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Experimental and Analytical Study of the Spring Back/Go Behaviour for Aluminium Alloy 6082-O Sheet Using V and U Bending Die

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Abstract—*In the bending process, the spring back/go phenomenon leads to effect on the dimension of forming parts and the geometrical shape of the component. Spring back/go caused due to elastic deformation of material during the bending process. In this present research paper, V-bending and U-bending processes were applied to the aluminium alloy AA 6082-O sheet of 2mm thickness. This research study is divided into two parts. Firstly, the laboratory experiment was performed using V and U bending die to findout the springback/go value of the bent components. Secondly, Finite element method(FEM)simulation was carried out by the Hyperform analysis software to measured the spring back/go value. The comparative study were also made to validate the accuracy between the experiment and simulation result in terms of springback/go value. The result showed good agreement between the experiment and simulation result in both the cases of V and U bending operation.*

Keyword*: Springback/go effect, V-Bending die, U-bending die, Hydrallic press, Hyperform*

1. INTRODUCTION

In the sheet metal bending process, Bending is a process by which a force, corresponding to a given punch displacement, acts on the workpiece. In V and U bending process, the bending load increases until the elastic limit of the material is exceeded. The material state enters the plastic deformation region and sheet metal can be formed.

S. Thipprakamas et al [1, 2]reported that effect of punch parametres on spring-back/spring-go in the V-bending process using FEM analysis. With respect to the angular punch radius and punch height, the FEM simulation results showed that the spring-back/spring-go phenomenon could be theoretically clarified on the material flow analysis and the stress distribution analysis. The amount of spring-go decreased as the angular punch radius increased and the amount of spring-back decreased as the angular punch radius decreased. Too-large punch height resulted in a large reversed bending zone and no gap formation between the workpiece and the die, the spring-go occurred. Kamil Ozdin et al [3]was investigated that the effect of spring-back/spring-go of AISI 400S and observed that the bending angle is decreased, spring-go increases. As the punch radius is increased, spring-go increases. If the punch radius is increased above a certain value, spring-back decreases to even negative values (spring-go).M. Bakhshi-Jooybari et al [4] studies of the effects of significant parameters including sheet thickness, sheet anisotropy and punch tip radius on spring-back/spring-go in V-die and U-die bending processes of CK67 steel sheet have been conducted. In V-bending and U-bending processes increasing the sheet thickness result in a decrease in the spring-back and spring-go angle. The amount of the spring-go decreased as the punch tip radius increased and the amount of the spring-back increased as punch tip radius increased. In U-bending there is no spring-go and the amount of spring-back increased as the punch tip radius increased. Sutasn Thipprakmas et al [5]was examined that effects of process parameters, such as bending angles, sheet thickness and stress distributions. It was determined that the bending angles and sheet thickness had a great effect on bending processes for both spring-back and spring-go. The sheet thickness was strongly considered in the case of spring-back. In contrast, the bending angle and subsequent material thickness were strongly considered in the case of spring-go and also observed that Taguchi Method and ANOVA technique was an effective tool to predict the degree of importance of process parameters in the V-bending process. Jaydeep R. Shah et al. [6]was investigated spring-back effect in U-bending process with different parameters such as sheet thickness, sheet anisotropy and punch tip radius simulation with Altair hyper works. It was conclude that the thickness of the sheet metal increases there will be a decrease in the spring back effect. The material strength increases the spring back effect decreases. G.M. Sayeed Ahmed et al [7] experimentally evaluated Springback in Mild Steel of various thicknesses like 1.2 mm, 2mm, 3mm.It has been observed that as the thickness of sheets increases the spring back angle decreases. S. Dutta et al [8] investigated the experimental evaluation of factors effecting springback in Aluminium Alloy Sheet AA 6082-T6.It was reported that the springback increases on decreasing the bending angle and vice versa. Higher bending Angles are recommended to minimize springback and springback increases on increasing the blank width. lastly, the springback increases on increasing the punch velocity. S.K. Panthi et al [9]performed Finite element analysis(FEM) of sheet metal bending process to predict the springback. The Springback highly depends on material properties (yield stress, Young's modulus, strain hardening) and geometric parameters (thickness of sheet, die radius, sector angle) at minimal load condition and it decreases with increase in compression depth. It was also found that the friction has negligible effect on springback. AB Abdullah et al [10]experimentally investigatied springback of AA6061 Aluminium Alloy strip via V-Bending process. The effects of length, thickness and bend angle have been studied and the result depicted that the springback is significant to the thickness and bend angle changes.

