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The Influence of Punch Angle on the Spring Back during V-Bending of Medium Carbon Steel

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Abstract. This study presents the influence of punch angle on the behavior of spring back for the medium carbon steel under V-bending by the experimental and analytical studies. Punch angle from 80^o, 85^o and 90^o were applied to the samples, which were bent on a 90° V-shaped die for the spring back evaluation. The result of experiment and calculation indicates that the spring back has the similar results for the punch angles of 80^o, 85^o and 90^o.

Introduction

Bending process is widely used in metal forming mainly to making products and components in the manufacturing process such as production of components for the electronic panels, car panels, tool box, leaf wheel, hand tractors, etc. As it is known that the sheet bending is one of the manufacturing processes which essential, but there are some technical problems such as predicting the causes and effects of spring back after forming [1]. The spring back is a phenomenon in which a piece of metal is not formed itself after the forming operation and it generally occur in sheet metal forming, which caused the elastic stress redistribution after the punch load is removed (unloading) [2-3]. Spring back is a condition that occurs in the plate sheet after bending process done where after the punch load is removed the bent plate sheet has a tendency to return to the original shape.

Spring back is not only affected by the tensile strength and stress but also influenced by the thickness of the plate, bending radius and angle. In addition, according to Kazan "Spring back is an important parameter in designing the equipment and obtaining the desired part geometry"[4]. Controlling spring back in bending process is applied in practice become difficult for several reasons, especially in mass production [5]. Sheet metal has been widely used in the industry and can be done by processes such as bending, stretching and drawing, but the selection of sheet materials and design tools always depend on trial and error conditions [1, 6].

The spring back issue has been studied over the years to compensate for the undesired shape errors and to identify the influence of main factors, such as material of workpiece, tooling geometry, and process parameters, on the amount of spring back, both experimentally and numerically. Asnafi examined the influence of process parameters on the spring back in the V-bending process by developing theoretical models for stainless-steel sheets[7].

Therefore, the spring-back prediction was a very serious issue in sheet metal forming. The determination of accurate spring-back value in designing and making the V-bending punch is a very critical problem. In this paper, there are two ways of determining the amount of spring back in the V-bending process of medium carbon steel materials both theoretically and experimentally.

Calculation of Spring back

Spring back is a back force caused by the influence of the elasticity of plate material experiencing a process formation. The amount of back force is determined by the value of elasticity modulus in the material. In this bending process should be considered force back or spring back. Spring back occurs because of the irregularities on bending angle is formed. A simple example can be seen during the

bending process. For bending the plate with an angle 90^o then required size of the angle 'V' on the die is less than 90^o ($< 90^o$), thus the process can produce the angles of bending plate on 90^o. The spring back process of bending establishment can be seen as in Figure 1.

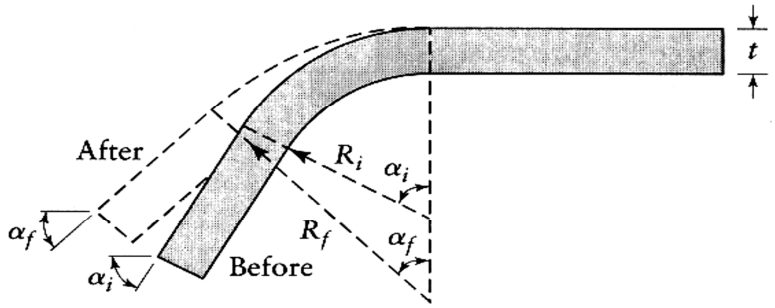

Fig. 1 Spring back in bending process [8]

In the forming process, the metal will experience changes in dimensional after loading abolished. This is caused by the elastic properties of the metal and the strain change that produced by the elastic recovery. If the load is removed, the total strain will be reduced and causing the elastic recovery. Elastic recovery effect on spring back, which could spring back increase if the yield stress is higher, or lower elastic modulus and plastic strain increases.

Spring back can be applicable to all processes of bending; in particularly most easily observation that bending results. The radius of curvature (R_i) will be smaller than the radius of curvature (R_f) after the load is removed. Spring back can be calculated using equation 1 and 2[9]:

$$Ks = \frac{\alpha f}{\alpha i} = \frac{(2.Ri/T)+1}{(2.Rf/T)+1} \tag{1}$$

$$\frac{R_i}{R_f} = 4\left(\frac{R_i Y}{E\,T}\right) - 3\left(\frac{R_i Y}{E\,T}\right) + 1 \tag{2}$$

where Ks is the factor of spring back, αf is the angle of bend plate (^{0}), αi is the punch angle (^{0}), R_i is the punch radius in mm, T is the thickness of plate in mm, R_f is the plate radius after bent in mm, Y is the yield strength in N/mm^2, and E is the modulus of elasticity in MPa.

