Optimization of Design Parameter of Constant Blank Thickness by Varying Friction Coefficient Using Explicit FEA on Deep Drawing Process of A Cylindrical Plate

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Abstract— Customarily, most metal forming systems have been tried tentatively utilizing experimentation or observational strategies, which are costly and tedious methodologies as dies, blank holders and punches need to be manufactured. By making utilization of finite element analysis the forecast of punch force, the blank holder force, the thickness distribution through sections of the metal and the lubrication requirements can be determined. This can altogether reduce the manufacturing costs.

However during deep drawing process the design parameters have a significant effect on the quality of the drawn part. In this a 3D finite element model is developed for the deep drawing process of a cylindrical plate. Then the influences of design parameters including die shoulder radius, punch nose radius, Sheet metal thickness and coefficient of friction on the process are investigated by simulation. From the simulations the thickness distribution and thinning of the blank with respect to the die design parameters can be predicted. Furthermore, with numerical simulation, working parameters can be optimized without expensive shop trials

Index Terms— Dies, Blank Holder, Punches, Finite Element Model

I.INTRODUCTION

Deep drawing is a process which is used to produce cups, shells, boxes and similar parts from metal blank using the principle in which the blank material is radically drawn into the forming die by the movement of the punch. It is thus a shape transformation process with material retention. A simple drawing operation is shown in fig 1..1. A round blank is first cut from flat stock. The blank is then placed in the draw die, where the punch pushes the blank through the die. On the return stock the cup is stick with punch, to avoid this blank holder is used. Generally, a drawing operation is referred to as shallow drawing when the depth of cup is less than the diameter of cup and drawing of cup is deeper than half its diameter then it is called deep drawing.

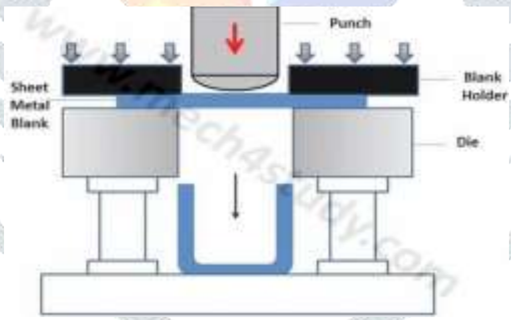


Figure 1: Typical deep drawing operation

II .OBJECTIVE AND METHODOLOGY

2.1. Objective

The objective of this paper is to perform explicit dynamic analysis on blank material for manufacturing a cylindrical shell part, by varying different parameters like die shoulder radius, punch nose radius, Sheet metal thickness and coefficient of friction with respect to blank thickness.

2.2. Methodology

- In this paper the first step is to design a 3D model (assembly) of die, punch, blank material with thickness and a blank holder.
- Next, the total assembly is converted into .xt file format which is than imported into Ansys workbench to perform explicit dynamic analysis.
- First, providing all the initial steps are performed like applying material properties, contact between two surfaces are applied by changing the blank thickness the analysis will be performed.
- Now, by selecting the particular blank thickness by varying coefficient of friction the analysis is performed and at last selecting the best process.
- Next, by selecting the particular blank thickness and coefficient of friction by varying die shoulder radius the analysis is performed and at last selecting the best process.
- Now, from the best process by varying the punch radius with similar contact the analysis is performed and at last selecting the best process.
- Now all the results are tabulated and a graph is plotted by selecting the parameter with blank thickness with respect to results

III. MODELLING

Table 1: The Geometry was modeled by using the following dimensions and all are in mm

Punch radius (r_p)	56
Punch nose radius	4
Height of the punch	67.7
Die radius (r_d)	57.7
Die shoulder radius	6
Blank diameter (r_j)	224
Blank thickness (t)	1

