

Study on the Influence of Thickness on the Cold Bending Limit of Magnesium Sheets

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Abstract. The plastic property of AZ31B sheet is poor at room temperature, so taking it as the object. Based on ABAQUS platform, FEM models are established. Moreover, ductile damage value is used as the indication of the crack, and based on the linear interpolation mathematical model, the minimum relative bending radius in each finite element model can be calculated. The effects of sheet thickness on the bending limit of AZ31B magnesium sheet are studied.

Introduction

AZ31B magnesium sheet is the most widely used and excellent performance wrought magnesium alloy at present [1-2]. In this paper, the experimental research method is used to simulate the multi-point bending forming of AZ31B sheet with different thickness[3-4], and the influence of thickness on AZ31B cold bending limit is obtained, so as to enhance the magnesium plate cold bending limit [5]. It has important reference value for the process design of the production.

Test Method

The "V" shape punch surface, punch surface and sheet surface contact directly, as shown in Fig.1. In order to ensure that the final shape of the workpiece can be broken. The sheet uses AZ31B magnesium alloy material, V shaped angle $\Phi < 80^\circ$, and the punch radius of R must be less than 2.5mm.

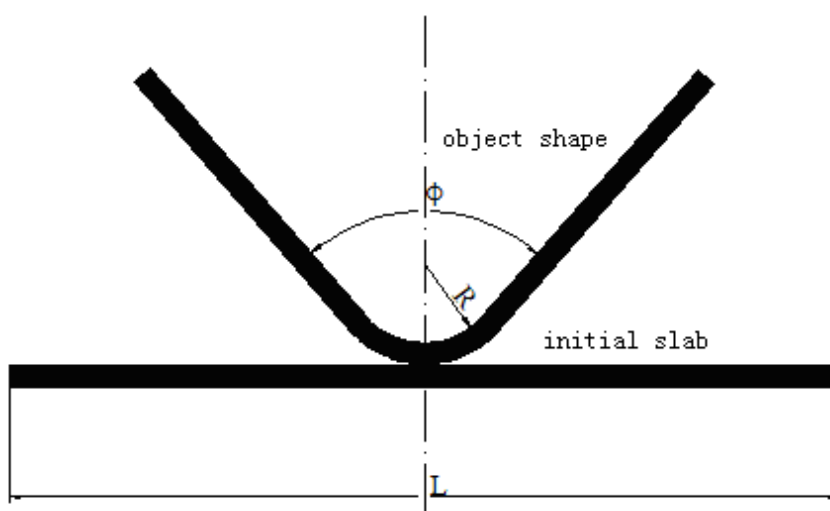


Fig.1 V shaped piece bending diagram

Under the premise of ensuring the constant initial condition of each test, including the punch diameter, sheet length and width dimensions, contact state and friction condition, take $\Phi=70^\circ$, $R=2\text{mm}$, and change the thickness of the sheet as 1.5mm, 2mm, 2.5mm, 3mm, 3.5mm, and finally

get the cold bending limit value γ_{\min}/t of the corresponding thickness, γ_{\min} for minimum relative bending radius, t for the thickness of the sheet. Therefore, five sets of simulation tests are required, as shown in Table1.

Table1. Simulation test design scheme

Simulation test number	Punch radius R/mm	Sheet length and width L×B/mm× mm	Sheet thickness t/mm
1	2	60×40	1.5
2	2	60×40	2
3	2	60×40	2.5
4	2	60×40	3
5	2	60×40	3.5

Test Procedure

Establish Finite Element Model. In order to be able to observe the change of the damage value in the thickness direction of the sheet, the solid model is built by software, and all the parts are exported to Parasolid format. Then it is imported into the ABAQUS software, after the corresponding positioning and assembly, the component initial location model is obtained. Structured mesh generation is used for the sheet, and the punch shape is less rules with the free mesh, the unit size is 0.5mm.

Define Material Model. In the numerical simulation, the sheet is made of AZ31B alloy material, and it is assumed to be isotropic and homogeneous. The mechanical parameters of the materials are obtained from the tensile test at room temperature, as shown in Table 2. It is assumed that the material obeys Mises Yield Criterion and the Prandtl-Esther Flow Rule [6].

Table 2. Material mechanics parameters

Material	Yang's elastic modulus E (GPa)	Poisson ratio ν	Yield stress σ_y	Density ρ (Kg/cm ³)	Elongation δ
AZ31B	44.83	0.33	220	1.77	22%

The real stress and strain curve fitting according to the mechanical parameters of AZ31B is shown in Fig.2 [7]. It can be seen from the figure that the material begins to fracture as the strain $\epsilon > 0.2$.

