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SAMPLE WIDTH IMPACT ON THE FINAL GEOMETRY OF A FORMED PART MADE FROM TAILOR WELDED STRIPES

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ABSTRACT
This paper refers to some simulation tests concerning the formability and springback of a U-shaped part manufactured from tailor welded stripes. The final geometry of the obtained part is seriously affected by springback phenomenon. This paper work is trying to prove out the important role samples dimension has on the springback phenomenon. The influence of the samples width on the tailor welded stripes springback is examined during simulation tests using four different part widths.
Keywords: tailor welded stripes, sample width, springback.

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 having different width 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, part dimensions (elastic modulus, Poisson's coefficient, constitutive behaviour in plastic field) etc. [8, 9]. The purpose of this study was to investigate the influence of sample width on springback effect of a U-shape part manufactured by tailor welded stripes. To achieve this goal, simulation tests were carried out with different samples width.

2. MATERIAL PROPERTIES

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.

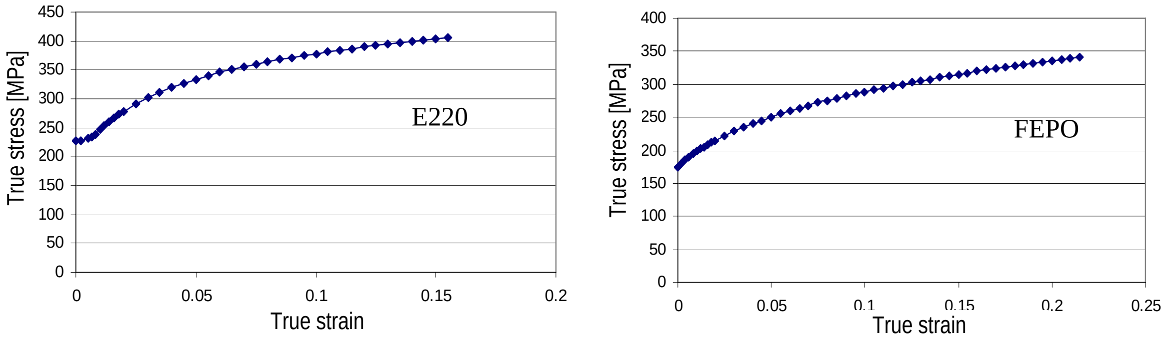

Figure 1. True stress-strain curves E220 and FEPO materials

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 elastic-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 rigid because they have the advantage of reduced calculus efforts and a good contact behavior. Rigid body movements are controlled by reference points.

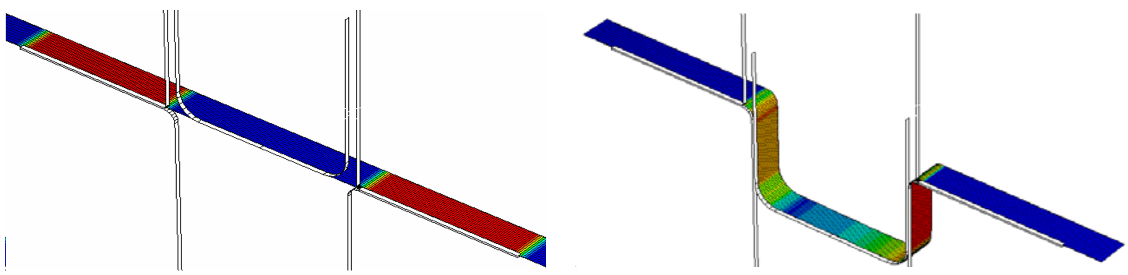

Figure 2 Geometrical model

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.

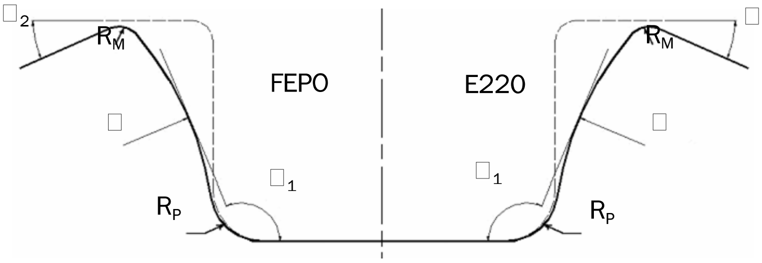

Figure 3. Geometrical springback parameters

4. SIMULATION RESULTS

For the determination of the influence of samples width on the springback parameters, the simulations where done with sample widths of 30, 60, 90 and 120 mm. The forming process parameters where: blank holder force F = 15 kN, the simulation tests were carried out without lubrication of the sample and tools active surfaces (friction coefficient is 0.177).

The equivalent stresses state before and after springback is illustrated in figure 4.

