Forming analysis using PAMSTAMP 2G

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Abstract- *Drawing is a process of producing cups, shells, boxes and similar articles from metal blank. There are many process parameters which may cause this failure such as Punch speed, Punch radius, Blank holding force, Friction, etc. Fluid assisted blank holding system we can overcome these effects or can reduce the effect of this process parameter on deep drawing process. By Experiment we can study the thickness distribution, effect of blank holding force, Wrinkling, Cracks etc.*

Modern optical measuring methods based on digital image processing providing full-field information of 3D surface geometry and strain and thickness reduction distribution of formed sheet metal pans ARGUS. These optical systems have become important tools in industrial tool making and sheet metal forming processes in the last years and together with the simulation of forming, they have significant potential for quality improvement and optimization of development time for products and production.

As pan of complex process chains smooth interfaces to conventional CAD/CAM and numerical simulation systems are of particular importance. Comparing the stress, strain values from ARGUS analysis with FE-simulation in, helps in validating the results obtained from experimentation. Experimental results are analyzed by using grey relational analysis to obtained optimized parameter for process.

Keywords- Forming, Simulation, Optical measurement, Strain analysts, ARGUS, PAM-STAMP (2G), GRA.

I. INTRODUCTION

Metal forming is a process in which fashioning metal parts and objects through mechanical deformation are done. Forming is a process in which no addition and removal of metal occurs and its mass remains unchanged. Forming operates on the principle of plastic deformation in which physical shape of material is permanently deformed.

Forming techniques are mainly classified according to applied stresses as following:

Compressive forming involves those processes where the primary means of plastic deformation is either uniaxial or multi-axial compressive loading.

Tensile forming involves those processes where the primary means of plastic deformation is either uniaxial or multi-axial tensile stress.

Combined Tensile and Compressive forming involves those operations where the primary means of plastic deformation involves both tensile stresses and compressive loads.

Forming by bending involves those operations where the primary means of plastic deformation is bending load.
Forming under shear condition involves those operations where the primary means of plastic deformation is shearing load.

Sheet metal forming process is those in which force is applied to the piece of metal part in order to modify its geometry. The application of forces tends to stretch the metal beyond its yield strength, causing the material to physically deform without undergoing any failure. By doing this the sheet can be bent or stretched into variety of complex shapes. It is one of the fundamental forms used in metal working and it can be cut and bend into variety of shapes. Nowadays many automobile industries are in construction of sheet metal parts every day and it is countless in no almost .Extremely thin thickness can be categorized into leaf or foil and pieces thicker than 6 mm are considered as plate.

Sheet metal forming is used to produce various products from aluminum, mild steel, and stainless steel, copper, etc. To reduce costs and increase the performance of manufactured products, more and more lightweight and high strength materials have been used as a substitute to the conventional steel. Available materials have limited formability thus a thorough understanding of a deformation process and the factors limiting the forming of sound parts is important. In sheet metal forming a piece of material is plastically deformed between the tools to obtain the deformed products. Sheet metal forming is characterized by the conditions in which the stress component normal to plane of sheet is generally much smaller than the stresses in plane of sheet. Generally common defects which occur in sheet metal forming are wrinkling, earing, necking, cracks, scratching and orange peeling. Wrinkling occurs in areas of high compressive strains and necking in areas with high tensile strains. Scratching is caused by defects on the tool surface and the orange peel occurs after excessive deformation depending upon the grain size of the materials.

II. LITERATURE REVIEW

Mark Colgan, John Monaghan[1] [2003]:investigated deep drawing process to determine the most important factors influencing a drawing process, utilizing the help of a design of experiments and statistical analysis. The parameters varied include the punch and die radii, the punch velocity, clamping force, and friction and draw depth. It seems that the punch/die radii have the greatest effect on the thickness of the deformed mild steel cups compared to blank-holder force or friction. The smaller is the punch/die radii, the greater is the punch force and shorter is the final draw. If the blank-holder force is not kept within the upper and lower limit of reasonable range it does have a significant effect on depth of draw, with the punch tearing through the bottom of the cup if the force is too high and if too low wrinkling of the flange area occurs.

