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MILD STEEL SHEET METAL FORMING USING ABAQUS SOFTWARE: INFLUENCE OF DRAWBEADS IN MINIMIZE SPRINGBACK

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ABSTRACT

Introduction of drawbeads can minimize the springback.Springback which in the elastic recovery occurs after the sheet metal forming process will result inaccurate geometry of the deformed parts.The objectives of this project are to study the influence of various geometries of the drawbead to the spring back for the mild steel sheet metal. To achieve the objectives, the computational investigation analysis by finite element method based simulation package will be employed to analyze the best drawbead geometry to reduce springback on mild steel. Drawbead applied to control the material flow in a stamping process and improve the product quality by controlling the drawbead restraining force. A simulation approach by using ABAQUS software used to study the influence of adding drawbeads geometry, whether it helps in minimizing the springback. There are four types of drawbeads geometry involve that investigated that is: (1) without drawbeads, (2) circular drawbeads, (3) rectangular drawbeads and (4) triangular drawbeads. The result shows that the triangular drawbeads reduce springback more compared to other geometry.

Keywords: springback, drawbead, metal forming, abaqus software.

INTRODUCTION

Sheet metal forming refers to various processes used to convert sheet metal into different shapes for a large variety of finished parts such as aluminum cans and automobile body panels. Typical forming processes include stamping, bending, spinning, stretching, drawing, ironing, wheeling, roll forming and incremental sheet forming. Stamping simulation is a technology that calculates the process of sheet metal stamping and predicting common defects such as splits, wrinkles, springback and material thinning. Also known as forming simulation, the technology is a specific application of non-linear finite element analysis. One of the capabilities of stamping simulation is springback prediction. A springback prediction performed after the forming stage completed. Common stamped materials exhibit both elastic and plastic deformation tendencies. Elastic deformation, also called springback is inherent to all stamped sheet metals, which is cannot be eliminated but only minimized. The nonpermanent deformation allows a spring to return to its original size. In contrast, plastic deformation is the permanent shape change intended for a sheet metal part.To minimize the springback, drawbeads are introduced. The drawbeads geometry is critical as it can influence the springback reduction. Drawbeads force material to bend and unbend before entering a die cavity. This action creates a restraining force on the sheet metal, which causes the material to enter the die cavity at a reduced rate and at a reduced volume. In this research study, the influence of different drawbead geometries on the springback behavior is examined.

PROBLEM STATEMENT

Springback is an elastic deformation that always occurs after the sheet metal forming processwhen the stamped part removed from the forming tools. The springback changes the part's geometry, so it can cause difficulties during a subsequent assembly process or cause the twisting in the assembled part. One of minimizing springback methods can be conducted by introducing drawbeads. Drawbead applied to control the material flow in a stamping process and improve the product quality by controlling the drawbead restraining force. The mechanism and the influence of the drawbeads to the springback however are not well developed. The behavior and influence of the drawbeads geometries are required to investigate. It is important to carry out an investigation on the effect drawbeads to minimize the springback.

OBJECTIVES

There arethe several objectives of this project. To achieve the objectives, the computational investigation analysis by finite element method based simulation package will be employed to analyze the best drawbead geometry to reduce springback on mild steel. The objectives of this project are:

- To study the influence of various geometries of the drawbead to the spring back
- To determine the most effective drawbead geometry of the spring back
- To understand the springback mechanism through visual simulation using ABAQUS software.

SCOPE OF STUDY

The scopes of this project are:

- Simulating the springback under various drawbead geometries.
- Providing a benchmark simulation result in two-dimensional.
- Choosing the best result geometry of drawbead to reduce springback.
- Focusing on 1mm mild steel sheet metal.

