THE INFLUENCE OF THE BLANK HOLDER FORCE ON THE WELDING LINE MOVEMENT DURING FORMING OF A RECTANGULAR PART MADE FROM TAILOR WELDED BLANKS

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***Abstract*:** The current work deals with numerical simulation connected to forming of a rectangular shaped part made from tailored blanks (TWB's), having the welding line positioned symmetrical with respect to the part geometry. During the deep drawing process, due to dissimilar base materials of the TWB's, the welding connection modifies its initial position. The presented work is trying to demonstrate the important role of the blankholder force on the welding line movement during the deep drawing process. To simulate the forming process the academically version of the PAM STAM 2G software have been used. After each simulation the obtained part is analysed and measured to quantify the movement of the welding line.

***Keywords*:** forming, TWB's, welding line displacement

1. INTRODUCTION

Utilisation of new manufacturing concepts and advanced materials is of interest to the major automotive manufacturers, who are continuously seeking means to reduce weight and cost. One such concept is the use of tailor-welded blanks (TWBs), which are used to replace multiple stampings that are formed separately, then assembled or joined to produce the final product. To achieve those objectives, the auto makers must diminish the body weight without affecting the integrity of the final result. TWBs are being used in the manufacture of different automotive components due to their positive impact on weight and stiffness [1].

An economic and ecologic solution to the problems described before was given by the scrap metal collectors. The welding technology was used to unify the smaller parts and to obtain a usable part for forming. Hence, they have comprehend the grate benefit of TWBs. Tailor welded blanks (TWBs) are blanks of similar or dissimilar thicknesses, materials, coatings, etc. welded in a single plane before forming. This welded blank is then formed like un-welded blanks to manufacture automotive components, with appropriate tooling and forming conditions [2]. Applications of TWBs include car door inner panel, deck lids, bumper, side frame rails, etc. in automotive sector [3]. The applications have spread over a wide range of press work.

Any product that requires a change in material properties within a metal sheet component can be improved by use of tailor welded blanks. The white good industry could benefit from the advantages of TWBs. For instance, in the manufacture of washing machines where steel with thicker galvanized coating could be used on the vulnerable areas (surround doors, seals, draws) and normal treated steel for the rest of the body. The manufacture of a garage door is an example from construction industry. The door could be made from strength steel on the brackets area, from steel with thicker galvanized coating in the bottom area and from normal treated steel on the rest [4].

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Recently there are studies presenting a wide range of information concerning the formability and failure mechanics of TWBs. Howbeit, description of the welding line movement is not easy to be found. The final part shape has great effect on the amplitude of the welding line displacement. Whether produced with different materials or the same material with different thickness, the more resistant material in the TWBs will oppose deformation more than the weaker material, causing a welding line movement during the forming process. This phenomenon restrains the capacity of the designer to position the specific material properties in the final stamping where desired. One parameter with great influence on the welding line displacement is the blankholder force.
In this paper work, TWBs made from different two steel types by the laser welding, having the same thickness combinations have been used as semi-finished product for the deep drawing process. The major objective is to find the weld line displacement in case of a square shaped part with respect to the blankholder force. To accomplish this goal, simulations were carried out using PAM STAM 2G software and different blankholder forces.

2. MATERIAL PROPERTIES

The mechanical properties of the base materials and of the welding line have been obtained with help on a universal tensile testing machine, equipped with force cells of 5 tf and an electronic measurement system. The data acquisition has been made with Perception software, which is a modularly structured platform for high speed measurement data acquisition. For data processing and visualisation the platform GlyphXE were used.

The specimens were cut with respect to the material rolling direction resulting sets of specimens corresponding to the direction of 0º and were worked by milling and grinding in order to obtain the prescribed dimensions. The specimen length was equal to 50 mm. To avoid measurement errors or material micro-defects for each set of tests have been used 3 specimens [4]. The welding line is approximately 2 mm, so to determine its mechanical properties, from the original TWB, a 4 mm wide stripe has been removed using electric discharge machining.

The flow stress and true total strain were calculated for each tested sample. For a better understand of the material behaviour the total strain was decomposed on elastic strain and plastic strain using determined Young module. To obtain the desired precision of FEM modelling in case of small deformation, there was reconciled the functional stress – strain curves in errand of the stress – strain curves in the numerical structure.

Table 1 presents the mechanical properties of FEPO steel and E220 steel obtained for 0º material rolling direction are. In the same table are presented also, the mechanical properties of the welding line. In Figure 1 are presented the stress – strain curves for FEPO and E220 steels and for the welding line material.

Table 1. Mechanical properties [4].

