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Analyzing the Effect of Blank Holder Shape in Deep Drawing Process Using Fem

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Abstract*—Minimization of errors and maximization of efficiency is the most important parameters in the competeting world. Sheet metal forming is a widely used and costly manufacturing process, in industrial applications. This work is done to study the finite element (elastic-plastic) analysis of sheet metal forming process using the finite element software. Ansys simulation is carried out to gain accurate and critical understanding of sheet forming process. Simulation of elastic-plastic behavior of mild steel sheet is carried out with non-linear condition to investigate sheet metal forming process to compare experimentally available data. In the present work contact elements are generated between sheet metal and the dies for forming process. Displacement convergence is considered in the problem to get correct shape. All the results are represented with suitable graphical and pictorial views. The analysis is based on nonlinear properties with bi-linearity in the problem. Initial problem is carried out to compare experimentally available punch load with analysis value to analyse the use of finite element techniques in manufacturing industry. Total of 116 steps are considered for proper convergence of the problem. The critical stresses of radial, hoop and vonmises stresses are represented for the problem along with contact pressure distribution.

Keywords*— Sheet metal forming. Deep drawing. Ansys simulation. FEM. Critical stress.

I. INTRODUCTION

Drawing is a sheet metal forming operation used to make cup-shaped, box-shaped, or other complex-curves, hollow-shaped parts. It is performed by placing a piece of sheet metal over a die cavity and then pushing the metal into the opening with a punch. The blank must usually be held down flat against the die by a blank holder. A lot of efforts have been put into the design phase in order to produce a defect-free part. Given material and part shape, the optimum deep drawing design, in general, focuses on three main aspects: the blank design, tooling design and process design. The blank design includes optimizing blank geometries and thickness. The tooling design is to determine the optimal punch and die radii, the punch and die clearance, the draw bead shape and location. The process design tends to find the best setting of process parameters such as the friction (lubricant type and procedure), the punch speed and the blank holder force.

Malekani.A.Mostafa Pour et.al [1]: - In this paper, the effect of die and blank holder shape on the punch and blank holder load, max depth of drawing and material flow is investigated. As represented by numerical and experimental results, increasing in slope has not visible effect on the magnitude of punch load and lowers the blank holders force.

Heinrich Markstaedter et.al [2]: - In this paper, Different tool designs and process control parameters for hydro mechanical deep drawing of a T-shaped aluminum alloy AA6061-T0 were investigated. A tool for hydro mechanical deep drawing of T-shaped parts was built using the numerical results. Jamal
H.Mohamed et.al [3]: - In this paper, maximum thinning of the dome wall occurs nearly at the apex of the dome .The larger is the friction, the larger is the distance between the apex and the point of maximum thinning..

Jamal H.Mohamed et.al [3]: - In this paper, maximum thinning of the dome wall occurs nearly at the apex of the dome .The larger is the friction, the larger is the distance between the apex and the point of maximum thinning. The more uniform distribution the more reasonable and smallest values of stress, strain and work done are for the value of punch nose radius equal to (12 times sheet thickness).

Dr. Waleed Khalid Jawad[4]:-In this paper, The simulation and experimental results showed that increasing the punch profile radius leading to increasing the cup height about (20 % for FEM Simulation & 18% for experimental work), and increasing the value of spring back to about (1.75 % for FEM Simulation & 1.25 % for experimental work)) for punch nose radius ranging from (3 to 21.5mm). The punch load decrease slightly with increasing punch nose radius .

Engr. C.o. Osueke et.al [5]: - in this paper, a probabilistic design approach is used to obtain the variable bhf profile by re-optimizing the deterministic design approach used by past researchers. Analysis conducted showed that the deterministic approach has a leak in its ability to withstand or overcome wrinkling which proves that its option is not a robust one. The probabilistic approach closes this failure gap by overcoming wrinkling & thinning. It ultimately improves the product yield to 99.08% from the 45.78% established by the deterministic approach. The concept of probabilistic design.

Present work is focused on analysing the effect of blank holder shape in deep drawing process. The optimum value for slope of blank holder is predicted by numerical solution.

