Prevention of Springback of High Strength Steel Sheet in L-Bending Process

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Abstract— Nowadays steel sheets are widely used in the industry due to the advantages of this materials in offering high strength with light weight. However due to the high tensile strength the manufacturing process need an improvement to overcome the defects occurred in the production. Therefore, a proper method is required in order to prevent the defects. In this study, a dies set with chamfers are developed to substitute the large radius that are used in current bending process. Bending process were conducted for high strength steel sheets with tensile strength of 780 MPa; to test the effectiveness of the developed die. By using this die, the chamfers enable smaller bending radius to substitute the large radius that cause the springback. It was found that the small radius produces by the chamfers are more effective in reducing the springback in L-bending of high strength steel sheets and the high press-speed will also contribute to the reducing of the springback.

Keywords— High strength steel sheets, springback, chamfers, bending radius

1. INTRODUCTION

Automotive industry nowadays is focusing on the production of light weight vehicle to react with the customers' needs in reducing their fuel consumption [1]. Regarding the matter, high strength steel sheets are favourable as it offers high strength with light weight that is the main factor to the fuel consumption. However, the high strength steel sheets have low formability characteristic that can lead to failure during the forming process. In straight bending process, the high strength steel sheets tend to have greater springback due the strength of the sheets. Springback is the geometrical changed of sheets after bending process [2] and also defined as undesirable change of part shape happened when constraint is removed after forming process. This is due to the elastic recovery of the part [3]. In other word, the sheet does not maintain the final radius of curvature of the load condition, but it recovers to a much larger final radius of curvature [4]. Springback issues are a growing concern as the high strength steel sheets are widely used in the industries since the materials has higher strength-to-modulus ratios than the traditional low-strength steel [5]. Springback was monitored during stamping process by using borescope [6]. The effect of springback to the manufacturers are; this springback produces downstream quality problem and assembly difficulties [7]. More than that, springback of high strength steel sheets also occurred in hemming process [8]. Nowadays there are many ways to reduce the spring back that is applied by the industry, including compensation of springback but there still no way to eliminate it. In this present paper, a dies set that used chamfers instead of large radius at the edge of the die and punch was developed. This tool has the function of using small initial radius through the chamfers as bottoming rather than radius at the edge of the die in normal flanging. This will reduce the springback ratio.

2. THE USE OF CHAMFERS IN DIE AND PUNCH

The springback is analyses according to its springback ratio between the initial radius; which is the specification radius of the product, or the bending radius; and the final radius which is the bent radius or the radius after the springback. The ratio between the radii is calculated according to the equation as shown below.

$$\frac{R_i}{R_f} = 4\left(\frac{R_i Y}{ET}\right)^3 - 3\left(\frac{R_i Y}{ET}\right) + 1 \qquad (1)$$

Equation (1) shows that the initial radius, R_i affected the ratio of the initial radius and final radius, $\frac{R_i}{R_f}$. The Y, E, and T are referred to the yield stress, modulus of elasticity, and the thickness of the material respectively. Based on the equation, increasing of R_i value will increase the ratio $\frac{R_i}{R_f}$ value; thus the springback ratio is increased. Therefore, in order to reduce the springback ratio, the initial radius, R_i are reduced to satisfied (1). The current research suggesting the design of die to use chamfers instead of radius at the edge of the die as shown in the Fig.1. The usage of chamfer as bottoming will involve only small initial radius compared to the usage of radius at the edge of the die in normal flanging. Therefore, the springback ratio can be decrease. The detailed of the chamfers are in Fig.2(a). Fig.2(b) shows the current punch type that is used in industry where large radius is applied. The idea of this method is to use chamfers instead of large radius to satisfy (1). By comparing the punch in Fig.2 (a) and 2 (b) below, the radius 20 mm were substituted by three chamfers that can bend to the same specification, as the Fig.2 shows.