Property	FEPO	E220	weld
Yield strength $R_{p0,2}$ [MPa]	203	268	252
Tensile strength **Rm** [MPa]	381	458	417
Percentage elongation after fracture A_{80} [%]	–	35.3	–
Elongation for max. load A_{gt} [%]	31.8	20.4	17.3
Strain-hardening coefficient **n**	0.222	0.190	-
Plastic strain ratio **r**	1.860	1.420	1.29
Poisson's ratio ν	0.286	0.297	0.278
Young modulus **E** [MPa]	200825	204271	203253

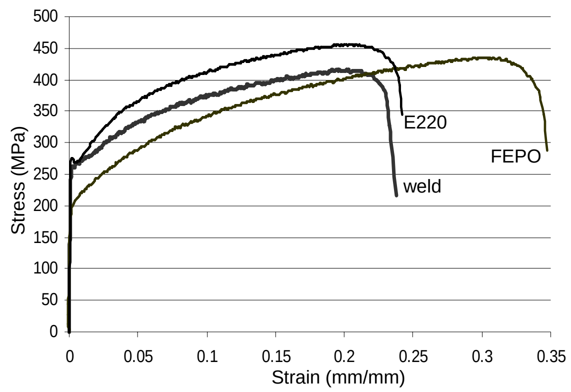


Fig. 1. Stress – strain curves for 0º [4].

3. SIMULATION CONDITION

The simulations were made for five different blankholder forces. The dimensions of the semi-finished metal sheet were 200x200 mm for the deep drawing of the rectangular part, the transversal section of the punch is a square 100x100 mm. The draw die radius was 10 mm and the punch stroke is 25 mm. The mesh is done automatically by a function of the PAM STAM 2G software**.** The function is called adaptive mesh (Figure 2), and is able to re-mesh the blank in the parts only in the areas where the material suffer larger deformation.

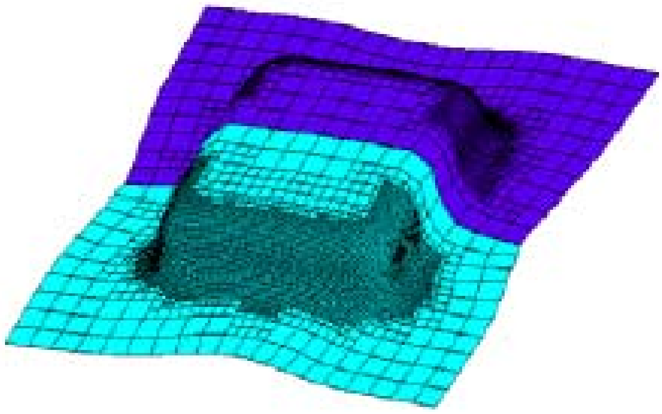


Fig. 2. Adaptive mesh in case of rectangular part.

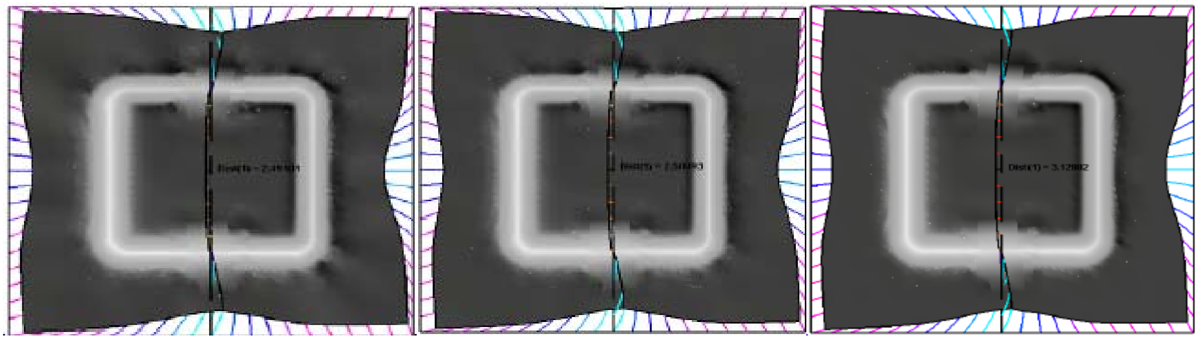
The simulation of the forming process is accomplished, as in real deep drawing press in two phases: (i) application of the blankholder force (the blank holder is coming in contact with the TWBs and is pressed against them with a predetermined force); (ii) the punch effectuate a translation movement only in one direction with predetermined amplitude. The welding line movement is an important indicator of the overall deformation behaviour of the TWBs. Its displacement is determined by the properties of the base materials and the restraining forces with some small influence from local friction coefficient. Both base materials of the TWBs have been modelled with the same thickness, and the welding line was positioned in the middle of the blank as a symmetry axe. The friction coefficient between all the components was chosen by default with a value of 0.125. The data obtained during simulations was loaded in postprocessor software for measurements.