Chandra Pal Singh, Geeta Agnihotri[2] [2015]:studied different research papers and they reviewed that deep drawing process has been an important manufacturing process to produce automotive parts of good strength and light weight. There are many process parameters and other factors that affect product quality produced by deep drawing. This paper is highlighting recent research work and results in deep drawing. Deep-drawing operations are performed to produce a light weight, high strength, low density, and corrosion resistible product. These requirements will increase tendency of wrinkling and other failure defects in the product. Parameters like as blank-holder pressure, punch radius, die radius, material properties, and coefficient of friction affect deep drawing process. So a great knowledge of process is required to produceproductwithminimumdefects.Thisreviewpaperhasgiventheattentiontogather recent development and research work in the area of deep drawing.

S.Rajesham, P.R.Reddy, T.P.Kumar, J.Goverdhan[3] [2015]: studied that The effects of various deep drawing process parameters were determined by experimental study with the use of Taguchi fractional factorial design and analysis of variance for AA6111 Aluminum alloy. The optimum process parameters were determined based on their influence on the thickness variation at different regions of the blank material. Three important process parameters i.e., punch nose radius, die shoulder radius and blank holder force were investigated in this study. Plan of experiments based on Taguchi's technique were used for acquiring the data. An orthogonal array, the signal to noise ratio and the analysis of variance were employed to investigate the deep draw ability characteristics. Influence on thickness due to variation of these parameters was individually evaluated in terms of percentage. The results showed that the blank holder force (56.98%) was the most significant parameter followed by punch nose radius (30.12%) and the least influence (12.90%) was with die profile radius.

S.Yossifon, J.Tirosh [4] [1992]: studied that : The feasibility of replacing the rigid mechanical blank holder in the conventional deep drawing process with a soft' hydrostatic fluid pressure is examined. There commended fluid pressure range (the 'working zone') which guarantees sound product in different circumstances is presented. The locus curve, for possible failure by wrinkling of the flange and the locus curve for possible ductile rupture along the wall provide the lower and the upper limits respectively of the 'working zone'. These loci are found by a systematic series of deep drawing tests with different constant fluid pressure blank holders for three kinds of materials (copper, aluminum and stainless steel) at various thicknesses and friction conditions. The influence of the friction coefficient, the drawing ratio and the work piece wall thickness on the blank holder fluid pressure needed to suppress flange wrinkling becomes evident experimentally.

They found that, the Fluid Assisted Blank holding process seems to work satisfactorily within certain fluid pressure limits. The higher the drawing ratio the less fluid pressure is needed to suppress wrinkling

III. PROBLEM IDENTIFICATION AND OBJECTIVES

This study aims to design, develop FAB system for Deep Drawing process and experimentally analyze the effect of punch force and blank holding pressure on strains and thickness reduction of material

OBJECTIVES OF PROJECT:

- To design and develop a FAB system in deep drawing.
- To reduce the No. of draws in deep drawing.
- To measure major Strain, minor Strain and thickness reduction using ARGUS analysis.
- To evaluate major strain, minor strain and thickness reduction using FE-simulation.
- Statistical analysis of response parameters.

- To develop the FLD curve in simulation software. i.e. (to check forming severity of component)

IV. MODELING AND SIMULATION

Modeling and Simulation is a practical methodology for understanding the high level dynamics and complex manufacturing system. The use of modeling and simulation within engineering is well recognized. Modeling and simulation has already helped to reduce costs and increase the quality of products and systems and lessons learned are documented and archived. Modeling and simulation is a discipline on its own. Using simulations is as a rule cheaper and safer than conducting experiments with a prototype of the real thing. In present work deep drawing parts has been modeled and then assembled in PAMSTAMP-2G. The materials used in the present work are Aluminum 1050 and Mild Steel 2062 of 1 mm thickness. These materials are extensively used in automobile and other industries for deep drawing application. According to same DOE plan the simulation runs are carried out to obtained major strain, minor strain and thickness reduction.

