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AN ANALYSIS OF THE BLANK SHAPES EFFECT TOWARD THE QUALITY OF THE SQUARE DEEP DRAWING PARTS

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ABSTRACT
One cause of material waste in sheet metal forming of rectangular parts is the trial determination of the form and the dimensions of the blanks. In the paper are analysing starting from a real case, the principal trial methods for the assessment of the blanks forms and dimensions of the deep drawn rectangular parts and then using the FEM are simulated the processes of deformation of investigated blanks. Future investigations will be made to determine more realistic the shape and the dimensions of the blanks for rectangular parts
***Key words:** sheet metal forming, deep drawing, FEM, process design*

1. INTRODUCTION

The development of finite element method and computer technology, gives a realistic image of the process of sheet metal deformation even in the case of complex parts such as rectangular or irregular pieces.

There are (at least) two primary goals for the use of Finite Element Method (FEM) in analysis of a sheet metal forming process. First, analysis aims to reduce the trial and error in tooling and process design, and thereby reduce the material waste and lead times to produce a new part. Second, the analysis aims to influence the design of the desired part for ease of manufacture.

One cause of material waste in sheet metal forming of rectangular parts is the trial determination of the form and the dimensions of the blanks.

In accordance with the [1], the parameters, which are considered in design of the blank shape of the rectangular part, are: the radius on the corner (r_c), the height (H) and the width of the piece (B).

Depending upon the ratio $r_c/(B-H)$ the calculus of the dimensions and the blank shape determination are largely presented in [1] and its takes on account the degree of the material pushing from the corners regions toward the lateral walls of the rectangular piece.

In the paper are analysing starting from a real case, the principal trial methods for the assessment of the blanks forms and dimensions of the deep drawn rectangular parts and then using the FEM are simulated the processes of deformation of investigated blanks.

2. THEORETICAL DETERMINATION OF THE SHAPE AND DIMENSIONS OF THE RECTANGULAR PART

It's considered to obtain a rectangular piece which dimensions are presented in figure1.

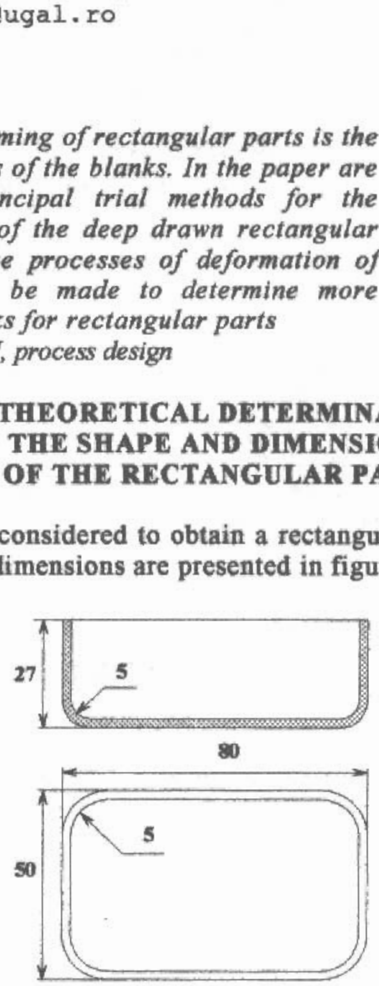

FIG. 1. Sketch of the rectangular part

If it is considering the ratio $r_c/(B-H)$, it's result that the part from point of view of blank determination [1], it is place on a transition zone, where it could be apply two schemes for blank calculus.

The two schemes for the blank shape determination are presented in figure 2 and 3. The scheme from figure 2 is applying when the ratio is between 0,17 and 0,4. In this case an important displacement of material from the corners to the lateral walls takes place. The scheme from figure 3 is applying when the ratio is less then 0,17. In this case the material displacement from the corners to the lateral walls is small. The notations and the calculus are presented in [1].

Also it was considered, for practical reasons, a blank, which is composing from to straight opposite lines connected with two semi arcs.