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LITERATURE REVIEW

Most common metal used nearly in all industrial and domestic purposes is Mild steel. Mild steel is relatively economical and possess metal properties that making it suitable for many uses especially in petroleum, chemical and electrochemical industries and power production [1]. Metal forming classified into two basic categories, namely bulk deformation processes and sheet metal working process. Bulk deformation processes generally characterized by significant deformations and massive shape changes, and the surface area-to-volume of the work is relatively small. There are many different metals that can be made into sheet metal, such as aluminum, brass, copper, steel, tin, nickel and titanium [2]. Bending is a common technique to process sheet metal. Bending is the forming of solid parts where angled or ring-shaped work pieces produced from sheet or strip metal. The most common bending process is including the stamping operation. Stamping is a metalworking process where sheet metal strips punched using a press tool, which is loaded on a machine press or stamping press to form the sheet into a desired shape.

Numerical simulations are deployed widely in product design. However, the accuracy of the numerical tools is not yet always sufficiently accurate and reliable. To improve the springback prediction by Finite Element analysis, guidelines regarding the mesh discretization provided and a new through-thickness integration scheme for shell elements is launched. ABAQUS is one of the adaptable Finite Element Analysis software that can be used to model structures both homogenous and heterogeneous, on a macro as well as a micro scale [3].

The damping value, integration points, the number of the blank mesh size and the punch velocity are the several factors that affect springback simulation in sheet metal forming. Numerical simulation uses numerical techniques to integrate various quantities over the volume of each element by evaluating the material response at each integration point in each element. From the previous research, a reasonable value for the explicit method in springback simulation obtained as follows:

- The nodal damping value shall not be too large or too small. Usually, pre-simulation being needed to obtain a suitable damping value [4]
- Too many or too few a number of integration points have disadvantage for the explicit solution in springback simulation. Usually, seven integration points are the best value
- The blank sheet element size is sensitive in springback simulation. Usually, five elements contacting die radius being required
- In springback simulation, the punch velocity shall not exceed $1 m/s^2$

Since the size of the drawbeads usually very small compared with the remaining portion of the die surface, the sheet metal pulled through the drawbeads during drawing modeled by very small elements to reflect the effect of bending deformation of the sheet metal around the drawbeads. A finite element model with such small elements results in an increase number of elements, contact segments and a decrease in the minimum time step. In consequence, it proves to be uneconomical in terms of the computation time. Hence, an equivalent drawbead model developed to replace the full-scale physical modeling of the drawbead in the finite element simulation of a sheet-metal forming operation to save computation time (Figure-1 and Figure-2) [5].

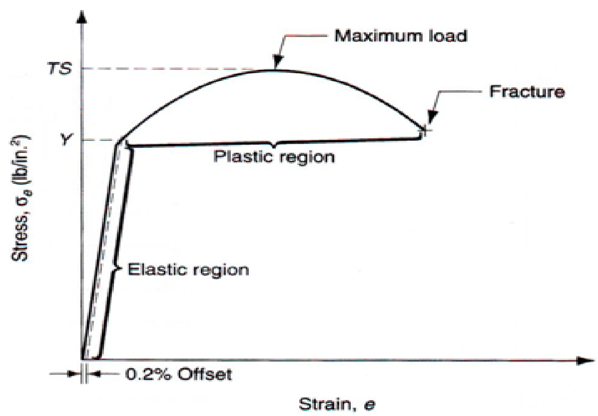

Figure-1. Engineering stress strain curve.

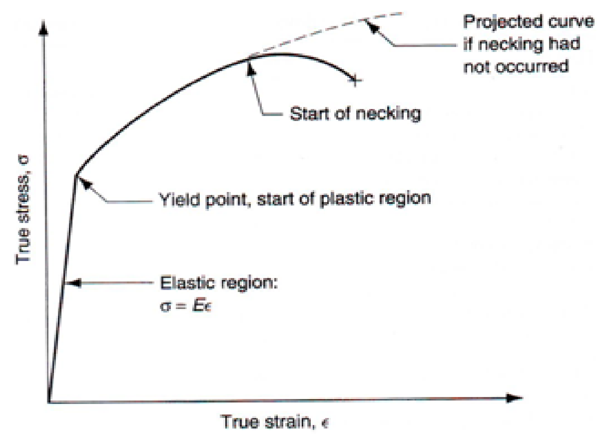

Figure-2. True stress strain curve.