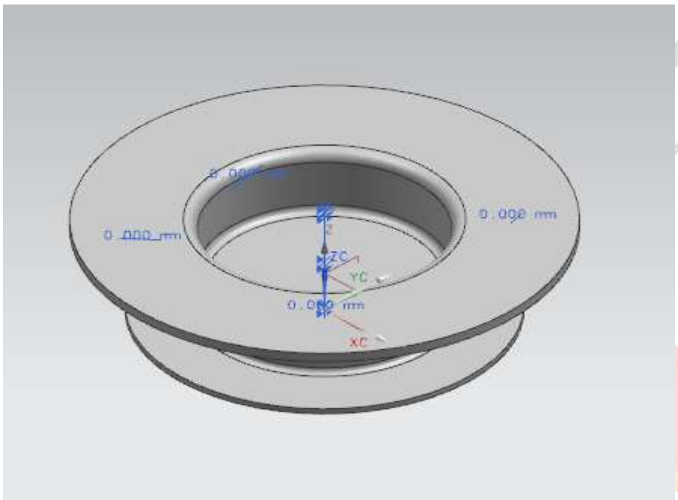


Figure 2: Model of Die

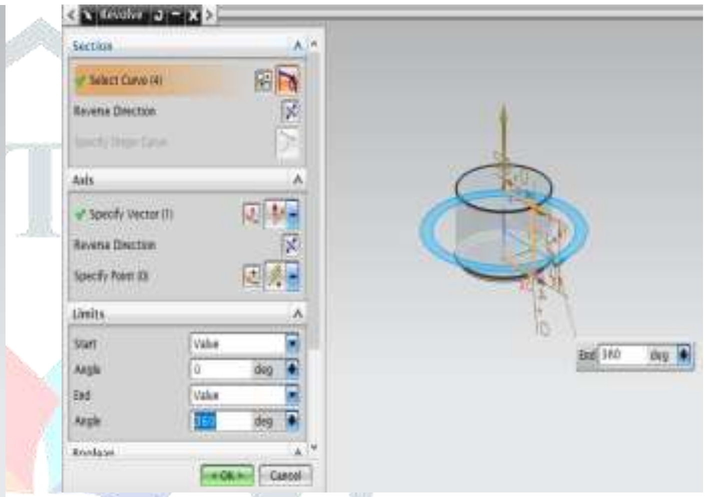


Figure 3: 3D Model of Punch

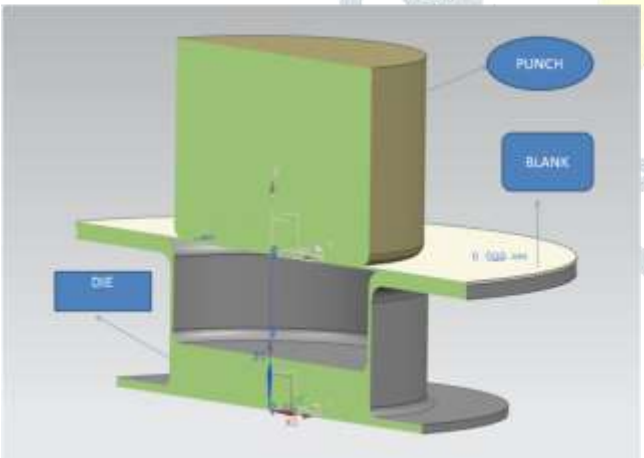


Figure 4: 3D Model of Blank

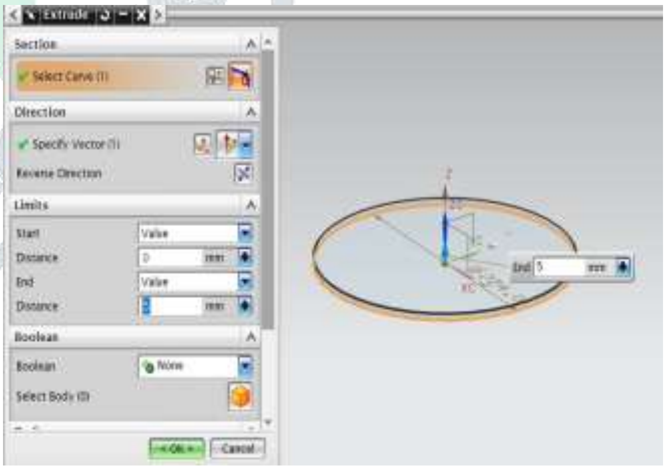


Figure 5: The figure shoes the final isometric view of ssembly

IV. ANALYSIS BY USING EXPLICIT DYNAMICS IN ANSYS WORK BENCH

The Implicit and Explicit are two types of approach methods to solve the finite elemental problem. The implicit finite elemental analysis approach is useful in solving the problems where which time dependency of the solution is not an important factor [e.g. static structural, harmonic, modal analysis etc.] whereas the Explicit Dynamics approach is helpful in solving higher deformation time dependent problems such like as Crash, Blast, Impact, deep drawing, drop test etc.

