INVESTIGATION BY SIMULATION OF TOOLS LUBRICATION INFLUENCE ON SPRINGBACK EFFECT OF A U-SHAPE PART MANUFACTURED BY TAILOR WELDED STRIPES

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Abstract. This research study is trying to reveal the influence of tools lubrication on springback effect of a U-shape part manufactured by tailor welded stripes. Final shape of the parts manufactured by tailor welded stripes is greatly affected by springback effect. The intensity of this phenomenon depends on the parameters of the forming process. The influence of tools lubrication on the final part springback is examined using the simulation by finite element method. The tailor welded strips have as based materials FEPO and E220 steel.

Keywords: tailor welded stripes, springback, tools lubrication

1. INTRODUCTION

The automotive industry is often used as an example of how the construction industry should be operating, with high levels of mechanisation and controlled environment providing suitable conditions for the manufacture of high quality components. Tailor welded blanks have generated enormous interest in the automotive industry as of late due to the substantial economical and environmental benefits they produce [1]. Tailor Welded Blanks (TWBs) are blanks where various materials are welded together prior to the forming process. The sheets joined by welding can be identical, or they can have different thickness, mechanical properties or surface coatings. Various welding processes, laser welding, mash welding, electron-beam welding or induction welding, can join them [2].
The techniques of simulations analysis applicable for sheet metal forming have been considerably developed for the last several years. However, accurate prediction of the springback remains elusive [3]. Many studies presented a wide range of information about the formability and failure patterns of welded stripes. A wide range of information about the formability and failure patterns of tailor-welded stripes and the springback of non-welded sheet metal parts has been presented. However, the springback characteristics of tailor-welded stripes have hardly been found [4–6].

Published results on springback prediction of tailor welded stripes are minimal. Control of the blank holder forces can greatly influence on springback as well as formability. Since the springback is also affected by the material properties, such as Young’s modulus and initial yield stress, the process design for TWB is more complicated than a single stripe. Though novel approaches relating to the formality of TWB are available, the change of springback due to the characteristic of each process should be verified by finite element method [7].

In this study, the tailor welded stripes (joined together without taking in consideration the welding line) with two types of material having the same thickness, are used to investigate springback characteristics in U-shape forming.

Springback is mainly influenced by the punch and die profile radii, initial clearance between punch and die, friction conditions, blankholder force, material properties (elastic modulus, Poisson’s coefficient, constitutive behaviour in plastic field) etc. [8,9,10,11]. The purpose of this study was to investigate the influence of tools lubrication on springback effect of a U-shape part manufactured by tailor welded stripes. To achieve this goal, simulation tests were carried out with different friction coefficients.

2. MECHANICAL PROPERTIES OF MATERIALS

The mechanical properties of FEPO steel and E220 steel are presented in table 1, respectively in table 2.

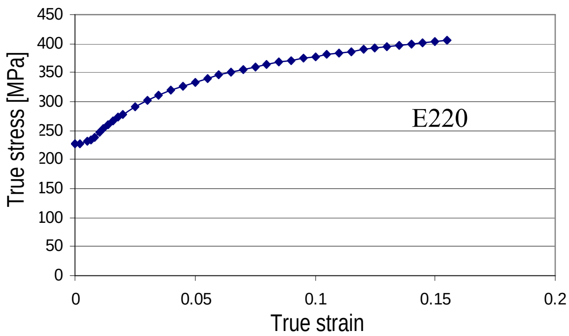
Table 1. Mechanical properties of FEPO steel

Deformation direction	Young modulus MPa	Tensile strength MPa	Uniform Elongation %	Total Elongation %	Plastic strain ratio r	Strain-hardening coefficient n
0°	200 825	281	17.3	28,8	1.86	0.234
45°	213 091	271	13.5	24,1	1.77	0.232
90°	206 467	274	17	28,0	2.42	0.233

Table 2. Mechanical properties of E220 steel

Deformation direction	Young modulus MPa	Tensile strength MPa	Uniform Elongation %	Total Elongation %	Plastic strain ratio r	Strain-hardening coefficient n
0°	204 000	348	10.2	20,4	1.42	0,190
45°	241 000	356	9.7	19,5	1.73	0,188
90°	203 000	346	9.3	19,8	1.64	0,180

The true stress-strain curves for both materials are presented in figure 1.