METHODOLOGY

In order to define the stamping simulation, four major steps will be involved that is preprocessing, forming simulation, springback simulation and springback measurement.

Preprocessing process

In this stage, the physical model of the die set will be created by using MSC.Patran software. The die sets model includes the punch, the die, the blank sheet and the blankholder (Figure-3 to Figure-6). The blankholder involves four different shapes of the drawbeads, (1) without drawbead (Figure-3), (2) circular drawbead (Figure-4), (3) rectangular drawbead (Figure-5) and (4)

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triangular drawbead (Figure-6). Due to the symmetry of the tooling, half of the geometry is generated along with the applied of boundary conditions (Figure-7).

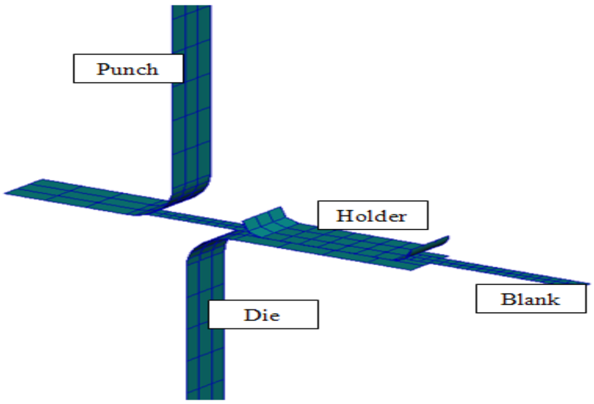

Figure-3. Die set for the blankholder without drawbead.

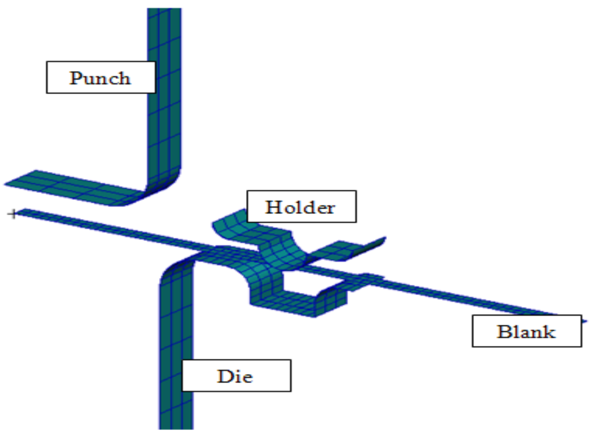

Figure-4. Die set for the blankholder with circular drawbead.

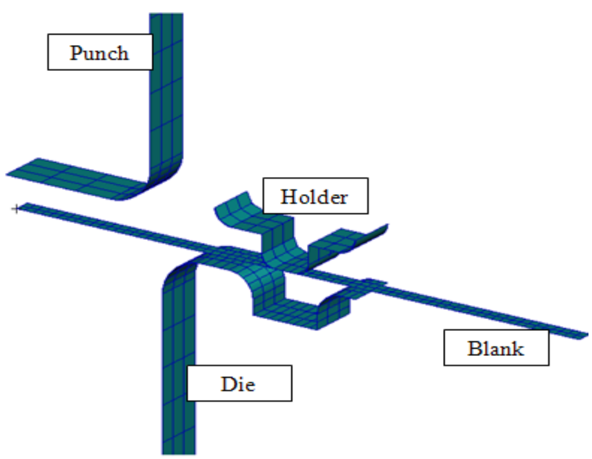

Figure-5. Die set for the blankholder with rectangular drawbead.

