Investigating the Influence of Draw bead Geometries on Spring back in Mild Steel Sheet Metal Forming Using Abaqus Software

Tarun Nharwal[1], Dr. Kishan Pal Singh[2]

Research Scholar, Mechanical Engineering Department Mangalayatan University Aligarh
Associate Professor, Mechanical Engineering Department Mangalayatan University Aligarh

Corresponding Author: - tarunnharwal@gmail.com

Abstract

This research study aims to investigate the influence of draw beads on minimizing spring back in the forming of mild steel sheet metal using the Abaqus software. Springbucks, which refers to the elastic recovery and inaccurate geometry of deformed parts after the forming process, can be reduced by introducing drawbeads. Four different drawbead geometries, namely without drawbeads, circular drawbeads, rectangular drawbeads, and triangular drawbeads, are examined through computational analysis using the finite element method. The results indicate that the triangular drawbeads are the most effective in reducing springback compared to the other geometries.

Keywords: Springback, Draw-bead, Metal Forming, Abaqus/Explicit Software.

Introduction

Sheet metal forming involves various processes used to shape sheet metal into desired forms, such as stamping, bending, and drawing (Trzepiecinski, & Lemu, 2017). Springback, an elastic deformation that occurs after the forming process, can pose challenges in subsequent assembly processes, and cause geometric distortions. Drawbeads are introduced to control material flow and improve product quality by applying restraining forces (Soualem, & Hakimi, 2018). However, the influence of drawbead geometries on springback behavior is not well understood. This research aims to investigate the effect of drawbead geometries on minimizing springback

Numerical simulations play a crucial role in product design, providing valuable insights into various aspects of the manufacturing process. However, there are still challenges in achieving accurate and reliable results using numerical tools. To address these issues and enhance the prediction of springback in Finite Element (FE) analysis, researchers have proposed guidelines for mesh discretization and introduced a new through-thickness integration scheme for shell elements (Maia et al., 2017). Among the FE analysis software available, ABAQUS is a versatile option that enables the modeling of structures, both homogeneous and heterogeneous, at macro and micro scales (Neto et al., 2017). When it comes to springback simulation in sheet metal forming, several factors significantly influence the accuracy of the results.

To optimize springback simulation, it is important to carefully select appropriate values for these factors. The damping value at the nodes should be neither too large nor too small, and often a preliminary simulation is necessary to determine the suitable damping value (Wang et al., 2017).

- The size of the blank sheet elements is another crucial consideration.
- To ensure reliable results, the punch velocity should not exceed $1m/s^2$. Adhering to this limit helps maintain the accuracy and stability of the simulation.

When dealing with drawbeads, which are typically much smaller in size compared to the rest of the die surface, a different approach is required. Modeling the sheet metal's bending deformation around the drawbeads using very small elements is necessary to capture this effect. However, employing such small elements results in an increased number of elements and contact segments, leading to a decrease in the minimum time step and significantly longer computation times **(Sumathi, & Mohan, 2019)**. To overcome this issue and save computational resources, an equivalent drawbead model has been developed. This model replaces the full-scale physical modeling of the drawbead in the finite element simulation, enabling efficient and time-saving computations **(Mohd and Ishak, 2015).**

Furthermore, the use of equivalent drawbead models offers a practical solution to reduce computation time without compromising the representation of the bending deformation around the drawbeads. These advancements contribute to the overall efficiency and effectiveness of numerical simulations in product design and manufacturing processes.

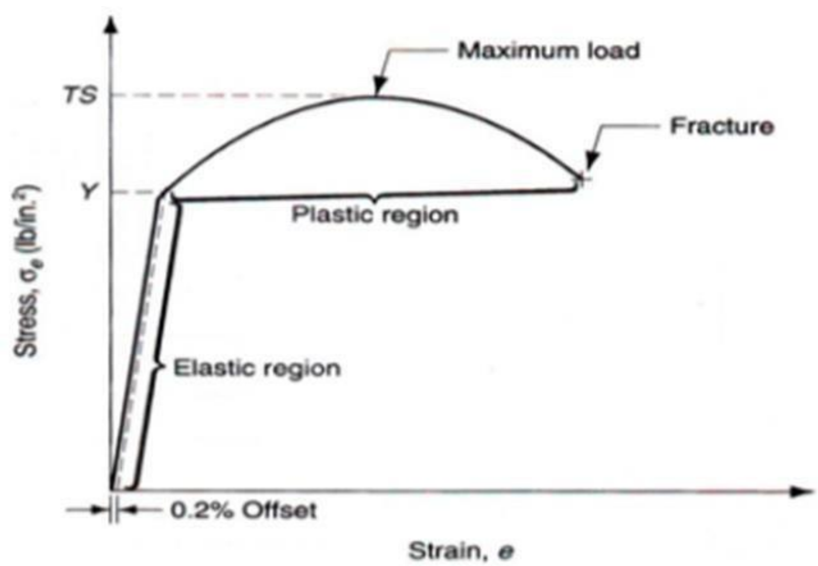


Figure-1.1. Engineering stress strain curve (Koniki, and Ravi Prasad, 2019)