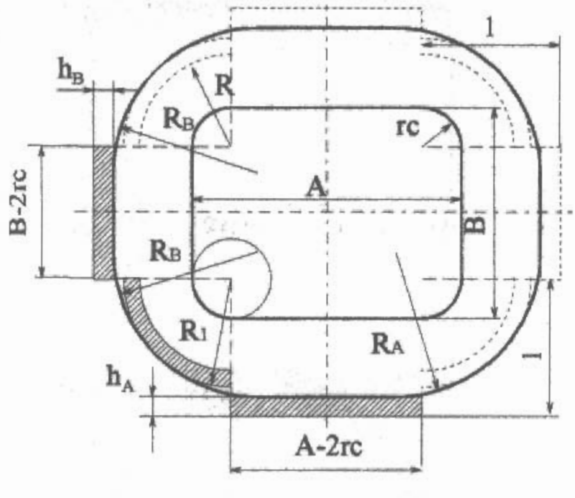

FIG. 2. Scheme for the rectangular part shape determination

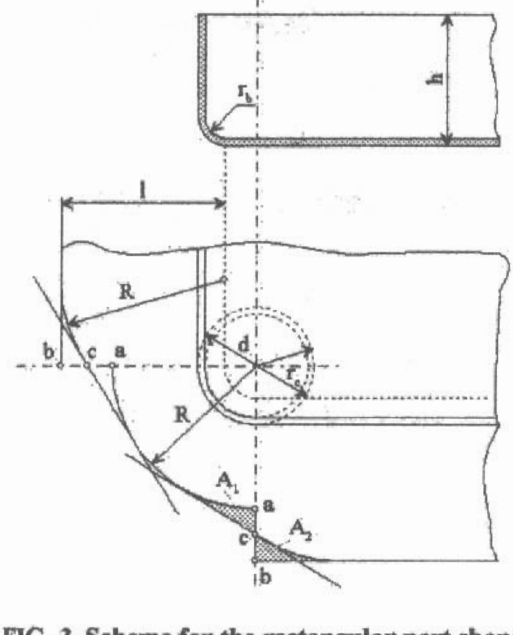

FIG. 3. Scheme for the rectangular part shape determination

3. NUMERICAL SIMULATION OF RECTANGULAR PART DEEP DRAWING

The material used in experiments was mild steel, with a thickness of 0,8 mm. The mean tensile properties of the material were: the yield stress of 180 MPa; the ultimate tensile stress of 303 MPa; *n*-value of 0,2037 and *K* of 540,6 MPa. The average *R*-value was 1,705.

The punch speed was 10 mm/second. The maximum forming depths was set at 40 mm. Binder force was set at 200 kN.

A commercial explicit finite element program LS-DYNA was used for the simulation. The elements used were 4-node Belytschko-Tsay shell elements, which provide five integration points through the thickness of the sheet metal. The tooling was modelled as rigid surfaces (figure 4). A Coulomb friction law was used with a friction coefficient of 0,1.

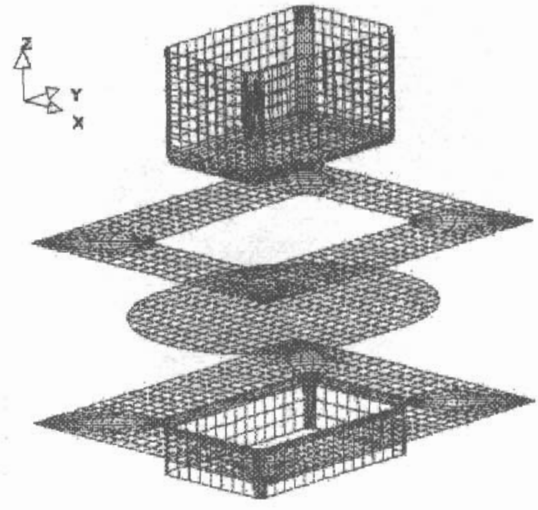

FIG. 4. The tooling used in FEM simulation

The material was assumed to be anisotropic. The yielding of the material was modelled using a power law, as:

$$\sigma = K\,\varepsilon^{n} \qquad (1)$$

In figure 5 is presented the clearance (j) between the die and the punch, and it was chosen from practical reasons. This clearance is not uniform as it can see from the figure. The die has a radius at the corners of 3 mm and the punch has the radius of 5 mm.