4.1. Explicit Dynamics

Explicit Dynamics is used to perform analysis for high-speed impact simulation i.e. like collision of two objects. It is also used to perform drop test simulation analysis i.e. when an object falls down from a certain height onto floor with some gravity.
A time dependence integration method is used in Explicit Dynamics analysis system.

Once the meshing of the geometry is completed the next step is to provide the initial conditions like (initial velocity, Angular velocity), this settings are varied for different problems. In analysis setting, time step must be defined time dependently.

The time steps include:-

- Initial time step
- Minimum time steps
- Maximum time step
- Time step safety factor

4.2. Methodology Adopted In Ansys Part

This analysis was carried out by using Explicit Dynamics module in Ansys Workbench. As the analysis is highly non-linear the time integration method will be used explicitly which is very efficient for each time step but the run time would be too enormous to be accepted.

4.3. Selecting the Suitable Analysis Part

In the Ansys toolbox the explicit dynamics is selected and the required engineering data, geometry, model and setup is created and then the software is made to run for the solution.

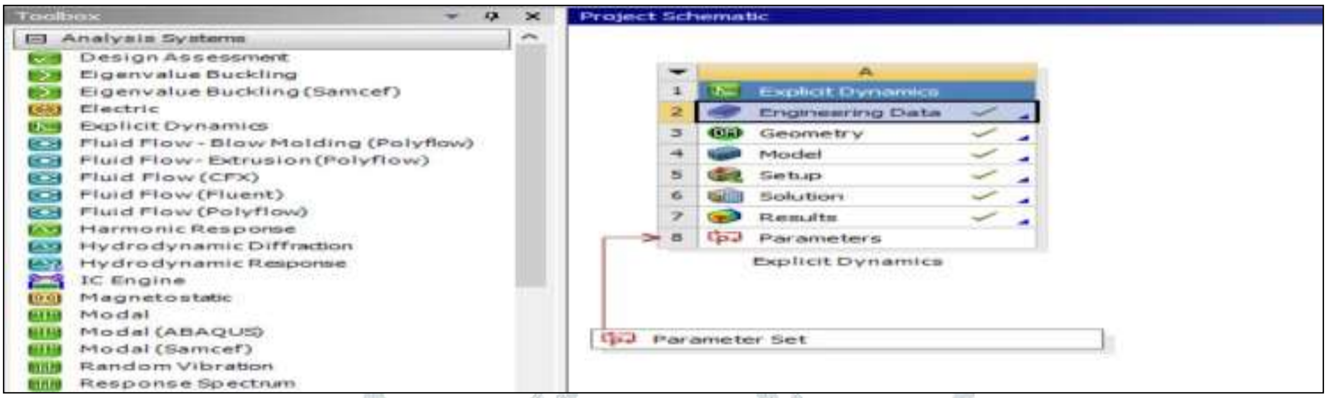


Figure 6: The schematic view explicit dynamics.

4.4. Selecting the Engineering data

After selecting the explicit dynamics first Engineering data should be provided for what type of material is using for different components. In the project the blank was designed with the Aluminium alloy material properties and remaining die & punch are been done with structural steel.

