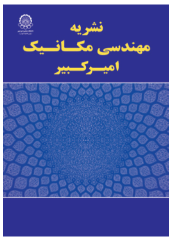


Amirkabir Journal of Mechanical Engineering

Amirkabir Journal of Mechanical Engineering, 49(4) (2018) 299-302
DOI: 10.22060/mej.2016.807

Experimental and Numerical Study of Hydrodynamic Deep Drawing Process of Rectangular Cups and Blank Shape Optimization

A. Haghparast, H. Gorji*, M. Bakhshi, G.M. Alinejad

Faculty of Mechanical Engineering, Babol Noshirvani University of Technology, Babol, Iran

ABSTRACT: Production of rectangular sheet parts by traditional deep drawing methods is associated with many problems. The absence of axisymmetry and the difference between the length and width of the part makes the forming of these products difficult. In this paper, forming of rectangular cups in a single step which is not possible by traditional methods for the desired depth and corner radius, has been examined by hydrodynamic deep drawing process with radial pressure. In this research, after designing and manufacturing of die and forming of rectangular parts, the obtained results from simulation were compared and verified by those of experiments. Moreover, the effect of forming pressure on thickness distribution has been investigated. The study illustrated that increasing forming pressure up to an optimum value improves formability and thickness distribution. In addition, in order to remove flange area and to improve formability, optimization of the sheet dimensions has been performed using sensitivity analysis. It was concluded that optimizing the blank shape can improve thickness distribution, eliminate final flange trimming and decrease one stage of manufacturing, resulting in decreasing production time and cost. Finally, it was illustrated that it is possible to adequately form rectangular cups in one stage using optimized blanks.

Review History:

Received: 26 January 2016
Revised: 7 May 2016
Accepted: 29 May 2016
Available Online: 8 November 2016

Keywords:

Hydroforming
Rectangular cups
hydrodynamic deep drawing
Finite element simulation
Optimization

1- Introduction

Among the forming methods of metal sheets, hydroforming process, due to several advantages, has had much attention [1]. In this process, a chamber consists of one kind of fluid is replaced with the solid die. During the punch movement into the chamber, the fluid is compressed and inserts pressure under the sheet, and pushes the sheet onto the punch tightly. Thus, the sheet gets the form of the shape of the punch [2].

Meng et al. [3] investigated the effect of chamber pressure on hydrodynamic deep drawing of rectangular cups. They showed that producing rectangular parts by multi-stage traditional deep drawing process has some problems, such as low surface accuracy and high producing time. They formed the mentioned part by hydroforming process in one stage by a suitable pressure path. They illustrated that the formability is improved by increasing the chamber pressure.

Shim et al. [4] optimized the shape of blank in simple deep drawing process. They investigated the optimization of the blank dimension according to an algorithm on square, clover-like and L-shaped sheet parts. They discovered that with regards to the geometry of the defined parts, the optimization of the blank dimensions can be performed accurately in some stages.

In this paper, forming of rectangular parts by using hydrodynamic deep drawing process with radial pressure and optimizing the initial dimension of blank was performed. To perform the finite element simulation, ABAQUS software was used. Moreover, in order to improve the formability, to remove the flange area, and to reduce the production time and cost, optimization of blank dimension was carried out by sensitivity analysis. Finally, to verify the optimization results in the simulation process, the rectangular part with the optimized blank was formed experimentally.

Corresponding author, E-mail: hamidgorji@nit.ac.ir

2- Methodology

In this research, optimization of the initial blank dimension was carried out by sensitivity analysis in some stages. After defining the target curve, an initial blank was first considered. After the analysis of the process in ABAQUS software, the difference between the desired curves was obtained by using Solid Works software and the data were transferred to Excel software. After modifying the blank shape, the analysis of the forming process has been repeated until reaching the deviation error of target curve (ε) to the determined amount of each external node. Fig. 1 shows the optimization procedure in this research.