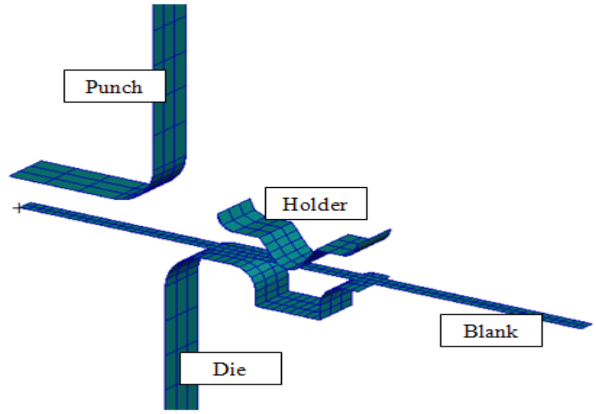

Figure-6. Die set for the blankholder with triangular drawbead.

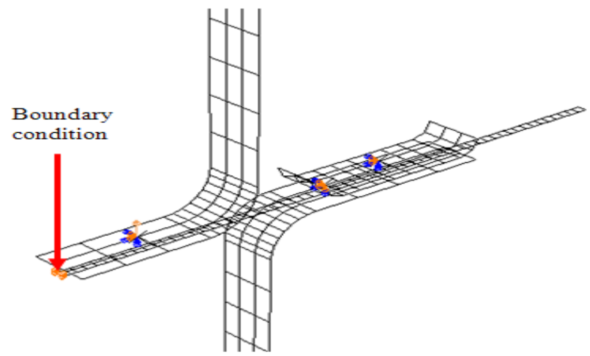

Figure-7. Boundary condition for all blank nodes.

The benchmark geometry is a sheetmetal strip of size 70 x 6 x 1 (in mm). The material properties of the strip are as follows where elastic modulus are 69GPa (aluminum) and 210GPa (mild steel), Poisson's constant are given as 0.33 and 0.3 for aluminum and mild steel. The friction between the sheet and tooling are given as 0.144 (aluminum) and 0.125 (mild steel). The simple tension curves are describing as illustrated in Figure-8 and Figure-9.

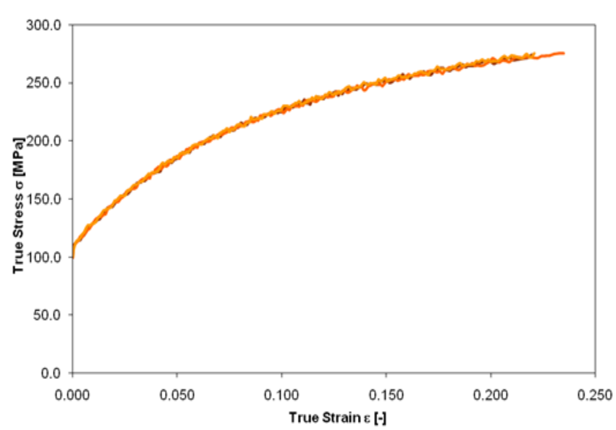

Figure-8. Aluminum true stress strain curve.

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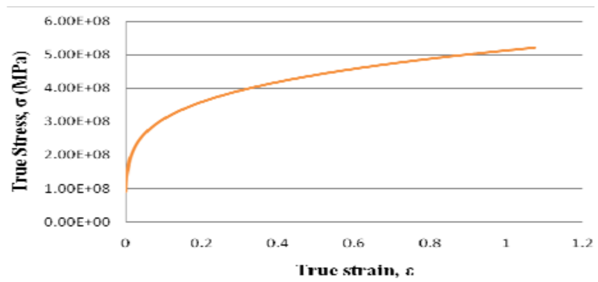

Figure-9. Mild steel true stress strain curve.

Forming simulation process

The results from the MSC/Patran are imported into ABAQUS/Explicit. ABAQUS/Explicit is a special-purpose analysis product that uses an explicit dynamic finite element formulation. It is very efficient for highly nonlinear problems involving changing contact conditions, in forming simulations. First, all nodes of the blank as shown in Figure-7were applied with the symmetry boundary conditions in the plane of symmetry and boundary condition. Then, the forming process simulated in two steps. The blank holder force applied in the first step of the analysis. To minimize inertia effects, the force ramped on with a smooth step definition. By prescribing the velocity of the rigid body reference node for the punch, the second step of the analysis, the punch moved down 30 mm. The velocity applied to a triangular smooth step amplitude function, a peak velocity occurring in the middle of the time with starting and ending with zero velocity (Figure-10). In this research, the velocity of punch is 1m/s. Depending on the complexity of the problem being analyzed and the power of the computer being used, it may take anywhere from seconds to days to complete an analysis run. At the end of the step, deformed geometry and residual stress state will occur.