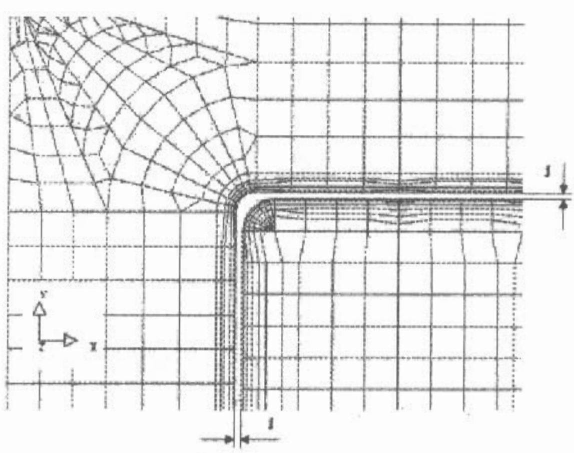

FIG. 5. The clearance of the deep drawing die

The shapes of the blanks used in simulation are presented in figure 6, a-c. In figure 6.a, the blank is composing from to straight opposite lines connected with two semi arcs. In figure 6.b, the blank was determinated using the scheme from figure 3. In figure 6.c, the blank corresponds to the scheme from figure 2.

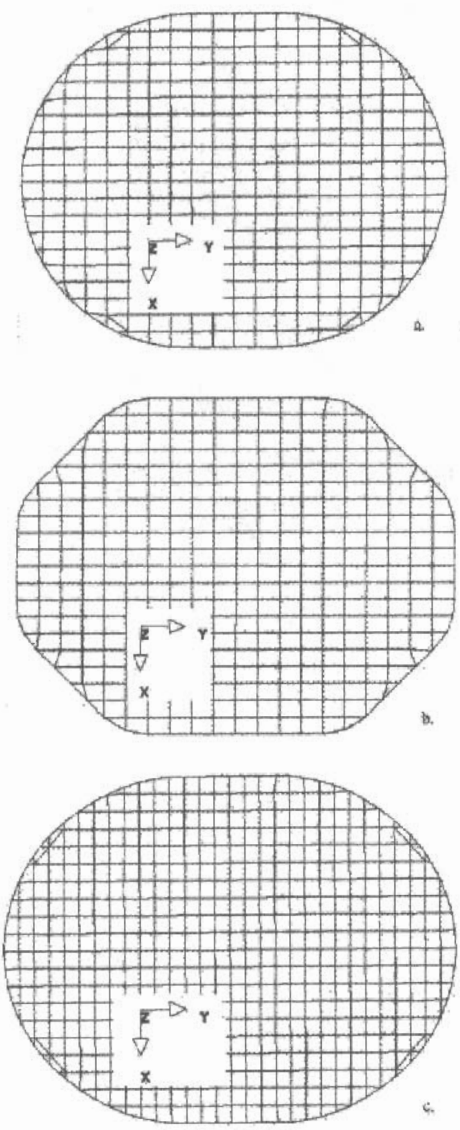

FIG. 6. The blanks shapes used in FEM simulation

The intermediate stages of deformation for the types of blanks, when the part was drawn with 13,5 mm, are presented in figure 7, a-c.

In the first case, from figure 7.a it is observing the displacement of the material mainly from the lateral walls parallel with the length direction. Also the radii from the left and right sides of the blank become linear.

In the second case, from figure 7.b it is observing an important material displacement both in width and length directions. In opposite with the first case the linear regions from the blank corners become curves zones.

In the third case (figure 7.c), the material displacement as compared with figure 7.a. is smaller.