II. METHODOLOGY

The different components used in the problem are represented by different colors. Punch, sheet metal and container are represented with different colors. The curvature is provided as per the requirements. Sheet metal in circular form is represented with 3mm thickness. The thin strip of low strength material will be shaped as per the die shape.

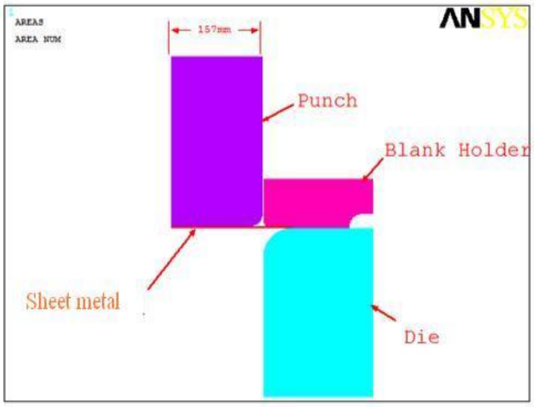

Fig-1

Ansys mixed up approach is used to built the geometry as shown in fig-1. Boolean operations are used to built the curved geometries. The structure is divided to ease map meshing of the problem. Workplane options are used to divide the structure. An axisymmetric approach is used to built the geometry. Axisymmetry is the best option to built and analyse deep drawing circular formations. Different components are represented with different colors to identify the components. Ansys axisymmetric analysis is proven to match with theoretical solution and reduces the time of analysis when compared to the complex three dimensional analysis.

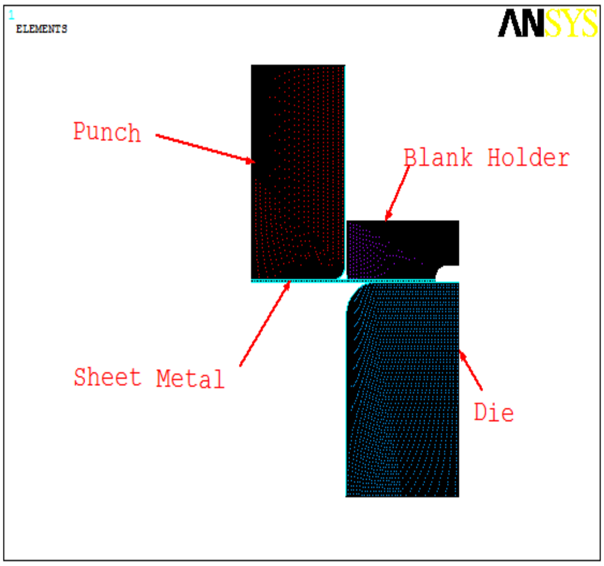

Fig-2

The figure-2 shows meshed model of the problem. A 4 noded element(Plane182) is used to mesh the structure. The structure is map meshed with high density at the curved regions. Both steel dies and magnisium sheet are represented with different colors. Generally map mesh is good for accurate results as well as for graphical representation which is not proper with free mesh. Both die and sheet metal are meshed with different material. The colors shown in the figures represents this change in mesh. An expansion option available with Ansys is used to represent in the three dimensional space. 23011 elements and 22983 nodes are used for meshing

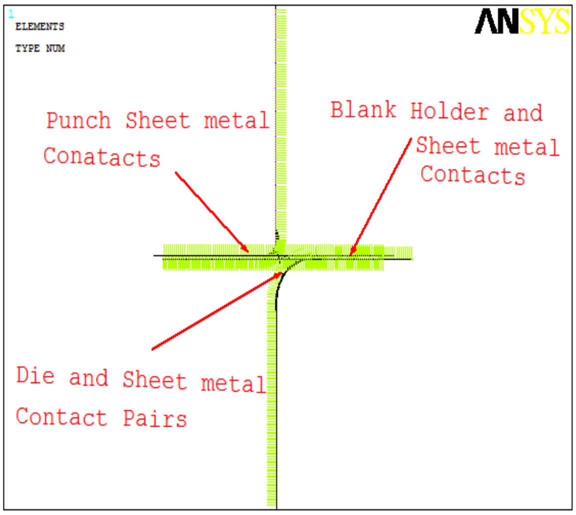

Fig-3

The figure-3 shows contact elements created in the nonlinear problem. Top die bottom surface and top line of the sheet metal are created with one contact pair and the bottom line of sheet metal with top line of bottom die are created with another pair. Ansys contact manager is an useful tool for building this contact pairs. Contact friction also can specify through the contact manager. Targe169 and Contac172 elements are automatically built for the pairs for contact estimation. These elements are created after grouping the nodes attached to corresponding lines.