3- Results and Discussion

Fig. 2 shows the formed part at 22 MPa pressure. After forming of the rectangular part, the results obtained from simulation were compared and validated with those of experiments. After confirming the simulation and investigating the effect of forming pressure on the process, by performing the optimization of blank dimension and examining it on simulation and experiments, the following results were obtained:

Optimizing the blank dimension was carried out by sensitivity analysis in three stages and it was concluded that by using the optimized initial blank it is possible to achieve the desired geometry of flange area in one forming step, and that by reducing wrinkling in this area, the final trimming will be eliminated and one production stage will be reduced. Figs. 3 and 4 show the initial and optimized blanks and the formed parts.

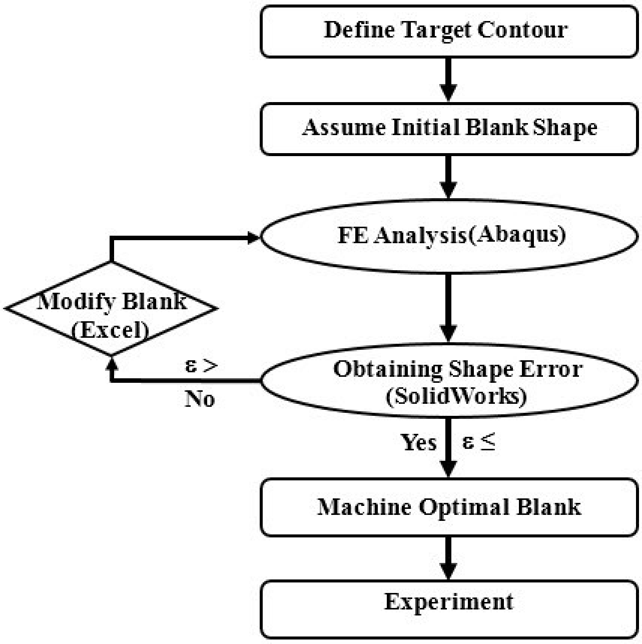
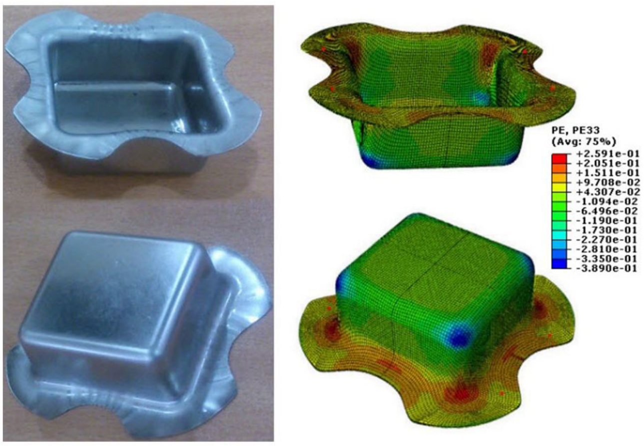


Figure 1. The proposed algorithm for optimization of the initial sheet blank



(a) (b)

Figure 2. Rectangular part formed by hydroforming process at 22 MPa pressure, drawing depth 30 mm, a) Experimental, b) Simulation

By investigating the forming pressure, it was concluded that by increasing pressure up to 25 MPa, the thickness distribution is improved and the maximum thinning is decreased. Rectangular part with dimension of 61.5*56.5 mm, corner radius of 6 mm and drawing depth of 35 mm was formed just in one stage without any fracture. By simple deep drawing method, the mentioned part is torn in critical area of punch corner radius.

4- Conclusions

The following conclusions have been obtained:

1. Increasing forming pressure up to an optimum value improves formability and thickness distribution.
2. Optimizing the blank shape can improve thickness distribution, eliminate final flange trimming and decrease one stage of manufacturing, resulting in decreased production time and cost.
3. It is possible to form adequately rectangular cups in one stage using optimized blanks.

