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INFLUENCE OF FRICTION IN THE DRAWING A CYLINDRICAL PART STEEL – PART I

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Abstract: *In this paper are analyzed the variation of deformation, the stresses of flow, the wall thickness in case of drawing process simulation conducted under two conditions: without the use of a lubricant used in liquid form. The analysis aims to establish the influence of friction on the quality of the drawing steel piece.*
Keywords: *punch, die, A steel piece*

Introduction

Deep drawing process simulation was performed without thin wall thickness with the aid of finite element software named Marc Mentat [1]. The piece is cylindrical flange, flat base, connected with the vertical wall. The blank is a disc made of a drawing annealed steel disc A3k mark being considered as steel A [2], with a diameter of 17 mm and a thickness of 0.4 mm ([3], [4]).

Conditions of the simulation

To achieve the the simulation had to be introduced through the points of the characteristic curve σ-ε (fig. 1) [1], which has been used characteristic curve recorded data from the tensile (fig. 2) ([5], [6]).

The form of the active elements is shown in fig. 3. They were considered rigid linear elastic with $E = 2.1 \cdot 10^5$ N/mm^2 and Poisson's ratio $v = 0.3$ [1].

Their dimensions are: the punch diameter d_p =7.7 mm, the die diameter d_m = 8.5 mm, the punch radius r_p = 2 mm, the die radius r_m = 2.5 mm, the height of piece h = 5 mm, the clearance of active elements j = 0,4 mm, coefficient of deep drawing without thinning admissible m = 0.56 ([3], [5]).

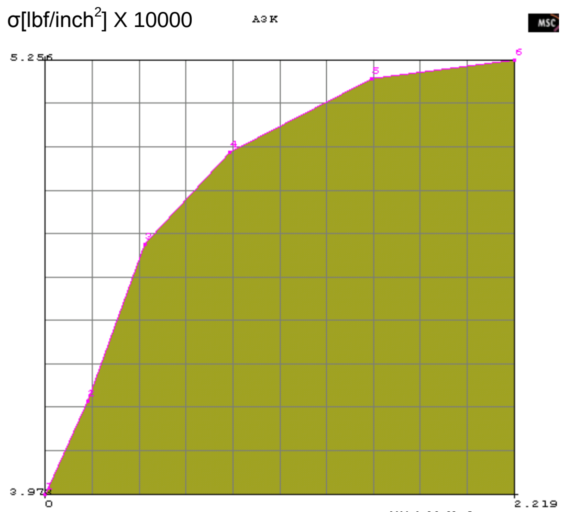
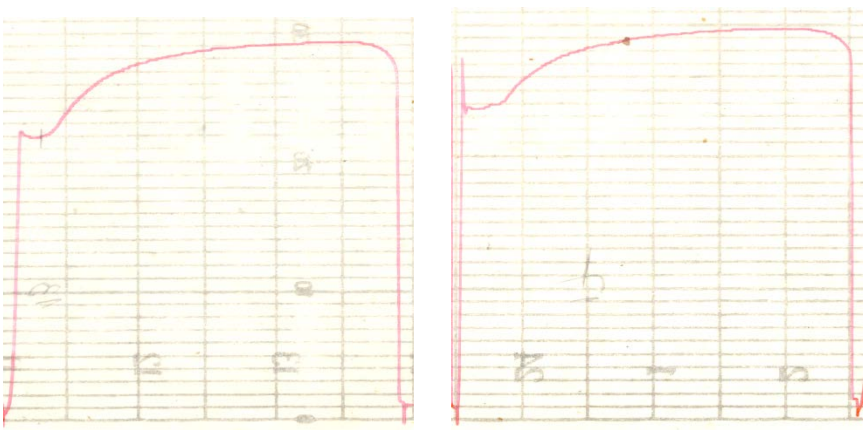


Fig. 1: The characteristic curve σ-ε for A steel introduced by points



a) b)