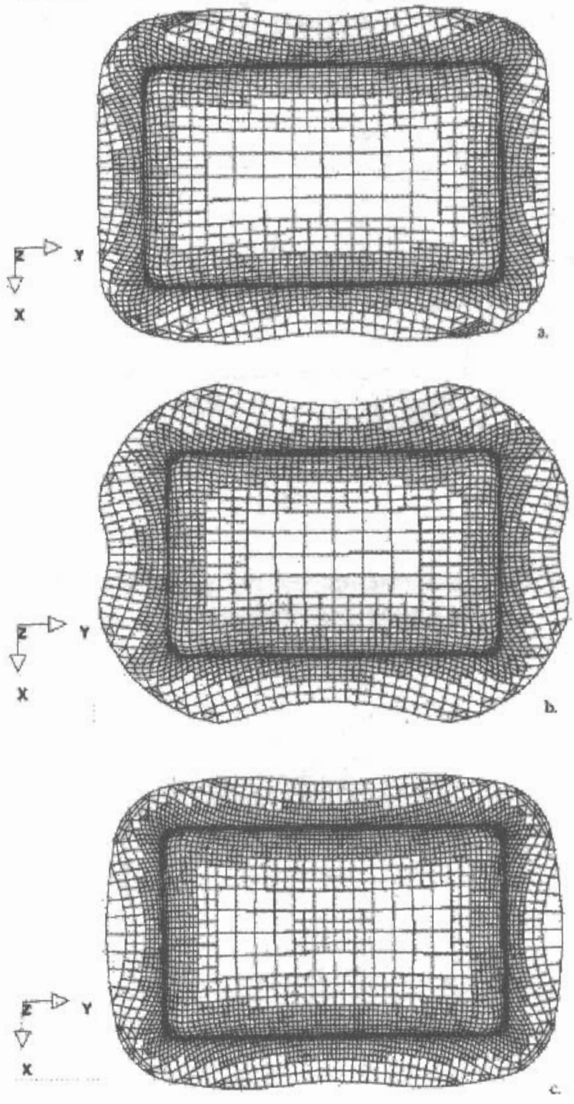

FIG. 7. The intermediate shapes of the blanks in FEM simulation

The final shapes of the blanks are presented in figure 8, a-c.

In figure 8.a, important ears appear in the corners of the part. The heights of these are about 6 mm, measured on simulation model.

In figure 8.b, the final form of the part is quite inadequate. Important wastes are obtained in this case.

In figure 8.c, the level of the ears is smaller in comparison with the case 8.a. The heights of these ears are about 4 mm. Also, the heights on lateral walls are more uniform.

4. EXPERIMENTS OF RECTANGULAR PART DEEP DRAWING

In figure 8 are presented the shape of the blank having the width of 80 mm and length of 150mm.

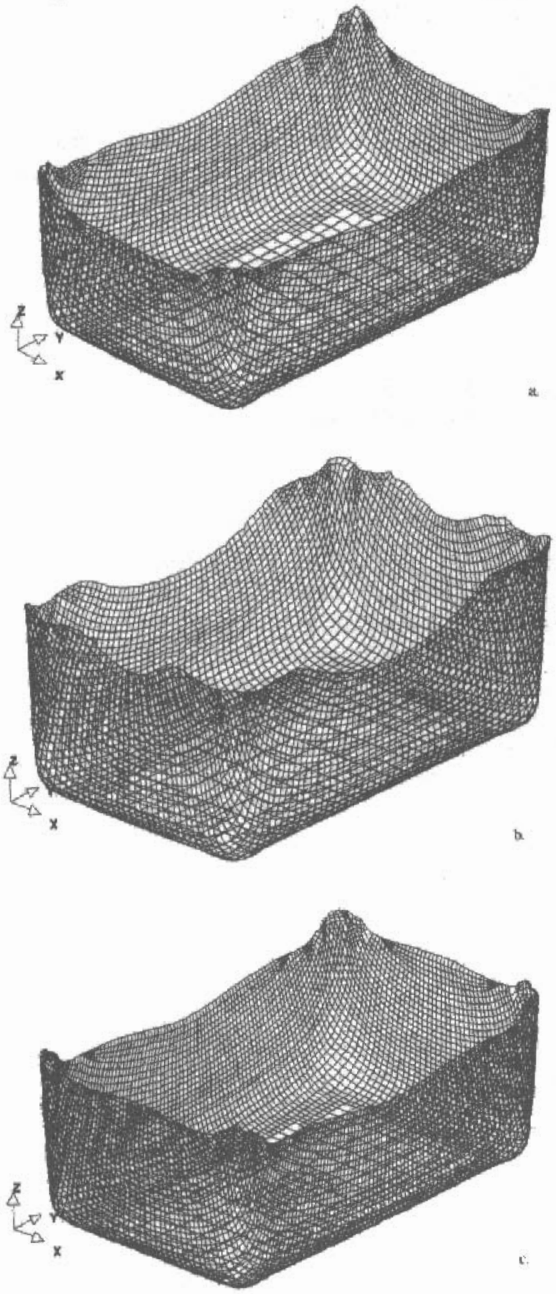

FIG. 8. The final shapes of the blanks in FEM simulation

Using the same material and process parameters as in simulation, were performed a series of experimental tests.