Materials and Experimental Methods

In this study, the material used was medium carbon steel shaped the plate with a thickness of 6 mm in size and has the specifications shown in Table 1. These plates would be tested by using a press tool die set which installed on the Universal Testing Machine (Galdabini Type PM 100).

Table 1. The Specification of material for V-bending

Specifications	Medium carbon steel
Maximum of tensile strength (kgf/mm^2)	57.633
Yielding strength (N/mm^2)	480.77
Elongation (%)	25.2

In the experiments, the bending test was performed for two conditions, namely the punch angle and the punch radius. The punch angle was tested in 80°, 85°, and 90° for the variation of punch radius was 2 mm, 4 mm, and 6 mm.

Results and Discussions

Based on the experiments, the bending testing was generated the spring back data as listed in Table 2, as well as the results obtained with spring back calculation which refer to Eq. 1 and 2.

Table 2. The value of spring back resulted by equation and experiment

Punch Radius*(mm)*	Punch Angle *(°)*	Die Angle*(°)*	Spring back *(°)*	
			Equation	*Experiment*
2	80	90	-9.97	-9.06
	85	90	-4.97	-4.72
	90	90	0.03	-0.97
4	80	90	-9.93	-9.36
	85	90	-4.92	-5.17
	90	90	0.08	-0.31
6	80	90	-9.87	-9.78
	85	90	-4.86	-3.53
	90	90	0.14	0.47

Table 2 and Figure 2 are the descriptions of the relationship between the punch and the spring back angle and it is known that the spring back that occurs for the third punch radius there are positive and some are negative. Spring back angle formed positive means more than 90°, while for negative spring back means bending angle formed less than 90°. Based on Figure 2, there are indications that the greater the angle of the punch then spring back values generated tend to be small or close to zero. These results were confirmed by Livatyali and Altan which examined spring back can be predicted by using CAD. It was concluded that made a comparison between the analytical model and experimental results which will obtain the trend in [10] that showed good results, such as lower back spring obtained at a lower gap and also at a smaller die radius.

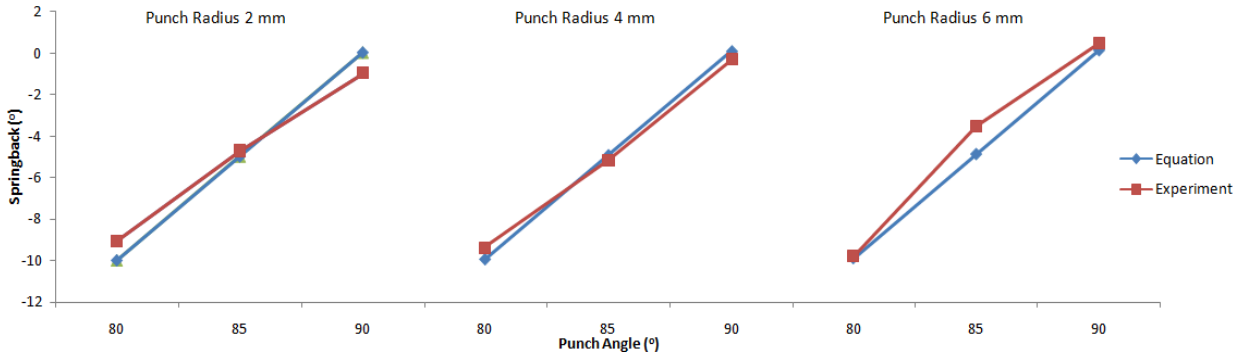

Fig. 2 Graph of spring back result

The spring back value for measured and calculated was shown in Fig. 2. The all of punch angles (80°, 85° and 90°) has a tendency to approach each other between which measured and calculated spring back.

Summary

Spring back has become an essential issue in the process of sheet metal forming. For investigating spring back, there have been numerous studies have been conducted and compared to theoretically spring back. It concluded that spring back can be predicted effectively and easily applied using the proposed analytical model, specifically for punch angle of 85° and 90°. Based on the analysis results could be predicted that the model gives good approval in accordance with experiments on a variety of different conditions.

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