In contrast it has a very less effect to the length of the workpiece. E.H Ouakdi et al [11]evaluated springback under the effect of holding force and die radius in a stretch bending test. The results of this work that springback decreases in a non-linear fashion with stretching height and increase in blank holding force reduces sliding of the sheet between the die and the blank holder and reduces springback by increasing the tension. Volkan Esat et al [12] presented the effects of mechanical properties of two different aluminium materials on the amount of springback. It was reported that springback increases with greater yield strength. In this present research, comparative study was made by experimental and analytical result of the Spring back/go value for Aluminium Alloy 6082-O sheet using V and U bending Die.

2. MATERIAL AND METHOD

2.1 Material Study

AA 6082 material has good strength in 6000 series alloys. The large amount of manganese which controls the grain structure of the alloy. In this present study, AA 6082-O soft annealed material was used . It is also known as the structural alloy and widely used for the highly stressed applications, trusses, bridges, beer barrerls etc. AA 6082-O with sheet thickness of 2 mm was selected to perform the experiment. Chemical composition the material was cheked by the spectrometer and find out the percentages of the alloys with the base aluminium material shown in Table-1. The physical properties of the material as shown in Table 1.To findout the tensile properties of the material, the standard specimen sub size was cut by the waterjet machining process based on ASTM E8M-04 standard. The tensile specimen was experimented on the universal testing machine(UTM) and then tensile properties and elongation value were achived after the tensile test shown in Table 1.With the help of tensile test data, the stress vs strain and load vs displacement curve of the material has been drawn shown in Figure 1 and Figure 2.

Table 1: Chemical and physical properties of AA 6082-O

Chemical Properties	
Al	95.54
Cr	0.37
Cu	0.10
Fe	0.60
Mg	1.33
Mn	0.83
Si	0.30
Zn	0.20
Mechanical Properties	
Ultimate tensile strength	120 MPa
Tensile yield strength	80 MPa
Elongation at break	24%
Modulus of elasticity	69 Gpa
Poisson's ratio	0.33

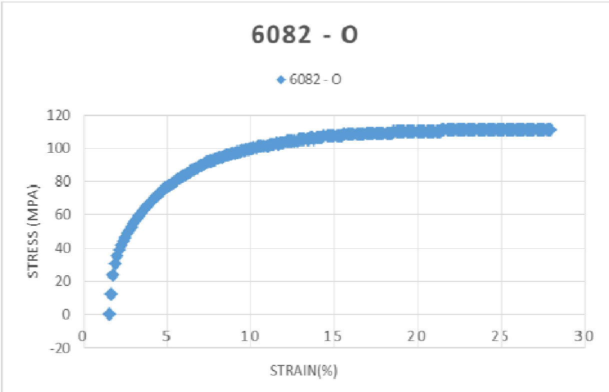

Figure 1: Stress vs Strain

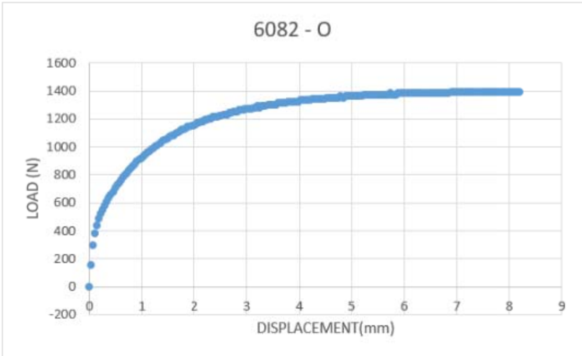

Figure 2: Load vs Displacement

2.2 Designing, Manufacturing and trial of Die

In the design process, Unigraphics CAD software has been used to design the V-bending and U-bending dies. During the die designing, bend angle of V-bending was fixed to 120° and 90° for U-bending die. With the reference of earlier research papers , Blank size 30 x 100 x 2.0 mm^3 for V-Bending Die and blank size 40 x 120 x 2.0 mm^3 was selected [3, 13].Other parameter was also taken from the die design shown in Table 2.According to sheet thickness, the clearance between die and punch has been calculated and applied in U-bending die. As per the bending force calculation, 51 Kgf required for V-Bending Die and 112 Kgf required for U-bending Die.

