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SECTION 7. Mechanics and machine construction.

A DETERMINATION OF THE STRAIN STATE OF THE THIN-WALLED HOLLOW DETAIL OF SQUARE SHAPE AFTER THE DRAWING OF THE SHEET METAL WITH THE BLANK HOLDER

Abstract: The article was made the analysis of the limiting deformations of the thin-walled detail the boxing shape after a forming operation of the sheet stamping.

Key words: a drawing, a thin-walled detail, a deformation, wrinkles.

Language: English

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Introduction

In the work [1] a research of the degree of a plastic deformation of the box thin-walled detail after the drawing process of a sheet metal of the square shape was performed. By the greatest plastic deformation is exposed the material in the area at the vertical edges of the formed thin-walled detail.

To reduce of the residual stresses and the prevention of the microcracks formation [2] in the material of the detail you need to choose of the optimal geometry of the forming tools drawing die, and, in particular, the sizes of the rounding radiuses of the edges of the working part of the punch and the working die hole. These works [3; 4] were devoted this issue. The authors suggested a comparison of the change of the drawing force from the value of the corner radiuses of the punch. Determined that during the drawing of brass, aluminium alloy and steel by the punch with the small corner radiuses required application of less force than when the press of the punch with the larger corner radiuses.

A research of the influence of the thickness of a sheet metal on the degree of deformation of the material was made in the work [5]. With decreasing of thickness of the square blank the degree of the deformation of the material is increased. The conclusion was obtained on the basis of the calculated elongation ratios.

During the drawing of the square blank in a cylindrical die, the plastic deformation in the cross section of the protrusion significantly exceeds the

magnitudes of the deformations in the area of the hollow [6].

The comparison of the simulation results of the drawing process of the detail of square shape and the production experiments is given in the work [7]. It is established that the calculated values of the drawing force less the actual values at 11.5 %. Therefore, when the critical calculations must take this error.

Let us consider the degree of the possible limit plastic deformations of the material of the thin-walled detail of square shape after sheet stamping.

Materials and methods

Simulation of the process of the drawing the box thin-walled detail was performed in the program of engineering analysis LS-DYNA.

The outer and inner surfaces of the models of the details of the drawing die and a sheet metal were accepted by the square shape. To reduce of the local deformations of the blank material during pressure processing was carried out the rounding radiuses of the edges of the working part of the punch, the working die hole and the hole in the blank holder by the size of 7 mm.

Anisotropic elastic-plastic metallic alloy was subjected by the pressure processing. For this material it is necessary to specify mass density (7870 kg/m³), Young's modulus (207 GPa), Poisson's ratio (0.28), yield stress (127.6 MPa), anisotropic hardening parameter (1.0) and the load curve ID defining effective yield stress versus effective plastic



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strain (2.0). Only transverse anisotropy is taken in the model. This plasticity model is fully iterative and is available only for shell elements.

The drawing depth of the sheet metal was amounted to 20 mm.

Results and discussion

The analysis of the pressure processing of the material was carried out in the interface "Forming

limit Results". Opening of the dialog window "Formability" allows to receive a visual display of the color contours of the plastic deformation on the model of a processed detail.

The character of the plastic deformation of the thin-walled detail box shape after the drawing process is presented in Fig. 1.

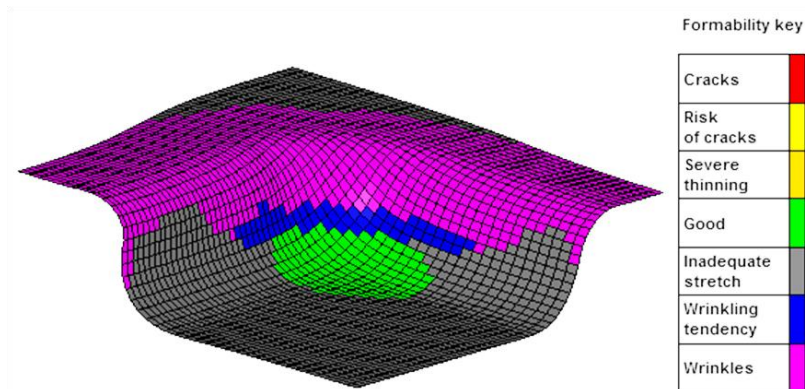


Figure 1 – The character of the plastic deformation of the thin-walled detail after the drawing process.

For assessment of the deformation degree of the material is proposed the option "Middle surface".