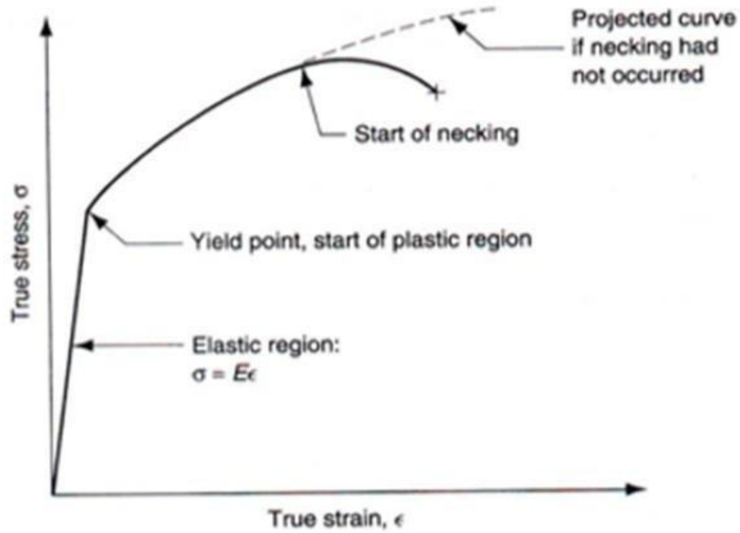


Figure-1.2 True stress strain curve (Moradi, Bagherie, & Esfahani, 2016).

Problem statement

Springback in sheet metal forming leads to inaccurate part geometry and difficulties during assembly. Introducing drawbeads is a method to minimize springback, but the mechanism and influence of drawbead geometries need to be explored further.

Objectives of this study

- Investigate the impact of different drawbead shapes on springback.
- Determine most effective drawbead geometry for reducing springback.
- Gain insights into the springback process through visual simulation using Abaqus software

Study's Scope

This research emphases on simulating springback in different drawbead shapes for 1mm mild steel sheet metal. The simulation results will provide a benchmark for two-dimensional analysis and help select the most effective drawbead geometry for reducing springback.

Methodology

The project involves four major steps: preprocessing, forming simulation, springback simulation, and springback measurement. Preprocessing includes creating the physical model of the die set using MSC.Patran software. The forming and springback simulations are conducted using Abaqus/Explicit, which employs an explicit dynamic finite element formulation **(Ghaei, 2012).** Finally, springback measurements are performed by analyzing the angle changes in the blank before and after Springback using Abaqus/Explicit.

Forming Simulation Process

The research study utilizes ABAQUS/Explicit, a specialized software for highly nonlinear problems in forming simulations. The process involves importing the results from MSC/Patran and conducting a two-step analysis. In the first step, symmetry boundary conditions are applied to the blank, and the blank holder force is gradually increased using a smooth step definition to minimize inertia effects. In the second step, the punch is moved downward by 30 mm with a prescribed velocity using a triangular smooth step amplitude function. The analysis run time varies depending on the complexity of the problem and the computational power available. At the end of the analysis, the deformed geometry and residual stress state are obtained.

