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FINITE ELEMENT SIMULATION OF TUBES PRESS BENDING PROCESS

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Abstract:

In this paper is presented a finite element model for simulation of tubes Press Bending Process. The finite element model, used commercial code ABAQUS. Also in this paper is present some results for simulation of different angle of the bending. Cold bending of metal tubes is very important production method considering that metal tubes are widely used in a great variety of engineering products, such as automobile, aircraft, air conditioner, air compressor, exhaust systems, fluid lines.

1. INTRODUCTION

One of the most troublesome problems that are facing tubing production industry is wall thickness change (Jin, 2001). In the outside of bend, the tube wall is subjected to tensile stress and the wall become thin, while in the inside of the bend appear compressive stress and the tube wall become thick.(Stachowicz, 2000)

In our previous works (Achimas, 2005) and (Lazarescu, 2005)], we have developed a finite element model for simulation of rotary draw bending process. This finite element approach can be used to optimize the product, the tools design and bending parameters. In the literature there are a few papers which use the finite element simulation to studies tube bending process. The finite element model, developed by ABAQUS/Explicit, was used to study the influence of the bending radius on the wall thickness change both in case of using a mandrel inside of the tube and in case of bending without mandrel. The paper (Achimas, 2007) present the simulation results on pre-bending and hydro forming process that are used to form an automotive part.

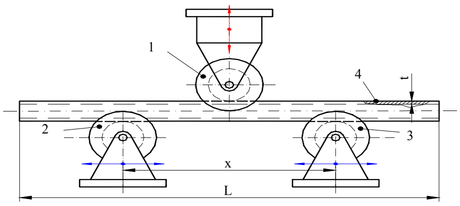
2. PRINCIPLE OF PRESS BENDING

The device used during this manufacturing consists of rolls 2 and 3 which are fixed on the table of a press, while roll 1 is fixed by the battering ram of the same press (Fig

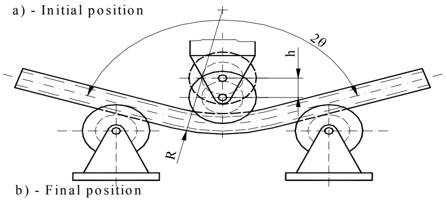
1). In order for the bending to occur, pipe 4 is placed on rolls 2 and 3, as roll 1 moves vertically on the pipe causing it to deform. The bending radius, as well as the bending angle are controlled using quotes x and h. The distance between rolls 2 and 3 can be adjusted by moving the rolls horizontally. The three rolls are placed on a surface with a channel that comes into contact with the pipe. The channel’s dimensions are proportional to the diameter of the pipe.

The advantage of this procedure is that it can produce different bending radiuses without changing the rolls, because the bending radius is not dependant on the radius of the roll, but on the position of the three rolls.

On the other hand, the disadvantage of this procedure is the fact that the bending radius is determined indirectly using quotes h and x, and it is a little more difficult to adjust.



a) - Initial position



b) - Final position

Fig.1 *The principle of press bending*

1. upper roll; 2-3 lower rolls; 4 – pipe (Semi-manufactured); 2θ - bending angle; h – the distance covered by the upper roll during the bending; R – the bending radius

3. FINITE ELEMENT MODELING OF PRESS BENDING

A finite element model of press bending was developed by ABAQUS CAE as shown in figure 2 and figure 3.

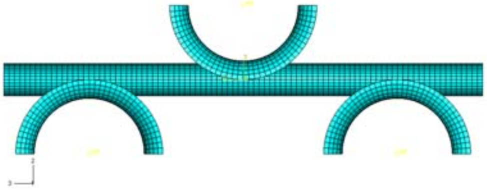


Fig.2 *The finite element of press bending*

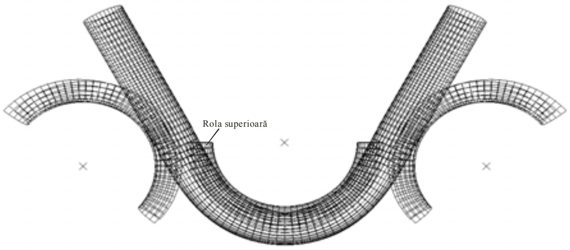


Fig.3 *The final position of press bending*

The tube was modeled as 3D deformable part of which material are behave elastic-plastic and the tools was modeled as 3D discrete rigid. Shell elements S4R were used to model the tube geometry.