The part obtained after the process of deformation is presented in figure 10.

The experimental results, shows the influence of the form blank toward the quality of the rectangular part. As it result from figure 10, in the corners of the parts excessive ears appear as the result of the strains and stresses in these regions. The height of these ears is about 6 mm, like in simulation. This form, as it can see from figure 8, was predicted using the simulation with the LS-DYNA FEM program.

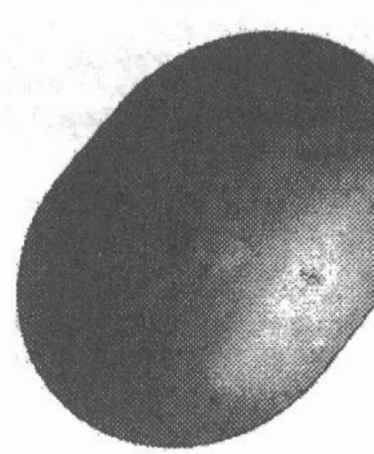

FIG.9. The shape of the blank

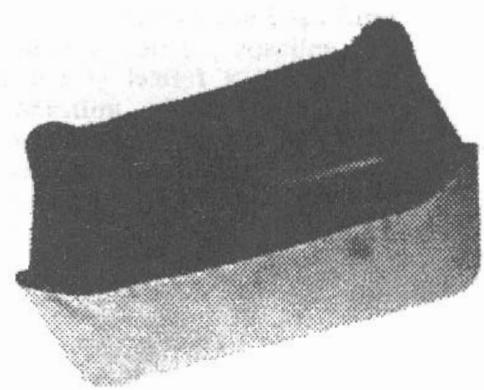

FIG.10. The shape of the part

5. CONCLUSIONS

The complex state of deformation in the case of rectangular parts forming lead to difficulties in assessment of blank shape and dimensions.

In all the analysed cases, the ears are the main problem. Depending of the method for the determination of the blank shape and dimensions, this phenomenon is more or less important. It result that the theoretical methods proposed in literature only approximate the necessary form of the blanks.

Future investigations will be made to determine more realistic the shape and the dimensions of the blanks for rectangular parts.

6. Acknowledgements

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ANALIZA INFLUENŢEI FORMELOR SEMIFABRICATELOR ASUPRA CALITĂŢII PIESELOR PARALELIPIPEDICE AMBUTISATE

Rezumat

Una din cauzele pierderilor de material la deformarea plastică a pieselor rectangulare este utilizarea unor metode aproximative de determinarea a formei şi dimensiunilor semifabricatelor. In lucrare se prezintă, plecând de la o aplicaţie practică, o analiză a metodelor teoretice aproximative, de determinare a formei şi dimensiunilor semifabricatelor pentru piesele rectangulare şi apoi utilizând metoda elementului finit sunt simulate procesele de deformare a semifabricatelor determinate cu metodele considerate. Rezultă necesitatea introducerii unor noi elemente de calcul pentru obţinerea unor forme de semifabricate care să conducă la fabricarea de piese rectangulare de calitate superioară.

EINE ANALYSE DES FREIEN RAUMES FORMT EFFEKT IN RICHTUNG ZUR QUALITÄT DER QUADRATISCHEN TIEFEN ZEICHNENDEN TEILE

Zusammenfassung

Eine Ursache der Materialvergeudung, bei der Blechformung der rechteckigen Teile ist die Probeermittlung der Form und der Maße der freien Räume. Im Papier analysieren das Abfahren von einem realen Fall, die Hauptprobemethoden für die Einschätzung der Formulare und Maßen der tief gezeichneten rechteckigen Teile und das FEM dann verwenden werden die Prozesse der Deformation der nachgeforschten freier Räume simuliert. Zukünftige Untersuchungen werden gebildet, um realistischer die Form und die Maße der freien Räume für rechteckige Teile festzustellen