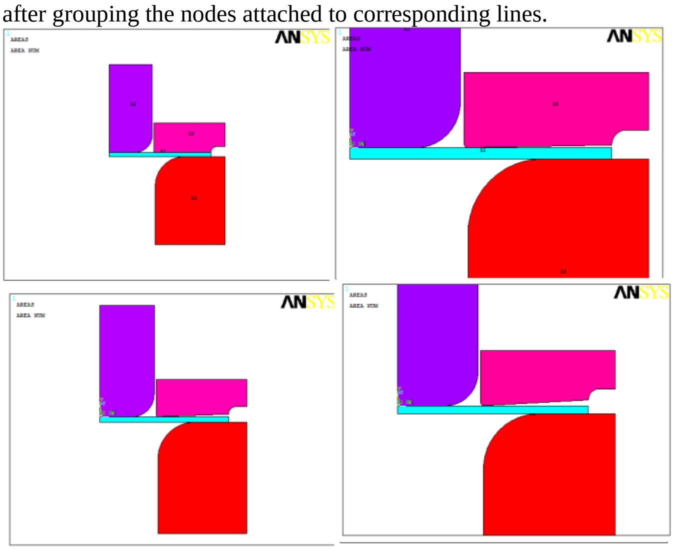

Fig 4: Geometry with different blank holder angles

The figure shows change in angle of blank holder from zero degrees to 3 degrees with one degree increment. These models are built in Ansys using mixed approach.

III. MATERIAL DESCRIPATION

Geometrical Details

Case 1 problem:

Punch diameter :	314mm
Punch corner radius	12mm
Thickness of blank	3mm
Height of Drawing	252mm

Case 2 Problem:

Punch diameter :	30mm
Punch corner radius	12mm
Thickness of blank	1.5mm
Height of Drawing	18mm

Material Properties:

For case 1 problem
Blank Material=Mild Steel

Young's Modulus	200Gpa
Poison's ratio	0.35
Friction coefficient	0.1
Yield stress	200Mpa
Tangent modulus	1388

For Case 2 problem:
Material -Magnesium alloy

Young's modulus	44.8Gpa
Poison's ratio	0.3
Yield Stress	190MPa

Sheet metal formation during deep drawing process is simulated using Finite element software and analysis is carried out to find the load requirements with hot forming process.

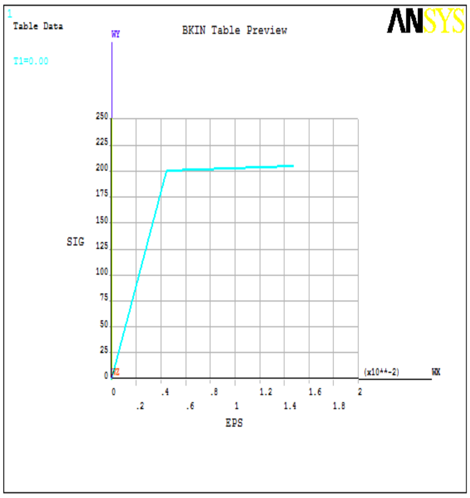

Fig-Material Data curves

Axisymmetric approach is used to analyse the deep drawing process of sheet metal formation with contact elements between punch, sheet metal interface and sheet metal figures. The results obtained are checked with experimentally

IV. RESULTS AND DISCUSSION-

The sheet metal formation using deep drawing process is carried out in number of iterations. The formations of sheet metal along with resulting stresses are represented as shown in the following figures.

