8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

AN OPTIMIZATION STRATEGY FOR THE BLANK HOLDER FORCE IN DEEP DRAWING

***R. Padmanabhan[1], M.C. Oliveira[1], J.L. Alves[2] and L.F. Menezes[1]**

[1] CEMUC, Dept. of Mechanical Engineering,
University of Coimbra, Polo II
Coimbra 3030-788 Portugal
{padmanabhan,marta.oliveira,
luis.menezes}@dem.uc.pt

[2] Dept. of Mechanical Engineering
University of Minho, Campus de Azurém
Guimarães 4800-058, Portugal
jlalves@dem.uminho.pt

Key Words: *Blank holder force, Optimization, FEM, Deep drawing.*

ABSTRACT

Deep drawing is a sheet metal forming technique by which automobile body parts, household goods, etc, are mass produced. In deep drawing, a thin blank is subjected to plastic deformation using forming tools to conform to a designed shape. During this process, the blank is likely to develop defects if process parameters are not selected properly. Therefore, it is important to optimize the process parameters to avoid defects in the parts and to minimize production cost. Optimization of process parameters such as die radius, blank holder force, friction coefficient, etc., can be accomplished based on their degree of importance on the sheet metal forming characteristics. Based on a previous study by the authors [1], blank holder force has significant contribution on the product quality. Appropriate blank holder force evolved through a process results in controlling the thickness variations in a deep drawn part and thus the quality of the part. An optimal blank holder force eliminates wrinkling as well as tearing, the two major phenomena that cause failure in formed parts. Generally, a constant blank holder force is applied during a forming process to minimize mechanisms in the forming tools. Changing blank holder force according to the process evolution will improve the product quality as the material flow characteristics is optimally controlled during the process. Several researchers have proposed different approaches to apply variable blank holder forces involving AI, GA, PID controllers, etc. The authors proposed a variable blank holder force scheme that traces the lower boundary in the process window [2], in steps. Initially, a very low force is applied until wrinkles accentuate. In the second stage, the force is increased proportional to the punch displacement where the proportionality depends on the material flow characteristics. The proposed variable blank holder force scheme improved the part quality significantly. This paper discusses a modified approach that determines and applies the required blank holder force based on the wrinkling tendency of the blank. The wrinkling height can be treated as a parameter governing the determination of optimal blank holder force [3]. The blank holder displacement is continuously evaluated during the deep drawing simulation process and a corresponding blank holder force is applied. The blank holder force required to contain wrinkles depends on the geometry of the part and the stage in deep drawing process. Deep drawing simulations were carried out on a circular cup example using DD3IMP, an in-house FE code. Figure 1 shows the optimal blank holder forces required to contain wrinkling tendency in the flange, at five different punch displacements. The

strategy determines the optimal blank holder force governed by the blank holder displacement, as in the following equation:

$$\mathrm{BHF}_{n+1} = \mathrm{BHF}_n \left(1.5 - 1.5e^{(1/10)} + 1.5e^{[(\mathrm{BHDisp}/t)/10]}\right).$$

Where BHF is the blank holder force, BHDisp is the blank holder displacement and *t* is the blank thickness.

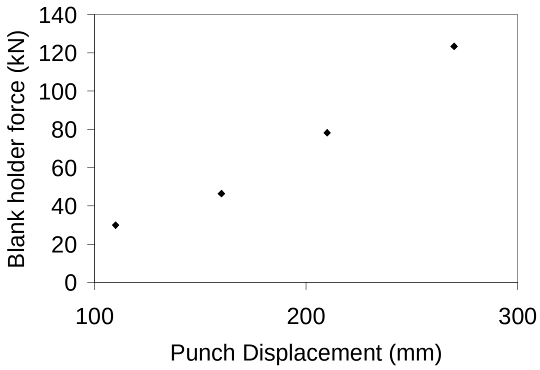

Fig 1. Blank holder force Vs Punch Displacement

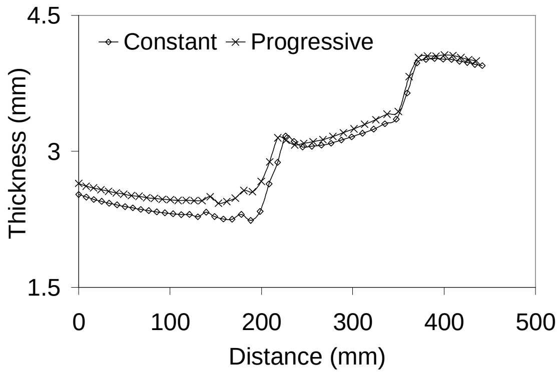

Fig 2. Thickness variation along a cut section

This strategy of progressive application of optimal blank holder forces improved the thickness distribution and reduced thinning tendency in the formed part, compared to a constant high blank holder force strategy. Figure 2 shows the thickness distribution along a cut section in the deep drawn part. The proposed strategy is simple to implement and results in significant improvement in the thickness distribution, as shown in Figure 2, especially at critical locations such as the punch radius.

REFERENCES

[1] R. Padmanabhan, M.C. Oliveira, J.L. Alves, L.F. Menezes, "Influence of process parameters on the deep drawing of stainless steel", *Finite Elements in Analysis and Design*, Vol. 43, pp. 1062-1067, (2007).

[2] Padmanabhan, R., et al., Numerical simulation and analysis on the deep drawing of LPG bottles, *J.Mater.Process. Tech.*, (2007),doi:10.1016/j.jmatprotec.2007.08.047.

[3] Lin Zhong-quin, Wang Wu-rong e Chen Guan-long, "A new strategy to optimize variable blank holder force towards improving the forming limits of aluminum sheet metal forming", *J. Mater. Process. Tech.*, Vol. 183, pp. 339-346 (2006).