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Effect of Clearance and Blank Thickness on Stress Distribution in Elliptical Deep Drawing without Blank Holder using ANSYS

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Abstract:- **In this paper a new mechanism for elliptical deep drawing was proposed to produce elliptical cup from thin circular plate of brass (CuZn37) (0.8,0.9, and 1mm) thickness and clearance (0.8,0.9,1, and 1.1)mm, without blank holder. In this technique the die assembly includes punch, die and die-punch. Due to symmetry a quarter finite element model was built using ANSYS15 software. Effect of the clearance and thickness of plate on maximum load and stress and strain distribution and on the wrinkling of the cup were investigated. It observed that a die with clearance =1 and thickness=0.8 need high drawability for the new technique and the product was without wrinkling but has earing. Clearance between punch and die 0.9mm gives best results in elliptical deep drawing without blank holder.**

Keywords: Deep drawing, finite element method, ANSYS, Elliptical Die, blank holder, Sheet metal forming.

1- INTRODUCTION:

Deep drawing is the process of forming of smooth (sheet) blanks into hollow parts [1]. It is a process which involves forming by tensile and compressive stress. The deformation of process takes place using: Deep drawing ring, Blank holder and Drawing punch. This paper deals with the drawing punch without a blank holder and its advantage are: The die assembly is simpler as the blank holder is not used, can be carried out on any single action press and both energy consumption and cost of dies decreased with the type of dies. The disadvantage of deep drawing without blank holder are: Demanding construction of the die and a greater press stroke and determined the thickness of blank. ***Abdullah A. Dhaiban et al., 2013***,[2] observed a new method for deep drawing of elliptic cups via a conical die without blank holder or draw beads. In this method the production of the elliptic cups by punching a circular blank using a flat elliptic punch via a conical die with an elliptic end. Ansys is used to built the three dimension finite element model. The influences of the geometry of die and punch inclusive, half-cone angle, fillet radius of die, aperture length of die and fillet radius of punch on the investigation of limit drawing ratio (LDR), drawing load and thickness strain of the cup. Finite element model results showed good agreement with experimental results. ***Ali and Ammer, 2015***,[3] proposed a new technique for deep drawing to produce circular cup without blank holder. In this technique the die assembly includes punch, die and die punch. A DEFORM 2D is used to analysis this problem. The Effect of die geometry of on maximum load, thickness distribution strain distribution and of clearance ratio effect between punch and die punch on the wrinkling of the cup were studied. Three die cone angles (15°, 30° and 45°) were used in order to form sheet metal blank of brass (CuZn37) which had initial thickness (1mm) at four clearance ratio (c/t) for die of 30° half cone angle. Finite element model results showed good agreement with experimental results**. *M.A. Hassan et al., 2015***,[4] used deep drawing for producing elliptic cups through a conical die without blank holder or draw beads in single-acting stroke. A flat-headed elliptic punch was pushed through a conical die with an elliptic aperture in a single stroke without blank holder using circular blank to produce an elliptical-cup. Finite element simulation was used to design the experimental tooling set to obtain optimum die half- cone angle, die aperture length, die fillet radius and punch fillet radius. The optimum drawability was found for a die with half cone angle of 18°and die aperture length of 3 mm. The results showed that this technique is convenient for drawing sheet metal of brass (CuZn33) of thicknesses between 1.5 and 2mm. In this paper the effect of clearance and blank thickness on the deep drawing process for elliptical die without blank holder is studied .

2-FINITE ELEMENT MODEL (ANSYS MODEL)

Finite element model is done via Ansys package. Ansys analyze a many problems[5]. There are two ways to use ANSYS: firstly via Graphical User Interface (GUI), and secondly by ANSYS commands[6].

A preprocessor to input the data for an ANSYS is a subprogram, which is included the definition of the element type, element real constant, material properties, loads, and the model geometry. The essential stage in building the finite element model are [7]:

- Generation the model within ANSYS .
- element type selection.
- Define the material properties.
- Generation the mesh.

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- Generation contact.
- Specify the analysis type and applying the load .