In U-bending, Pad has been designed which was actuated by action of spring for easily ejection of component form die after bending process completed. Sectional drawing view of V-bending and U-bending shown in Figure 3 and Figure 4.After Designing of die, both the dies were manufactured using the conventional machining process and CNC machine. Actual dies of V and U-Bending die shown in Figure 5.Hydraullic press with 5 Ton was selected for the trial of the dies. In the trial of the specimen using V-Bending die, 3 samples were experimented in atmospheric temperature and dry condition of sheet for the better result and consistency and the same procedure was used for the U-Bending Die. Spring back/Go value was measured of each samples of V and U shaped component using optical microscope and the result were achieved.

Table 2: Data used for V-bending and U-bending

Parameters	For V-bending die	For U-Bending Die
Angular punch tip radius, Rp(mm)	R4	R6
Die tip radius,Rd(mm)	R10	R5
Punch velocity (mm/sec)	20	20
Friction coefficient(μ)	0.1	0.1

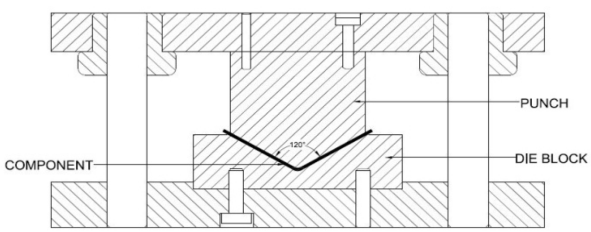

Figure 3: Sectional CAD data of V-Bending

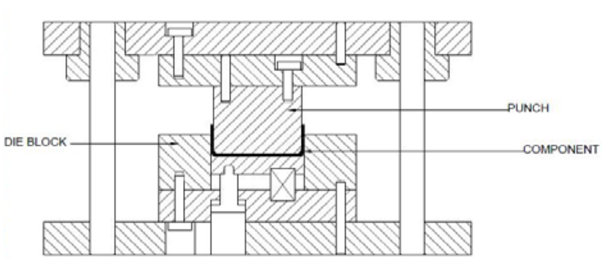

Figure 4: Sectional CAD data of V-Bending

(a) (b)
Figure 5: Actual Die (a) V-Bending (b) U- Bending

2.3 FEM-Analysis

In this present study, the Hyperform CAE simulation software was used and the complete simulaton model was taken from the CAD data of V-bending and U-bending die. During the simulation setup, AA6082-O sheet was set as an elasto-plastic type and rectangular meshing elemnent aproximately 3000 was generaeted for each die.Punch and Die was set as a rigid type.FEM model setup were perepared for simulation shown in Figure 6 and Figure 7.With the help of data, the simulation was done to findout the springback/go value.To easy understand the process of analysis, the flow chart for the simulation has been made shown in Figure 8.The analytical result of spring back/go value were also validated with the experimental result.

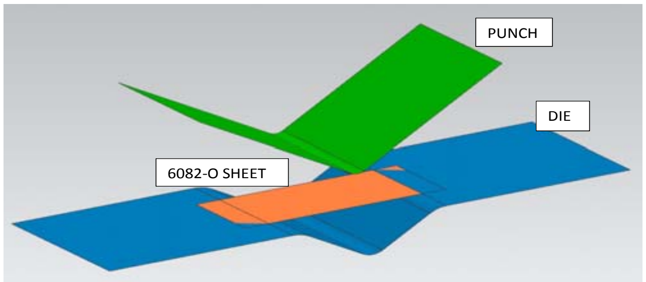

Figure 6: Setup for analysis of V-bending die

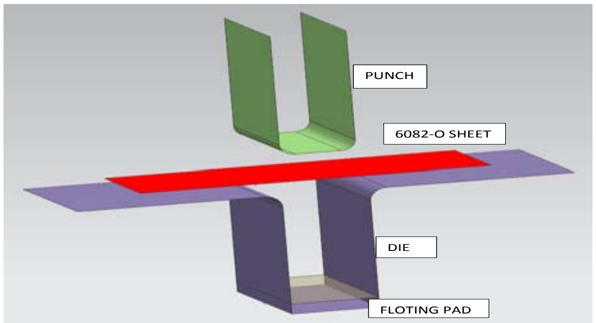

Figure 7: Setup for analysis of U-bending die

CAD model of die, punch and blank surfaces was converted into IGES format

⇩

Import surface data of die, punch and blank from UG NX to Hyperform in .iges format

⇩

Set up of input surfaces from the input sources

⇩

Assigned the material and sheet thickness of blank and meshed all the parts with the help of auto mesh function.

