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Research Article

Numerical Simulation and Experimental for the Effect of Springback on Sheet Metal Forming

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Abstract

Spring-back in metal sheet bending was studied through extensive experiments and finite element method (FEM) analysis. The experimental work has been carried out to study the factors affecting the Spring back in sheet metal with different thickness by using different die profile radius . In this paper aluminum alloy 3105 sheets with 1 mm, 1.5mm, 2mm thickness and die with 50mm ,55mm radius. The finite element method (FEM) was used to predict stress-strain state and part geometry under load and the amount of compensation. Spring-back is dependent on yield stress, thickness of sheet metal and radius of die profile . Von misses stresses and directional deformation in X-axis at different operating conditions are drawn.

Keywords: *Sheet metal, Finite element analysis, Springback*

1. Introduction

In sheet metal forming industry, especially in sheet bending process, spring-back has a very significant role. Spring back is generally referred as to undesirable change of part shape that occurs upon removal of constraints after forming. It can be considered a dimensional change which happens during unloading, due to the occurrence of primarily elastic recovery of the part(Cheng, *et al*, 2007). In the other words, spring back describes the change in shape of formed sheet upon removal from tooling (Papeleux and Ponthot, 2002). Spring back is one of the key factors to influence quality of stamped sheet metal parts in sheet metal manufacturing areas (Lee, 2005).(Al-Qureshi and Russo, 2002) Studied the spring-back and residual stresses in bending of thin-walled aluminum tubes. (Ragai, *et al*, 2005) Discussed the effect of sheet anisotropy on the spring back of stainless steel 410 draw-bend specimens. (Hilditch, *et al*, 2007) Studied the influence of low-strain deformation behavior on curl and spring back in advanced high strength steels (AHSS) by using a bend under- tension test. (Gau, *et al*, 2007) Investigated the spring back behavior of brass in micro sheet metal forming processes. (Kim and Koc ,2007)Conducted numerical investigations on spring back characteristics of aluminum sheet metal alloys in warm forming conditions .(Yilamua, *et al*,2008)Studied the bending and spring back phenomena of a stainless-steel clad aluminum sheet in V-shaped air bending. (Ahmed , *et al*, 2014) Presented the experimental study of spring back in mild steel and the results are validated with finite element analysis software LS-DYNA. (Lee, *et al*, 2015) Discussed the spring-back and spring-go behaviors in bending of thick plates of high-strength steel at elevated temperature . (Buang, *et al*, 2015) Studied the effect of the die and punch radii on the spring back in the air V-die free bending process of stainless steel sheet metal . (Leu , 2016) Proposed a simplified approach to distinguish between spring-back and spring-go in free U-die bending process of SPFC 440 sheets. (Neto, *et al*, 2017) Studied the influence of boundary conditions on the prediction of spring back and wrinkling in sheet metal forming . (Peng, *et al*, 2018)Investigated and characterized the spring back behavior of sheet metals affected by the size effect at micro/meso scale.

In this study, analytical and experimental studies were conducted to study the effect of different thickness of sheet metal and radius of die profile on spring back. The results of numerical simulations were compared with the experimental results to check the suggested model.

2. Experimental procedure

Experiment work has been executed to measure springback of the workpiece after bending operation for aluminum alloy by using two different die radius and three different thicknesses . The calculated average industry grade AA3105 density is 2.75 gm/cm3. Its Young's modulus, which is a measure of its stiffness is 69,000 MPa. In this study, AA3105

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specimen of length250mm and width 30mm with different thicknesses such as 1mm, 1.5mm, 2mm is considered. experiment set-up is composed of arm, different radius die profile(r1=50 ,r2=55 mm) and load cell to measure applied force which is shown in Fig1. The spring back occurs after removing the applied force on the blank .Dimensions of the bending die are same as the ones used in Finite Element Analysis.

(a)

(b)

Fig1.a) Bending die , b) The final specimens with different thickness and radius

3. Finite Element Analysis of Bending Operation

In this work, bending operation of AA3105 material has been analyzed by FEM software package, ANSYS workbench. Many results like quantity springback, max of von Mises stresses, directional deformation in coordinate axis . The input data are the material properties, boundary conditions, and applied force . The AA3105 sheets used in this work are assumed to be free of residual stresses before the loading action. Finite element model used in spring back simulations is composed of a rigid arm with roll and die and a deformable sheet metal. For all cases, the rigid arm moves to bend the workpiece. As shown in Fig 2. bellow model and mash of model.