In ANSYS two methods are used to generate the model: (1) solid modeling and (2) direct generation. With solid modeling, ANSYS automatically generate defining the shape geometry of the model, the keypoints, lines and volume then meshing the model with node and element and with the direct generation method, the location of all node is defining, and connectivity of all element to defining these node in the model geometry [8]. In our study the elements used to simulate the blank in 3D is solid185, the elements used to simulate the contact elements for 3D is CONTA174, and target element for 3D is TARGE170. Material properties are needed for element types, as with element types, material properties can be classified into three types: linear or nonlinear, isotropic, orthotropic or anisotropic and constant temperature or temperature dependent. The option anisotropy (ANISO) permits for different stress-strain behavior in the material x, y, and z directions as well as different behavior in tension and compression. A Von Mises yield criterion is used to determine yielding. The principal axes of anisotropy coincide with the material (or element) coordinate system. The materials used namely copper. Copper has a nonlinear inelastic anisotropic behavior. The geometrical model is converted to finite element model by meshing. The process of mesh generating consists of the following steps: Select area, select the number of material and element to define the area, input the step distance and element number and mesh the model Finally. Mapped meshing is applied to discretize the plate material. The simulation of deep drawing process is a contact problems which are highly nonlinear and need significant computer resources to resolve. It is significant to understand the physics of the problem and take the time to set up the model to run as efficiently as possible. Contact problems present two general classes: rigid-to-elastic and elastic -to- elastic. In rigid-to- flexible contact problems, one or more of the contacting surfaces are treated as rigid. In general, any time a soft material comes in contact with a hard material, the problem may be assumed to be rigid-to-flexible. Many metal forming problems present this category. The simulation of deep drawing process without holder is constructed with two "contact pairs" : Punch (rigid) and blank (flexible) and die (rigid) and blank (flexible). For simulating the forming processes, the "Newton-Raphson " implicit methodology was used to solve nonlinear issue.

In this paper, the upper punches stroke steps are defined at a time span, within all step, the substeps number of solution are reached to apply the displacement gradually. At each substep, a number of equilibrium iterations are defined in order to reach a convergence solution. Automatic contact technique in ANSYS15.0 was utilized to model the complex interaction between the sheet and tooling set. The tool set (punch and die) is modeled as rigid bodies and flexible blank. 3D 8-node quadrilateral target elements of TARGE170 were used to represent 3D tool part which are associated with the deformable blank represented by 3D 8-node contact elements of CONTA174. To reduce execution time and considering the symmetry characteristic, only one quarter of (3D) model have been used. The following procedures are used to simulate the elliptical deep drawing without blank holder.

2.1 Drawing the Outer Die.

In order to achieve the elliptical cup, the inverse deep drawing is used with the dimensions of the elliptical model (a=37mm , b=23mm). Due to symmetry only one quarter is modeled according to the ellipse equation:

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1, \text{ then } y=23*\left(1-\frac{x^2}{(37)^2}\right)^{0.5}, \text{ when a=37mm , b=23mm.}$$

After drawing the points of outer die Spline is made between the points then combine to one line as shown in Fig.(1)

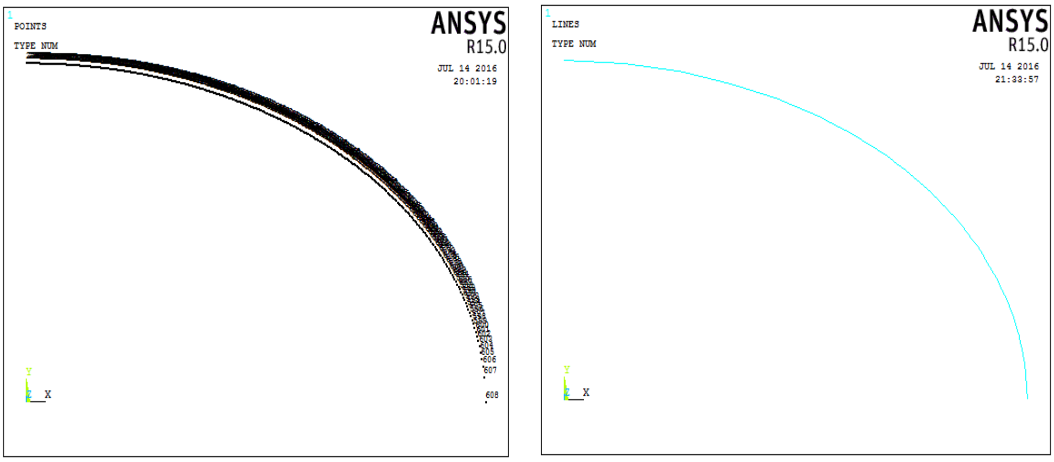

Figure (1)

After that the side faces of outer die is plotted as shown in Fig.(2)

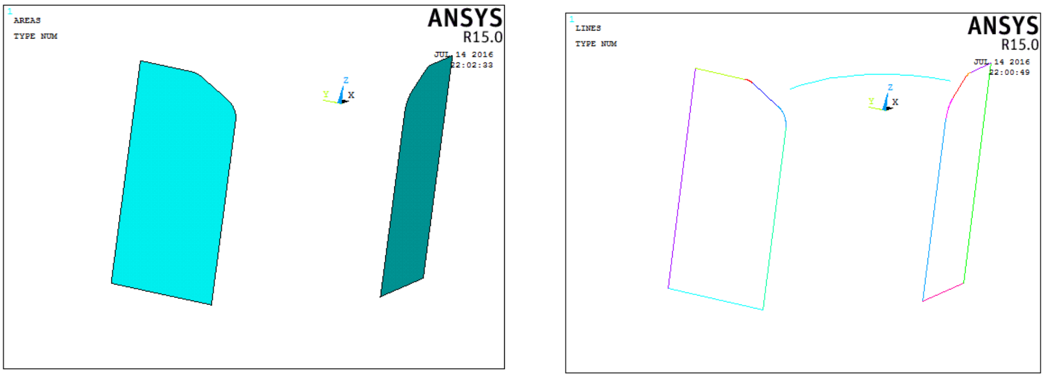

Figure (2)