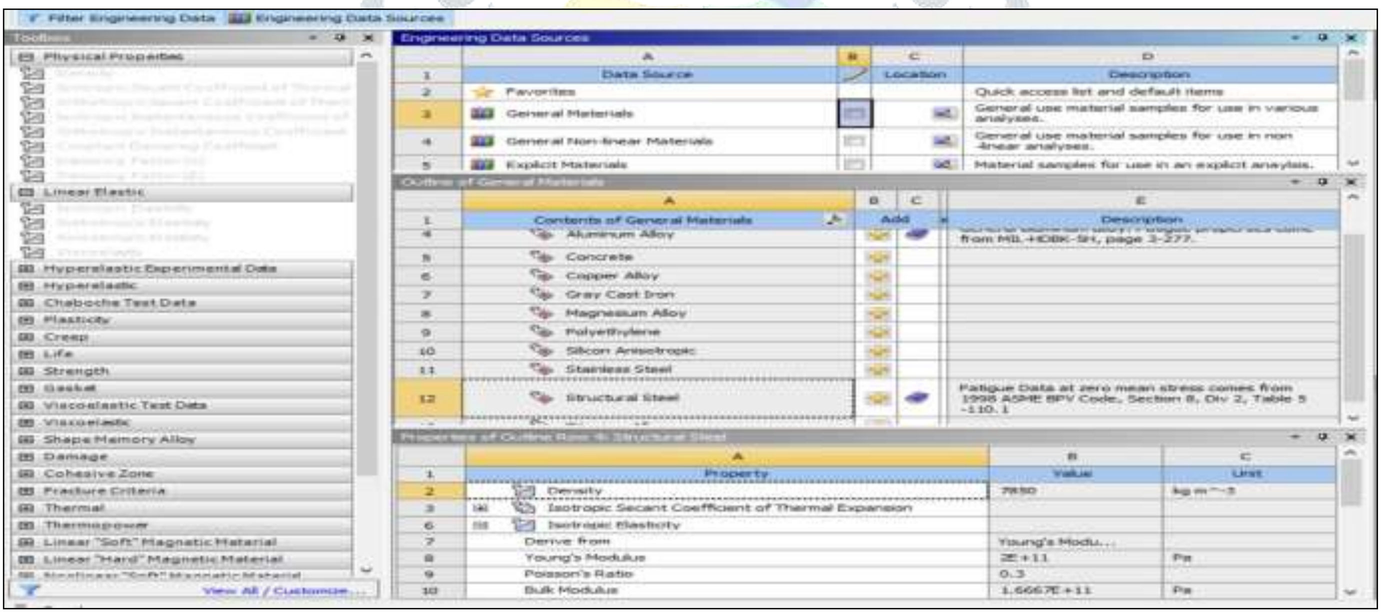


Figure 7: The view engineering data which shows the material used for different parts.

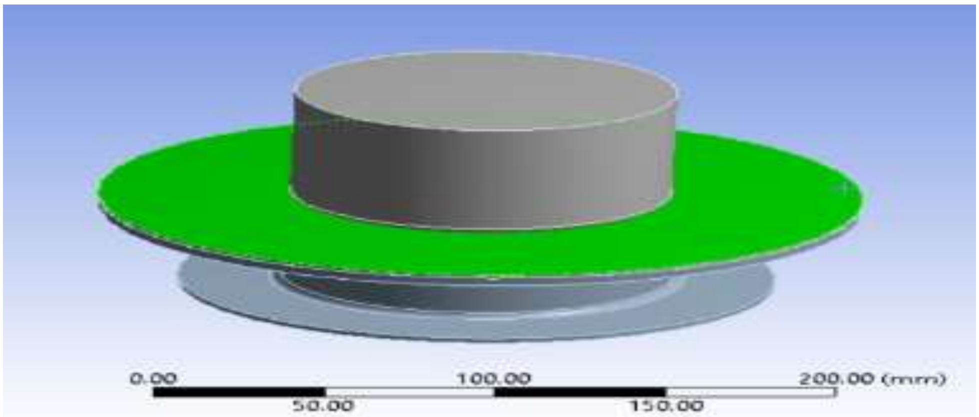


Figure 8: Deep drawing model

The geometry was modeled in Unigraphics. The deep drawing process setup contains Die, Blank holder, Punch & Blank. All the parts are drawn in solid body and the blank is drawn with some thickness. Geometry was divided in two equal parts and there by symmetry was assigned to the setup. The material assigned for blank is Aluminium alloy and the remaining parts are all structural steel.

