A Review on Optimizing Sheet Metal Forming

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Abstract—Optimizing process parameters in sheet metal forming is an important task to reduce production costs. To determine the optimal values for the process parameters, it is important to know their influence on the deformation behaviour of the sheet. This contribution presents basic overviews of sheet metal working, sheet metal forming and classification of base sheet forming processes and the application of the proposed FEA method. Various research works focus on the parameters that most influence the deep drawing process. By analyzing these parameters, defects such as wrinkles, tears, ear formation are reduced, and a high-quality product is also obtained.

Keywords—FEA, forming, modelling,sheet metal

I. INTRODUCTION

Sheet metal forming is one of the most important production processes in various sectors such as the production of industrial parts, office and home appliances, car bodies, aircraft parts, etc. The drawing process is based on the production of technical parts with specific shapes thanks to a strong plastic deformation of the flat sheets. An external force on a sheet causes this plastic deformation. This external force must be large enough to bring the material into the plastic zone and prevent the metal part from returning elastically or deforming again after the displacement of the external force. The final quality of the parts produced by this process is based on the final wall thickness and is free of kinks and breaks. [1]

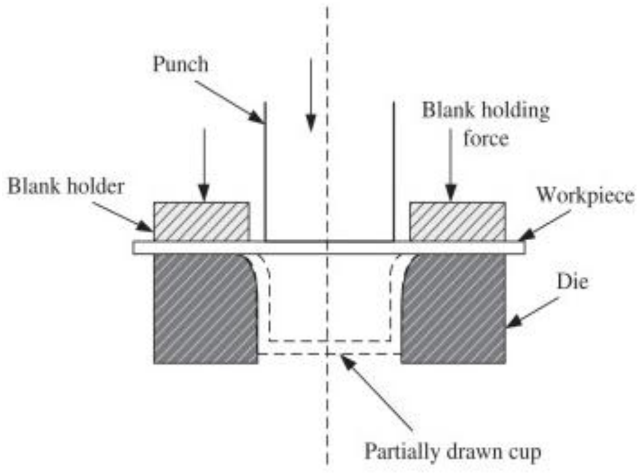

Fig. 1. Deep drawing.[2]

A. Sheet Metal

Sheet metal is a metal that is formed into thin, flat pieces by an industrial process. Sheet metal is one of the basic forms of metalworking and can be cut and folded into a variety of shapes. Countless everyday objects are made of sheet metal. The thicknesses can vary greatly; extremely thin sheet metal is considered a sheet or sheet, and parts larger than 6 mm are considered sheet metal. The sheets are available in flatpieces or rolled strips. The reels are formed by feeding a continuous sheet through a slitter rewinder.

B. Metal forming processes

- Metal forming:

Wide range of production processes in which the material is plastically deformed to take the shape of the tool geometry. The tools used for this forming process are called dies, punches, etc., depending on the type of process.

- Plastic deformation:

Stresses beyond the yield strength of the workpiece material are required.

C. Bulk-forming

- It is a strong deformation process that leads to a massive change in shape. The surface of the work is relatively small. Mainly under hot working conditions.

D. Classification of basic bulk forming processes

- Rolling: The plate or plate is compressed between two rollers rotating in the direction of the thickness, to reduce the thickness. The rotating rollers drag the slab into space and compact it. The final product is in sheet form.
- Forging: The part is compressed between two punches with shaped contours. The mould shapes are transferred to the final part.
- Extrusion: The piece is compressed or pushed into the mould opening to take the shape of the mould hole as a cross-section.
- Wire or rod drawing: similar to extrusion, but the part is pulled through the mould opening to take the cross-section.

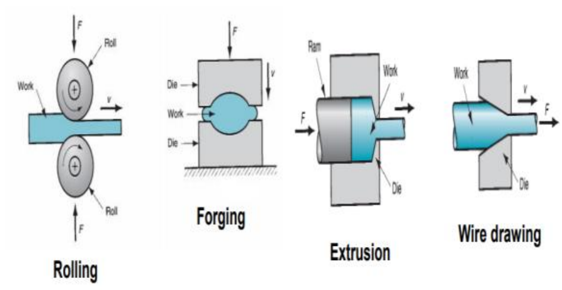

Fig. 2 Classification of basic bulk forming processes

E. Sheet forming

- Sheet forming: Sheet metal forming includes the processes of forming and cutting sheets, strips and coils. The ratio of the specific surface area to the volume of the base metal is relatively high. The tools include punch, die, which are used to deform the deformation sheets.