By dragging the two areas through the elliptical line , the die's quarter is generated as a volume then rearranged as an area model as shown in Fig.(3)

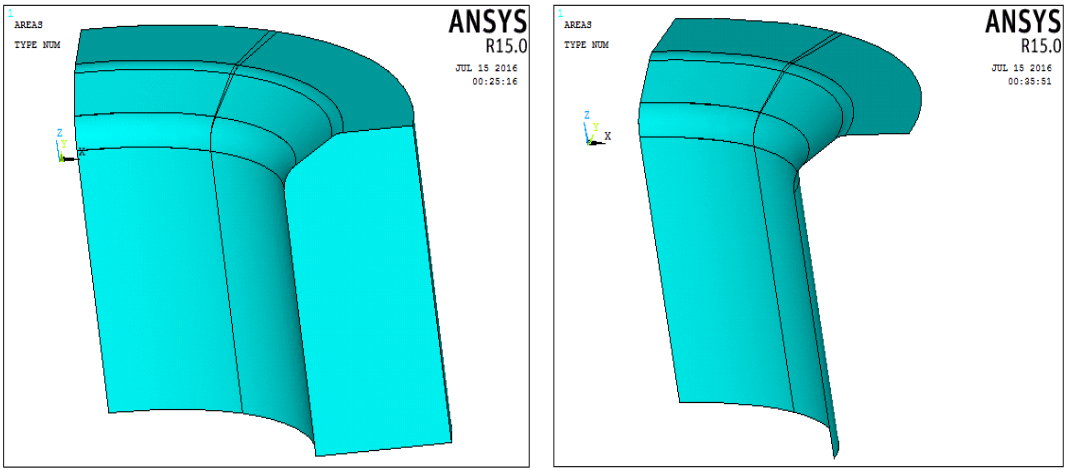

Figure (3)

2-2 Drawing the Punch.

The punch size is an elliptical shape with (a=28mm, b=14mm) using ellipse equation in the drawing, then the two sides are drawing and dragging via ellipse line as shown in Fig.(4) .

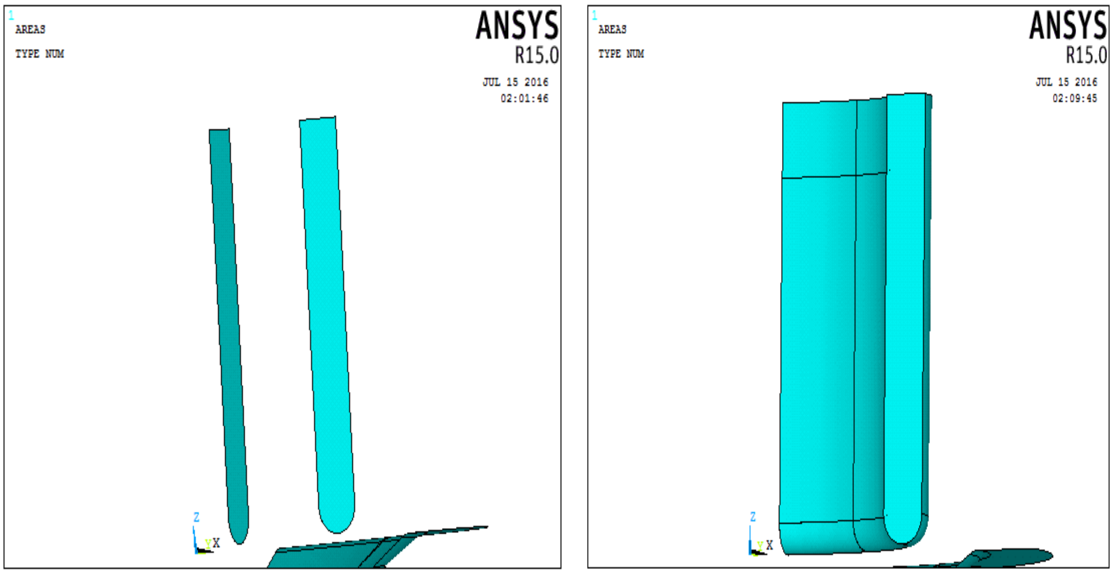

Figure (4)