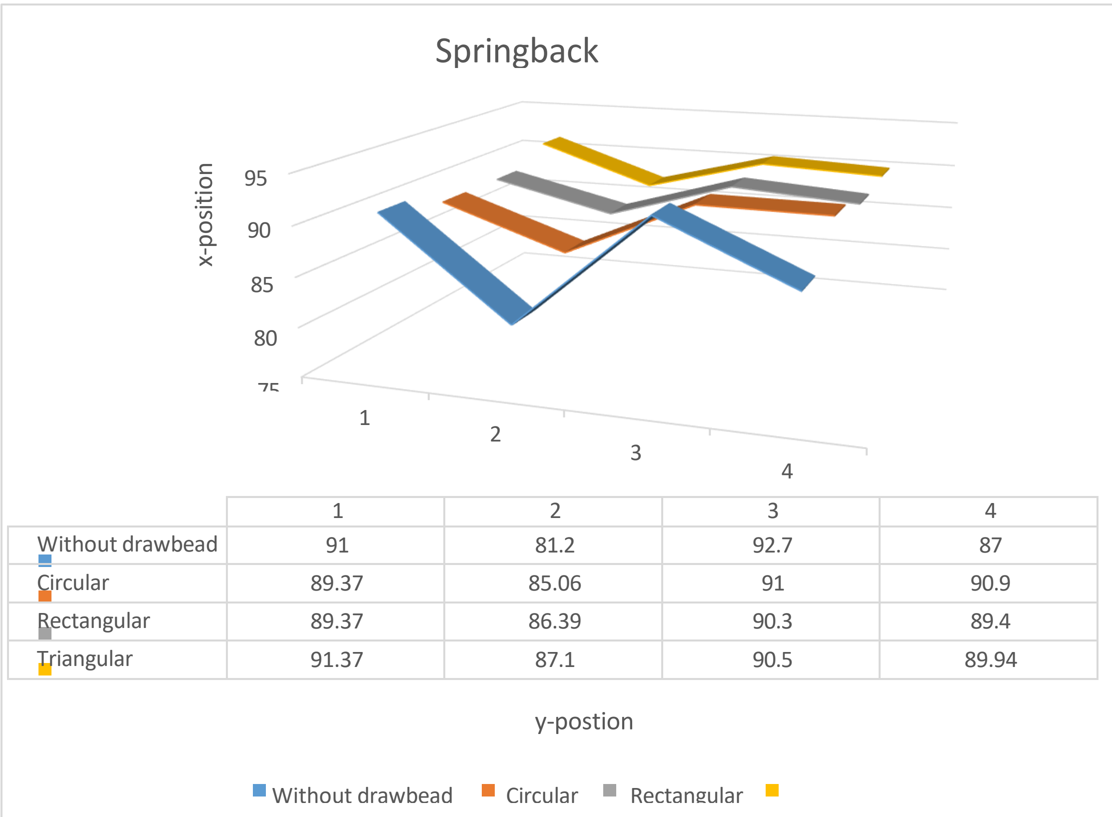
Results and Discussion: -

The simulation results for mild steel as given in the table 1 shows that the triangular drawbead geometry provides the closest approximation to the blank sheet before springback.

Table -1. Simulation results for mild steel

Blankholder	Before Springback ($\boldsymbol{O}$)		After Springback ($\boldsymbol{O}$)	
	θ_1	θ_2	θ_1'	θ_2'
Without drawbead	91.00	81.20	92.70	87.00
Circular	89.37	85.06	91.00	90.90
Rectangular	89.37	86.39	90.30	89.40
Triangular	91.37	87.10	90.50	89.94

It produces a more sufficient restraining force, resulting in effective springback reduction compared to other drawbead geometries shown in Figure 1.3. The drawbead plays a crucial role in sheet metal forming by allowing the material to flow more freely. In particular, the sharp shape of a triangle drawbead significantly affects the metal flow and reduces Springback. This is due to the draw bead’s ability to effectively hold the blank sheet within the die cavity. The force exerted by the holder is concentrated in small areas and acts in one direction. On the other hand, when using a blank holder without a drawbead or with circular and rectangular draw beads, the metal flow occurs more freely. This is because these shapes provide a larger area for the metal to flow. The force applied by the holder is distributed more uniformly across the entire area. By controlling the shape of the drawbead, manufacturers can influence the material flow during the forming process.



	1	2	3	4
Without drawbead	91	81.2	92.7	87
Circular	89.37	85.06	91	90.9
Rectangular	89.37	86.39	90.3	89.4
Triangular	91.37	87.1	90.5	89.94

Figure-1.3 Four different drawbead configurations were evaluated to assess their impact on springback in mild steel

The sharp triangle drawbead shape restricts the flow and leads to reduced springback, while other shapes allow for freer flow and potentially different springback characteristics. Properly selecting the drawbead shape based on the desired outcome can help optimize the forming process and improve the overall quality of the final product.

Key findings from the research include:

- The sharp shape of the triangular drawbead geometry is more effective in reducing springback compared to other geometries.
- The material properties of the blank sheet, particularly its softness, influence the occurrence of springback. Material selection is a significant concern for forming simulations.
- Thicker blank thickness can contribute to more effective springback reduction compared

to thinner blanks.

- The simulation results show a relatively small percentage error compared to experimental data, validating the use of simulations for springback prediction.

Conclusion:

In conclusion, this research study confirms that drawbeads are an effective solution for minimizing springback in sheet metal forming. Among the different drawbead geometries investigated, the triangular drawbead demonstrates the best results. Its sharp shape allows for better control of material flow, creating a sufficient restraining force on the blank sheet. This results in a reduced rate and volume of material entering the die cavity, effectively reducing springback. Conversely, larger drawbead geometries such as rectangular and circular allow for freer material flow and less effective springback reduction.

- Conduct three-dimensional simulations to better represent the actual parts produced in industries, as they are typically three-dimensional in nature.
- Expand the range of drawbead geometries investigated to explore more effective options for minimizing springback.

By implementing these recommendations, further advancements can be made in optimizing drawbead design and reducing springback in sheet metal forming processes.

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