F. Classification of basic sheet forming processes

- Bending: In this, the sheet material is strained by a punch to give a bent shape (angle shape) usually in a

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straight axis.

- Deep (or cup) drawing: This process involves shaping a flat sheet of metal into a hollow or concave shape such as a cup by stretching the metal in certain areas. The blank is fixed to the mould with a blank holder while the punch presses into the sheet. The sheet is pulled into the shaped hole and takes the shape of the cavity.
- Shearing: This is nothing but the cutting of sheets by shearing action.

II. LITERATURE REVIEW

Walzer, Stefan, and Mathias Liewald[3] In the study presented in this paper, two-phase steel sheets of grade DP600 with a thickness of 1.2 mm were subjected to one-sided embossing near the surface. To evaluate the effects of the targeted embossing parameters on the mechanical properties, on the deformation behaviour and the influence of the locally induced pre-hardening of the sheet, tensile tests were carried out with embossed sheet samples. A key result of this study is that the increase in yield strength largely depends on the distances between the individual embossing's.

V. S. Subramanyam and G. Ramakrishna[4] the embossing and restoration technique is performed as a simple method of reinforcing sheet metal. Experiments are used in the survey. The results show that the restorative technique effectively increases the stiffness of thin plates. By considering several important parameters, the improvement in stiffness can be improved, as this study shows. It should also be emphasized that this technology can be used not only to increase sheet stiffness but also to produce decorative sheets without special forming tools.

Abe Y, Mori K-U, Maeno T, Ishihara S and Kato Y[5] To improve formability during punching, a blank was locally work-hardened by indenting with a punch. Local strength, expressed as the product of yield strength and thickness, is increased by lowering to a certain stroke of the punch since the influence of increased yield strength on local strength is greater than that of thickness reduction. The effects of the printing ratio, the number of punches and the raw material on the deformation behaviour during punching were evaluated. The malleability has been increased by indenting the thinnest sections of the blank. The approach is effective for sheets with a high hardening exponent such as stainless steel.

Tomasz Trzepieciń ski [6] This study aims to summarize current development trends in the digital and experimental fields of conventional deep drawing, packing gland, sheet metal forming by stamping, electromagnetic forming and computer-controlled forming processes such as incremental sheet metal forming. The advances in the SMF industry that have been observed over the past decade are primarily concerned with the development of unconventional processes to form difficult-to-model lightweight materials for automotive and aeronautical applications.

T. Hakoyama and T.Kuwabara[7] The influence of the variation of the r-value on the accuracy of the deformation limits predicted by the analysis of the Marciniak-Kuczynski (M-K) type deformation limits for cold-rolled steel sheets without gap (IF) is examined. To measure the change in the r-value, uniaxial tensile tests with a digital image correlation system are used. To measure the multiaxial plastic strain behaviour and strain limits of the test material, a tube is placed under tensile stress under linear paths in the first quadrant of the stress zone.

Bruschi S, Altan T, Banabic D, Bariani PF, Brosiusd A, Cao J, Ghiottia A, Khraisheh M, Merklein M and Tekkaya AE[8] The article deals with testing and modelling the response of metals when subjected to sheet metal forming operations. Emphasis is placed on modelling the curing behaviour and flow criteria, as well as describing the formability limits of the sheet. In this context, the article provides a critical overview of the models available today to predict the behaviour of materials at both the industrial and scientific levels, as well as the tests required to identify the material parameters of the models. Recent advances in this field will also be presented and discussed, with particular emphasis on the challenges currently facing the sheet metal forming industry.

Namoco CS Jr, Iizuka T, Sagrado RC, Takakura N and Yamaguchi K[9] In this study, the restoring behaviour of sheet metal with heel deformation was investigated experimentally and numerically. Mild aluminium (Al - O), mild steel (SPCC) and stainless steel (SUS) sheets of various thicknesses were used as specimens. The height of the balls and the diameter of the balls have also been changed. The effects of these parameters on the behaviour of the restoration and the formation of wrinkles after restoration were investigated. The results showed that when a swollen sample was compressed into a flat plate, circular wrinkle patterns appeared on the surface of the plate due to the swelling of the swollen portion during compression.

Merklein M, Allwood JM, Behrens BA, Brosius A, Hagenah H, Kuzman K, Mori K, Tekkaya AE and Weckenmann A [10] This article discusses the current state of scientific research on custom blanks. The review presents the potential of technology and the opportunities for new scientific research.