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After that deleting the volume and re-arranged the model as shown in Fig.(5)

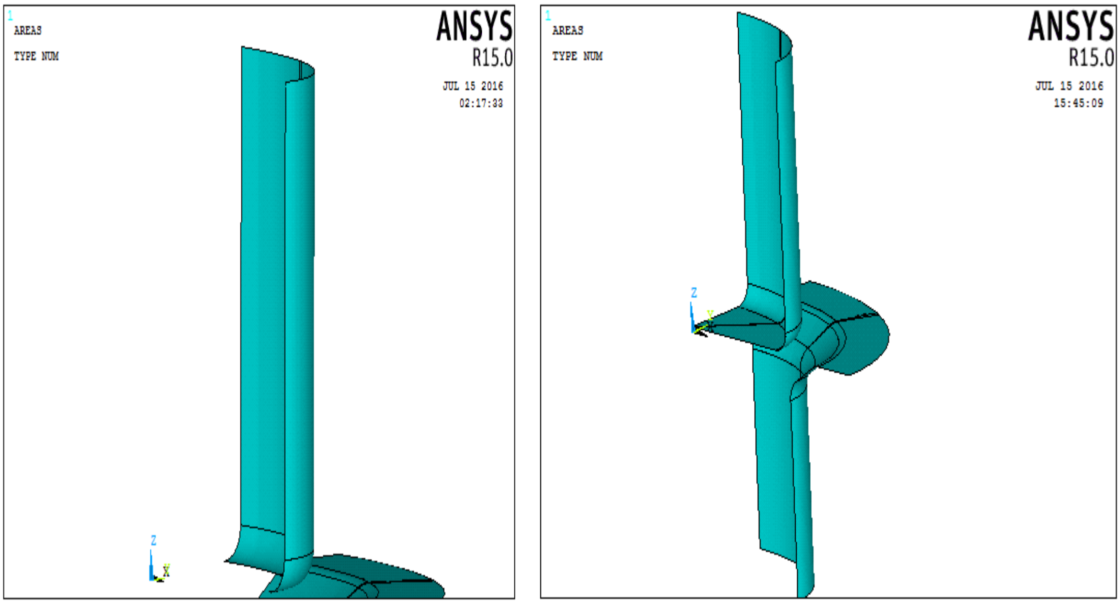
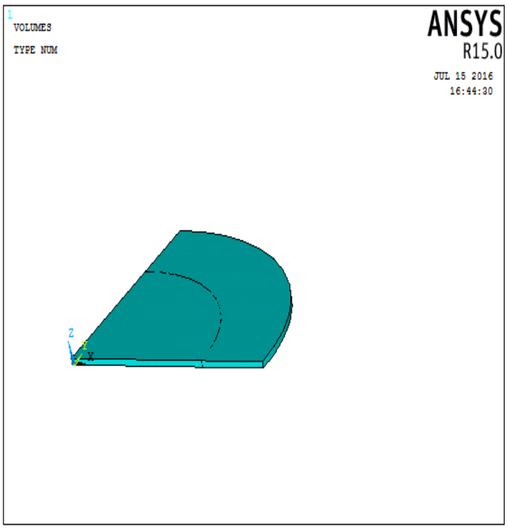
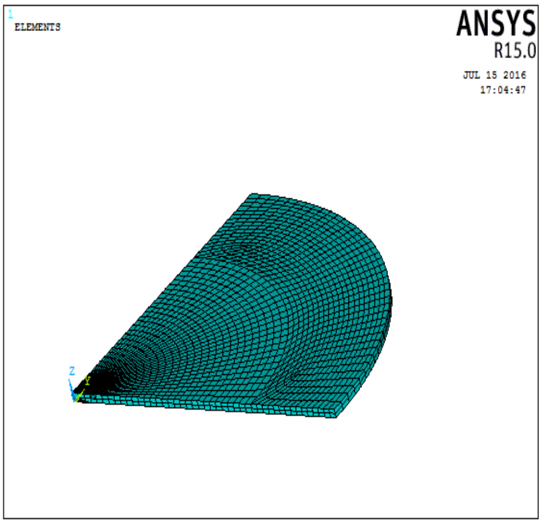


Figure (5)

Then the forming sheet metal of brass (CuZn37) with 44mm radius with 1mm thickness is plotted as shown in Fig.(6) . In order to mesh the blank, the element Mesh200 with keyopt(1)=6 is used to mesh the plate sides and then Solid185 is used to mesh the volume as shown in Fig.(7).