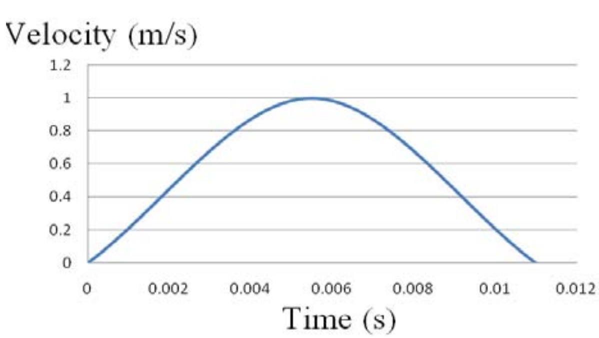

Figure-10. Tabular amplitude definition of punch.

Springback simulation process

Using the *IMPORT option, the springback analysis is performed with ABAQUS/Explicit. The forming simulationexecute the results in ABAQUS/Explicit are imported into ABAQUS/Explicit, and the springback calculated in a static analysis. Boundary condition applied to the blank before simulation running. The end of the step is the springback obtained at the displacement, and the stresses give the residual stress state. ABAQUS/Implicit is a general-purpose analysis product that can solve a wide range of linear and nonlinear problems involving the static, dynamic, thermal and electrical response of components.

Springback measurement

The measurement of springback will be doing at θ_1, θ_1', θ_2 and θ_2'. θ_1 is an angle between A and B, θ_2 is an angle between B and C for blank before springback, while θ_1'is an angle between A' and B', θ_2'is an angle between B' and C' for the blank after springback (Figure-11). The angle of the blank before and after springback is measured by using ABAQUS/Explicit.

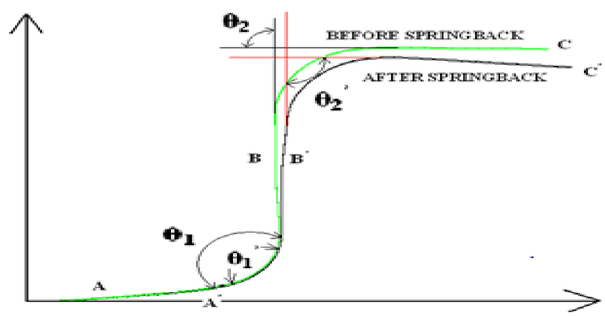

Figure-11. Springback measurement.

RESULTS AND DISCUSSION

Simulation results using mild steel

Figure-12 shows the comparison of the blank sheet after springback with four different of drawbead geometry for mild steel. From the figure below, triangular drawbead more approximated the blanksheet before springback. As the result from the aluminum, it is shown that triangular drawbead can produce more sufficient restraining force than other drawbead geometry. It causes springback reducing more effectively.

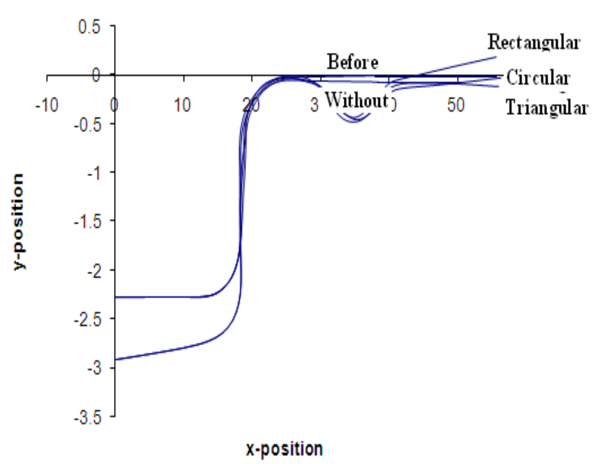

Figure-12. Springback results with four different drawbead for mild steel.

