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Finite element analysis on the coined-bead mechanism during the V-bending process

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ABSTRACT

The coined-bead technique is commonly applied to solve the spring-back problem in the V-bending process. However, the coined-bead mechanism on the spring-back/spring-go feature has not been clearly identified yet. In this study, the finite element method (FEM) and laboratory experiments were used to investigate the coined-bead mechanism and its effects on the spring-back/spring-go feature. The features were clearly identified using a stress distribution analysis. The results revealed that the mechanism of the coined-bead technique not only increases the compressive stress on the bending allowance zone, where the spring-back feature decreases, but also increases the reversed bending zone on the leg of the workpiece, where the spring-go feature increases. Therefore, after compensating for the increases in the compressive stress and the reversed bending feature, the amount of spring-back on the bent part was decreased. The FEM simulation bending force and bending angle results were agreed with those from the experimental results.

1. Introduction

Bending is a well-known process for curvature-shaped fabrication in which the workpiece is plastically deformed, where the load is greater than the yield strength but less than the ultimate tensile strength. The bending process is used for widespread applications, such as when a press break machine is used for small quantities or prototype productions and when a press machine is used with a press form tooling for moderate production or mass production. The basic principle of the bending process is applying a pressing force on a punch to press sheet metal into a die. However, it is sometimes difficult to control the product quality due to the difficulty in selecting suitable process parameters related to the material property and its thickness. The primary challenge with the bending process is the difficulty in achieving the required bending angle due to the occurrence of the spring-back/spring-go feature. In the past, many researchers have studied the bending process using the finite element method (FEM) and experiments; most have analyzed the spring-back feature and there are a few researches have studied the spring-go feature. Several researches have studied the effects of process parameters on spring-back and spring-go features, including bending angle [1,2], punch radius [2,3], material thickness [1–3], material properties [2–5], friction condition [2,5,6], working temperature [6,7], and punch height [8,9] in various bending processes with the different ways. In addition, to assess the accuracy of part geometry, a precise prediction of spring-back/spring-go seems a primary challenge.

Many researches have been done for assessing the precise prediction of spring-back/spring-go in various bending processes with the different ways. Wang et al. [10] proposed a practical incremental bending methodology to control punch displacement using the workpiece properties estimated from measured loaded and unloaded bend angles. Meinders et al. [11] developed an analytical model for the spring-back prediction, compensation, and optimization based on the through-thickness integration scheme for shell elements. Kazan et al. [12] proposed the spring-back prediction in wipe-bending process using neural network. Thipprakmas and Rojananan [13] also clearly identified the spring-go phenomenon using FEM. However, there were only a few works that focused on the bottoming and coining techniques in the bending process. Leu and Hsieh [2] investigated the influence of the coining force on the spring-back reduction in the V-die bending process. The spring-back related to material property, material thickness, bending angle, punch radius, and friction condition was also investigated.

The coined-bead technique has long been known to reduce the amount of spring-back [14,15]. It is known that the technique controls the bending angle by canceling out the spring-back feature in the bending allowance zone. The principle behind the coined-bead technique is shown in Fig. 1. The workpiece is coined on the die by applying an extreme force on the punch tip with a bead. This feature results in increasing the compressive stress on the bending allowance zone, and thus, the spring-back feature decreases

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