

INVESTIGATION BY SIMULATION OF THE BLANKHOLDER INFLUENCE ON SPRINGBACK EFFECT OF A RECTANGULAR PART MANUFACTURED BY TAILOR WELDED STRIPES

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Abstract. This paper deals with some numerical simulation issue related to tailor welded stripes forming and springback. Final shape of the parts manufactured by TWB is greatly affected by springback effect. The intensity of this phenomenon depends on the parameters of the forming process. This paper work is trying to reveal the important role that blankholder force has on the springback reduction. The influence of the blankholder force on the TWB springback is examined using the simulation by finite element method.

Keywords: tailor welded stripes, springback, blankholder force, finite element method

1. INTRODUCTION

A tailor welded stripe consists of two or more sheets that have been welded together in a single plane prior to forming. 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]. And, the techniques of numerical analysis applicable for sheet metal forming have been considerably developed for the last several years. However, accurate prediction of the springback remains elusive [2]. 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 [3–5].

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 [6]. 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 rectangular 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 behavior in plastic field) etc. [7,8,9,10]. The purpose of this study was to optimize the blankholding force for minimizing the springback effect of the TWB. To achieve this goal, simulation were carried with different value of the the blankholding force.

2. ANALYSIS OF THE INFLUENCE OF BLANKHOLDER FORCE ON SPRINGBACK EFFECT

The simulation of rectangular forming operation was made using finite element method. 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 analyzed geometrical parameters are punch radius R10, die radius R5, α sidewall angle and β flange angle (fig. 1).

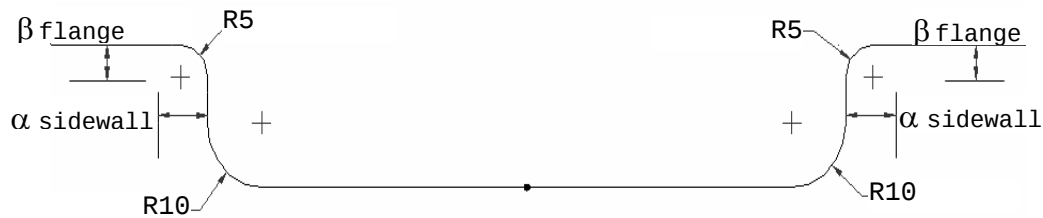


Fig. 1 Parameters affected by springback

2.1. Simulation methodology

The simulations considered a plane strain state, and because of the symmetry only half of the assembly was modeled. 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 analyzed geometrical parameters are punch radius R10, die radius R5, α sidewall angle and β flange angle. The material was modeled as elasto-plastic, where elasticity is considered isotropic and plasticity is modeled as anisotropic using Hill quadratic anisotropic yield criterion.

Table 1 Forming device dimensions

Punch dimensions (mm)	78×120
Punch profile radius (mm)	10
Die opening (mm)	80×118
Die profile radius (mm)	5
Punch stroke (mm)	22

The geometrical model and tools dimensions are presented in fig. 2. The initial diameter of the TWB is 220mm and 0.8 mm thick. The sheet was modeled as deformable body with 2296 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. The blankholder has attached a 25 kg weight.

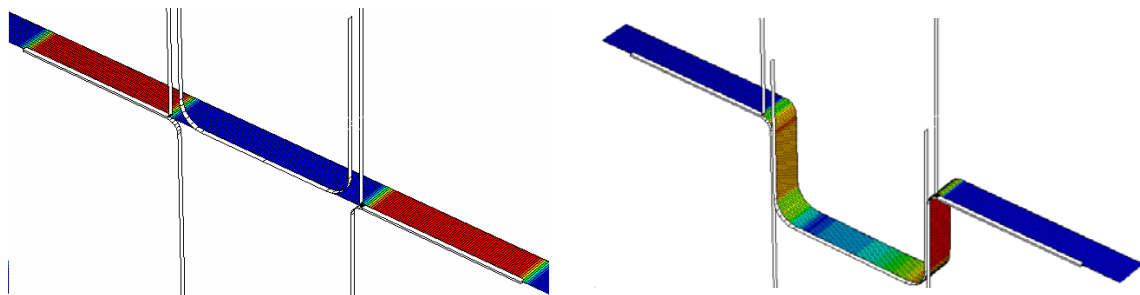


Fig. 2 Geometrical model

As only half of the assembly was modeled, a symmetry condition was necessary. 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.