Figure(6)



Figure(7)

Boundary condition is made symmetry as a quarter part with contact surface between die and blank and between punch and blank as shown in Fig.(8):

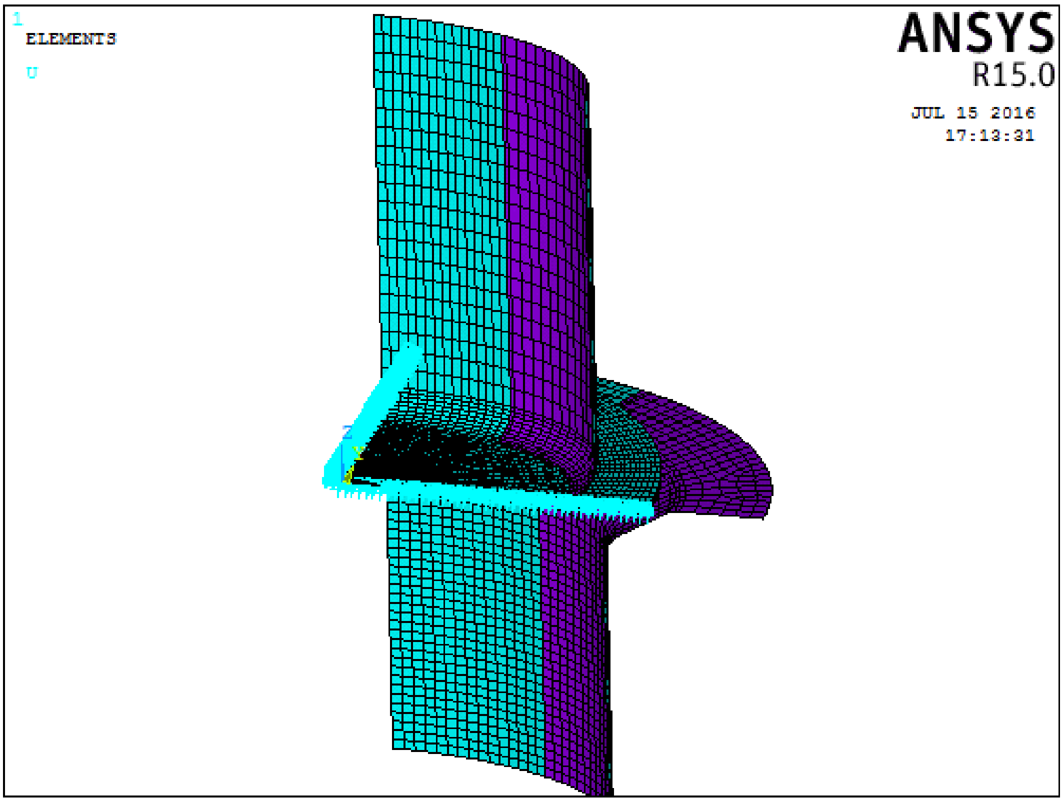


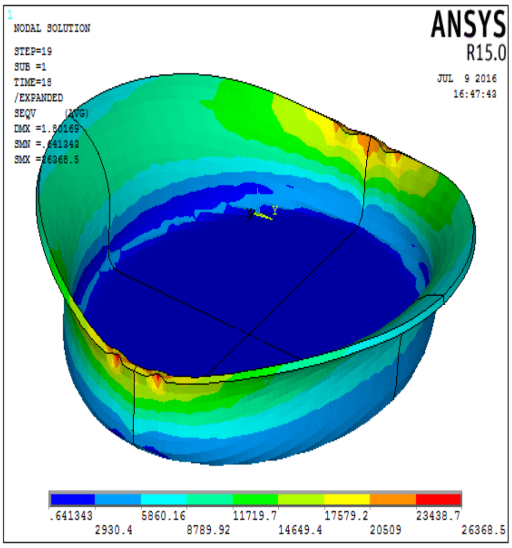
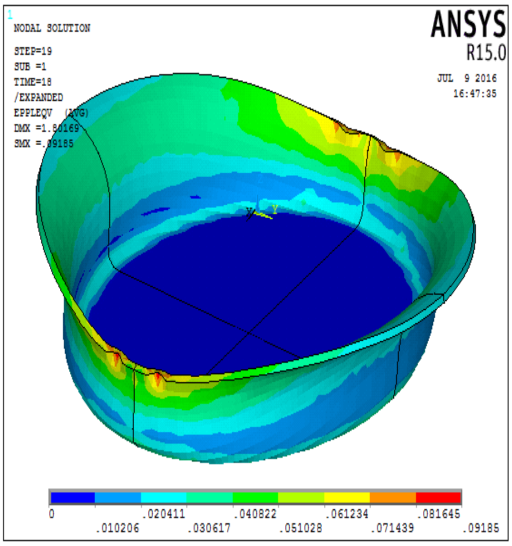
Figure (8)

3-RESULTS AND DISCUSSION

In order to study the effect of clearance and blank thickness on the stress distribution in the reverse deep drawing to produce elliptical cup without blank holder. Three thickness of blank is taken (0.8, 0.9, 1)mm, with four clearance (0.8, 0.9, 1, 1.1)mm, as shown in the Table(1), which is expressed the stress and strain distribution in the elliptical cup and its punch force with deflection. Finite element simulation is made to investigate the developed setup in order to determine the optimum clearance to thickness. The max. effective stress as shown in Table(2) appeared that at the case (C=1.1mm,t=0.9mm) is the maximum.