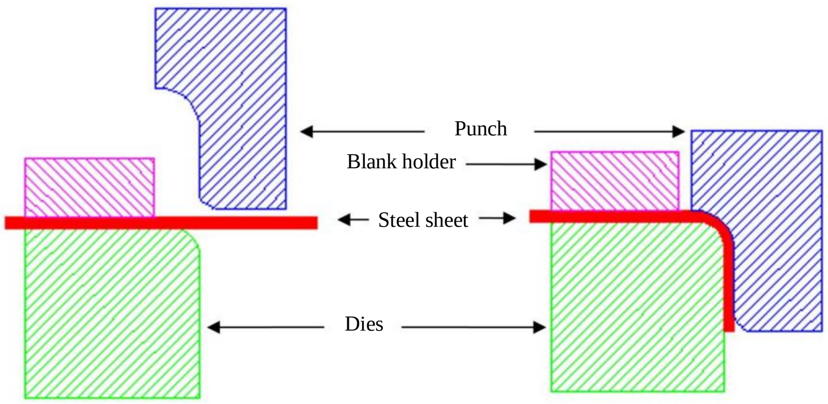
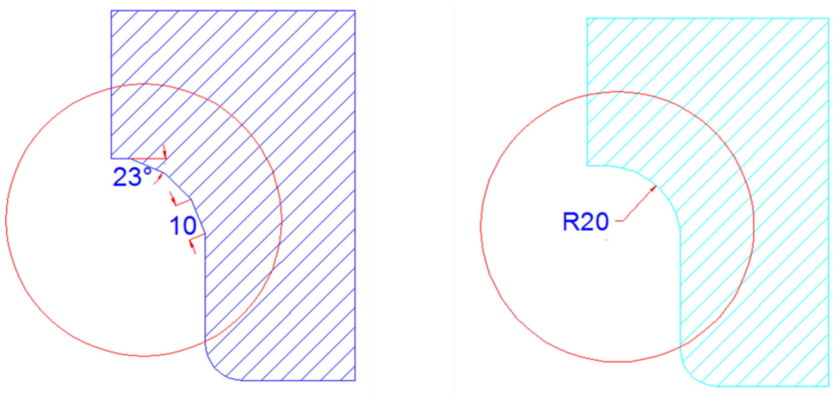


Figure 1: Bending process by dies set with chamfers



(a) (b)

3. Reducing Springback by Using Chamfers

The fabricated dies set is shown in the Fig.3. The specification of the dies set was set to fit with the specification of the press machine especially for the die high. There will be two type of punches and dies; the first one is the normal punch and die for L-bending where large radius was involved and the other one is the punch and dies that have chamfers that substitute the large radius. The chamfers in detailed are shown in Fig. 4 (a) and 4 (b).

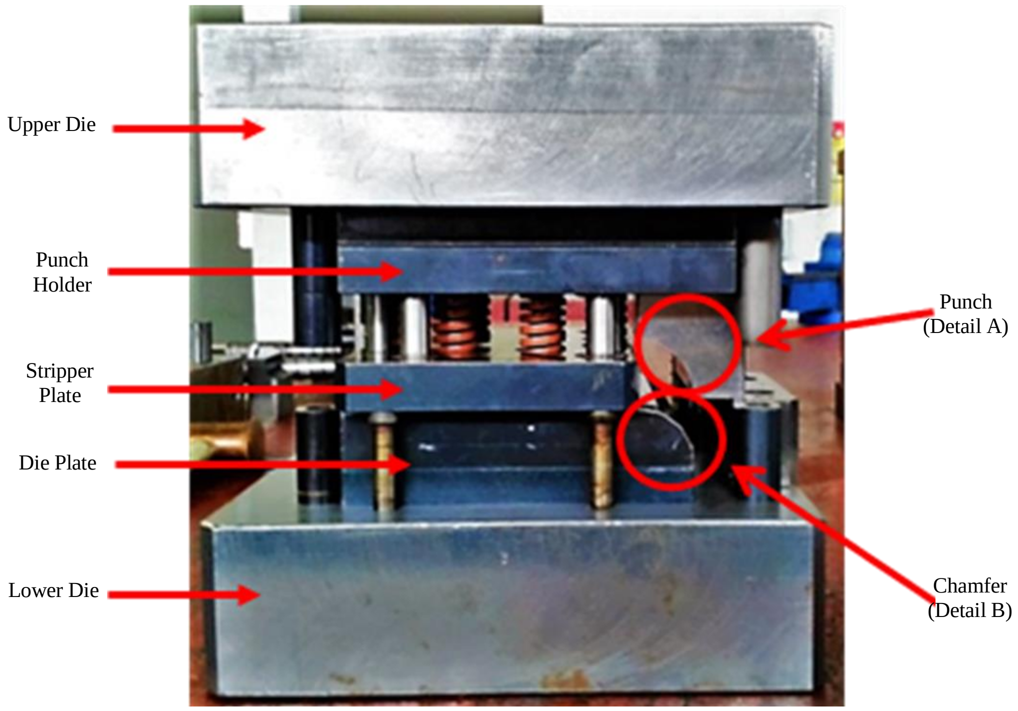
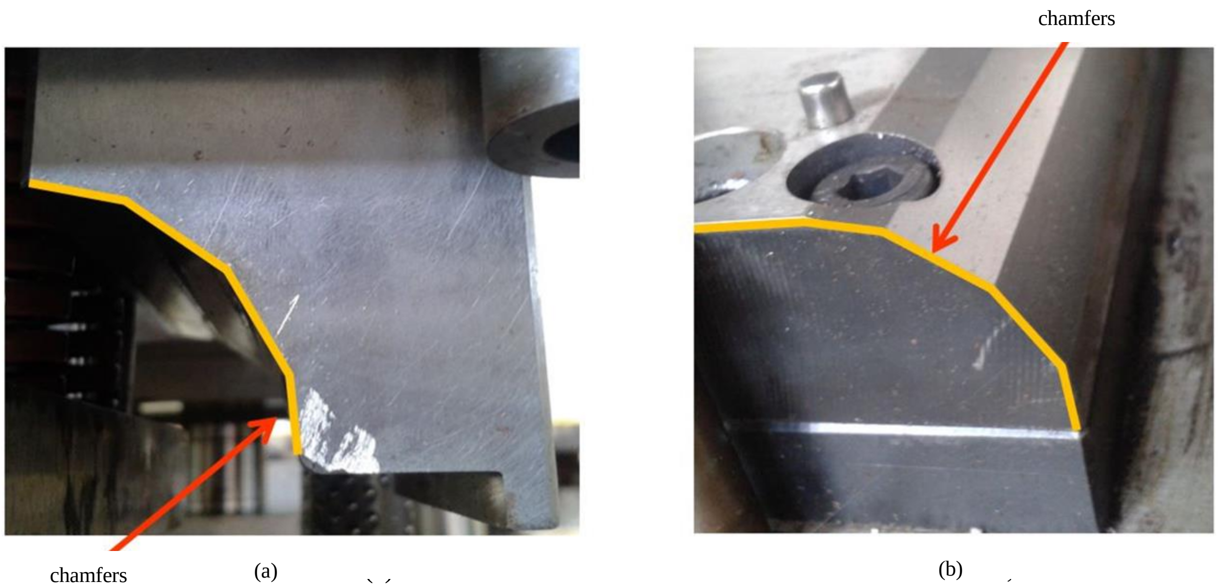


