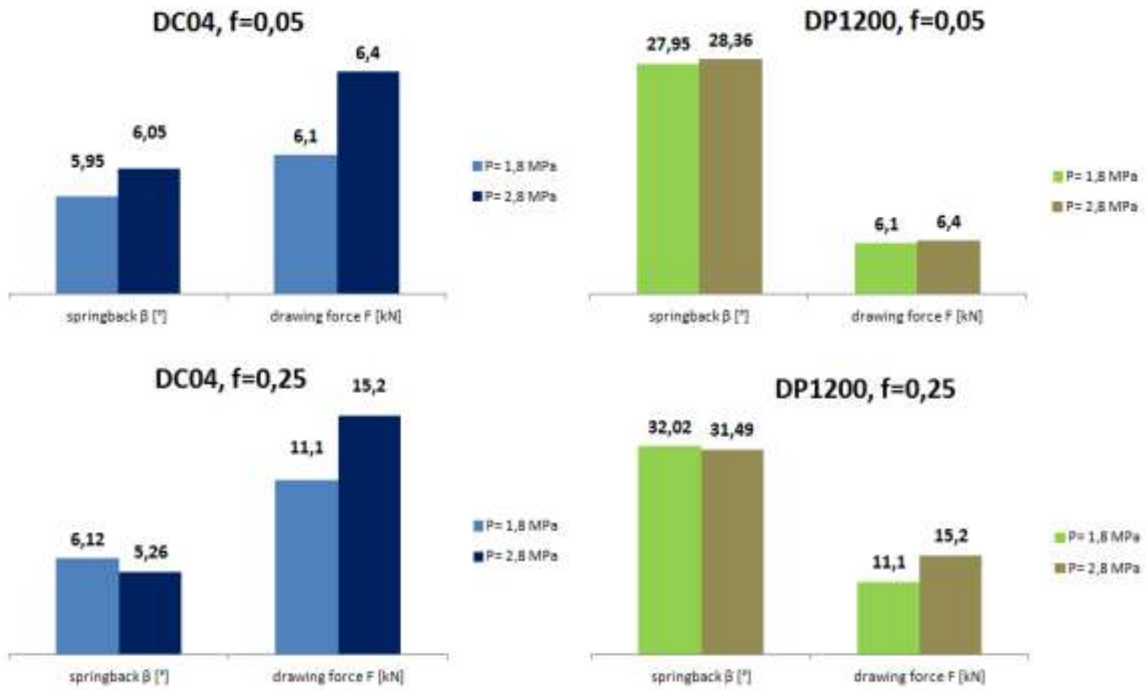


Fig. 4 Graphs showing opening angle ß and drawing force F for both steels in used in formed blank with different values of blank holder pressure [MPa] and friction coefficient f [-]

IV. CONCLUSION

Springback of the U shaped part, made of tailor welded blank was greater in the right side of the formed part which consisted of DP1200 steel (Fig. 5). The main reason for it may be the higher value of Yield stress in comparison with DC04 steel. Two values of blank holding pressure were tested – 1.8 MPa and 2.8 MPa in the forming simulation of the U - shaped part. Higher values of applied pressure by blank holder had positive effect on reducing springback only with higher value of friction coefficient.

Values of friction coefficient had effect on springback, measured opening angle ß. Higher value of friction coefficient f = 0.25 showed in most cases less springback than value f = 0.15. Also drawing forces are much higher with higher coefficient of friction, drawing forces were almost twice higher in the case with use of higher friction value – f = 0.25.

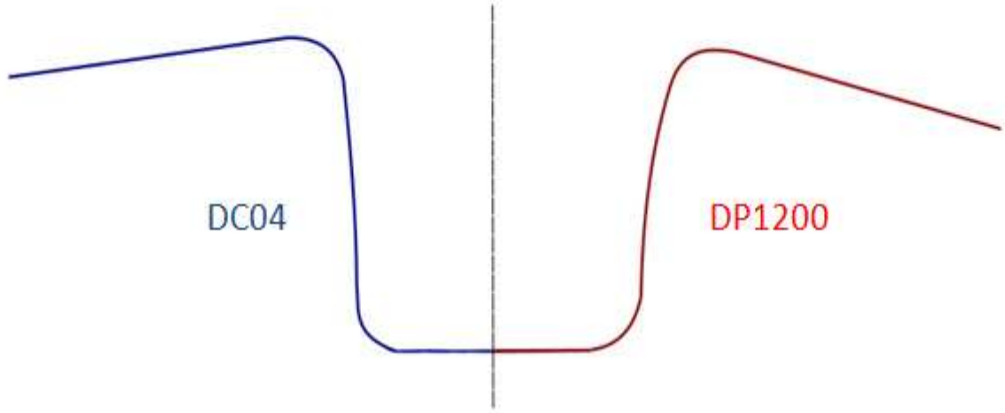


Fig. 5 Springback of U – shaped part after springback calculation in tool with blank holder, value of the blank holder pressure was 1.8 MPa, value of coefficient of friction was set to 0.25

ACKNOWLEDGEMENTS

The authors are grateful to VEGA 1/0441/17.

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