Table(1): The Cases Studies

Case -1-

	Equivalent Stress distribution	Equivalent strain distribution
t=1 C=1		

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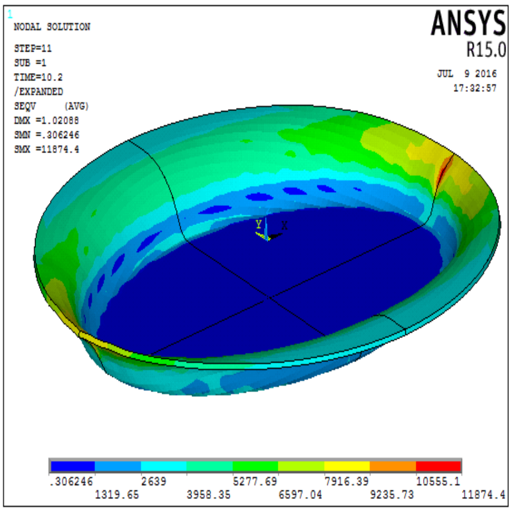
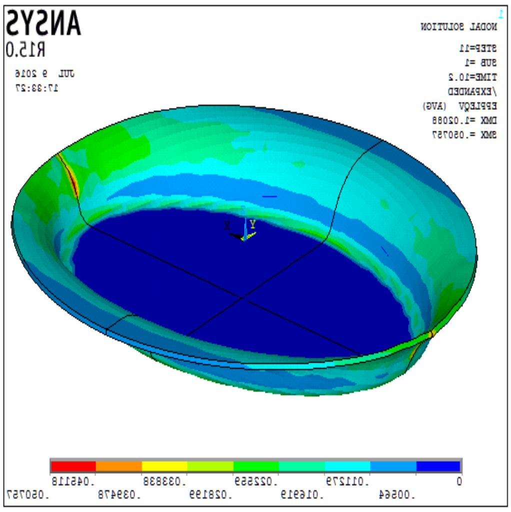
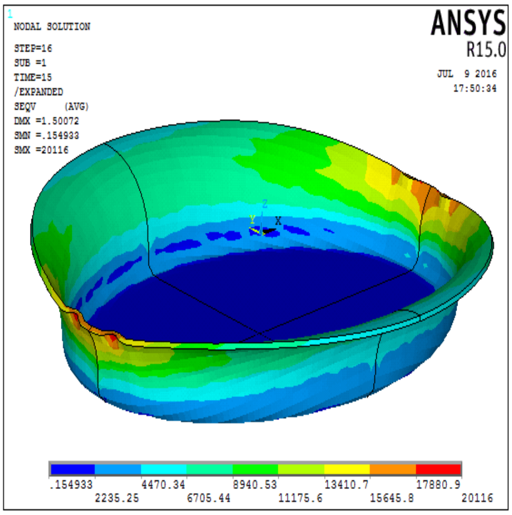
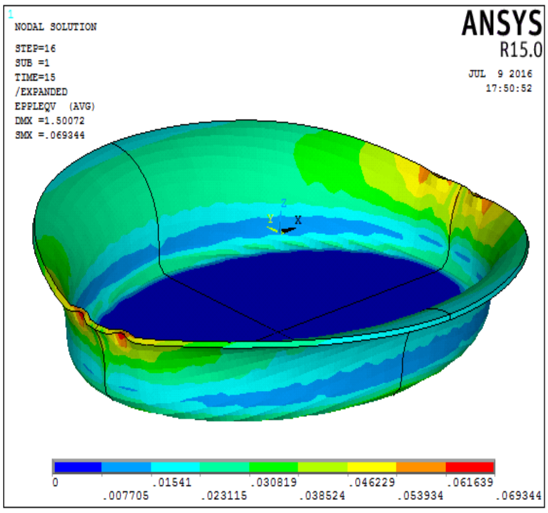
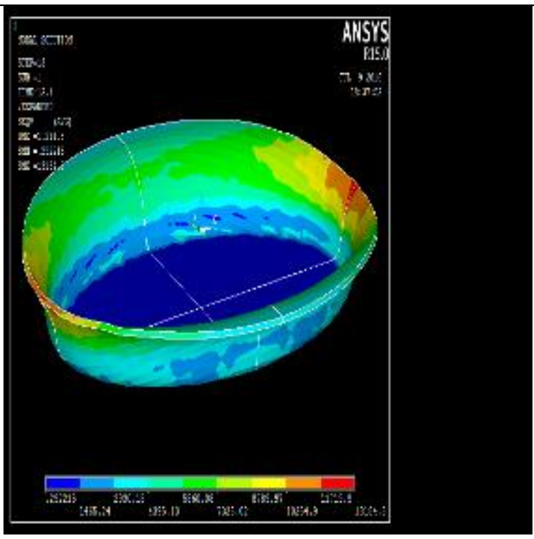
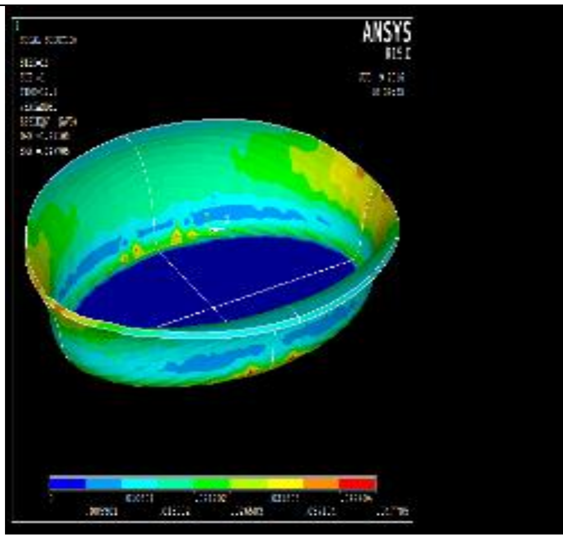
<table>
<tr><td>t=0.9
C=0.9</td><td></td><td></td></tr>
<tr><td>t=0.8
C=0.8</td><td></td><td></td></tr>
</table>