Figure 3: Dies set that are fabricated



(b) The detail view of fabricated die

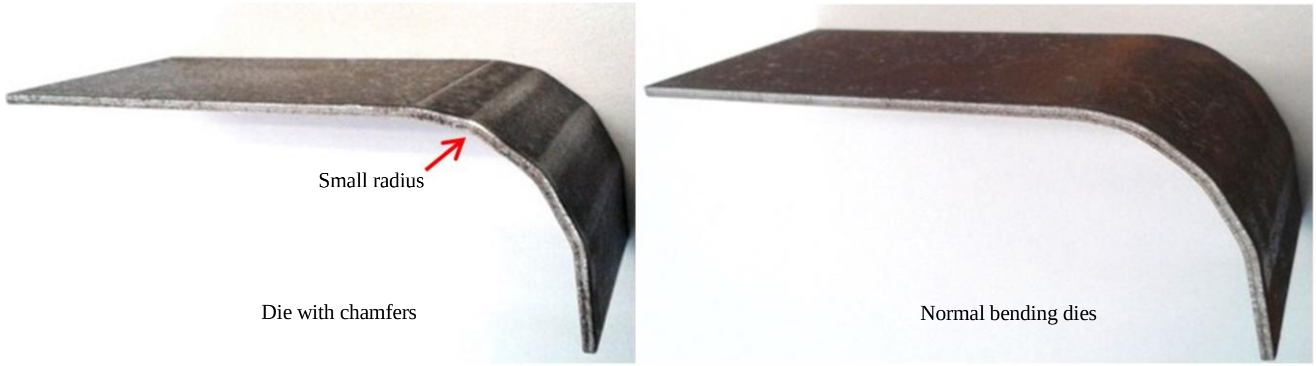


Figure 5: The bent sheets by die with chamfers and normal bending die

A press machine having maximum load of 60 Ton was used for the bending process. The dimension of the high strength steel sheets that are used for bending process are 116mm x 50mm and the thickness is 2 mm. The high strength steel sheets have yield strength of 780 MPa. For both type of dies, the press speed will vary which are 0.10, 0.13, 0.15, and 0.18 m/s. The speed was controlled by manipulating the stroke speeds that are set to 40, 50, 60, and 70 strokes per minute (spm). The condition of the bent sheets after unloading is observed. The geometrical or the shape of the sheets also is observed and the bending angle is measured. It is found that the die with chamfers are producing more accurate bending which is approximately 90° compared the die with large radius. The sheets bent by the die with chamfers are using small radii at each chamfers as shown in Fig. 5. The die with chamfers is effective in reducing the springback in L-bending process.