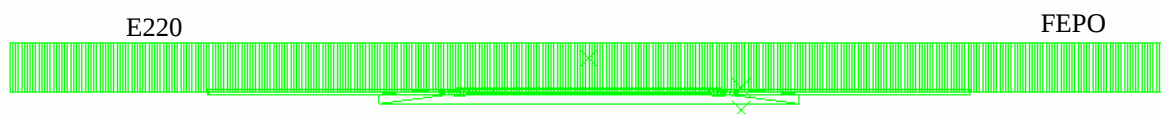


Fig. 3 Simulation model of TWB

The TWB considered in our simulation is done by joining two different types of steel E220 and FEPO having the same thickness. Those two materials are assembled without taking in account the welding process needed in real life or the heat affected zone. In the following charts are presented the true stress-strain curves for E220 and FEPO that show the behavior of both materials in the plastic deformation area. This information has been used by ABAQUS software to simulate the forming process. The mechanical properties of E220 and of FEPO were investigated by applying the microhardness and parallel tensile test in conjunction with the rule of mixture, and by analyzing the strain variation during parallel tensile test using the image analysis method.

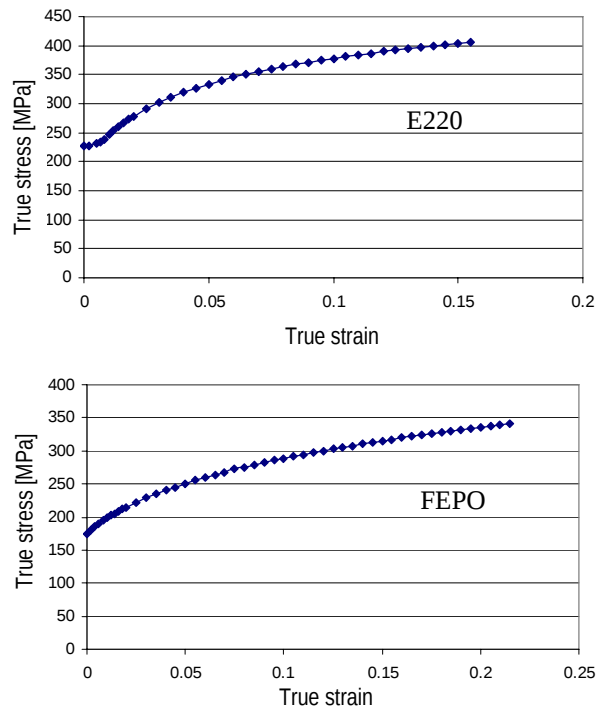


Fig. 4 True stress-strain curves E220 and FEPO materials

2.2. Simulation results

The simulation is done four times with identical condition, only the blankholder force is modified. The used holding forces are 10kN, 20kN, 30kN and 40kN. If the forming process is done with a holding force lower than 10kN the wrinkling phenomena affect the flange. If the holder acts with a force higher than 40kN fracture appears in part body. The variations of springback parameters as functions of blankholder force are presented in table nr. 2 and 3.

Table 2 Springback effect on E220 and FEPO

Blank holder force	E220				FEPO			
	R10	R5	sidewall	β flange	R10	R5	sidewall	β flange
10 kN	10.0491	4.7844	3.7877	-0.106	10.745	5.7844	-1.2950	0.447
20 kN	9.9499	4.9463	4.1704	-0.2257	10.6887	5.609	0.4419	0.3951
30 kN	10.4663	5.5753	4.3125	-0.6499	10.4906	5.4919	1.0498	0.3022
40 kN	10.3078	5.3168	4.9742	-0.7343	10.2034	5.116	2.1199	0.1511

Table 3 Springback effect on joining line

Blankholder force	R10	R5	sidewall	β flange
10 kN	10.239	5.707	0.1328	-0.135
20 kN	10.3792	5.6602	0.3473	0.0695
30 kN	10.4841	5.4449	1.9285	0.151
40 kN	10.5951	5.2779	2.8165	0.0793

The profiles of the parts resulted from simulation with finite element for different blankholder force values are superposed in figure 5, 6 and 7.