III. PROPOSED METHODOLOGY

Finite Element Analysis (FEA) is a computer-aided method of predicting how a product will react to actual forces, vibrations, heat, fluid flow, and other physical effects. Finite element analysis shows if a product breaks down, wears out or performs as designed. This is called analysis, but in the product development process it is used to predict what will happen when the product is used.

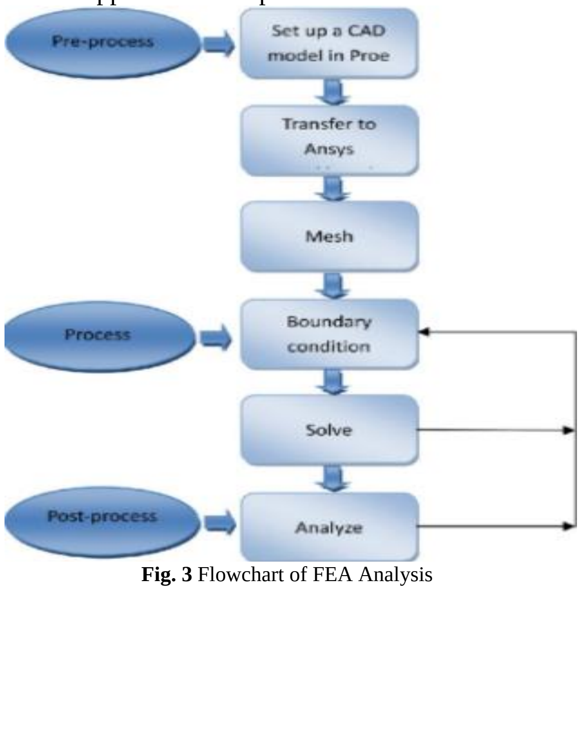

Fig. 3 Flowchart of FEA Analysis

A. Steps of Expected Methodology

1. Acquiring the design dimensions of the sheet.
2. Preparing the 3D model
3. Preparing the 3D model of cylinder cup CATIA V5 Software tool with selected dimensions & specific thickness.
4. Assigning the selected material to the sheet in ANSYS Software. Assigning suitable boundary conditions.
5. Further analysis will be carried at varying geometrical parameters.

IV. DEFECTS IN THE DEEP DRAWING PROCESS

Several defects may occur in deep-drawn parts. Fig. 4 shows the type of defects that may be found after drawing cups. The description of such defects is discussed below:

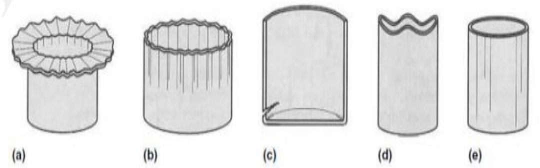

Fig. 4 Defects in deep-drawn cylindrical cups. (a) Flange wrinkling. (b) Wall wrinkling. (c) Tearing. (d) Earing. (e) Surface scratches

A. Earing

It occurs in deep-drawn parts made from anisotropic materials. Because of planar anisotropy, the sheet metal may be stronger in one direction than in other directions in the plane of the sheet. This causes the formation of ears in the upper edge of a deep-drawn cup even when a circular blank is used. In practice, enough extra metal is left on the drawn cup so that the ears can be trimmed.

B. Wrinkling in the flange

Wrinkling in deep drawn parts consists of a series of ridges that form radially in the flange due to compressive forces. Wrinkling in the wall occurs when ridges in the flange are drawn into the vertical wall of the cup.

C. Wrinkling in the wall

It occurs when ridges in the flange are drawn into the vertical wall of the cup.

D. Tearing

It occurs near the base of the drawn cup and results from high stresses in the vertical wall that cause thinning and failure of the metal at that location.

E. Surface scratches

It occurs in a drawn part if the punch and die surfaces are not smooth or if lubrication is not enough.

V. CONCLUSION

A detailed study is carried out about wrinkles elimination especially wall wrinkling. The main reason for the wrinkles occurrence in that industrial vessel is abruptly sectional changes and the ratio of the upper and base diameter is not constant in both stages of forming. So, it is important that this ratio within a certain limit. The punch and die radius should be large enough to reduce tearing in the deep drawing process. Blank holder force increases friction and hence the required punch load. Therefore, blank holder force should be just enough to prevent wrinkling of the flange. The edges of the punch and die are rounded for the easy and smooth flow of metal. In this paper presented are the sheet metal, sheet forming and Classification of basic sheet forming processes

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