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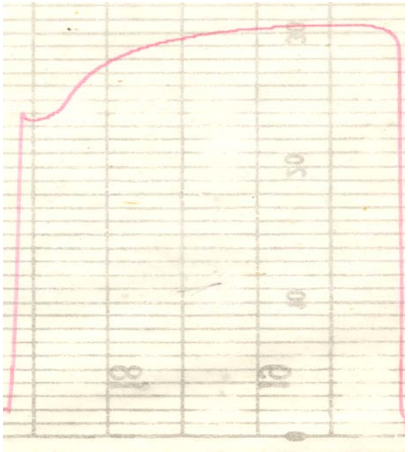
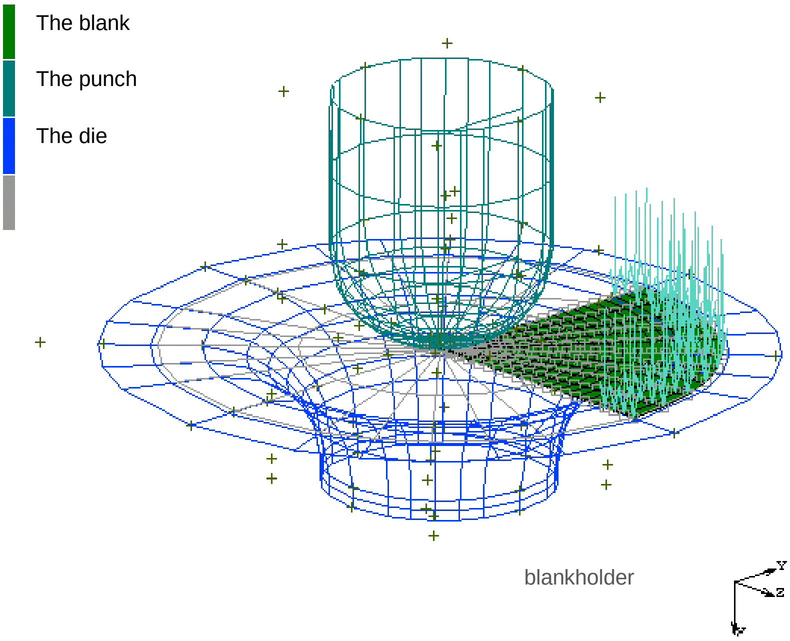


Fig. 2: The characteristic curve for A steel recorded for traction specimen taken: a) in a direction which is 0° to the rolling direction; b) in a direction which is 90° to the rolling direction; c) in a direction which is 45° to the rolling direction



Should be mentioned that in the graphic representations the total deformation equivalent values are given in percentage, of flow stress von Mises criterion - in psi (= 6894.8 N/m2), of variation force (depending on the increment) - in lbf (= 4.44 N) and of the variation cross-sectional thickness (for all representations noted by b)- in inch (= 25,4 mm) (in the abscissa is considered half of the value of the diameter of the piece, which is flared with the die radius).

Results of numerical simulation

Initial deep drawing process simulation was performed under the following conditions of friction: μ = 0.08 for contact between the blank and the die and μ = 0.25 for contact between the blank and punch. To see the influence of friction on the development process resumed deep drawing simulation for μ = 0.22 value at the contact between the blank and the die. The coefficient of friction between the blank and punch is kept the same.

a.1. The coefficient of friction at the contact between the blank and the die $\mu_{m\text{-}s}$ = 0.08 at the contact between the blank and punch $\mu_{p\text{-}s}$ = 0.25

a.1.1. Variation of total strain

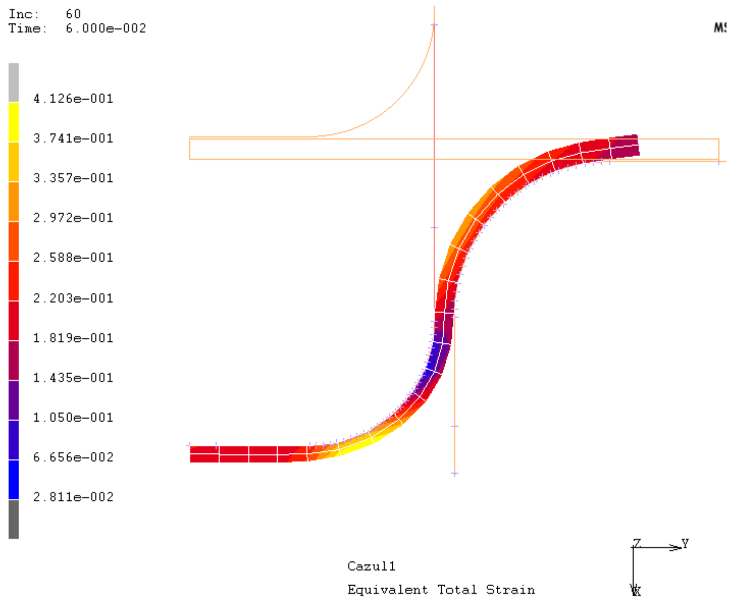


Fig. 4: Variation of total strain equivalent for A steel piece

The maximum values of the deformations are formed in the area corresponding radius the punch (fig. 4).

