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ScienceDirect
Materials and Design 29 (2008) 1526–1532
Materials & Design
www.elsevier.com/locate/matdes

Investigation of spring-go phenomenon using finite element method

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Received 11 October 2007; accepted 14 February 2008
Available online 23 February 2008

Abstract

Bending is an application used in the sheet metal forming processes in many industries. One of the main problems of the bending process is the occurrence of spring-back/spring-go. Past research has investigated the spring-back problem. However, the spring-go problem was rarely investigated. In this study, the spring-go phenomenon was investigated using the finite element method (FEM) on the V-bending process. The FEM simulation results clearly and theoretically clarified the spring-go phenomenon on the material flow analysis and stress distribution. The comparison between the spring-back and spring-go phenomena was also clarified.

Keywords: Forming; Elastic behaviour; Plastic behaviour

1. Introduction

The bending process is used in the sheet metal forming processes to fabricate curvature shapes such as the electronics part as shown in Fig. 1. The bending feature is not only employed in the bending process, but it also occurs in many sheet metal forming processes such as the deep drawing process and the flanging process. The major problem of the bending process is the occurrence of spring-back/spring-go. This problem is the key factor which affects the quality of the bended part. The amount of spring-back/spring-go is affected by many working parameters such as the material property, bending angle, bending radius and bending stroke [1,2]. Much research has been done to investigate and reduce the amount of spring-back. Esat et al. [3] studied spring-back in the bending of aluminum sheets by using the finite element method (FEM). Papeleux et al. [4] investigated the impact of physical parameters on spring-back appearing in the U-draw bending by using FEM. Ling et al. [5] studied the process parameters such as die clearance, die radius and step height and their effects on spring-back by using the FEM. Tekaslan et al. [6] determined the amount of spring-back on steel sheet metal of 0.5 mm in thickness in bending die. Panthi et al. [7] analyzed spring-back in sheet metal bending using the FEM. Jin et al. [8] studied the amount of spring-back on the spring material by using the FEM. However, the spring-go problem was rarely investigated, therefore, the basic database of spring-go information was insufficient to solve the spring-go problem. Also, the theoretical spring-go phenomenon lacks research. The spring-back problem was investigated by using the FEM and the FEM simulation results were also validated by experiments which showed the possibility of the using the FEM to investigate and predict spring-back characteristics in the bending process. In this study, the FEM was used as a tool for investigating the spring-go phenomenon on the V-bending process.

In this study, the FEM simulation results showed that the material flow analysis and stress distribution could theoretically clarify the spring-go phenomenon. Also, the comparison of the spring-back and spring-go phenomena

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0261-3069/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2008.02.002

Fig. 1. An example of bended part.

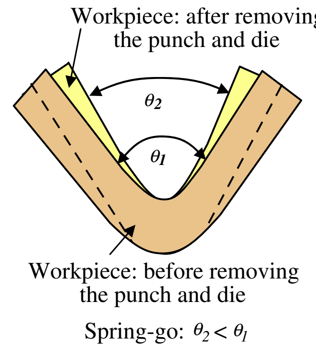

Fig. 3. Illustration of spring-go characteristic.

was explained. The FEM simulation results showed the relationship between the angular punch radius and the amount of spring-back/spring-go.

2. The spring-back principle

Fig. 2 shows the spring-back principle. When forming sheet metal, the material property is generally divided into two zones, the elastic zone and the plastic zone. In the sheet metal forming process, the forming load increases until the elastic limit of material is exceed. The material state becomes the plastic deformation zone, hence, the sheet metal can be formed. However, in the case of the bending process as shown in Fig. 2a, the material which contacts the punch has compressive stress occur, whereas the material which contacts the die has tensile stress occur. As a result of the stress distribution, the elastic band in the workpiece was generated and the material in this area tried to keep its original shape, hence, the material in the compression zone tried to enlarge and the material in the tension zone tried to shrink. The material tried to spring-back and the bended part slightly open as shown in Fig. 2b.

In contrast, the spring-go characteristic occurs as the bended part slightly closes as shown in Fig. 3. However, the idea of the spring-go phenomenon has not been theoretically clarified.

3. The FEM simulation method

3.1. The FEM simulation model

Fig. 4 shows the FEM simulation model. The V-bending model with the die radius of 6 mm and 60° bending angles was investigated. The angular punch radii of 1–6 mm were investigated as shown in Table 1. In this study, the model was a two-dimensional plain strain 70 mm in length and 3 mm in thickness. Half of the simulation model was used in order to reduce the calculated time.

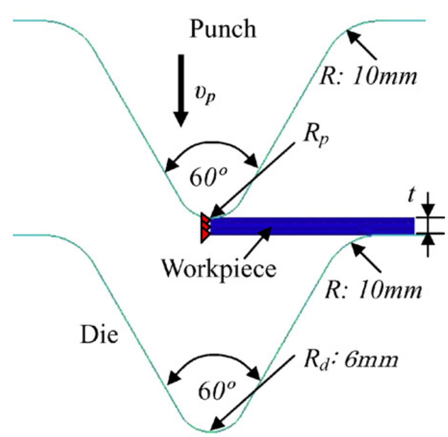

Fig. 4. FEM simulation model.

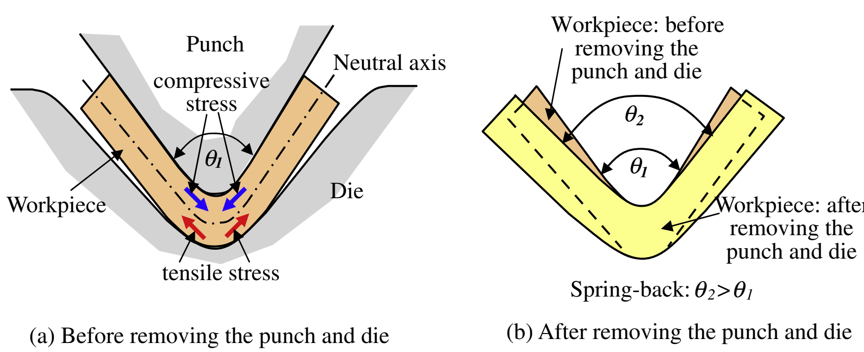

Fig. 2. Spring-back principle.