Analysis of Design Parameters of Spring Back in Plate Bending using Finite Element Analysis

Prashanth Gowda B C¹, Dr. S. N. Harish²
¹IV SEM, M-Tech Manufacturing Science and Engineering, Department of Mechanical Engineering, Ghousia College Of Engineering, Ramanagara, INDIA
²Assistant Professor, Department of Mechanical Engineering, Ghousia College Of Engineering, Ramanagara, INDIA

ABSTRACT
Spring back is the phenomenon which is a drawback with mechanical structures. This happens due to stress relaxation during loading and unloading cycles which is better explained by Bauschinger effect. Due to the advances in the analysis techniques, the parameters influencing this spring back is analyzed in the present work.

Initially problem under plate bending considered and spring back deformation is estimated as 0.0069 mm based on deformation for loading and unloading conditions. The geometrical configurations are built for the specified geometry and contact pairs are created for meshed object based on two dimensional analysis using planar elements which helps in faster execution along with better representation for stress and contact pressure results. Further axis symmetric bending is done with various design parameters to find the influence. Increase in the plate thickness shows reduced residual stress and contact pressure, but springback is observed to be more. Similarly the fillet radius of bent is increasing residual stress, contact pressure, but reducing the spring back. Even strain hardening parameter of plastic modulus or tangent modulus also influences the spring back.

Keywords---- Spring back, Bauschinger effect, Vonmises stress, Axi-symmetry

I. INTRODUCTION

Until the advances in the numerical based finite element techniques, design of forming tools is based on experience of trial and error methods. Today the design completely based on virtual simulations which helps the designer to check the parametric influence on the forming parameters. Great numbers of commercial and open source codes are available to check the manufacturing till the end point.

Many approaches are available to implement the computer codes for better manufacturing processes. But all the sheet metal processes constitutes nonlinear conditions as the process is above the yield point of the problem, also many times temperatures are considered which will change the physical properties of the materials like density, elastic modulus, poison’s ratio and thermal expansion coefficients. Most of the numerical methods use plane strain conditions for the sheet metal formation as it more relevant with the practical conditions. Three dimensional approaches are very difficult and time consuming requiring fast computers along with large memory requirements, even obtaining resolution is difficult with three dimensional modeling along with maximum number of simulations are not possible. Even the load requirements with surface finish details can be obtained through the finite element simulation process. The desired shape of rollers, punch, dies, holders and sheet metal can be designed with lesser time compared to the experimental techniques which require prototype model along with costlier setups. The forming process includes sheet metal bending, rolling and extrusion process which requires the material to be either cold worked or hot worked. The cold worked material has high resistance for forming and hot worked material has lesser resistance. So the design should include these parameters before going for actual forming process. Also type of material, extent of deformation, bends, fillets, notches and other shapes play important role in the formability of the product.

II. METHODOLOGY
Geometrical built-up by ansys mixed approach
Meshing with required considerations.
Contacts creation between die, punch and sheet metal using eulerian algorithms
Result Representation

III. PRIOR APPROACH

Hakim has discussed about finite element approach for sheet metal forming which is carried out in the elasto plastic conditions. He has applied plane strain approach with axis symmetric concept based on slip line theory to model and study the forming process. His idea is to minimize the response time and costs for better production rates in the competitive industrial environment. He suggested aluminum is better form material than steel for aero structures. He has discussed about spring back in the metals.

Spring back in bending is shown in the above Figure. Hosfold and Caddeell have proposed following formulae

\[
\frac{1}{R_0} - \frac{1}{R_f} = \frac{3\sigma_{ps}}{tE}
\]

for bending.
Where,  
- \(R_0\): original radius of curvature
- \(R_f\): radius of curvature after spring back,
- \(\sigma_{ps}\): yield stress
- \(T\): thickness of plate
- \(E\): elastic modulus.

IV. OUR APPROACH

Spring back is the phenomenon which is a drawback with mechanical structures. This happens due to stress relaxation during loading and unloading cycles which is better explained by Bauschinger effect.
the advances in the analysis techniques, the parameters influencing this spring back for different design parameters is analyzed in the present work. Further the objective of this work includes:

- Methodology used for sheet metal forming processes.
- Finding the effect of design parameters on the spring back behaviour.
- Estimation of residual stresses and strains during sheet metal formation.
- Modelling for elasto-plastic material behaviours.

Analysis has been carried out to find the spring back in the plate bending problems. Contact elements are defined using two dimensional algorithms and virtual simulation is carried out to find the forming process of deformation, resulting vonmises stress, plastic strain and contact pressure. Step by step simulation is represented in the problem. This helps in finding the critical locations of stress concentration, contact pressure built up and possible crack region etc. due to higher accumulation of plastic strains. Simulation process is represented as follows.

- **Axi-symmetric Bending with 1.25mm plate thickness**

![Fig.5: Deformation during loading process (Maximum deformation: 9.11457mm)](image)

Plate bending with aixi-symmetric concept is shown in the figure. Here also plane42 element with Axi-symmetry option is used for the problem. Maximum deformation observed is 9.11457mm at the centre. Expanded view is considered for the problem. The colour code represents variation of the deformation with the depth of penetration. Totally 21 steps are considered for the loading cycle. The sheet metal processes are highly nonlinear and requires setting up of convergence limits in the problem. By default both displacement and force convergences are set along with mathematical convergence for matrix. In the present problem deflection convergence is applied.

- **Axi-symmetric Bending with 1.5mm plate thickness**

Plate thickness values are changed to find the structural behavior during plate bending. The results are as presented below.

![Fig.6: Deformation at the end of loading process (Maximum deformation: 8.78589mm)](image)

The table shows increasing plate thickness is decreases the stress, contact pressure and plastic strain values, but increases the spring back. This can be attributed to resistance retained in the structure due to higher thickness.

### V. CONCLUSION

Analysis has been carried out to find the effect of design parameters on the structural spring back behavior in the structural members under bending. The overall process is summarized as follows:

- Initially a plate bending problem is considered and the geometry is built using Ansys Mixed approach. The geometry is split to map meshing
and members are separately grouped to ease contact pair creation.

- Axi symmetric plate bending is considered with variation of three design parameters. They are plate thickness, fillet at the bent region and the strain hardening parameter (Tangent Modulus or plastic modulus).

**REFERENCES**