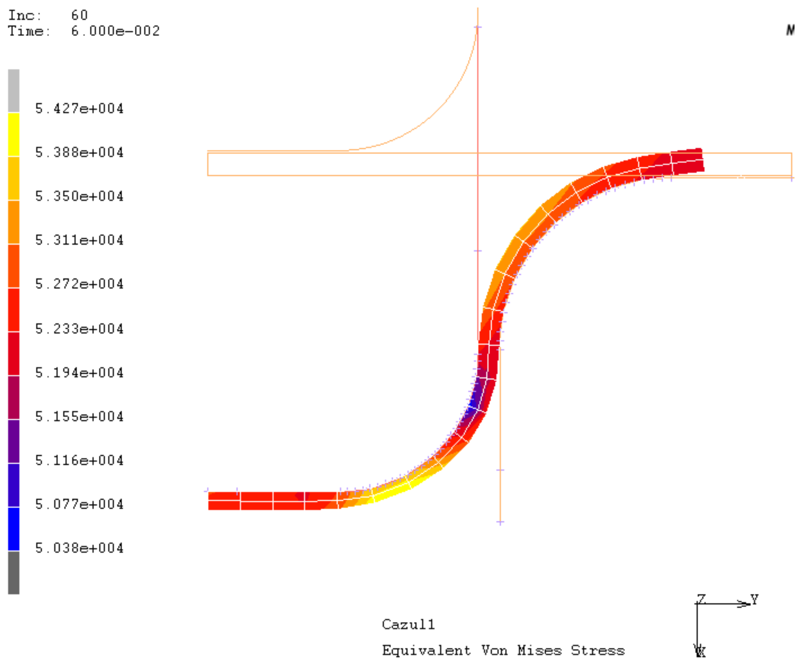


Fig.5. Variation of tension flow after von Mises criterion, for A steel piece

This is justified the deformation history of this portion of material: to get here this portion of the material passed from a flat blank shape by the tensile + compressive dominant compression in the connection area between the flange and the wall piece, then by the tensile-compression dominant stretch in the wall piece and finally has reached this strong area harden. The high level of deformation is explained by obtaining cylindrical walls.

a.1.2. Variation of tension flow after von Mises criterion

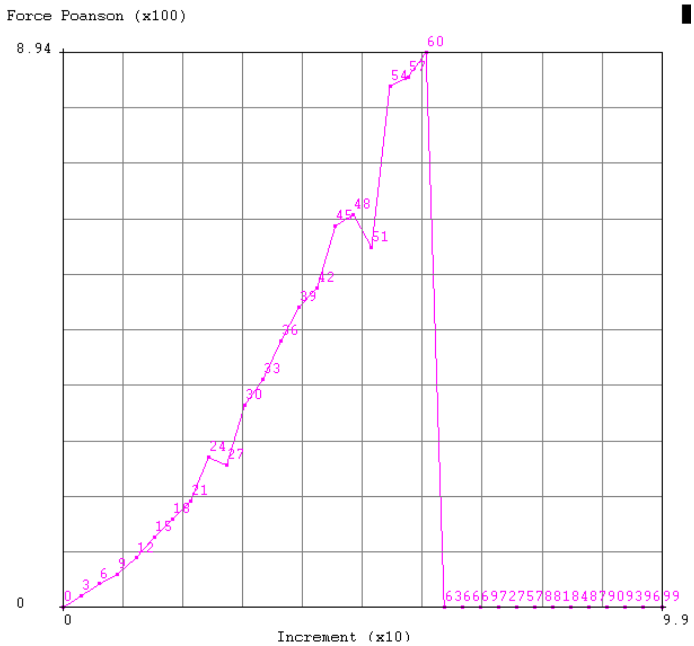


Fig. 6. The diagram force – stroke for A steel piece

The maximum values of flow stress (Fig. 5) correspond to areas of maximum strain, but on a larger distribution, because it is included and the radius of the die.