4.5. Material Properties

The material assigned for blank is **'Aluminium Alloy-6061'** with given material properties:

Table 2: Properties of Aluminium Alloy 6061

Density (ρ)	2770 kg/m^3
Modulus of Elasticity (E)	7.1E10 Pa
Poisson's Ratio (υ)	0.33
Ultimate Tensile Strength	310 MPa
Shear Stress (K)	207.5 N/mm^2
Maximum Allowable Stress	300 N/mm^2
Yield strength	276 N/mm^2

Table3: chemical composition of material Aluminum Alloy 6061

Component	**Amount (wt%)**
Aluminum	Balance
Magnesium	0.8-1.2
Silicon	0.4-0.8
Iron	0.7
Copper	0.15-0.40
Zinc	0.25
Titanium	0.15
Manganese	0.15
chromium	0.04-0.35

4.6. Calculations used in Analysis Process: The following calculations were performed to find out the required parameters in the Analysis Process:

1. **Blank holding Force (F_h):** Firstly the blank holding force 'F_h' will be calculated from the given formula:

$F_h = 0.015*3.14*Y*((D_b^2)-(D_p+(2.2*t)+(2*R_d))^2))$

2. **Drawing Force**: Drawing force is to be calculated by the following equation:

$D_R = D_b/D_p$; $F_D = 3.14*t*D_p*UTS*(D_R-0.7)$

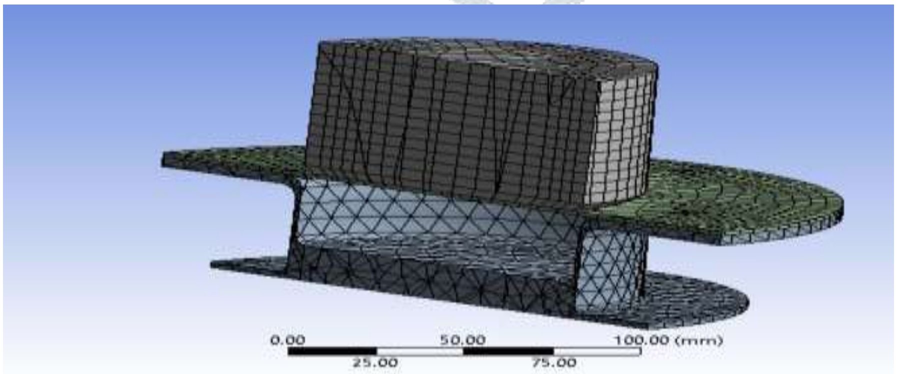


Figure 9: Meshed Model Of Total Assembly

V.ANALYSIS BY VARYING FRICTION COEFFICIENT

5.1. Plate Thickness 3mm And With Adding Friction Coefficient 0.15.

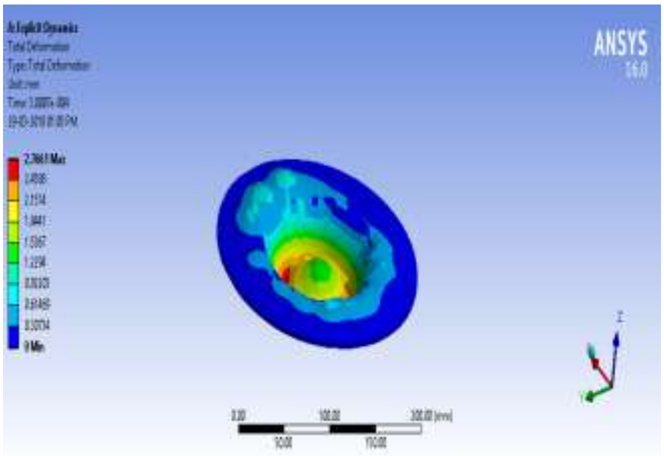


Figure 10: Total deformation of 3mm blank

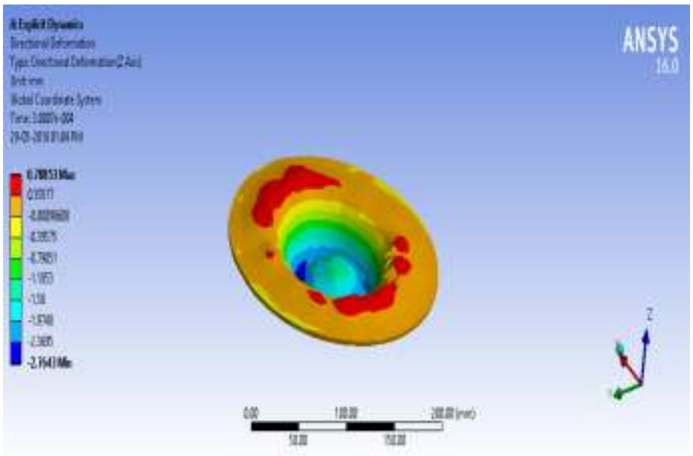
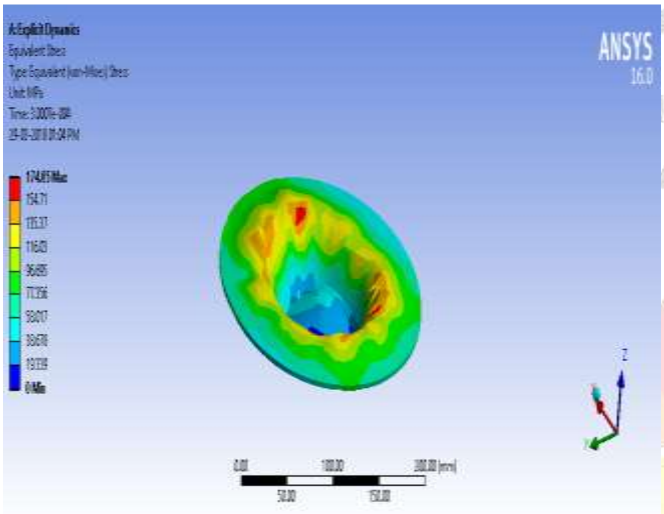


Figure 11: Directional deformation of 3mm blank



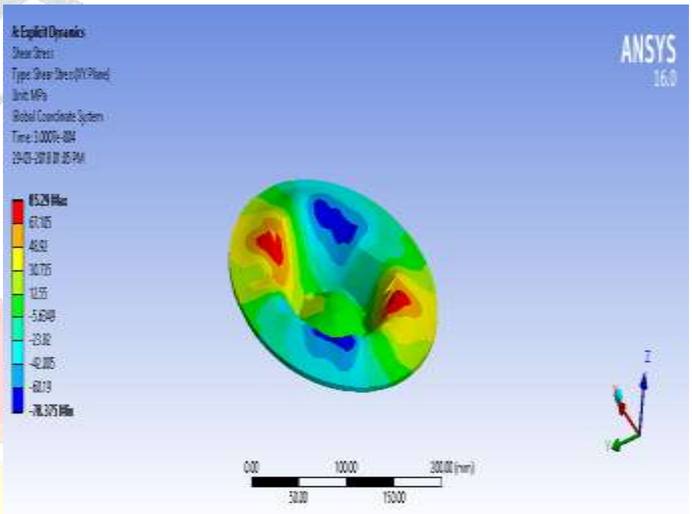


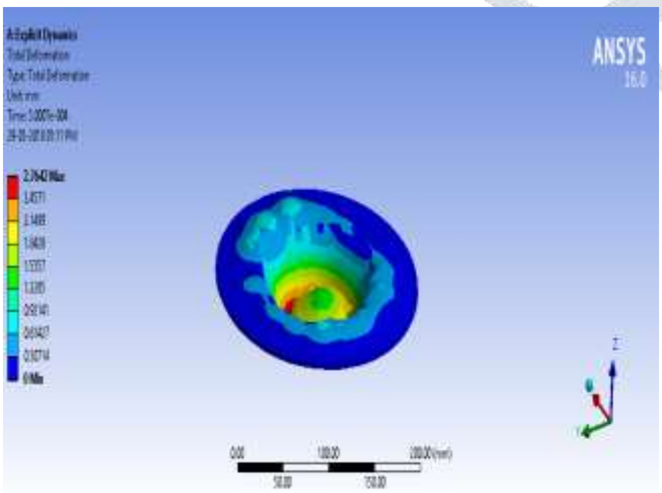
Figure 12: Von misses stress of 3mm blank.