⇩

Select the crash form and springback, input all the values of bending, distance, direction of bending etc.

⇩

Execution of simulation through radioss solver

Figure 8: Flowchart for simulation process

3. RESULTS & DISCUSSIONS

The simulation results were obtained from of AA 6082-O having sheet thickness 2mm for V-bending shown in the Figure 9..The spring go value 119.56˚was achived i.e nearby the actual bending angle 120˚. Spring go value were achieved due to higher bending angle[13].The result shows that when the bending angle of greater than 90˚, the sheet moves in negative direction, then spring go or spring forward occurs. In the case of U-bending Die, the simulation result was also achived, the spring back value 90.16˚ one side of flange wall was measured.

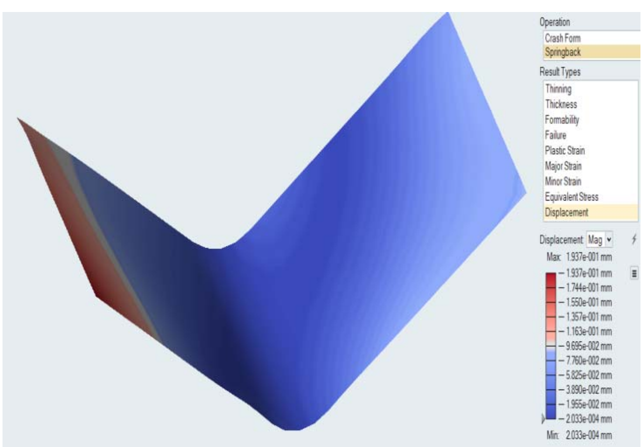

Figure 9: Simulation results for V-bending

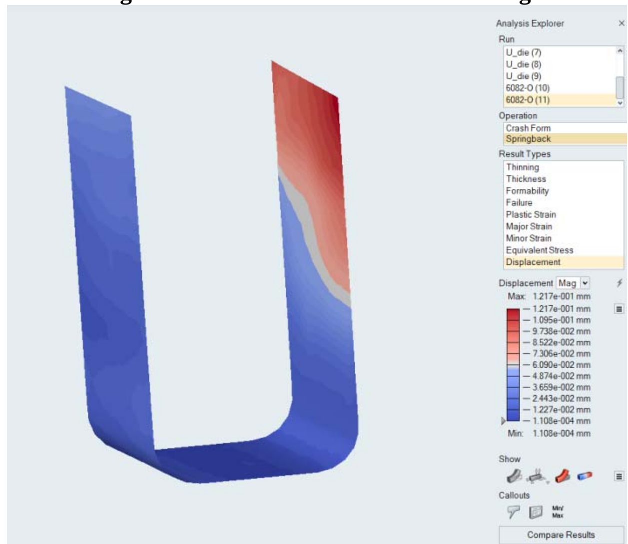

Figure 10: Simulation results for U Bending

AA 6082-O material with thickness 2 mm were used for the laboratory experiments. In which V-bending and U-bending dies has been used to shaped the blanks. Total 6 experiments were carried out in which 3 experiments of U-bending and 3 experiments of V-bending was perfomed. Results of all laboratory experiments as shown in Table 3.Actual trial components of V and U bending die shown in Figure 11.

Table 3: Spring back/go result

Sample	Spring back/go value(degree)	
	V-bending die	U bending die
1	119.60˚	90.20˚
2	119.62˚	90.22˚
3	119.55˚	90.20˚

Figure 11: Actual V bend and U bend component

4. CONCLUSIONS

The following result for AA 6082-O were obtained from the present study:

1) In V bending die, spring go value were achieved in both experiment and simulation result.
2) In U bending die, Spring back value was achieved in both experiment and simulation result.
3) Analytical result showed the minimum error in V bending angle compared with the experimental of approximately 1.8%.
4) Analytical result showed the minimum error in U bending angle compared with the experimental of approximately 2%.
5) It is found that the minor springback in U bending die and minor spring go in V bending die in experimental and simulation result.

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