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THE INFLUENCE OF THE WELDING LINE ORIENTATION ON SPRINGBACK BEHAVIOUR OF A U-SHAPED PART MADE FROM TAILOR WELDED STRIPES

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ABSTRACT
This paper refers to some experimental 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 of welding line direction with respect to the forming force direction has on the springback phenomenon. The influence of the welding line orientation on the tailor welded stripes springback is examined during experimental tests using transversal and longitudinal welding line.
Keywords: tailor welded stripes, welding line direction, springback.

1. INTRODUCTION
A tailored blank is one where sheet elements of different composition, coating, thickness and strength are butt-welded together in such a way that, when formed, the assembly provides the proprieties which are needed in exactly the right places. According to different users of tailor welded blanks their advantages are many and varied. For instance, by giving the required strength to a specific area of a blank for a car side panel, the number of reinforcements can be reduced which decreases the total number of parts to be assembled and the number of pressing dies and operations, minimizing material costs and reducing component weight.
Various welding processes, i.e. laser welding, mash welding, electron-beam welding or induction welding, can join them [1]. The laser is an ideal tool for welding the elements of tailored blank together because the hear-affected zone is small, and high-quality joints can be produced with minimal distortion. The narrowness of the weld also means that the corrosion resistant properties of coated steel are retained due to the sacrificial protection of the zinc either side of the weld.
Welding line can be placed transversal or longitudinal with respect to the forming direction (Fig. 1).

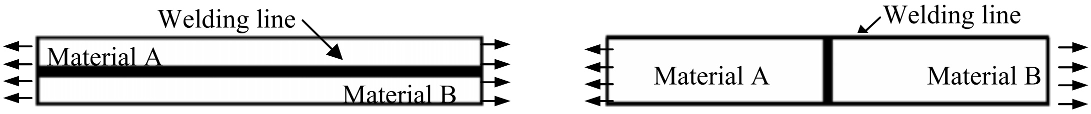

Figure 1. Different positions of the welding lines as a function of the forming direction

Despite all the made efforts concerning formability of tailor welded stripes, accurate prediction of the springback remains elusive [2]. Many studies presents a wide range of information about the formability and failure patterns of welded stripes. Springback is mainly influenced by the punch and die profile radii, initial clearance between punch and die, friction conditions, rolling direction of the materials, blankholder force, material properties (elastic modulus, Poisson’s coefficient, constitutive behavior in plastic field) etc. [4, 5].
The purpose of this study was to investigate the welding line direction influence on the springback effect of the tailor welded stripes. To achieve this goal, experimental tests were carried out with different orientation of the welding line with respect to the forming force direction.

2. EXPERIMENTAL RESEARCHES CONCERNING THE WELDING LINE DIRECTION

The laser welded stripes used in the experiments were made from FEPO and E220 steel. Stripes of 350×30 mm dimensions and 0.7 mm thickness were cut from the metal sheet along to the material rolling direction (fig. 2).

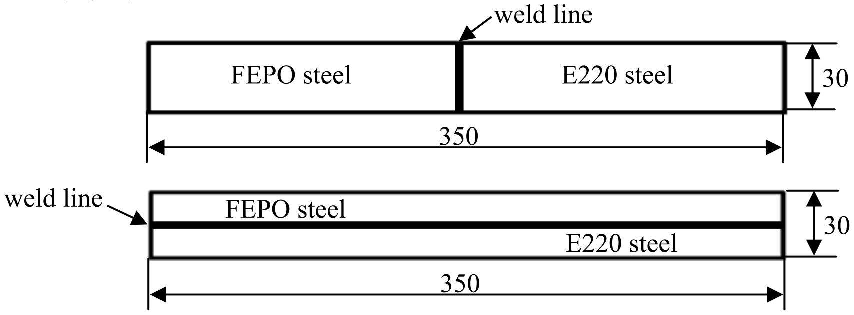

Figure 2. Tailor welded strips with transversal and longitudinal weld line (unit: mm)