Case – 2-

<table>
<tr><th></th><th>Equivalent Stress distribution</th><th>Equivalent strain distribution</th></tr>
<tr><td>t=0.9
C=1</td><td></td><td></td></tr>
</table>

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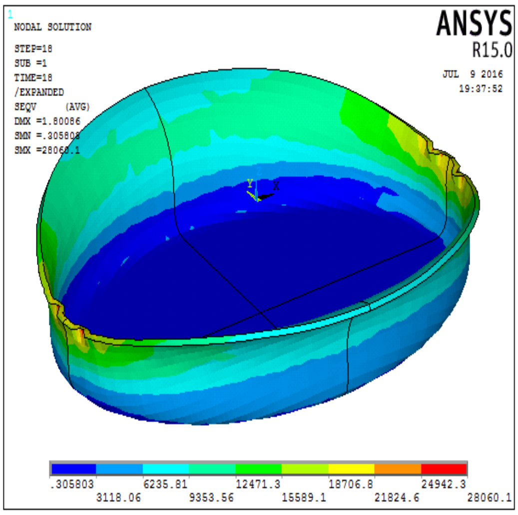
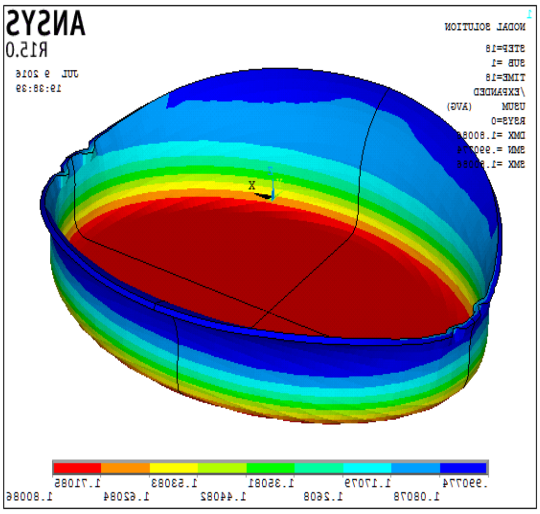
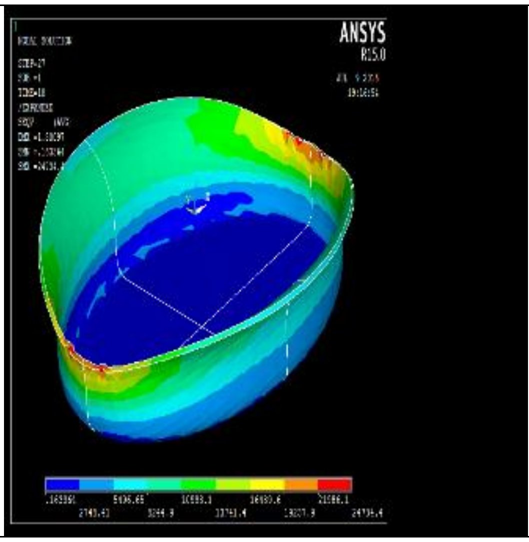
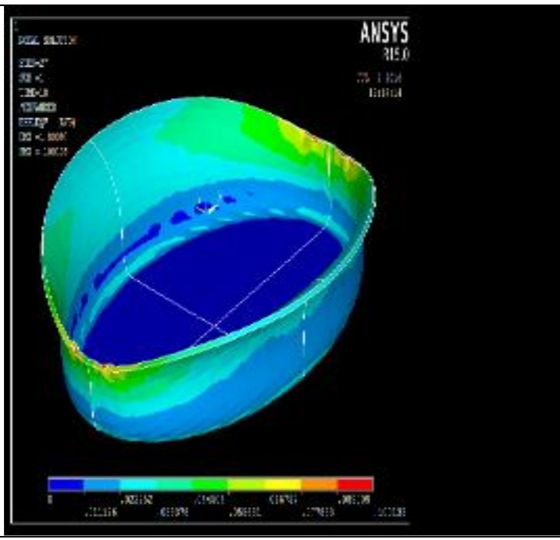
Case – 3-