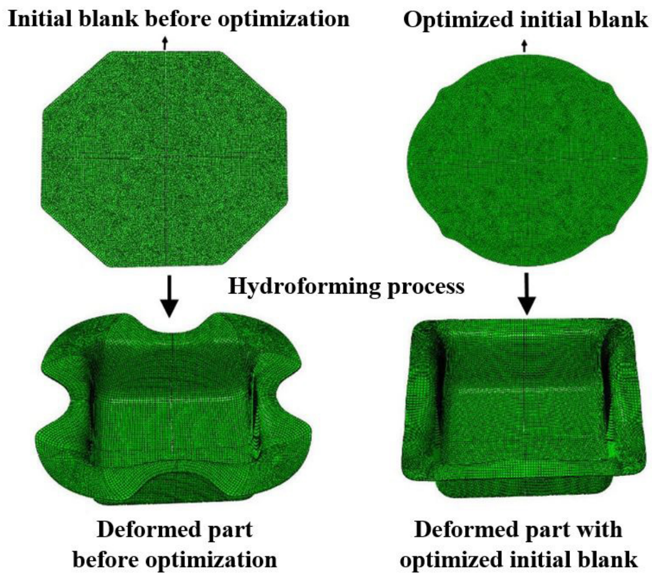


Figure 3. Initial sheet before and after optimization and corresponding parts, obtained from simulation

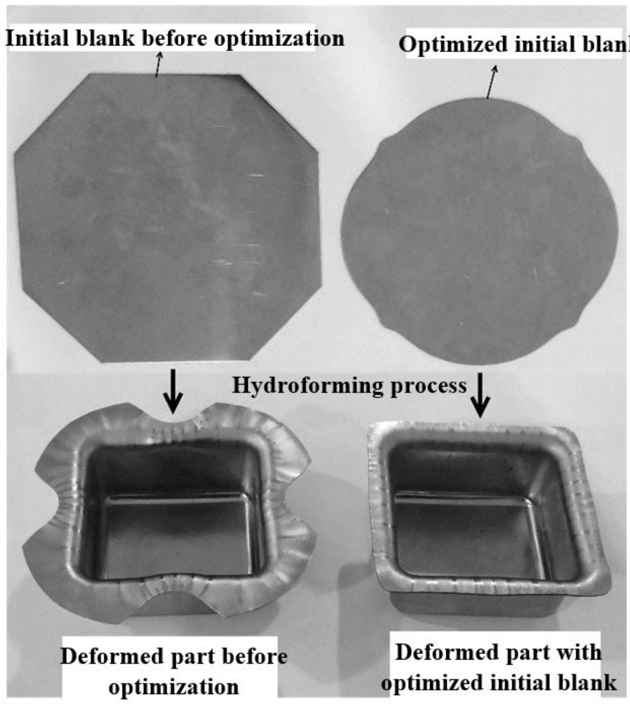


Figure 4. Initial blank before and after optimization and the corresponding deformed parts at 35mm depth and 25 MPa pressure, obtained from experiment

References

[1] S.H. Zhang, Developments in hydroforming, *Journal of Materials Processing Technology*, 91(1–3) (1999) 236-244.

[2] A. Kandil, An experimental study of hydroforming deep

drawing, *Journal of materials processing Technology*, 134(1) (2003) 70-80.

[3] B. Meng, M. Wan, S. Yuan, X. Xu, J. Liu, Z. Huang, Influence of cavity pressure on hydrodynamic deep drawing of aluminum alloy rectangular box with wide flange, *International Journal of Mechanical Sciences*, 77 (2013) 217-226.

[4] H. Shim, K. Sona, K. Kim, Optimum blank shape design by sensitivity analysis, *Materials Processing Technology*, 104 (2000) 191-199.

Please cite this article using:

A. Haghparast, A. Gorji, M. Bakhshi, G.M. Alinejad, Experimental and Numerical Study of Hydrodynamic Deep Drawing Process of Rectangular Cups and Blank Shape Optimization, *Amirkabir J. Mech. Eng.*, 49(4) (2018) 851-862.
DOI: 10.22060/mej.2016.807