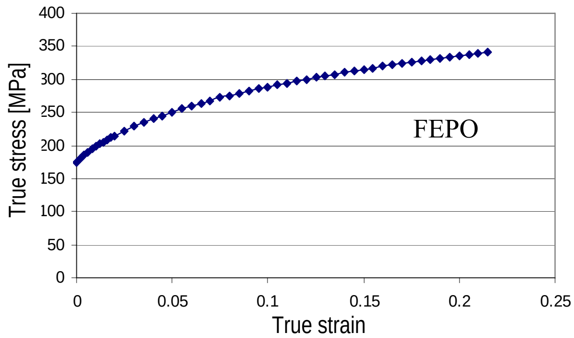


Fig. 1. True stress-strain curves E220 and FEPO materials

3. SIMULATION METHODOLOGY

The simulations considered a plane strain state. The objective is to create a model that allows an accurate prediction of springback intensity, stress and strain state at the end of the forming process.The material was modeled as elasto-plastic, where elasticity is considered isotropic and plasticity is modeled as anisotropic using Hill quadratic anisotropic yield criterion.

The geometrical model is presented in figure 2. The initial dimensions of the sheet are 350 mm length, 30 mm width and 0.7 mm thick. The sheet was modeled as deformable body with 400 shell elements (S4R) on one row with 5 integration points through the thickness. The tools (punch, die and blankholder) were modeled as analytical rigids because they have the advantage of reduced calculus efforts and a good contact behavior. Rigid body movements are controlled by reference points.

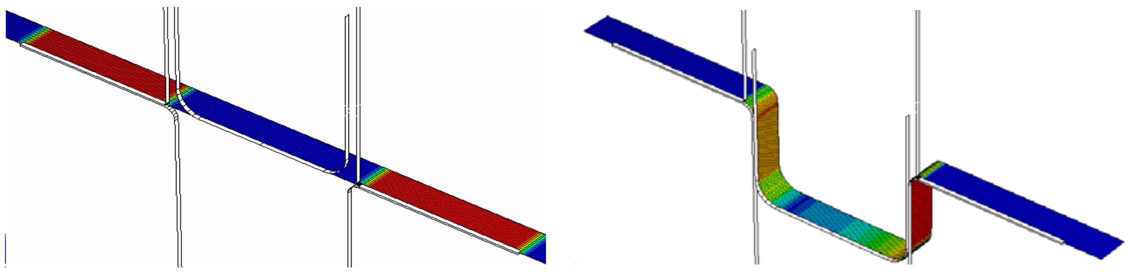


Fig. 2 Geometrical model

The boundary conditions imposed to the tools were intended to describe the experimental conditions as accurate as possible. For contact conditions a modified Coulomb friction law combined with penalty method was used.
Springback parameters that were observed during experimental investigations are the following (Fig. 3):

- θ_1 – angle between bottom and side wall;
- θ_2 – angle between flange and horizontal;
- ρ - side wall curvature.

Springback parameters have been determined for part area made by FEPO steel and for area made by E220 steel.

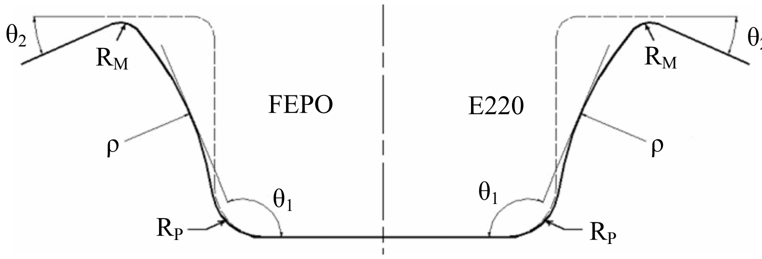


Fig. 3 Geometrical springback parameters

4. SIMULATION RESULTS

For the determination of the influence of friction conditions between specimen and tools on the parameters of springback, the experiments took place under the following conditions: the specimens, were cut out at an angle of 0^{o} to rolling direction; blank holder force F = 10 kN; the tests were carried under dry friction (friction coefficient is 0.177) and with lubrication (friction coefficient 0.1) of the specimen and tools active surfaces.
The equivalent stresses state before and after springback is illustrated in figure 4.