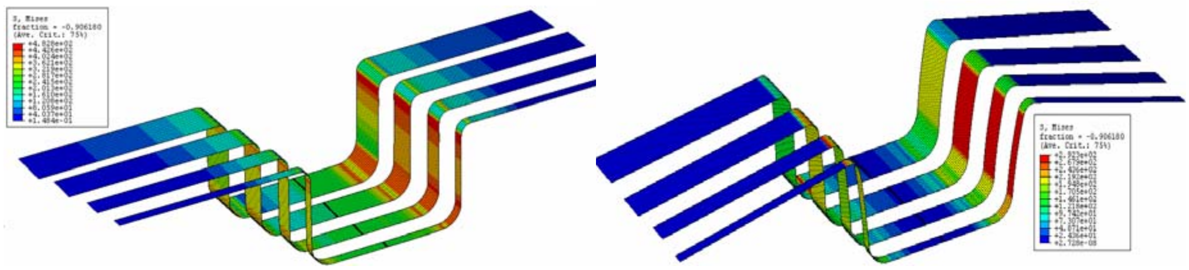

Figure 4. Equivalent stress before and after springback

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 for samples with 30 mm width (2.271e+02) in comparison with the maxim value of the von Mises stresses obtained for samples having 120 mm width (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 of the sample with 120 mm width, 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.

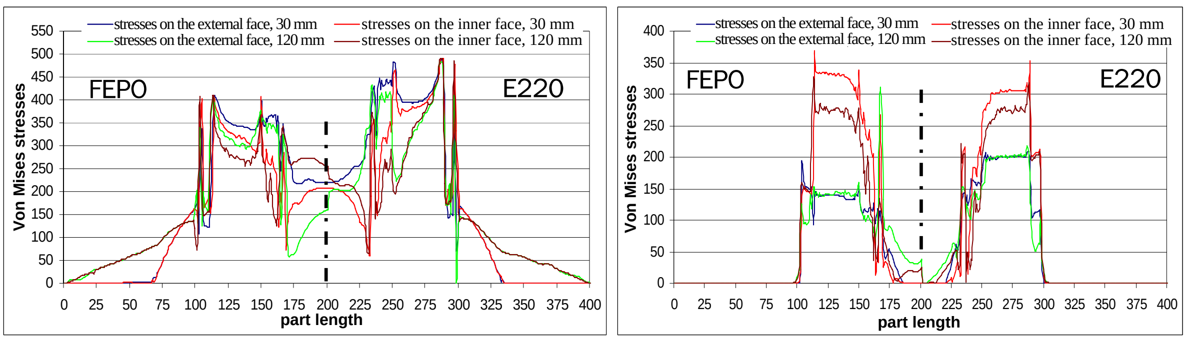

Figure 5. Equivalent stress distribution along the faces of the part before and after springback

The values of springback parameters are recorded in table 3.

Table 3. Springback parameters

Sample width [mm]	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
30	90	100.1	0	15.2	∞	146.93	90	104.3	0	20.3	∞	86.95
60		97.4		12.7		180.47		100.7		17.2		106.79
90		96.7		10.5		235.65		98.8		14.6		186.31
120		94.8		6.5		372.97		95.4		8.1		334.14

5. CONCLUSION

From the analysis of the Table 3 data, the following observations can be presented:

- the modification of the samples width leads to important variations of springback parameters;
- the springback angles θ_1 and θ_2 record values closer to the theoretic value for sample having 120 mm width;
- the values of sidewall curvature ρ are higher for widen samples.

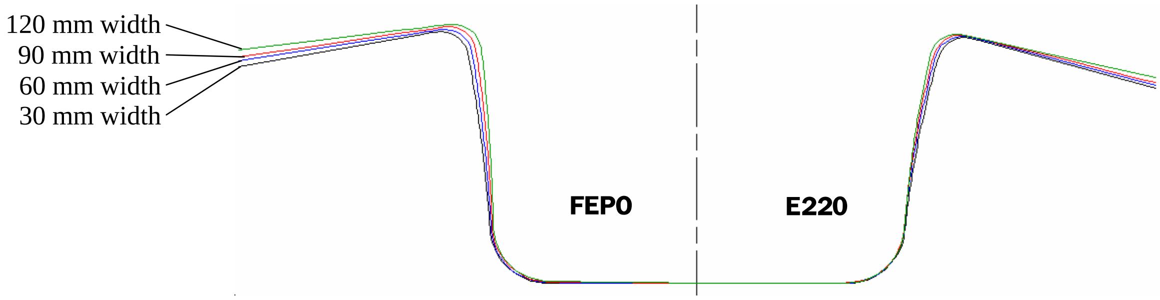

Figure 6. Sample width influence on springback of tailor welded stripes

The above presented conclusions are verified for both materials. These observations lead to conclusion that forming of samples having smaller width amplifies the effect of springback phenomenon in the case of U - shape forming of tailor welded stripes.

6. REFERENCES

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