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Finite Element Simulation about Deep Drawing of Welded Magnesium Alloy Plate Based on Msc.Marc Software

Fang Qian[1, a], Zhongtang Wang[2, b]

[1]Inner Mongolia University for Nationalities, Tongliao 028000, China
[2]Shenyang University of Technology, Shenyang 110159, China

[a]janeeyie@126.com, [b]ztwang@imr.ac.cn

Abstract. Through the studies of simulation about deep drawing, it meshed the rounded plate, formed a model of magnesium material, and summarized the weld movement regularity with different magnesium alloys, analyzed factors affecting the movement of weld. It can help to provide scientific basis for process analyzing and mold designing during production.

1. Introduction

For the purpose of lightweight and high performance, light alloy welding has been carried out successfully such as aviation, automobile and electronic products. During the light alloys, agnesium alloy has been known as most practical light structural material for its lower density, higher specific strength. The deformation research and application of magnesium alloy got widely attention [1-2]. Numerical simulation technology played a huge role in the field of sheet metal forming such as reducing the test time and production cost, speeding up the development cycle [3-5]. It can help finding out the influence of various parameters on the metal plastic flow, predicting defects such as wrinkling in production [6], calculating the shapes and sizes after springback [7], providing a scientific basis for technical analysis and mold design, by which greatly improved the efficiency of study. MSC.Marc is a nonlinear analysis software with comprehensive function, which could deal with all kinds of linear and nonlinear analysis of the structure. This article analyzed the weld movement of AZ31 and AZ80 welded plates by the support of MSC.Marc software.

2. Model forming

2.1. Meshing

The blank is a circle with the diameter of 160mm determined by the deep drawing calculation of cylindrical part, the circle including 1569 points and 1536 units. The thin shell elements are based on C1 theory of Koitor-Sanders, the weld is represented by a line of points in the direction of diameter, whose meshing grid is shown in figure 1.

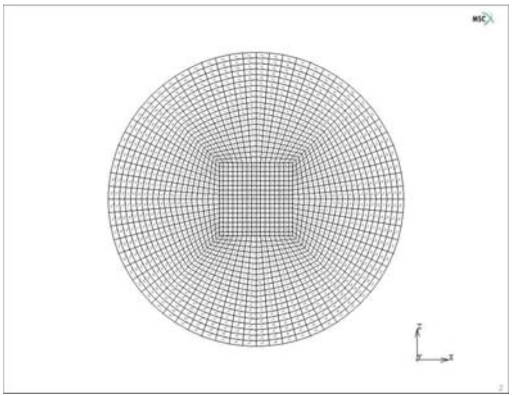

Figure 1. Meshing grid

2.2. Forming material model

Metal forming is a process with huge displacement and deformation. It is Suitable for the constitutive equation for elastic deformation, even plastic deformation [8]. Rate constitutive equation of Hill quadratic yield function based on orthogonal flow theory can be represented as

$$\dot{S}_J = D_{ep}\dot{\varepsilon} \quad (1)$$

$$D_{ep,ijkl} = D_{e,ijkl} - \frac{m_{ij}m_{kl}}{(4/9)\bar{\sigma}^2 H' + m_{rs}l_{rs}} \quad (2)$$

In the formula,

$\dot{S}_J$ —— Jaumann rate of Kirchhoff stress;

$\dot{\varepsilon}$ —— strain rate;

$D_{e,ijkl}$ —— elastic constitutive tensor;

H' —— hardening parameter

Among them, $l_{ij} = \partial f / \partial \sigma_{ij}$, $m_{ij} = D_{e,ijkl} l_{kl}$

Yield function:

$$f(\sigma) = \frac{1}{2(F+G+H)}\{F(\sigma_{yy}-\sigma_{zz})^2 + G(\sigma_{zz}-\sigma_{xx})^2 + H(\sigma_{xx}-\sigma_{yy})^2 + 2L\sigma_{yz}^2 + 2M\sigma_{zx}^2 + 2N\sigma_{xy}^2\} - \frac{1}{3}\bar{\sigma}^2 \quad (3)$$

In the formula, *F*, *G*, *H*, *L*, *M*, *N* ——determination of test material anisotropy parameters Material properties of AZ31 and AZ80 magnesium in simulation are shown in table1.

Table 1. Material properties

material	Young's modulus (GP)	Poisson's ratio	Thermal expansion coefficient (K)	density (g/cm^3)	Thermal conductivity (W/MK)
AZ31	44.8	0.34	2.76e^{-5}	1.82e^{-9}	58.62
AZ80	43	0.35	2.61e^{-5}	1.77e^{-9}	156

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2.3. Defining the contact body
During the stamping, the sheet was contacted by punch, die and blank holder. Sheet metal belongs to deformation, with other three rigid body. The die and blank holder were fixed, while the punch moved in the direction of negative Z. The model of cylindrical part was made by Marc software, it is shown in figure 2.