A. Finite Element Simulation

Modeling is a representation of geometrical data into model of actual part with the help of particular software. There are many soft-wares available in the market to simulate the deep drawing process like PAM-STAMP 2G, ABAQUS, LSDYNA, ANSYS and HYPERFORM etc. In current work, the PAMSTAMP 2G was used to model and simulate the deep drawing process of cylindrical cup. This software is very user friendly and modeling can be done in this software also. PAM-STAMP/CAE provides a pre-processing and post processing environment for the analysis of models. It is used in a wide range of industries like automotive, aerospace etc., and also is extensively used in academic and research institutions due to its capability to address non-linear problems. This software can provide elastic-plastic and rigid-plastic simulations of metal forming for a case of large deformation, significantly reducing the cost and time involved in tool and die design. Figure 4.1 shows the finite-element model for the deep drawing process.

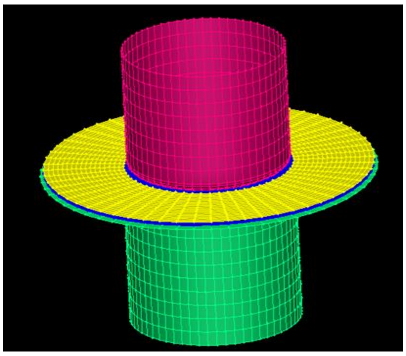


Fig. 4.1 Finite Element Model of Cup Drawing

B. Modeling

Tool dimensions for deep drawing have been selected from the IGES files available after punch die design in CAD software. The blank was modeled using 3D deformable shell element. Shell element is used, with five integration points. Blank for deep drawing is in sheet form that is why shell element is used for strain analysis. 3D modeling space with discrete rigid type shell was used to model the die, punch and blank holder. There is no need of deformation in die, punch and blank holder so rigid type shell is used. Modeling was done in the PAM-STAMP software.

Table 4.1 Tool Dimensions for Deep Drawing

Die Radius	26.25 mm
Die Profile Radius	5 mm
Punch Radius	25 mm
Punch Profile Radius	4 mm
Sheet Thickness	1 mm
Blank Diameter	100.95 mm

Tool dimensions which were used to model the parts of deep drawing process are mentioned briefly in tabulated form in Table 4.1.

C. Material Property

Since sheet metal is influenced by rolling conditions when manufactured and also mechanical properties of rolled sheets vary from each direction (with respect to rolling direction) to another direction, Hill introduced a yield criterion considering anisotropy of the sheet material. In the simulation, elastic/plastic material obeying Hill‟48 yield criterion was used. Hill‟48 classic yield surface function is the most prominent and frequently used yield function to account for plastic anisotropy of steel materials, mainly due to its simple handling in manual as well as in numerical calculations. Hill‟48 potential function is a simple extension of the isotropic von Mises function, which can be expressed in terms of rectangular Cartesian stress components as:

$$(f(\sigma))^2 = F(\sigma_{yy} - \sigma_{zz})^2 + G(\sigma_{zz} - \sigma_{xx})^2 + H(\sigma_{xx} - \sigma_{yy})^2 + 2L(\sigma_{yz})^2 + 2M(\sigma_{zx})^2 + 2N(\sigma_{xy})^2$$

Where x, y and z usually represent the rolling direction (RD), transverse direction (TD) and normal direction (ND), respectively and F, G and H are parameters representative of the current state of anisotropy and obtained by material tests in different orientations. They are defined as:

$$F = \frac{1}{2R_{22}^2} + \frac{1}{2R_{33}^2} - \frac{1}{2R_{11}^2}$$

$$G = \frac{1}{2R_{11}^2} + \frac{1}{2R_{33}^2} - \frac{1}{2R_{22}^2}$$

$$H = \frac{1}{2R_{11}^2} + \frac{1}{2R_{22}^2} - \frac{1}{2R_{33}^2}$$

$$L = \frac{3}{2R_{23}^2},\ M = \frac{3}{2R_{13}^2},\ N = \frac{2}{2R_{12}^2}$$

Where R_{11}, R_{22}, R_{33}, R_{12}, R_{13} and R_{23} are anisotropic yield stress ratios they are defined as:

$R_{11}, R_{13}, R_{23} = 1$

$$R_{22} = \sqrt{\frac{r_{90}(r_0 + 1)}{r_0(r_{90} + 1)}}$$

$$R_{33} = \sqrt{\frac{r_{90}(r_0 + 1)}{(r_0 + r_{90})}}\ R_{12} = \sqrt{\frac{3(r_0 + 1)r_{90}}{(2r_{45} + 1)(r_0 + r_{90})}}$$

These equations were used to calculate the constant that were used to model material to investigate strains and thickness in component. [5]

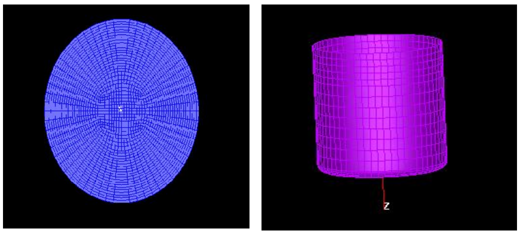
Table 4.2 Material Properties for Simulation

Material	Aluminium 1050	Mild Steel 2062
Young’s Modulus (E) (GPA)	69	210
Yield Stress (Mpa)	29.68	115
Strength of Coefficient (K) (Mpa)	173.5	431
Strain Hardening Exp. (n)	0.282	0.237
Coefficient of Friction (μ)	0.1	0.19
R_0	0.67	1.67
R_{45}	0.45	1.16
R_{90}	0.73	1.76

These are the material properties required to model the deep drawing process in simulation software

4.1.1 Meshing and Boundary Conditions

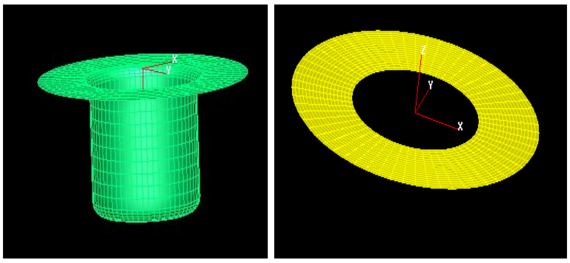
Blank was meshed with quads element using structured meshing technique. Global size of element was taken 3 mm. shell element was used for meshing a blank. A meshed blank is shown in Fig. 4.2 (a).



(a) Blank (b) Punch

Fig. 4.2 Meshed Blank and Punch

Other parts (Punch, Die and Blank Holder) were meshed with quads element using free meshing technique. Rigid element was used for meshing die, punch and blank holder. Meshed punch is shown in fig 4.3 (b) and die & holder are shown in fig. 4.3



(a) Die (b) Blank Holder

Fig.4.3 Meshed Die and Blank Holder

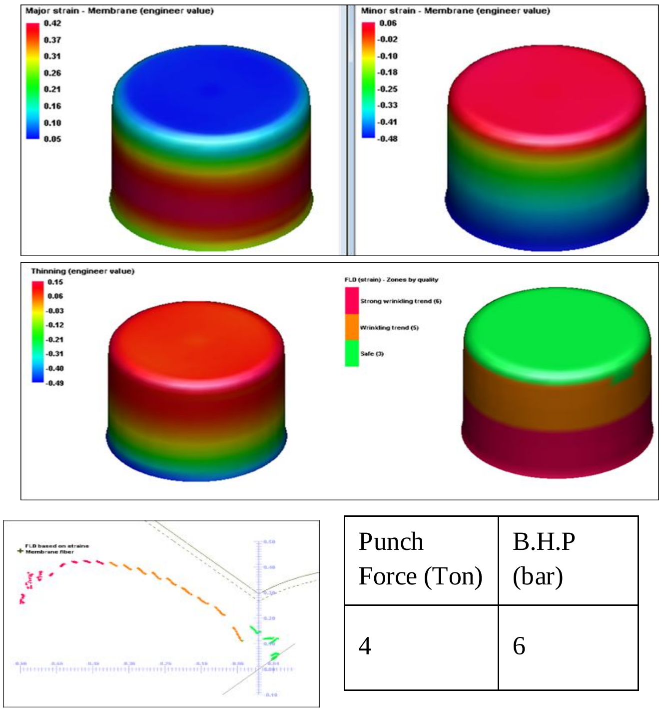
The die was fixed in all directions while the punch could move in the vertical direction. The friction behavior of blank-supported die/blank-forming tool was modeled using the Coulomb friction law.