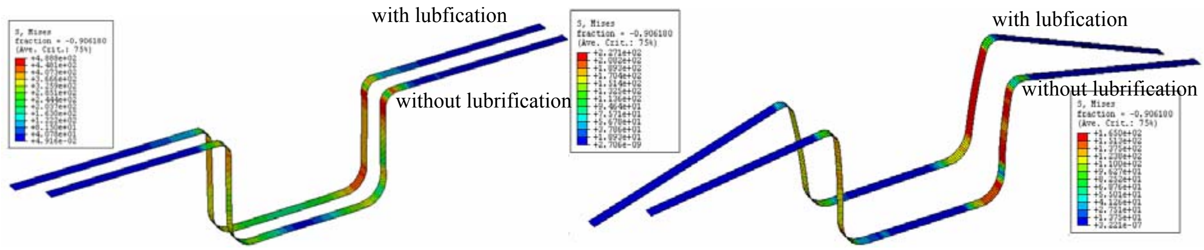


Fig. 4. Equivalent stress before and after springback

The distribution of the stresses on the two faces of the part before and after springback is illustrated in figure 5. It can be observed that after the part is released from the forming tools, the von Mises stresses are higher with lubrication (2.271e+02) in comparison with the maxim value of the von Mises stresses obtained without lubrication (1.650e+02). For both materials, stress distribution before springback effect, on both faces of the material, is similar except the stresses from the bottom of the part. In case of U bending without lubrication stresses on both faces of the part tend to 0. The maxim stresses are observed in the superior area of the walls, where the material is bended before having contact with the die.

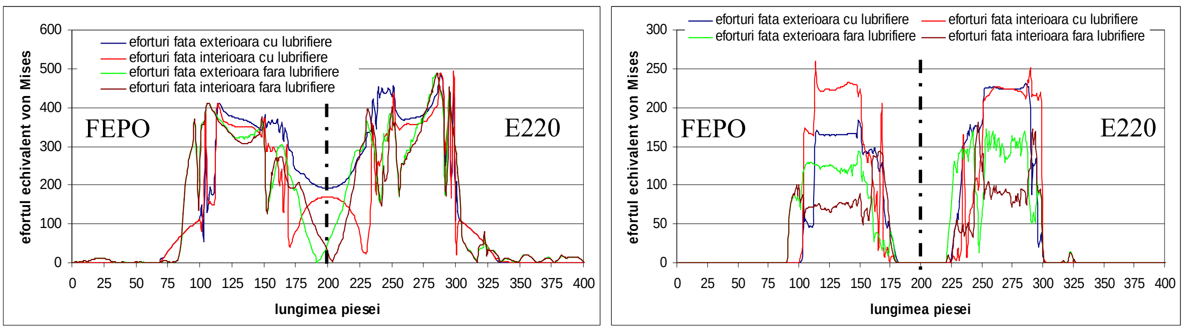


Fig. 5. Equivalent stress distribution along the faces of the part before and after springback

The values of springback parameters are recorded in table 4.

Table 4. Springback parameters

Friction coefficient	FEPO						E220					
	Angle θ_1 [grd]		Angle θ_2 [grd]		Angle θ_1 [grd]		Angle θ_2 [grd]		Angle θ_1 [grd]		Angle θ_2 [grd]	
	Theoretic value	Measured value	Theoretic value	Measured value	Theoretic value	Measured value	Theoretic value	Measured value	Theoretic value	Measured value	Theoretic value	Measured value
0.177	90	98.8	0	12.2	:	254.46	90	99.2	0	17.1	:	162.51
0.1	90	99.2	0	13.8	:	203.93	90	101.4	0	18.4	:	103.34

5. CONCLUSIONS

From the analysis of the table 4 data, the following observations can be presented:

- the modification of friction conditions leads to small variations of springback parameters;
- the values of springback angles θ_1 and θ_2 are higher when using lubrication than the cases of dry friction;
- the values of sidewall curvature ρ are higher in the case of dry friction.

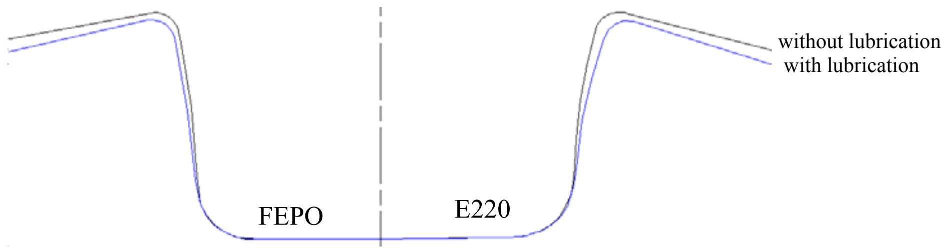


Fig. 6 Friction conditions influence on springback of tailor welded strips

These observations lead to the conclusion that lubrication does not improve springback parameters in the case of U bending of tailor welded strips.

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