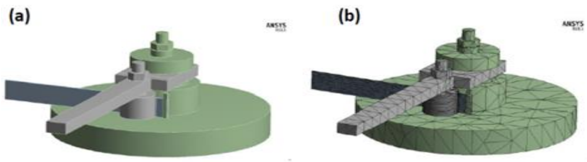
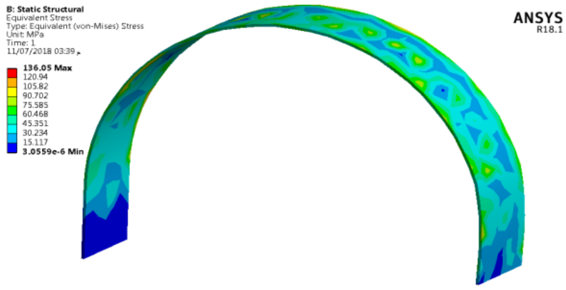


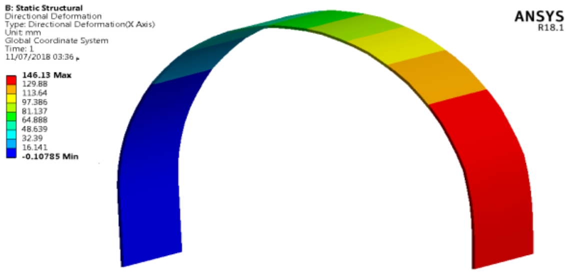
Fig 2. a) Model , b) Mash of model

4. ANSYS Results

Results such as maximum Von Mises stresses and directional deformation in X-axis(springback) are obtained.



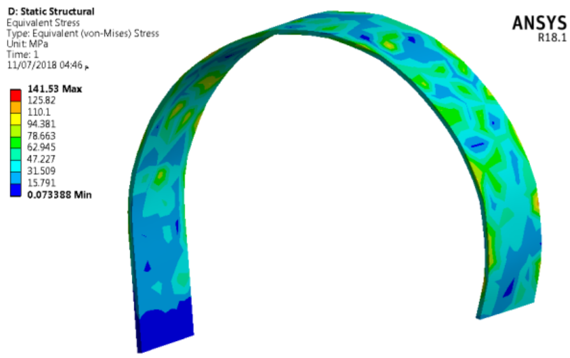
(a)



(b)

Fig 3. a)Von misses stress ,b) Directional deformation of 1mm thick for the radius of the die (R1=50mm

As seen top, the utmost Von Mises stress after removing the load of thickness 1mm with die profile radius R1=50mm is 136.05 MPa . The springback can be measured at the fully unloaded stage by directional deformation , the springback is 146.13 mm.



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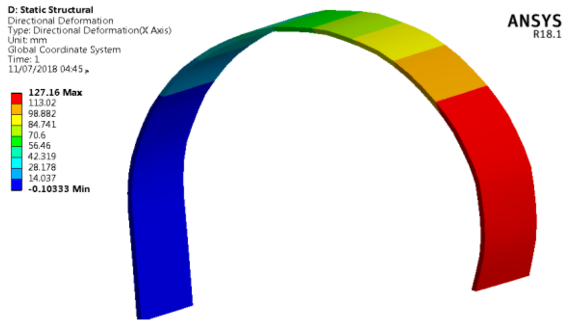
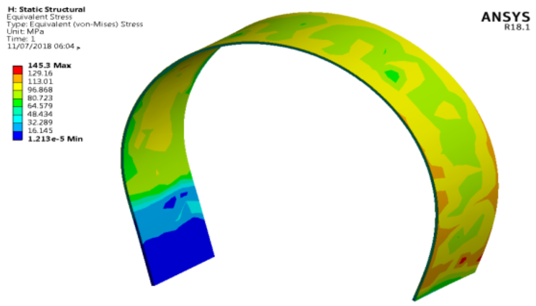
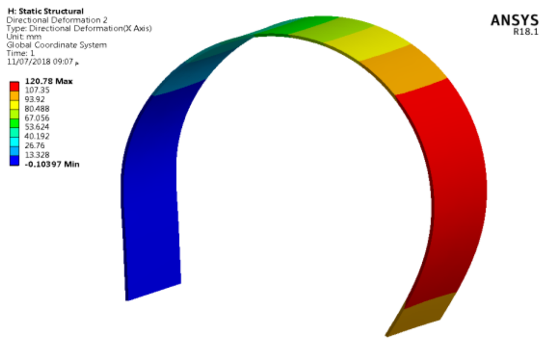


(b)

Fig 3. a)Von misses stress , b) Directional deformation of 1.5mm thick for the radius of the die (R1=50mm)



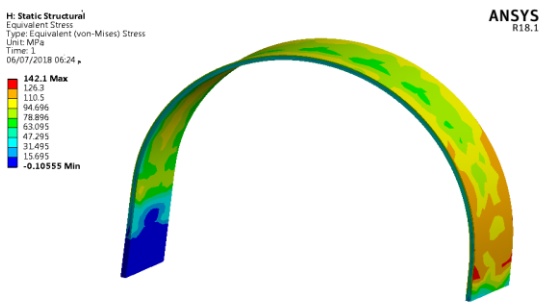
(a)



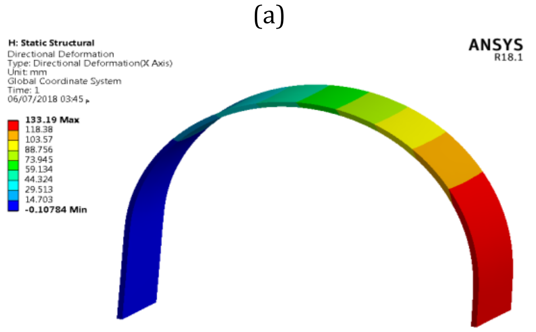
(b)

Fig 4. a)Von misses stress , b) Directional deformation of 2mm thick for the radius of the die (R1=50mm).