Contact between various pairs of surfaces: bend die-tube, pressure die-tube, wiper die-tube is defined using *CONTACT_SURFACE_TO SURFACE contact option, which allows sliding between these surfaces with a Coulomb friction model. The implement friction coefficient was 0,1 .

The tube material was laminated steel OLT 35(STAS 8183-87). To obtain the mechanical properties of the tube material a tensile test of a straight tube was performed. The stress was derived from load force and instantaneous geometry of the tube. The strains were determined from extensometer directly attached to the tube during the test. Figure 4 show the Stress-strain relation used in order to describe the material behavior during simulation. The elastic modulus was E=2.1x10^5 [N/mm^2] and Poisson's ratio 0,3

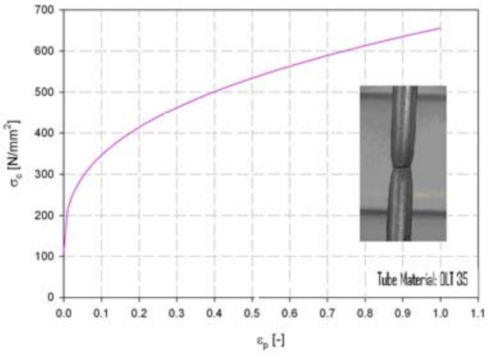


Fig.4 *Stress-strain relation obtained from tube tensile test*

4. Results of finite element simulation

In Figure 5 is presented the distribution of the wall thickness of the tube bending at angle 2θ = 25[^{o}] and diameter 27 [mm] made by finite element.

In Figure 6 is presented the distribution of the wall thickness of the tube bending at angle 2θ = 90[°] and diameter 27 [mm].

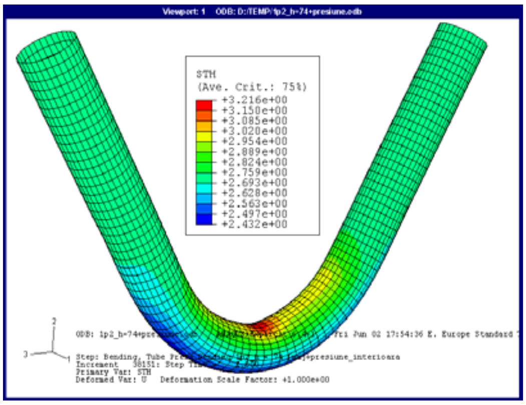


Fig.5 *Distribution of wall thickness of angle 2θ = 25[°]*

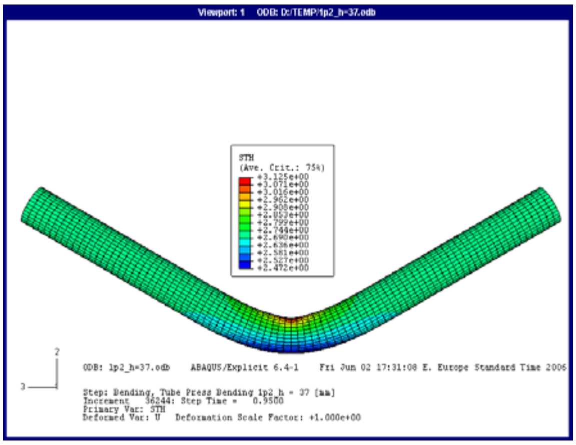


Fig.6 *Distribution of wall thickness of angle 2θ = 90[°]*

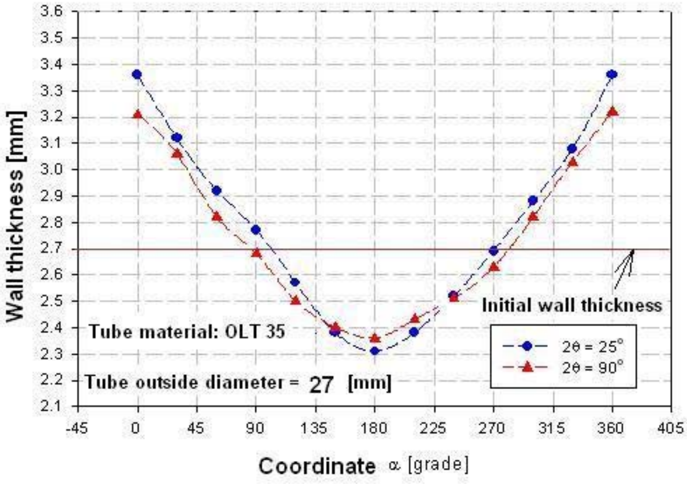


Fig. 7 *Variation of the wall thickness*

In figure 7 is present the variation of the wall thickness, the initial wall thickness. The smalls wall thickness is 2.4 and the biggest wall is 3.37 [mm].At 2.7 [mm] wall is the initial wall thickness.