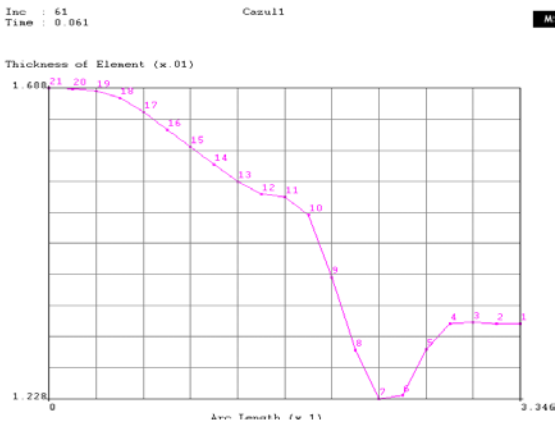
a.1.3. The diagram force - stroke

The diagram force - stroke punch is shown in fig. 6. A3k steel punch force necessary to drawing is in accordance with lower plasticity; also this correlation is observed with both strains and with variation in stress flow.

a.1.4. Variation of wall thickness in longitudinal section

Of fig. 7a deduce the conclusion that there is a bulging piece of the bottom. It is due to a residual bending moment caused by bending and straightening of the material which passes over the die radius and the stretch corresponding formation of part wall. This moment determines the final curving, which represents a form of the elastic comeback, because the material of the basis punch is in contact with only the punch radius.

Of fig. 7b is observed that the thinning increases from the point of connection to the radius of the bottom of the punch, on a part of the area connected, after which it begins to decrease slightly right of this area so that the thickness achieve the nominal value on the input portion in the radius of the die, the material is then thickened to flared end portion of the workpiece.



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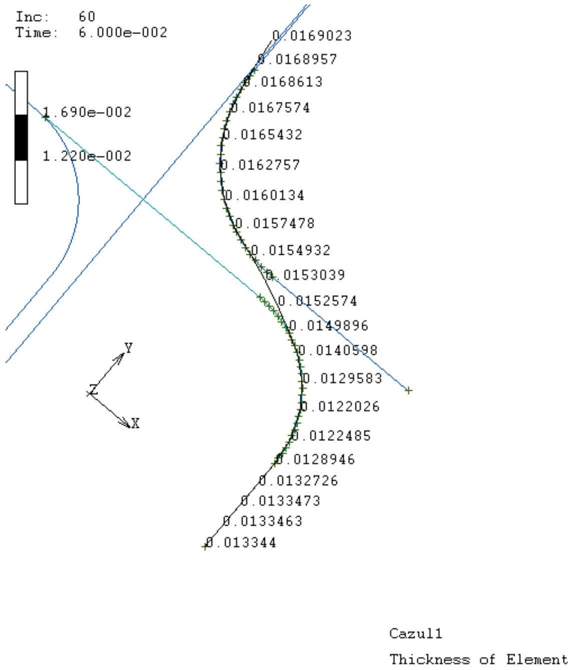


Fig. 7. Variation of thickness in longitudinal section for A steel piece

b.1. The coefficient of friction at the contact between the blank and the die $\mu_{m\text{-}s}$ = 0,22 at the contact between the blank and punch $\mu_{p\text{-}s}$ = 0.25

b.1.1. Variation of total strain

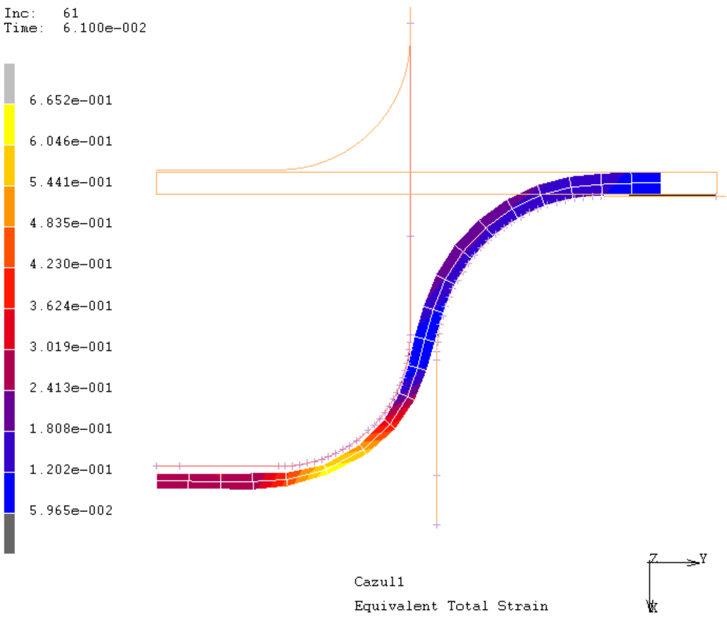


Fig. 8. Variation of total strain equivalent for A steel piece (without lubricant)