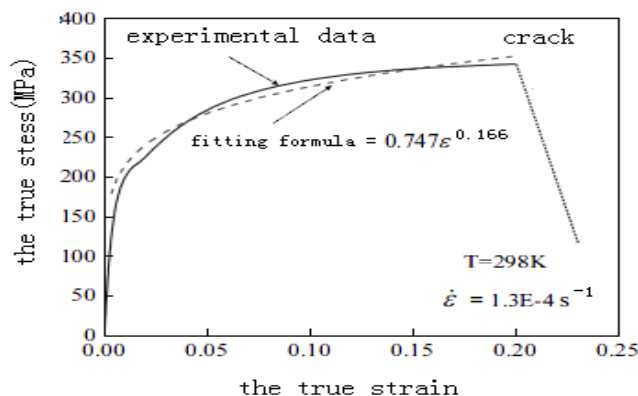


Fig.2 The true stress-strain curves of AZ31B sheets under room temperature

Defining Boundary Conditions. In the experiment, the boundary condition is mainly motion constraint boundary condition and the friction model of Kulun [8]. In order to ensure the consistency of the numerical simulation results and experiment, it is set that the sheet has six complete translation and rotation degrees of freedom. The upper punch unit group has only the translational degrees of **freedom** along the Z axis. The under punch unit group is fixed all of its translational and rotational degrees of freedom. And the friction factor between the sheet and the punch are 0.2.

Treatment of Experimental Results

The linear interpolation model is used to solve the bending limit of the plate, that is, when the toughness damage value is located at [D1, D2], the bending radius of the sheet is linear proportional relationship. D1 is the damage value of the incremental step before the critical bending of the sheet. D2 is the damage value of the incremental step after the critical bending crack. Obviously $D1 < D2$, γ_1 , γ_2 is the corresponding bending radius of toughness damage value D1 and D2. So by the linear interpolation proportional relation, the minimum bending radius γ_{min} is satisfied:

$$\gamma_{min} = (D_2 - 1) \gamma_1 / (D_2 - D_1) + (1 - D_1) \gamma_2 / (D_2 - D_1)$$

By the linear interpolation model, the minimum relative bending radius is calculated when toughness damage value is 1, as shown in Table 3.

Table 3. The cold bending limit of five groups of different sheet thickness

Simulation test number	γ_1	D1	γ_2	D2	γ_{min}	γ_{min}/t
1	5.05	0.949	4.59	1.061	4.84	3.23
2	6.56	0.910	5.50	1.102	6.06	3.03
3	6.46	0.964	6.11	1.287	6.42	2.57
4	7.71	0.913	6.36	1.139	7.19	2.40
5	8.94	0.896	7.06	1.141	8.14	2.33

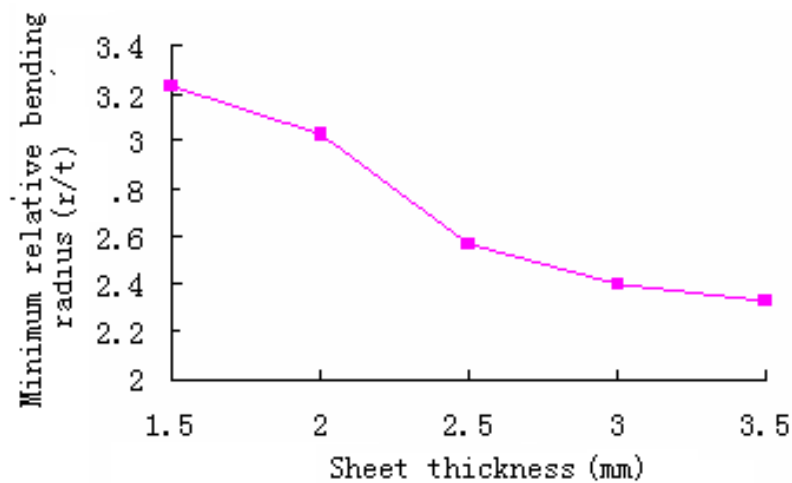


Fig.3 Effect of sheet thickness on cold bending limit

Fig.3 shows the effect of sheet thickness on cold bending limit of sheet. It can be seen from the horizontal that γ_{min}/t has been shown a decreasing trend with the increase of the thickness of sheet.

For multi-point bending forming that punch and sheet surface directly contact, the bending limit gradually decreases with the increase of the sheet thickness.

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