For E220 material, based on the results of simulation researches, as shown in figure 5, an optimum variation domain was established for the blankholder force between 10kN and 20kN. The smaller value of the holding force lead to a shape closer to theoretical profile of the part for E220 material.

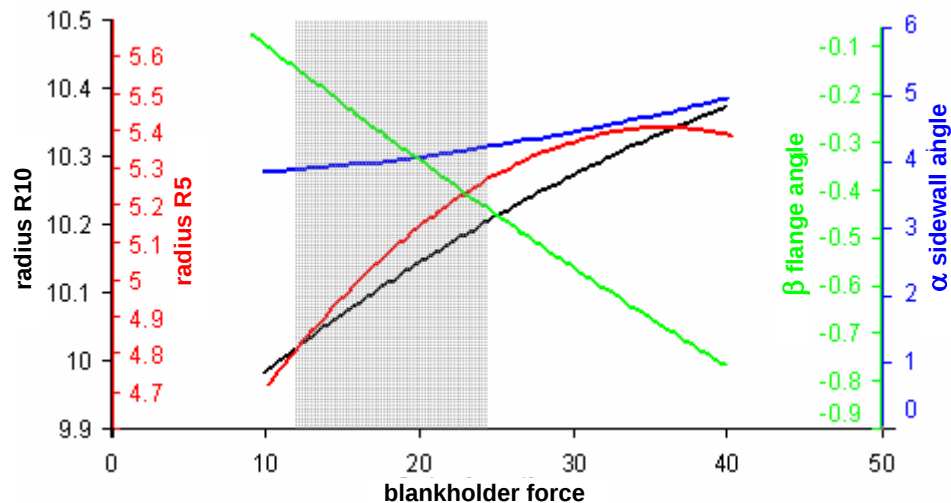


Fig. 5 Optimum variation domain of blankholder force for E220

For FEPO material, analyzing the results obtained simulation tests and, as shown in figure 6, an optimum variation domain was established for the blankholder force between 10kN and 20kN. The higher values of the force lead to shapes closer to theoretical profile of the part for FEPO material.

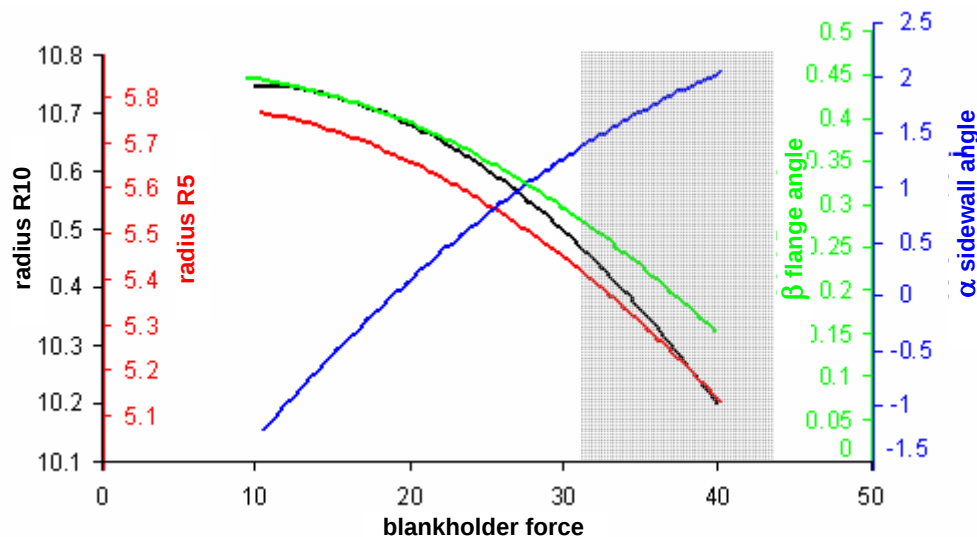


Fig. 6 Optimum variation domain of blankholder force for FEPO

For the joining line, based on the results of simulation researches, as shown in figure 7, an optimum variation domain was established for the blankholder force between 10kN and 20kN. The smaller value of the holding force lead to a shape closer to theoretical profile of the part for joining line, the same as for E220.