In fig. 8 are shown the values of equivalent total strains under conditions of changing the coefficient of friction. The maximum values of these deformations in the steel piece are highlighted in the radius punch. In this case, the thinning piece is very pronounced and deformation values are about 30% higher than with lubricant.

b.1.2. Variation of tension flow after von Mises criterion

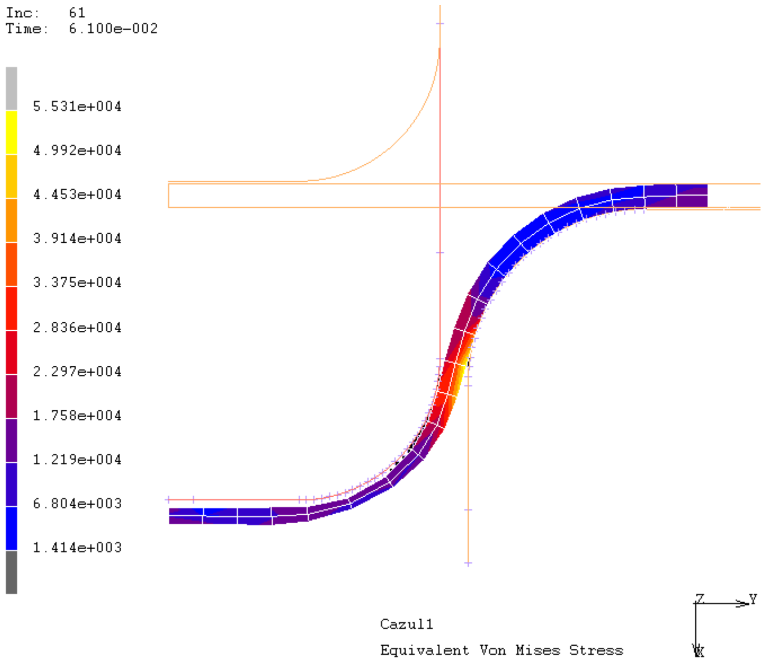


Fig. 9. Variation of tension flow after von Mises criterion, for A steel piece (without lubricant)

In fig. 9 is present the values of flow stress after von Mises criterion under conditions of changing the coefficient of friction. It is observed that the maximum stress flow corresponds to the cylinder wall, because this material plasticity smaller compared to others with greater plasticity.

b.1.3The diagram force – stroke

The diagram force – stroke is shown in fig. 10 and is observed that the values are close to the case analyzed above, which is in accordance with the maximum values of flow stress and strains.