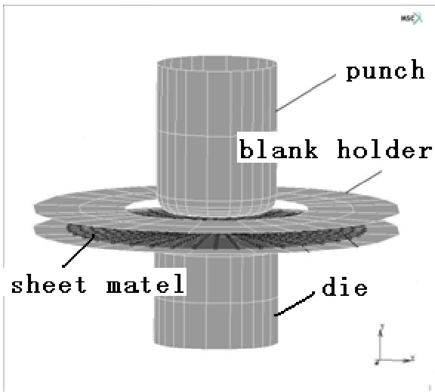


Figure 2. Model of the deep drawing plants

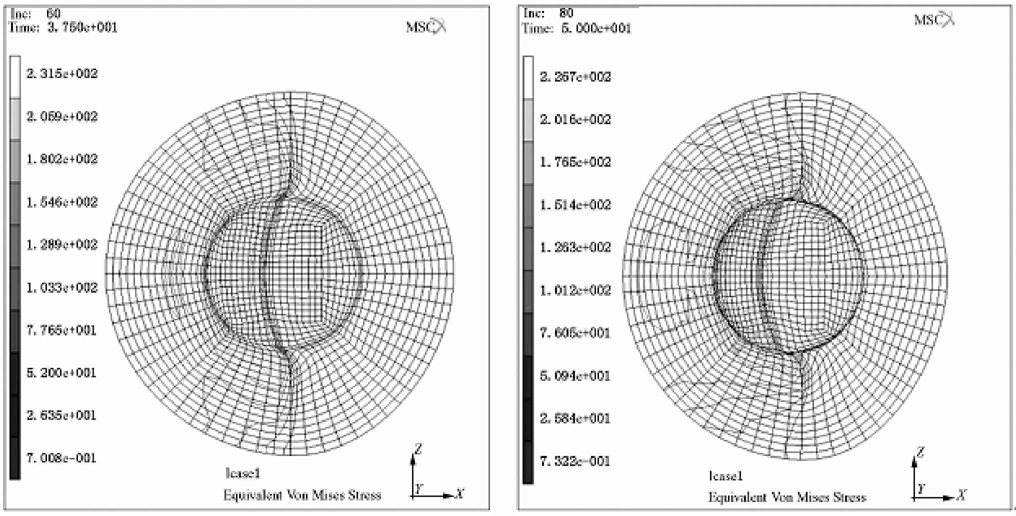
2.4. Defining the boundary conditions
First, define the weld points not rotating in any direction. There is no moving in Z, but migration and flow in other two ways. The second one is surface force in the direction of negative Z at the grid edge.

3. The numerical simulation

3.1. Weld movement regularity
With the parameters in table 2, it simulated the movement of weld formed by welded magnesium with different materials and thickness in figure 3. On the right side, AZ31, with the other side, AZ80.

Table 2. Parameters in stamping

parameters	numerical
blank holder force /KN	0
forming temperature℃	230
punch velocity /mm·s^{-1}	0.05
intensive interval /mm	1
Punch radius /mm	10
Die radius/mm	10
coefficient of friction between blank and punch(μ_{b-p})	0.2
coefficient of friction between blank and die(μ_{b-d})	0.05
coefficient of friction between blank and blank holder(μ_{b-h})	0.05



(a) (b)

Figure 3. Movement of the weld
(a—deep drawing 20mm, b—deep drawing 30mm)

Because of the difference of material performance, the weld offset to AZ80 magnesium cause of smoothly flowing of AZ31; Flange and the wall gone in opposite directions by the comprehensive impact of punch and blank holder. Weld migration law was found that the weld tend to the side of AZ80 at the bottom, tend to AZ31 at the wall and flange. The deeper drawing, the more offset, with the maximum appeared at the core of bottom.

3.2. Influencing factors of weld mobile

(1) Temperature

The maximum offset of the weld at bottom decreased when the temperature increased at the temperature range from 170 to 230℃. But there is no much change about the thickness at the core of bottom. On account of temperature's little effect on the degree of thinning occurred in the bottom. In order to reduce the weld offset degree, the deep drawing temperature was chosen 230℃.

(2) Punch velocity

The weld offset was significantly reduced while the punch velocity grown from 0.05 to 0.2mm/s, meanwhile the thinning degree at the core of weld reduced. The punch velocity should be higher in the actual when there is no rupture at the radium of the punch.

4. Conclusion

(1) Finite element simulation can be used to research the performance of the sheet metal during deep drawing process, which could help forecasting the quality of molding intuitively and modifying process parameters and guiding production.

(2) When deep drawing the sheet metal welded by different magnesium materials, the weld biased to the material with lower elongation at the bottom, the situation was opposite at the Wall and flange. It could ensure the material flown evenly.

(3) In order to reduce the weld offset, the deep drawing temperature should be higher in the range of available.

5. References

[1] Zhang Shihong, Wang Zhongtang, Some new progress of magnesium alloy sheet warm forming technology, J. Material review. 8 (2006) 114-118.
[2] Ji Huanming, Luo Tianjiao, Yang Yuansheng. Numerical simulation and experimental research

IOP Conf. Series: Materials Science and Engineering **394** (2018) 032105 doi:10.1088/1757-899X/394/3/032105

of semicontinuous casting with AZ80 magnesium alloy at low pressure pulse magnetic field, J. Chinese journal of nonferrous metals. 3 (2017) 468-476.
[3] REBELO N, NAGTEGAAL J C, HIBBrlT H D. Finite Element Analysis of Sheet Forming Processes, J. International Journal forNumefic. Methods in Engineering. 30 (1990) 1739-1758.
[4] Hu Zhong. The latest progress of finite element simulation technology, J. Plastic engineering journal. 3 (1994) 3-13.
[5] Zheng Ying, Wu Yongguo. The progress of numerical simulation in sheet metal forming, J. Plastic engineering journal. 3 (1996) 34-47.
[6] Liu Yuqi. Numerical simulation of local instability and wrinkling in sheet metal forming, J. Journal of mechanical engineering. 2 (1997) 88-92.
[7] Wang Chen. Numerical simulation of springback in sheet metal forming and the method study of mold design which considered the springback compensation, in: Shanghai jiaotong university, 1999.
[8] Xu Bingkun, Shi Fazhong, Chen Zhongkui. Some key problems in numerical simulation of sheet metal forming, J. Plastic engineering journal. 2 (2001) 32-35.