4.1.2 Simulation and Result

PAM-STAMP with explicit model was used to simulate the deep drawing process.

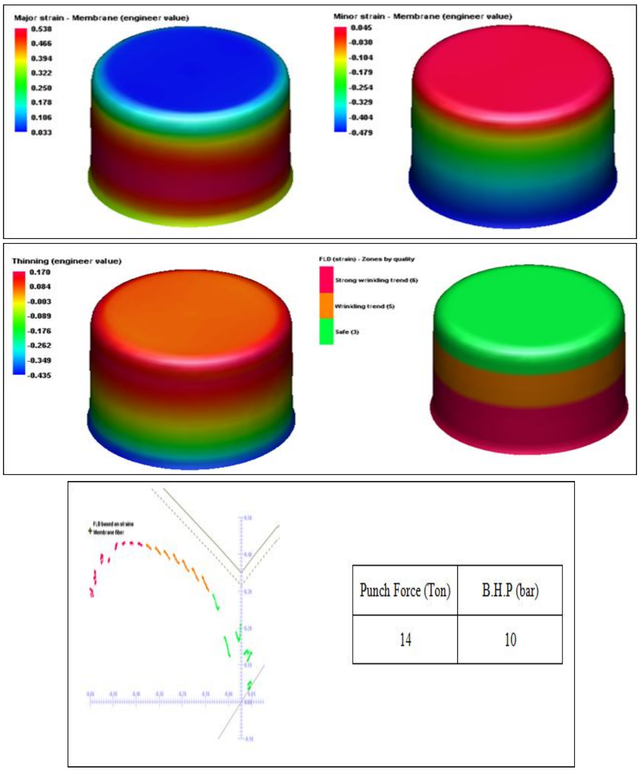
Simulation is done by applying same boundary conditions that are used for experimental runs. In simulation we carry out 9 runs for comparison purpose with experimental results. Punch force and Blank holding parameters are used to deform the blank.

Figure 4.4 shows the typical major strain, minor strain and thickness reduction in drawn cup.



Punch Force (Ton)	B.H.P (bar)
4	6

Fig. 4.4 Simulated cup showing strain and thickness



Punch Force (Ton)	B.H.P (bar)
14	10

Fig.4.5 Simulated cup showing thickness and strain contours

Material used in deep drawing process is aluminum and mild steel 2062. During simulation load applied are punch force and blank holding pressure respectively. Before simulation runs; performance of experiments is done therefore the comparison of experimental work against simulation work which has been noticed found to be in good agreement with each other.

V. CONCLUSION

Experimentation of Deep Drawing Process using fluid assisted blank holding system is done by taking punch force and blank holding pressure as input parameter. Deformed samples are under process through ARGUS analysis for determining strain and thickness reduction in formed component. Simulation of same process with parameters is done in PAM-STAMP to validate the experimentation. Following Conclusions can be drawn from experimental analysis and simulation.

1] FAB system helps to reduce the wrinkles on the formed component.
2] Using FAB system we get uniform thickness reduction and strains.
3] Strain and thickness reduction values obtained by ARGUS analysis are in good agreement with the simulated results obtained from PAM-STAMP.
4] Both ARGUS system and PAM-STAMP is very user friendly to analyses forming processes.
5] GRA shows that both parameters i.e. punch force and blank holding pressure are significant parameters in deep drawing process. Punch force is most significant parameter than B.H.P.
6] Optimum parameters obtained after performing GRA are:

Parameters	**Materials**	
	Aluminum 1050	**Mild Steel 2062**
Punch Force (Ton)	4	12
B.H.P (bar)	4	8

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