Fig. 6 show the measuring of the bend and bent angle. The θ_I indicate the initial angle or the targeted bending angle where the sheet is stamped. The θ_F indicated the final angle or the bent angle after springback effect take place after unloading. The collected data from the L-bending process were recorded in the table 1 and Fig.7 where the value recorded in the table are the average measurements for each of the stroke speeds. The measurement of the springback are done by measuring the angle of the bend angle, which is the targeted angle for the part and also the bent angle after the unloading. The bent angle is larger than the targeted bending angle due to the elastic recovery or the springback of the high strength steel sheets.

The specimens are bent 90° by both type of dies and the data collected shows that the bottoming with the chamfers have produce approximate to the bending angle which ranging from 95° to 96° that only shows maximum 6° of springback occurs when using the chamfers die and punch. Compared to the bent angle of the normal bending dies, the bent angle is ranging from 99° to 100° where resulting in about 10° of springback maximum. This show that the chamfers are reducing the springback in stamping of high strength steel sheets. For the press speed, the increasing speed show only a small change in values. For both type of dies, increasing of the press speed have increased the accuracy of the bent angle where 70 spm or 0.18 m/s resulting the closest value to the bend angle. With the same loads and dies, the highest speeds are more effective in reducing the springback in L-bending of high strength steel sheets.

4. CONCLUSION

The used of high strength steel sheets are increasing, therefore improvement of the bending process are required in order to reduces the springback that happens due to the elastic recovery of the high strength steels behaviour. The springback in L-bending can be reduces by using small radius bending therefore chamfers are considerably effective.

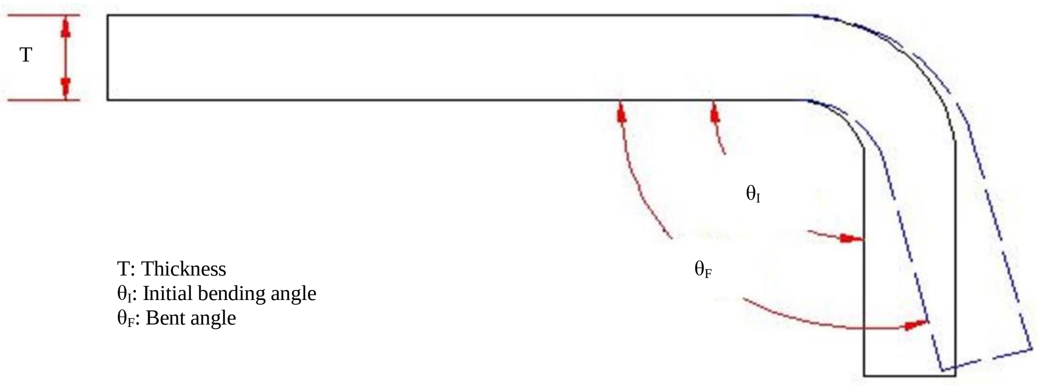


Figure 6: Bend and Bent angle measurement

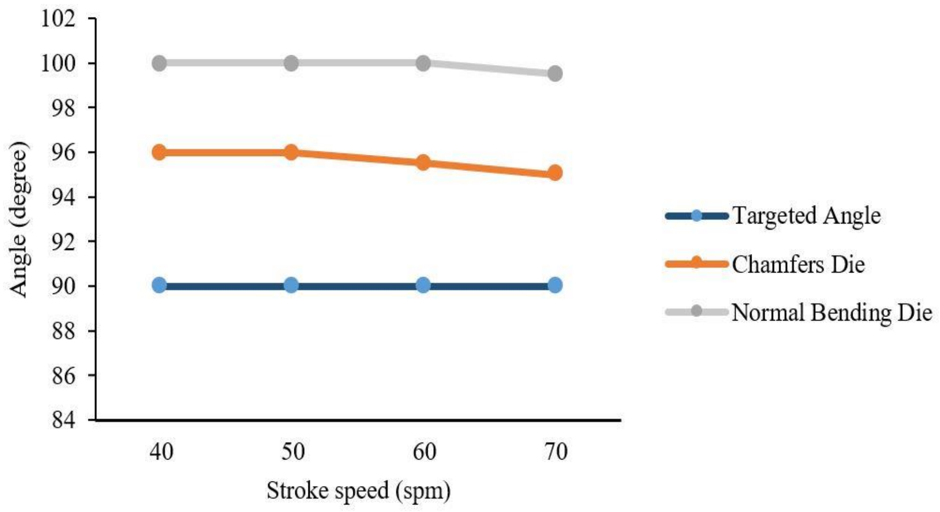


Figure 7: Graph of angle versus stroke speed

Table 1: Bend and Bent Angle from Bending Test

Machines Speed		**Targeted Bending Angle**	**Bent Angle**	
spm	**m/s**		**Normal Bending Die**	**Chamfers Die**
40	0.10	90	100	96
50	0.13	90	100	96
60	0.15	90	100	95.5
70	0.18	90	100	95

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