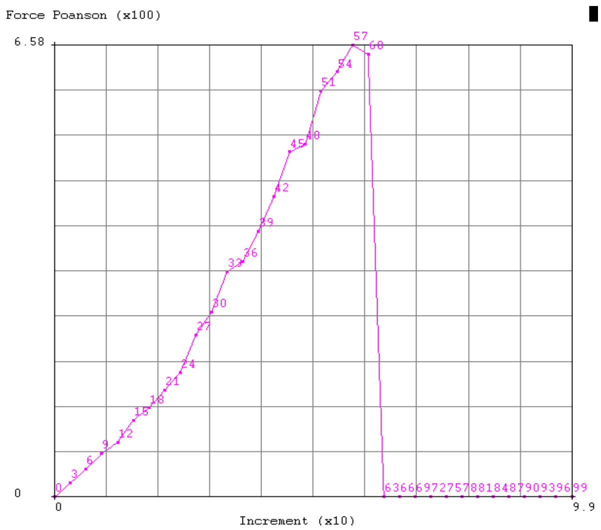
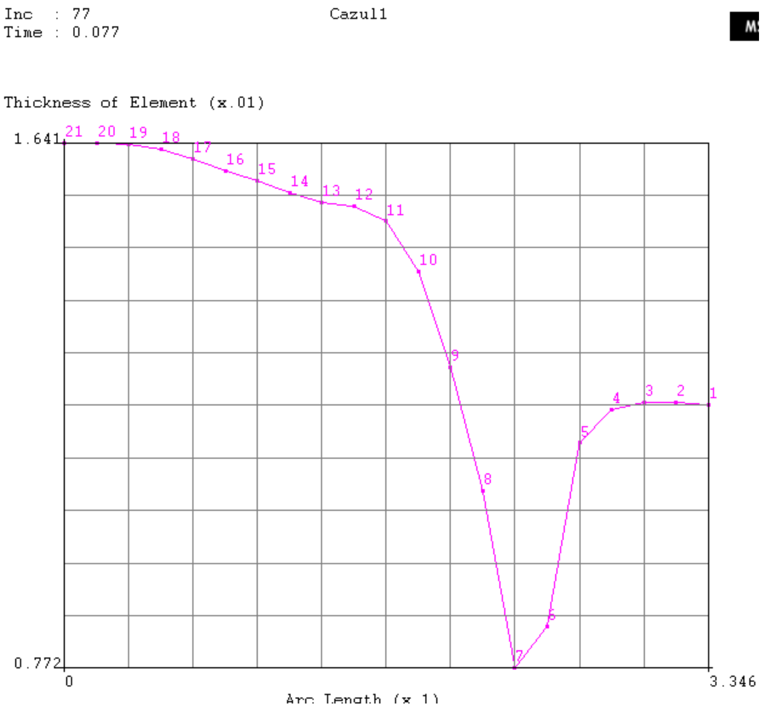


Fig. 10. The diagram force – stroke for A steel piece (without lubricant)



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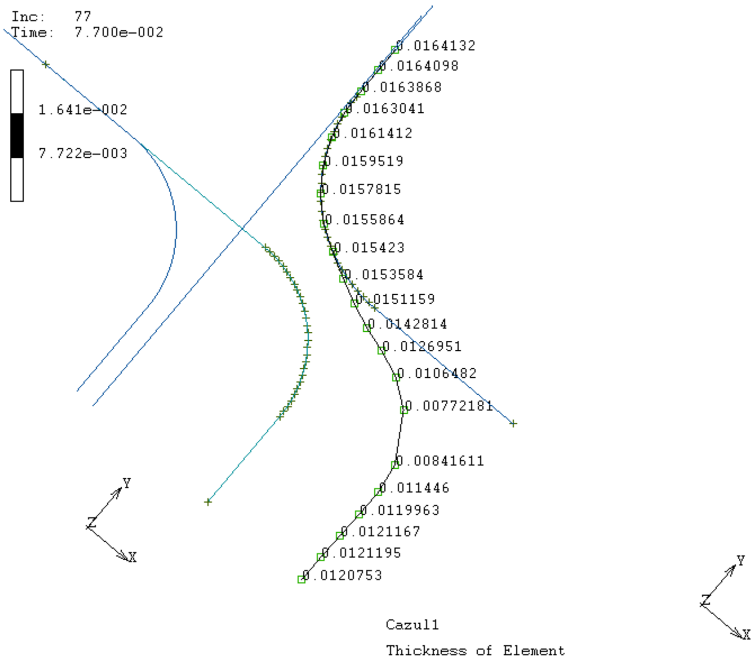

Fig.11. Variation of thickness in longitudinal section
for A steel piece (without lubricant)

b.1.4. Variation of wall thickness in longitudinal section
Variation of wall thickness in longitudinal section is shown in fig. 11. Thinning material is evidenced in the bottom flat. In the case of steel wall thickness decreases abruptly at the beginning of the bottom punch radius. The large distance between nodes suggests loss of continuity of the material, which is in accordance with the maximum deformation values corresponding to that area. Then the thickness starts to increase slightly reaching the nominal value near the exit of the die radius; follows thickening material to end the flared portion of the piece.

Conclusions

Comparing the latest results (corresponding to conduct of the drawing process without lubricant) to those outlined in section 3.1, for steel A (brand A3k), the following conclusions results:

- Increase the coefficient of friction leads to scrap;
- Can not discuss about manufacturing quality of steel piece drawing, because is not met the criterion of physical continuity of the material.

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