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Table-1. Simulation results for mild steel.

Blankholder	Before Springback (^{0})		After Springback (^{0})	
	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

The drawbead allows material to flow more freely. The sharp shape of the triangle drawbead causes the metal flow of the material decrease and reduces the springback. This is because the sharp shape of the drawbead can hold the blank sheet effectively in the die cavity. The force that had been attaches to the holder only act on the one direction in small areas as shown in Figure-13. However, for the blankholder without drawbead, with circular and rectangular drawbead the metal flow will be flowing freely because of the large area of drawbead. The force distributed uniformly around the area (Figure-14).

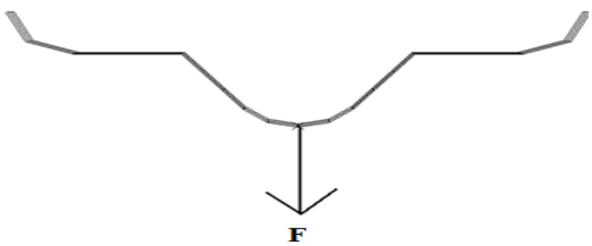

Figure-13. Force applied on triangular drawbead.

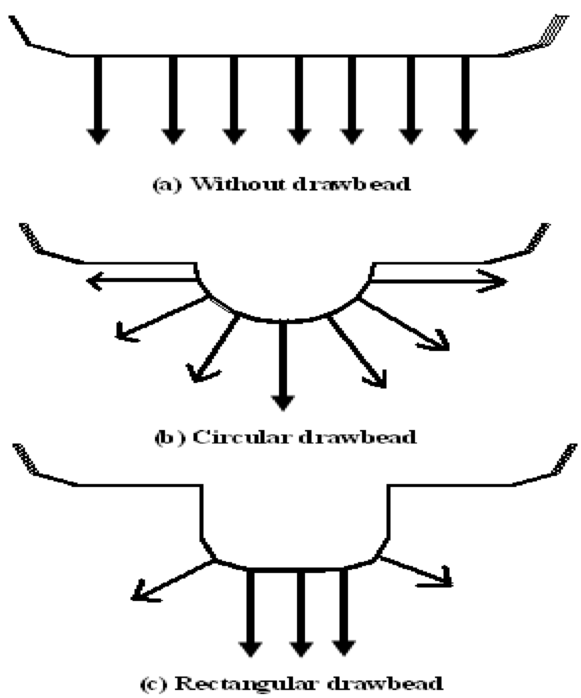

Figure-14. Force applied on without, circular and rectangular drawbead.

CONCLUSIONS

Based on this research, it had been proven that drawbead is one of the solutions in minimizing springback as illustrated in Figure-12 and Table-1. In order to minimize springback, the triangular drawbead show the best results compared to others drawbeads. That is because triangular drawbead had a sharp shape can control the material flow more effectively and created a sufficient restraining force on the blank sheet. The restraining force causes the material to enter the die cavity at a reduced rate and at a reduced volume. A sharp draw bead decreases metal flow and reduces the springback, while a large draw as rectangular and circular drawbead allows material to flow more freely. From this research, some findings occur are as follows:

- Sharp shape of the drawbead geometry of triangular will reduce springback more effectively rather than others geometry.
- More soften the material more springback appeared. This shows that the material property of blanksheet is an important consideration before making the forming simulation.
- Thicker blank thickness can reduce springback more effectively than thick blank thickness.
- Since the percentage error between simulation and experiment is not too large, it is validating the simulation results is can be used for the springback prediction.

Recommendation made as follows in order to reduce springback in forming process:

- In order to improve the study on springback, three-dimensional will be required. That is because usually in industries, the parts to produced are in three-dimensional. By using this method, the springback effect will be seen more clearly.
- Since this research only focused on four-drawbead geometry, in others research more drawbead geometry shape may be required in order to fine more effective drawbead geometry which to minimize springback.

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