The objective was to study the relation between the force applied in the blankholder and the displacement of the welding line. That was quantified in displacement of a node A that coincides with intersection of the semi-finished diagonals. The blankholder force is modified for each simulation setup, and all the others parameters are maintained constant. The blankholder force takes five different values and then the movement of the selected node is measured after each simulation with the postprocessor software module.

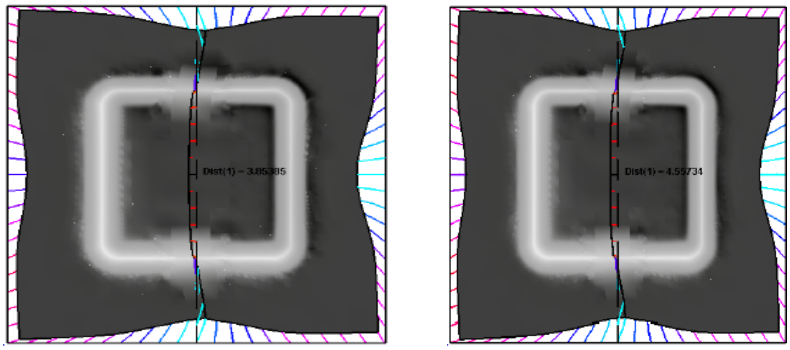
4. SIMULATION RESULTS

During forming of the TWBs, the weld line moves crosswise the blank, according to the strength of the base materials. In case of the rectangular part it is possible to identify tow areas where the welding line moves away from its original position: flange zone and bottom of the part zone. On the part bottom the welding line moves towards E220 steel side due to greater flow of the FEPO steel. On the flange area, the welding line moves towards the FEPO steel side, as it can be seen in the screen shots presented in Figure 3.

In the graphic below (Figure 4) it can be seen that it is a function (almost linear) between the welding line displacement, represented as movement of the node A, and the force applied by the blankholder. The weaker material, respectively the FEPO steel, flows more in the forming process, proportional with the increase of the binder force. The E220 steel (stronger material) is able to bear larger tensions that FEPO steel and its deformation is not so ample. If the first point is ignored the relation seems to be lineal.



$F = 8 \cdot 10^3 N$, $\Delta A = 2.49 mm$ $F = 1 \cdot 10^4 N$, $\Delta A = 2.50 mm$ $F = 3 \cdot 10^4 N$, $\Delta A = 3.12 mm$



$F = 5 \cdot 10^4 N$, $\Delta A = 3.85 mm$ $F = 7 \cdot 10^4 N$, $\Delta A = 4.55 mm$

Fig. 3. The maximum welding line displacement with respect to the blankholder force.

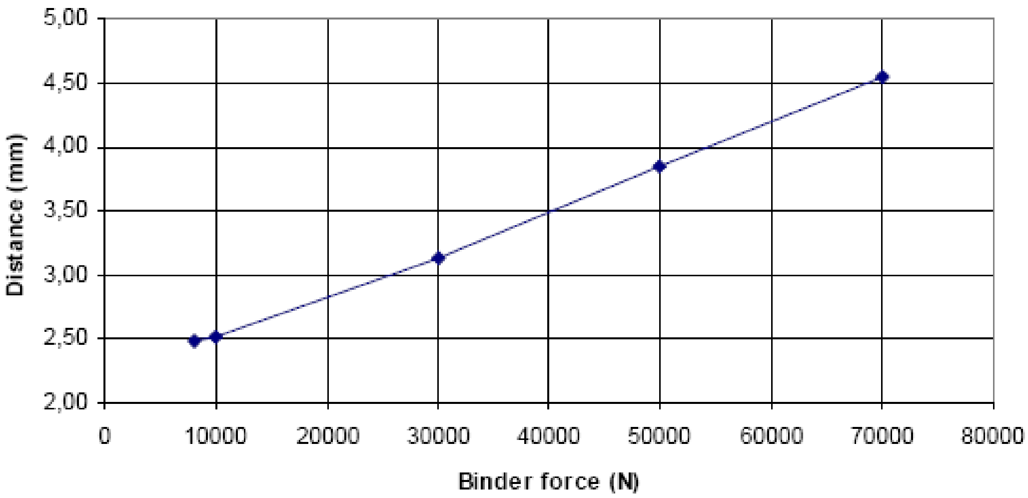


Fig. 4. Maximum welding line displacement with respect to the blankholder force for square shape.

3. CONCLUSIONS

In this study simulation were conducted for forming of a square shaped mart made from TWBs. Simulations have been made using PAM STAM 2G software. Displacement of the welding line is hardly affected by the blankholder force. Due to the complexity of the TWB forming process is not possible to control the welding line movement only by adjusting the blankholde force.

4. ACKNOWLEDGEMENTS

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