Tensile tests have been done to determine the mechanical properties of the base materials of tailor welded blank, E220 steel respectively FEPO steel. Whose mechanical properties were determined by uneasily tensile tests on a universal testing machine equipped with Hottinger cell force of 25tf and an electronic data acquisition system, type Spider 8. The measurement of specific strains for determination of stress-strain curves was performed using a uni-axial extensometer and Hottinger electric resistive wire strain gauges. The data acquisition, processing and visualisation were performed using a Catman - Professional software. The used rate of data acquisition was of 5 points/sec for a crosshead-rate of 10 mm/min. The specimens were cut as a function of the rolling direction being achieved sets of specimens corresponding to the directions of 0º, 45º and 90° and were worked by milling and grinding in order to obtain the prescribed dimensions. The reference length of the specimen was equal to 50 mm. To obtain a good accuracy of the results, 3 specimens were tested for each determination. In table 1 are presented the mechanical properties of FEPO and E220 steel determined for 0º, 45º and 90° material rolling direction.

Table 2. Mechanical proprieties

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

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

2.1 Experimental Layout

The experimental tests were realized using a die for rectangular parts that allowed utilization of different blank holder forces. The device is presented in figure 3. The experimental tests have been done with different welding line orientation with respect to the forming direction. The blankholder force was maintained constant to 10 kN. The forming force was generated using a mechanical tensile test machine. The profile of the obtained part and the parameters of springback were measured with a numerical controlled scanning machine Roland Model MDX-15 (Fig. 4), and the obtained data was processed in CAD software.

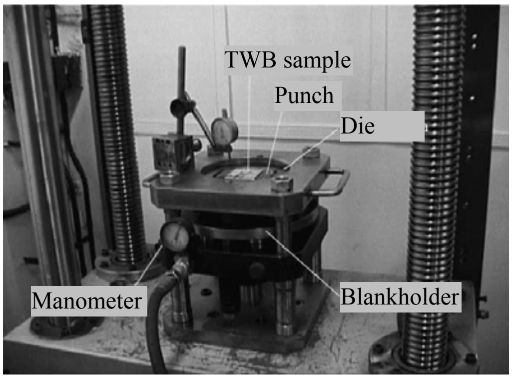

Figure 3. Experimental device

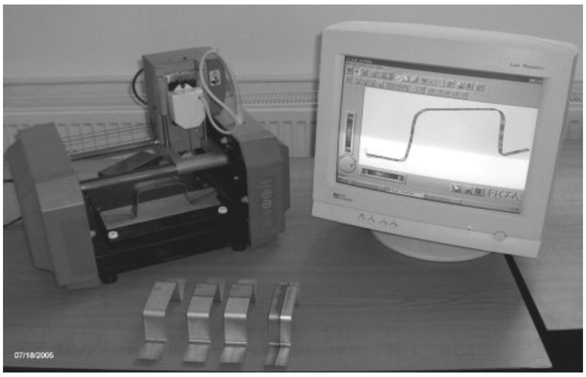

Figure 4. Measuring installation

Springback parameters that were observed during the tests are presented in figure 5:

- θ_1 – sidewall angle between real profile and theoretical profile;
- θ_2 – flange angle between real profile and theoretical profile;
- ρ – curvature radius of the sidewall.

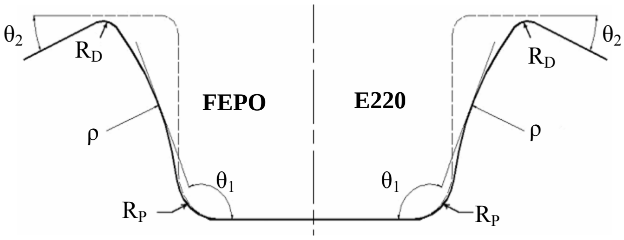

Figure 5. Geometrical springback parameters

2.2 Experimental Results

In figure 6 are presented two parts made by tailor weld blanks with transversal and longitudinal weld line.

Figure 6. Parts made by TWBs with transversal and longitudinal weld line

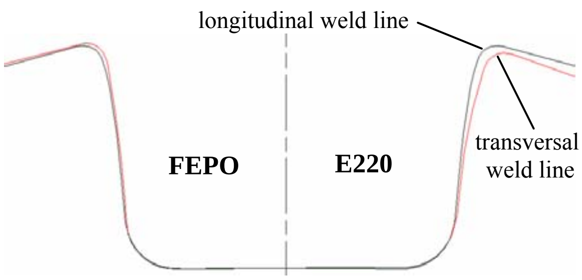

Figure 7. Weld line direction influence on springback of TWBs

The values of springback parameters are recorded in table 2 and presented in figures 8, 9 and 10.

