Effect of Punch Parameters on Springback for Mild Carbon Steel in A V-Shape Bending Process

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Abstract. The springback is variably sensitive to materials and process parameters. Considering springback occurred in a formed part is significant for designing tools and dies. In this paper, experiments of a V-shape bending test were performed for investigating the springback effect. The punch parameters variation has been observed in ASTM A-36 mild carbon steel. Punch radius used and punch angle. The V-shape bending of mild steel was performed using Universal Testing Machine (UTM) at various punch radius (2, 4, and 6 mm) and punch angle (80°, 85°, and 90°) and at constant of die radius (10 mm) and die width (50 mm). The experimental result indicates that the punch radius has a most significant impact on springback behaviour of these sheet metal. This is verified through our experimental work using V-shape bend testing.

1. Introduction
In metal forming techniques, bending is one of the most widely used methods, such as the automotive industry and the production of home appliances. The raw material in the form of a plate is formed using bending dies. Bending is a uniform stretching process around a straight axis of flat sheet material. At the point under review, the bending will produce a voltage that is directionally normal to the cross-section of the field. There are two types of bending process namely type V and type U. In the bending process, the elastic limit of the material will be exceeded but not exceed the yield limit [1].

The bending process for plates is usually accompanied by the springback phenomenon. Springback is a problem that cannot be avoided or prevented. The more widespread use of high strength steel and aluminum plates, the springback deviation problem will be even greater. However, springback can be minimized in many ways. One example is to use a smaller punch radius and angle compensation [2-4]. Therefore, the understanding of the springback phenomenon needs to be improved by various studies aimed at overcoming the springback phenomenon.

Various studies to investigate the phenomenon of springback on bending techniques have been widely practiced. Garcia-Romeu et al. [5] investigating springback for air bending on aluminum and stainless steels with a thickness of 2 mm and 3 mm, and a bending angle 22° to 90°. The results obtained from the springback regression model as a function of the end angle. Osman et al [6] developed a theoretical model for water bending along with experimental tests of V-bending annealed and pure commercial aluminum plates. Yilamu et al. [7] studied springback on aluminum clad aluminum on V-shaped water bending with die angle 90°. Simulation with finite element method is done to predict springback. Reche et al. [8] performed a two-dimensional mechanical analysis and simulation of 1.6 mm steel bending test plate with bending angles up to 150°.
This study investigates the punch parameters (i.e. punch radius and punch angle) on springback when V-shaped bending of mild carbon steel.

2. Experimental Details

This bending experiment is conducted by using die set tool in the Mechanical Laboratory of State Polytechnic of Ujung Pandang. The bending tool is installed on the Universal Testing Machine (UTM) Galdabini Type PM 100. The bending experiment can be seen in the following Figs. 1 and 2.

![Figure 1. Die Set Installed on Universal Tensile Machine (UTM)](image1)

![Figure 2. Bending Test on Universal Tensile Machine (UTM)](image2)

The process of bending experiment is performed by varying variables, namely punch angle of 80°, 85°, and 90°, and punch radius of 2, 4, and 6 mm. The dies are constant with the angle of 90° and radius of 10 mm. This experiment had been performed by Arsyad et al [9] for a thickness of 6 mm. The material used is carbon steel material ASTM A-36 with a thickness of 2 mm. The mechanical properties of ASTM A-36 are shown in Table 1.
| Tensile strength (MPa) | Yield strength (MPa) | Elongation (%) |
|-----------------------|----------------------|---------------|
| 416,062               | 365,000              | 35.86         |

3. Result and Discussion

3.1. Punch Radius on Springback

Based on a bending test of steel ASTM A36, it was obtained the punch radius data on springback as shown in figure 3.

![Figure 3. Bending Test on Universal Tensile Machine (UTM)](image)

Figure 3 shows the relationship between punch radius and springback. The smallest springback value is obtained at 5.97° at a 2 mm punch radius, while the largest is 8.25° and 4 mm punch radius. This figure also shows that the increase in springback to increase the punch radius, except at a radius of 6 mm for the corner of punch 85°. Vice versa, the smaller the punch radius and the greater the angle of punch, the resulting springback tend to be small.

3.2. Punch Angle on Springback

Similarly, for the punch angle results, it was obtained the punch radius data on the springback as shown in figure 4.
Figure 4 shows the relationship between the punch angle and springback. The smallest springback value is obtained at 5.97° at punch angle of 90°, while the largest is 8.25° at the punch angle of 85°. This figure also shows that springback looks quadratic curve for increased radius angle, except on 6 mm of punch radius and 85° of punch angle. Vice versa, the smaller the punch radius and the greater the punch angle and the resulting springback tend to be small. Based on the picture above, the smaller the punch radius and the greater the punch angle then the resulting springback tends to be small.

The reasonably small springback angle in this experiment is predictable since there has been a permanent deformation [1, 9]. Springback involves a small strain equivalent to a strain on the elastic deformation of the metal [10]. However, if the permanent deformation is quite dominant, it will reduce the elastic deformation required by the springback phenomenon. Plastic deformation was located in a bending region that changes shape due to pressure from the punch. Chongthairungruang et al. (2013) investigated springback effects of a mild steel grade JSC270C using method of experiments and simulations. It found that the material strength considerably affected the springback magnitude [11]. Oya et al. (2010) were studied the V-bending process on all of the samples to investigate their bending formability with a springback angle of 3.16, 4.86, 5.99 and 7.14. They stated that the usefulness of the multilayered steel sheet due to its improved plastic formability caused by the remarkable effect of the ductility enhancement [12].

4. Conclusion
The bending test of ASTM A-36 carbon steel was performed by using the universal tensile machine. The punch radius and punch angle were varied at 2, 4, and 6 mm and 80°, 85°, and 90°, respectively. The bending response evaluated was springback. It found that the smaller the punch radius and the greater the punch angle then the resulting springback value tends to be small.

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