Springback Measurement in Reverse Cup Drawing Process

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Abstract

This paper discusses a finite element analysis of springback and the effects of different process parameters in the reverse cup drawing process, taken from the NUMISHEET'99 benchmark. The simulations are preformed for an aluminum alloy. The results are compared with those reported in the literature. Effects of different process parameters such as initial sheet thickness and die gap and also hardening models on springback prediction are studied.
Keywords: Springback, Reverse cup drawing, Finite element analysis

Introduction

Springback is a phenomenon that occurs in many coldworking processes. When a metal is deformed into the plastic region, the total strain is made up of two parts, the elastic part and the plastic part. During removing the deformation load, a stress reduction will occur and accordingly the total strain will decrease by the amount of the elastic part, which results in springback [1]. Chun et al. [2] suggested the ANK model to investigate the role of Bauschinger effect in the simulation of reverse cup drawing and draw-bead tests and compared their model with other hardening models in springback prediction for the draw-bead process. The ANK model predicted the maximum punch forces more accurately with a correct trend for the reverse cup drawing process.

Finite element modeling

The reverse cup drawing problem in NUMISHEET'99 as shown in Figure 1 is a case study in this paper for one material: Al6016-T4. For efficiency, the simulation of the reverse cup drawing process is modeled in the finite element program ABAQUS\Explicit, while the springback analysis is simulated in ABAQUS\Standard. One quarter of the blank is modeled with 900 shell elements (S4R). The process is preformed in two stages: forward draw and reverse draw. Twenty fine integration points through the thickness are used in the modeling. Mass density used for the dynamic explicit code is 2.7 gr/cm^3 for the aluminum alloy. The blank diameter is 150 mm and the coefficient of friction is 0.168.

Model verification

In order to have confidence in the validity of the results, some of them are compared to the results reported in the reference [2]. In Figure 2 and Figure 3 the sheet thickness after the first and the second stage is compared with the experimental results. The edge thickness is omitted because it was not measured correctly due to apparent earring. Figure 4 shows a comparison between the different maximum punch forces applied in the process. It is observed that both the models show a reduction in the maximum punch force during the second stage because of considering the Bauschinger effect.
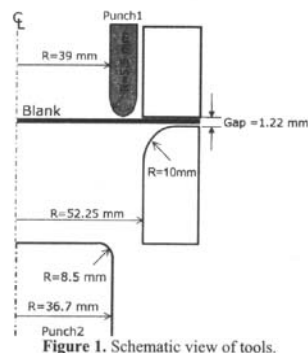
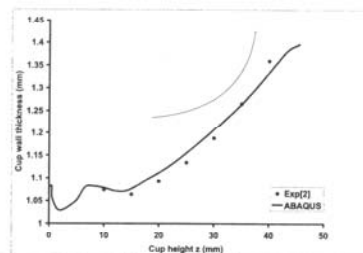

Figure 1. Schematic view of tools.

Figure 2. Sheet thickness along 45° line from the rolling direction after stage one.
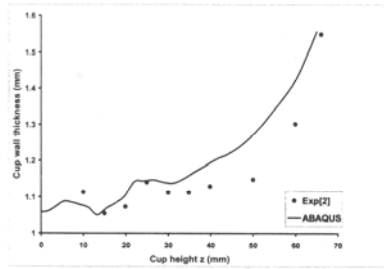
Figure 3. Sheet thickness along 45° line from the rolling direction after stage two.
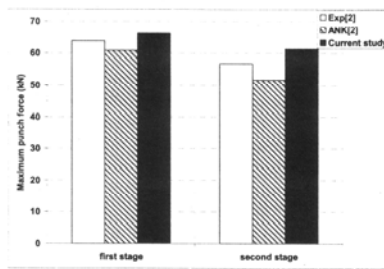

Figure 4. Maximum punch force.

Effect of initial sheet thickness

The size of the initial sheet thickness can affect on the final amount of springback in sheet metal forming processes. Figure 5 displays the final radius of curvature of the cup edge for different initial sheet thicknesses. The larger initial sheet thickness leads to the lower amount of springback. The presented radius of the curvature is the mean radius of the cup edge.
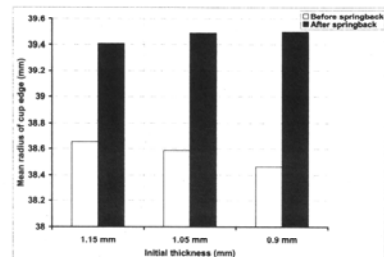

Figure 5. Mean radius of cup edge before and after springback for different initial sheet thicknesses.

Effect of die gap

Instead of applying force on the blankholder in the process, a gap is considered between the die surface and the blankholder surface. Different die gaps in the process lead to different amount of springback at the end of the process. Figure 6 demonstrates the final amount of springback for different values of the die gaps.
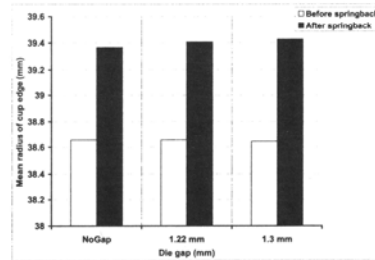

Figure 6. Mean radius of cup edge before and after springback for different die gaps.

Effect of hardening models

Two hardening models are considered, combined hardening (based on the Lemaitre and Chaboche model [3]) and isotropic hardening. In Figure 7 the final radius of the cup edge is shown for two hardening models. The combined hardening predicts larger amount of springback at the end of the process.
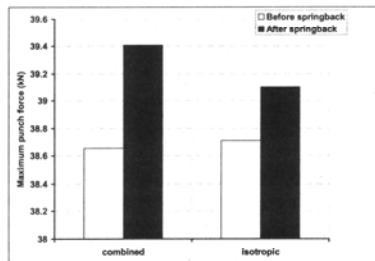

Figure 7. Mean radius of cup edge before and after springback for different hardening models.

Conclusions

In this paper the springback measurement of the reverse cup drawing process through the FE code, ABAQUS is studied. Effects of different parameters on springback are explored. Results show that the larger amount of the initial sheet thickness leads to the smaller amount of springback but the higher gap leads to larger amount of springback. Furthermore, the combined hardening model could predict larger amount of springback than the isotropic hardening one.

References

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