From Fig 3. above, the maximum Von Mises stress of thickness 1.5mm with die profile radius R1=50mm is 141.53 MPa , the springback is 127.16 mm. From Fig 4. above, the maximum Von Mises stress of thickness 2mm with die profile radius R1=50mm is 145.3 MPa , the springback is 120.78 mm.



(a)



(b)

Fig 5. a)Von misses stress , b) Directional deformation of 2mm thick for the radius of the die (R1=55mm).

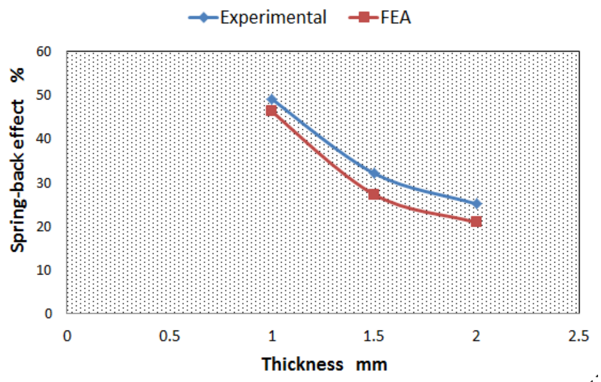
As seen top, the utmost Von Mises stress after removing the load of thickness 2mm with die profile radius R1=55mm is 142.1 MPa . The springback can be measured at the fully unloaded stage by directional deformation , the springback is 133.19 mm. After all the numerical analysis, springback is measured for each case and tabulated as below.

Table.1: Variation of the spring back with different thickness at R1=50,R2=55 mm

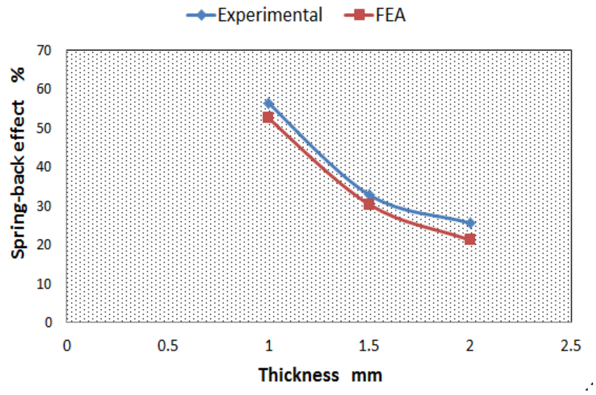
Thickness mm	Springback at R=50mm	Springback at R=55mm
1	146.13 mm	167.65 mm
1.5	127.16 mm	143.24 mm
2	120.78 mm	133.19mm

5. Results and discussions

The results from the FEA analysis using ANSYS workbench and experimental values of spring back are listed and compared below.



(a)



(b)

Fig 6. Variation of springback effect for different thickness for the radius of the die (a) R=50 mm) , (b) R= 55 mm.

Fig 6. Shows the variation in the experimental and numerical values of spring back with the different thickness. As the thickness of the sheet increases the spring back decreases. The experimental springback for thickness 1mm, 1.5mm, 2mm respectively for the radius of the die (R=50 mm) are 149 , 132, 125 mm. The experimental springback for thickness 1mm, 1.5mm, 2 mm respectively for the radius of the die (R=55 mm) are 172, 146, 138 mm.

Table2: Comparison of experimental and FEA values of springback for the radius of die R=50 mm

Thickness mm	Radius of die mm	Experiment springback effect (mm)	FEA springback effect(mm)	Error %
1	50	149	146.13	2.264
1.5		132	127.16	3.8
2		125	120.78	3.49

Table3: Comparison of experimental and FEA values of springback for the radius of die R=55 mm

Thickness mm	Radius of die mm	Experiment spring back effect (mm)	FEA springback effect(mm)	Error %
1	55	172	167.65	2.59
1.5		146	143.24	1.92
2		138	133.19	3.61

Conclusions

In this study, springback effect is evaluated under different thicknesses and die profile radius . Also FEA study has also been done with the help of ANSYS. Experimental study on springback has been done by considering aluminum alloy (3105) of various thicknesses like 1 mm, 1.5mm, 2mm. It has been observed that as the thickness of sheets increases the springback decreases from 146.13 to 120.78 mm for the radius of the die (R=50 mm). The von-Mises stresses are observed to increase with an increase in sheet thickness .The von misses stress is not affected or very small with change the radius of the die and when the thickness of the sheet increases for the particular materials used. The spring back of sheet metal thickness increase with an increase in the radius of the die . The ratio between the radius of die and thickness of sheet metal(R/t) is the ruling ratio for increasing or decreasing the amount of spring back .

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