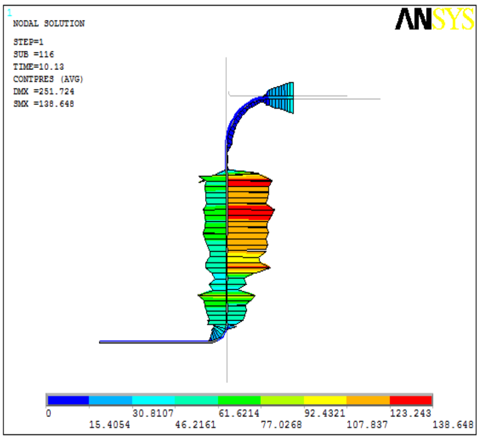

Fig-Contact Pressure Plot

Initially the punch, sheet, blank holder and fixed die are modeled as per the specifications. Later the structure is meshed with 4 noded quad elements(Plane182). The element is capable of representing the large deflection effect with plastic capabilities. Contact pairs are created between punch, sheet metal interface, die , sheet metal interface, blank holder and sheet metal using Targe169 and Contac172 elements. The displacement load is applied and problem is executed in the nonlinear domain using material properties specified with yield stress and tangent modulus.

Analysis has been carried out for load requirements for sheet metal formation. The results shows load estimation for the problem. The stress values for radial, hoop, vonmises and contact pressure are represented. From the finite element simulation, the region of thinning and probable regions of failure can be identified. Higher stress regions are the major regions of failures. Finite element simulation helps in avoiding prototype built up and checking for the required load calculations. The results shows closeness of experimentally available punch load and the numerically obtained value.

Again second model is built with smaller dimensions to analyse the effect of blank holder angle on punch loads and stress generation on the sheet metal. The results shows increased punch loads with inclination of blank holder. 2^0 inclination is giving the best stress distribution in the sheet metal. Higher blank holder forces which induces interference between sheet metal and blank holder also reduces the load on punch, but increases the stress generation in the sheet metal which is not desirable for error free sheet
metal formation.

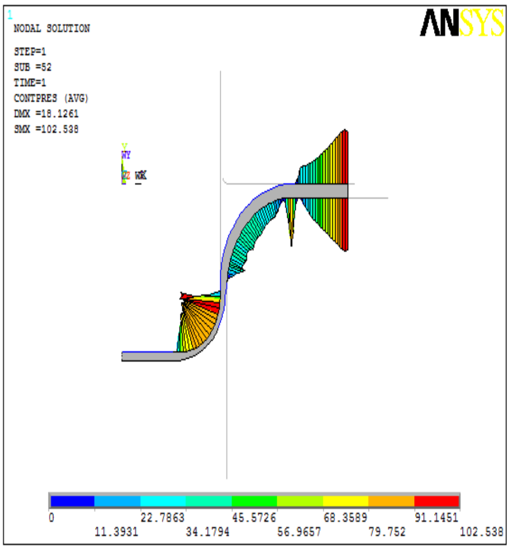

Fig-Contact pressure distribution

V. CONCLUSION

Sheet metal forming is an important metal forming operation used in Engineering Industry. It finds wide usage in Automobile and house hold industry. Sheet metal forming requires metal to be formed, die, blank holder and punch. The accuracy of sheet metal formation depends on many factors like yield stress, temperature and die rigidity etc. Also nature of load effects the accuracy of the deep drawn objects. In the present work, a comparison done between experimentally available punch loads with finite element solution.

Further to analyse the effect of blank holder angle on punch load requirements and stress behaviour of the deep drawn object, analysis is continued with smaller sized magnesium alloy material. Depth of deep drawing is limited to 18mm for comparative study which is difficult with 252mm deformation. Convergence is the main draw back with the finite element solutions. Also mesh size plays important role in finding the accuracy of the problem. For different blank angles analysis is carried out between zero to 3^0. For zero degrees, the results shows contact pressure development at both blank holder and die surfaces showing distribution of punch loads. But with the inclusion of blank holder angle, the contact pressure is reducing at the blank holder showing reduced load on the blank holder. But increase in punch load can be observed. As the blank holder angle increases, the load on blank holder is reducing But after certain angle, punch loads changes are minimum as the blank holder is not playing any role on load sharing. But the stress development in the sheet metal is reducing which is an important parameter for error free products.

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