Table 2. Springback parameters

Welding line orientation	FEPO steel					
	Angle θ_1 [grd]		Angle θ_2 [grd]		Angle θ_1 [grd]	
	Theoretic value	Measured value	Theoretic value	Measured value	Theoretic value	Measured value
transversal	90	97.4	0	12.7	∞	180.47
longitudinal	90	98.4	0	13.2	∞	168.36

Welding line orientation	E220 steel					
	Angle θ_2 [grd]		Angle θ_2 [grd]		Angle θ_2 [grd]	
	Theoretic value	Theoretic value	Theoretic value	Theoretic value	Theoretic value	Theoretic value
transversal	90	100.7	0	17.2	∞	106.79
longitudinal	90	98.4	0	13.2	∞	168.36

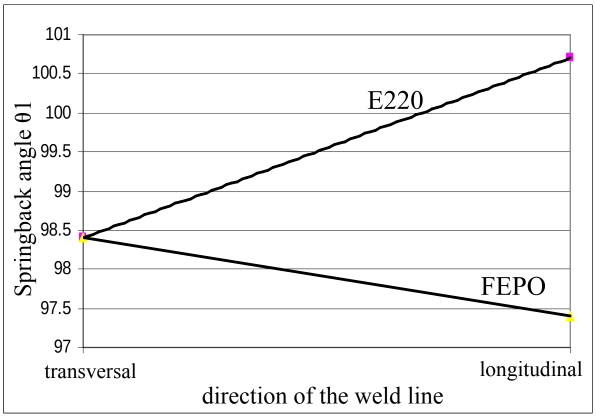

Figure 8. Influence of weld line direction on angle θ_1

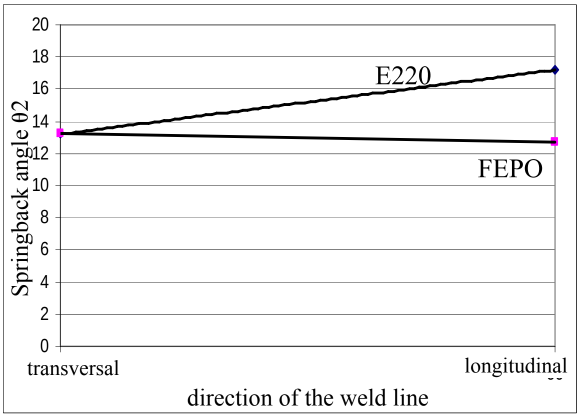

Figure 9. Influence of weld line direction on angle θ_2

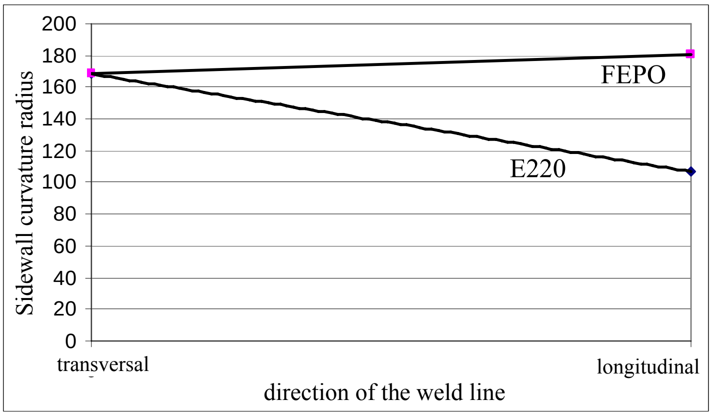

Figure 10. Influence of weld line direction on sidewall radius ρ

4. CONCLUSIONS

The following conclusions can be stand out from the present research concerning the influence of welding line direction with respect to the forming direction on springback parameters:

- the TWBs part with the weld line placed longitudinally have both angles θ_1 and θ_2 approximately equal with those of the FEPO steel area from the part with transversal weld line;
- the part area made by E220 present a springback intensity higher that the part with longitudinal weld line;
- sidewall radius of the longitudinal weld line part is smaller than the sidewall radius of FEPO area from TWBs with transversal weld line and smaller that sidewall radius of E220 area.
- use of TWBs with longitudinal weld line leads to a diminution of springback effect. The springback intensity of parts with longitudinal weld line is given mainly by the springback of the weld line.

5. REFERENCES

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