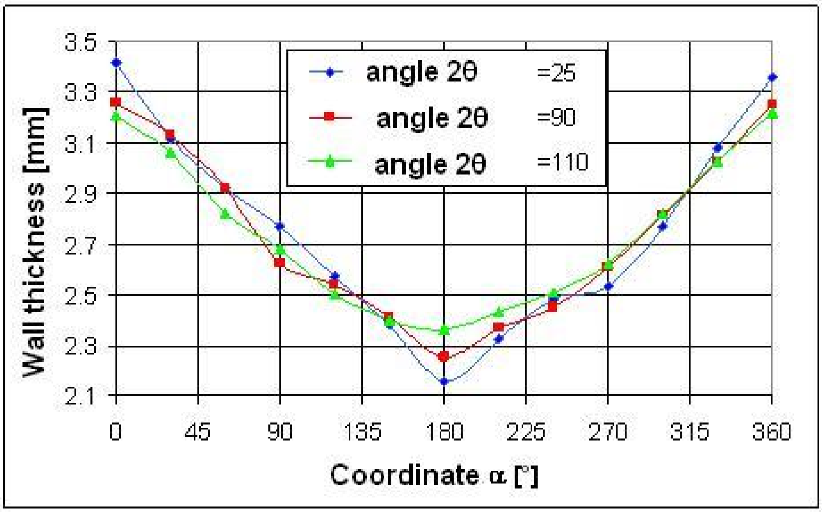


Fig.8 *Wall thickness of 3 angle*

In figure 8 it is present three angle which the tubes was bending on the press.

In figure 9 is presented the influenced of the pressure inside of the bending tubes.

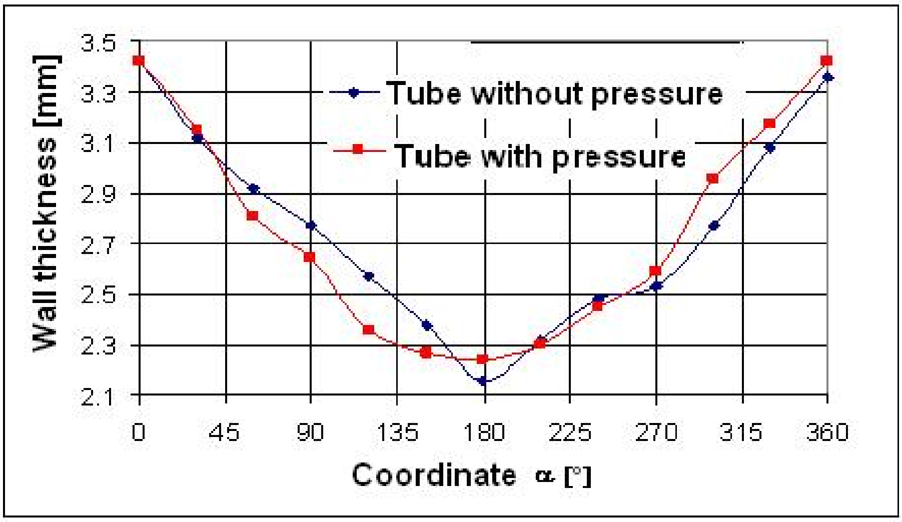


Fig.9 *The influenced of the pressure of wall thickness*

5. CONCLUSIONS

The objected of this paper was to study the wall thickness change of bent tubes, using the finite element simulation. For this aim it was realized a finite element model for simulation of press bending of tubes. Whit help of this finite element model was studied the influence of the angle on wall thickness change, both in case of bending whit pressure and in case without pressure. It was three angle: 25, 90, 110.

The results show that angle of bending has a strong influence on wall thickness change. Also it was observed that if the angle is smaller ($2\theta = 25[^o]$) the wall thickness change is more bigger that if the angle is big ($2\theta = 90[^o]$ or $2\theta = 110[^o]$).

Also is observed that if inside of tubes is pressure the deformation of the wall thickness is smaller that if inside of tubes isn't preassured.

6. REFERENCES

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