	Equivalent Stress distribution	Equivalent strain distribution
t=0.9 C=1.1		

Case – 4-

	Equivalent Stress distribution	Equivalent strain distribution
t=0.8 C=1		

Table(2): Max. equivalent Stress for each case

cases	Max. Equivalent Stress (MPa)
Thickness=1, Clearance=1	26368.5
Thickness=0.9, Clearance=0.9	11874.4
Thickness=0.8, Clearance=0.8	20116
Thickness=0.9, Clearance=1	13184.8
Thickness=0.9, Clearance=1.1	28060.1
Thickness=0.8, Clearance=1	24734.4

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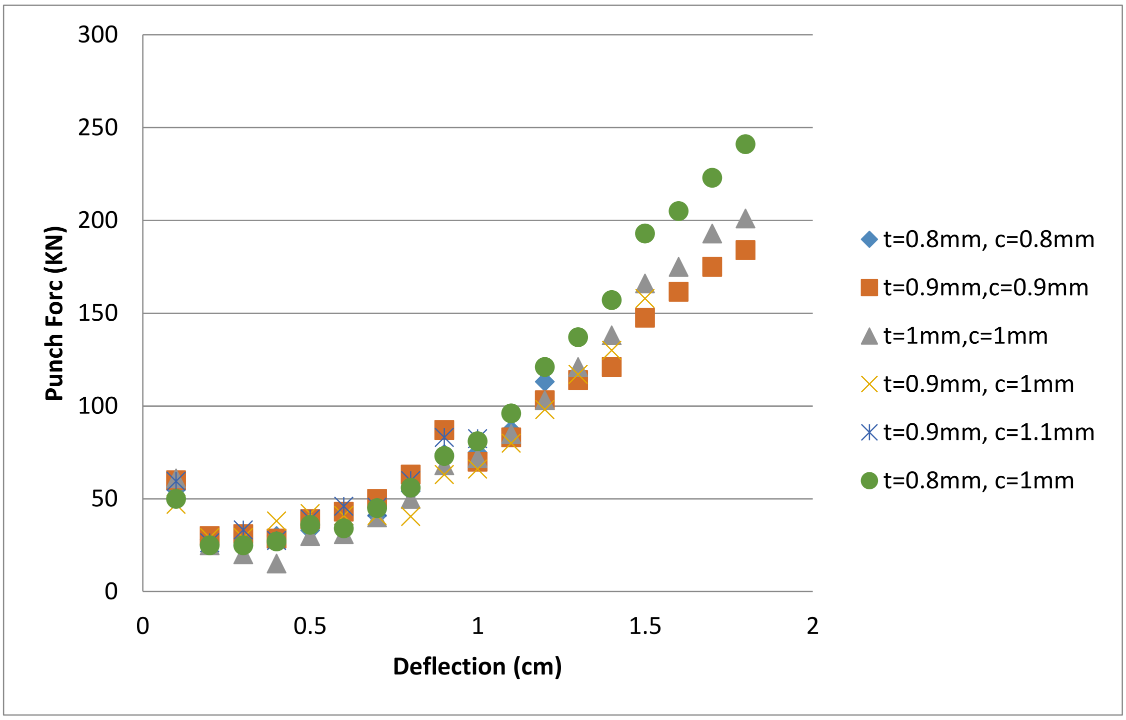
Figure(9) illustrated the punch force relation with the deformation of the blank for the cases studies.



Figure(9) Punch force vs deflection for elliptical deep drawing process without blank holder

4. CONCLUSIONS

A new technique is introduced in this paper for producing elliptical cup from thin circular blank (0.8, 0.9, 1)mm thickness and clearance (0.8,0.9,1, and 1.1)mm, using tooling set without blank-holder . A die with clearance =1 and blank thickness=0.8 needed high drawability for the new technique and the product was without wrinkling but has earing. Clearance between punch and die (0.9mm) gives best resul in elliptical deep drawing without blank holder.

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