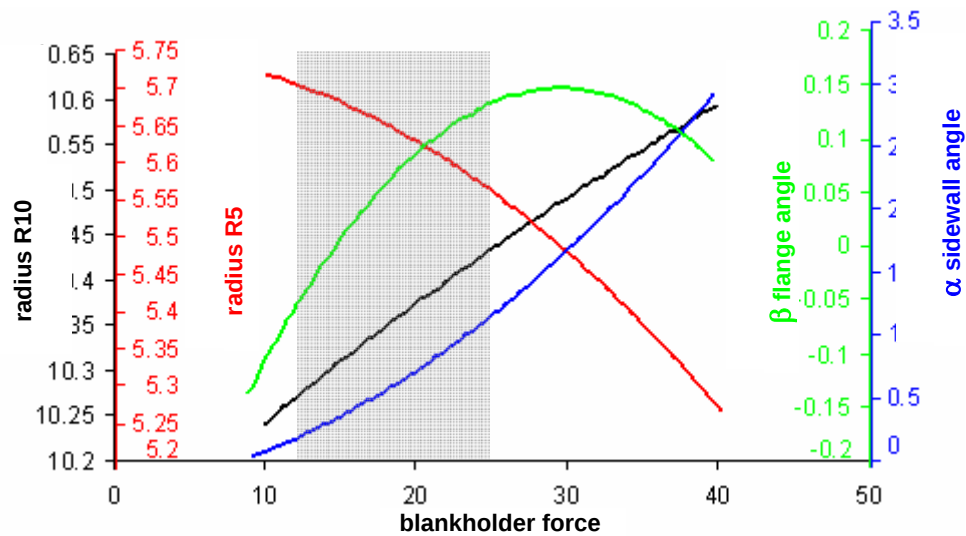


Fig. 7 Optimum variation domain of blankholder force for joining line

3. CONCLUSIONS

Analyzing simultaneous the values of all four parameters (punch radius R10, die radius R5, α sidewall angle and β flange angle) that describes the springback effect, for different blankholder forces, in case of E220 material, results closer to the theoretical profile are obtained when the holder force vary between 10kN and 20kN.

The same analysis but for FEPO material convey to conclusion that results closer to the theoretical profile are obtained when the holder force vary between 30kN and 40kN. The optimal domain for E220 material has no overlap with the optimal domain of FEPO material, so is not possible to reduce the springback effect for both materials in the same time using a uniform blankholder. The springback of the analyzed TWB can be reduced using a non-uniform blankholder, able to hold the E220 material with one force (10 - 20kN) and FEPO material with another force (30 - 40kN).

Table nr. 4 presents the dimensional deviation between the theoretical parameters values and the simulation parameters values for both materials function to different blankholder force.

Table 4 Deviation caused by the springback effect for E220 and FEPO

Blank holder force	E220				FEPO			
	R10	R5	sidewall	β flange	R10	R5	sidewall	β flange
10 kN	0.0491	-0.2156	3.7877	-0.106	0.745	0.7844	-1.295	0.447
20 kN	-0.0501	-0.0537	4.1704	-0.2257	0.6887	0.609	0.4419	0.3951
30 kN	0.4663	0.5753	4.3125	-0.6499	0.4906	0.4919	1.0498	0.3022
40 kN	0.3078	0.3168	4.9742	-0.7343	0.2034	0.116	2.1199	0.1511

Table 5 Deviation caused by the springback effect for joining line

Blankholder force	R10	R5	sidewall	β flange
10 kN	0.239	0.707	0.1328	-0.135
20 kN	0.3792	0.6602	0.3473	0.0695
30 kN	0.4841	0.4449	1.9285	0.151
40 kN	0.5951	0.2779	2.8165	0.0793

Table nr. 5 presents the dimensional differences between the theoretical parameters values and the simulation parameters values for the E220-FEPO joining line, function to different blankholder force.

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