The absence of the defects at the area of the coupling of the side wall and the bottom of the thin-walled detail says about the rational choice of the size of the rounding radiuses of the edges of the working part of the punch. The significant material defects of the thin-walled detail (cracking and wall thinning) are not observed. The use of the blank holder does not completely eliminate the formation of wrinkles on the surfaces of the thin-walled detail.

The concentration of the wrinkles occurs on the flange of a sheet metal and partially on the side walls of the formed detail. The bottom of the thin-walled detail and excess material on the flange of a sheet metal are subjected by the inadequate stretch.

For determination the possibility of the forming sheet material when different ratio of the deformations is constructed forming limit diagram [8].

The forming limit diagram of the material under sheet stamping is presented in Fig. 2.

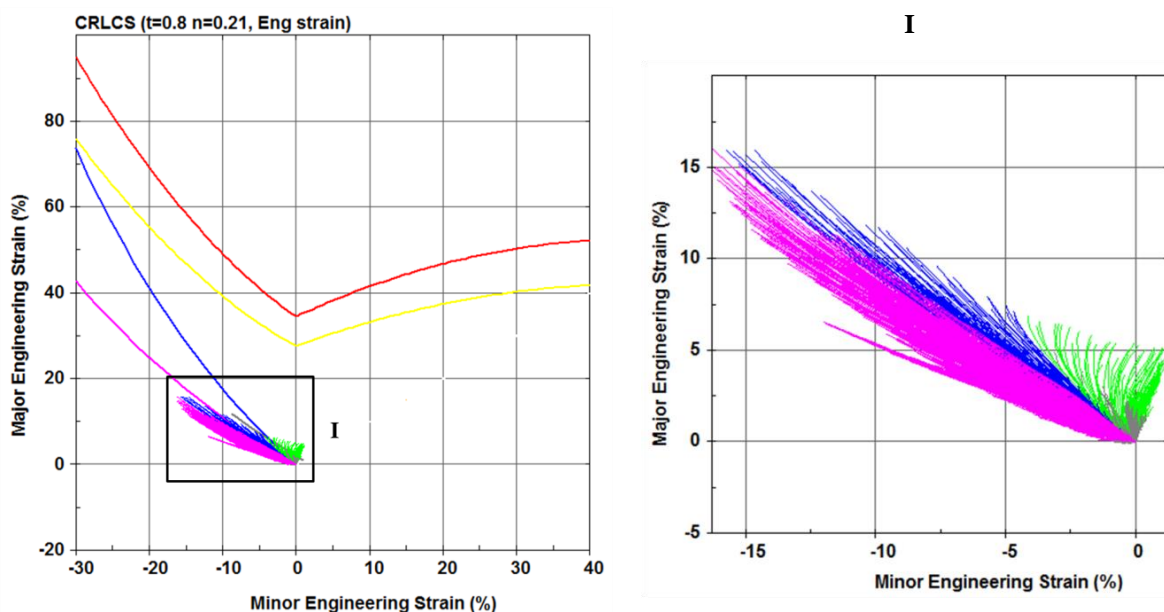


Figure 2 – Forming limit diagram.

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On the diagram are shown the typical zones of the material deformations of the thin-walled detail. On the axes of abscissa and ordinate are delayed values of the minor and major engineering strains (in percentage terms) in which different defects are occurred. The positive values of the engineering strain correspond by the elongation of the material, the negative values – the compression. The deformation zones are separated by the respective color boundaries. The deformation curves of all finite elements of the model are presented in the figure to the right.

The following parameters for constructing the curves in the diagram are proposed: sheet thickness – 0.8 mm, forming limit diagram crit. formula index – 0.21, % limit of forming limit curve (limit % FLC) – 0, safety margin percentage from forming limit curve (safety margin % FLC) – 20, level of acceptable thinning (allowable thinning) – 0.3, required amount

of thinning (essential thinning) – 0.02, acceptable amount of thickening (allowable thickening) – 0.01, coefficient of thermal resistance (R-value) [9] – 1.82.

All material deformations of the thin-walled detail are occurred with the positive values of the major engineering strain and the negative values of the minor engineering strain. The optimal formation of the detail is occurred when slight stretching or compression (in the diagram to 5 %).

Conclusion

Thus, on the basis of the conducted analysis the deformation zones of the material of the processed detail were identified. The maximum deformation of the thin-walled detail after the process of the drawing is not more than 20 % of the local deformation (taken as 100 %), in which the fracture of the material is occurred.

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