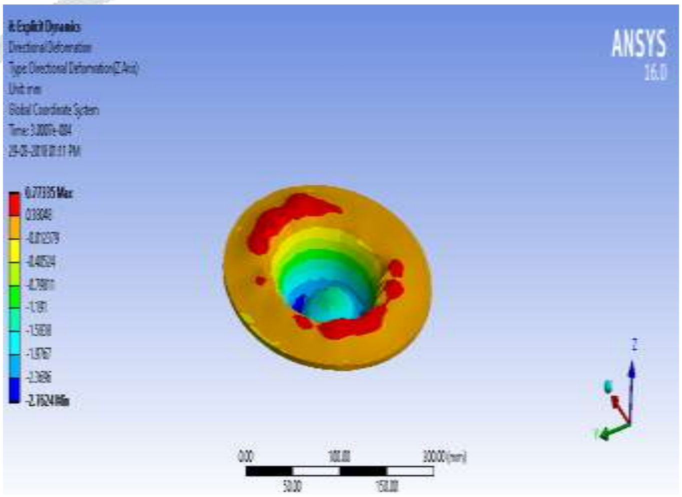
Figure 13: Shear stress of 3mm

5.2. Plate Thickness 3mm And With Adding Friction Coefficient 0.20.

Figure 14: Total deformation of 3mm blank.

Figure 15: Directional deformation of 3mm blank.





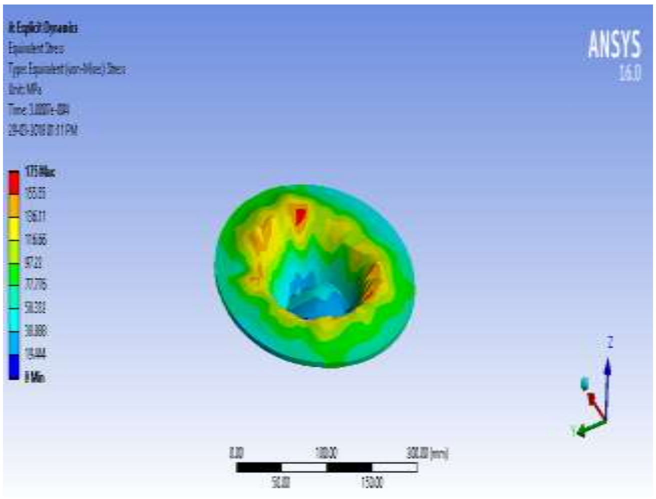


Figure 16: Von misses stress of 3mm blank

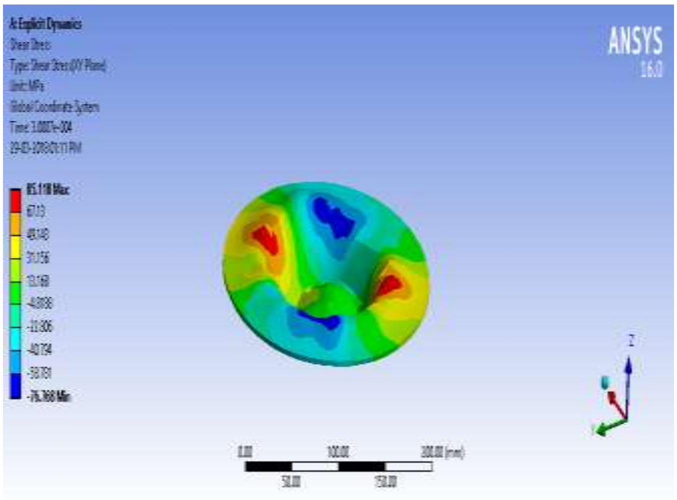


Figure 17: Shear stress of 3mm blank

5.3. Plate Thickness 3mm And With Adding Friction Coefficient 0.25.

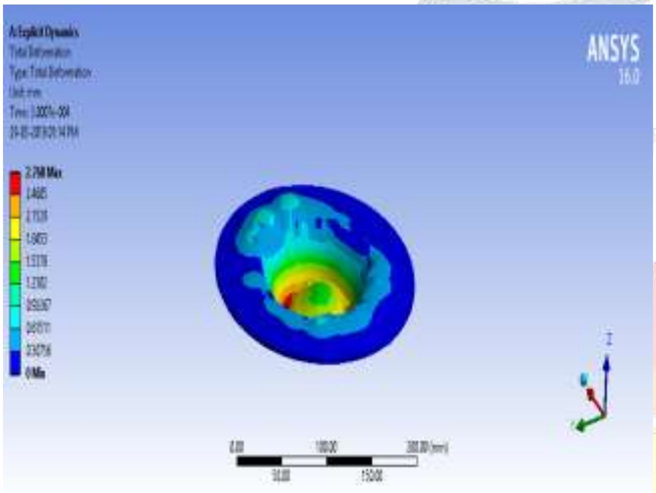


Figure 18: Total deformation of 3mm blank

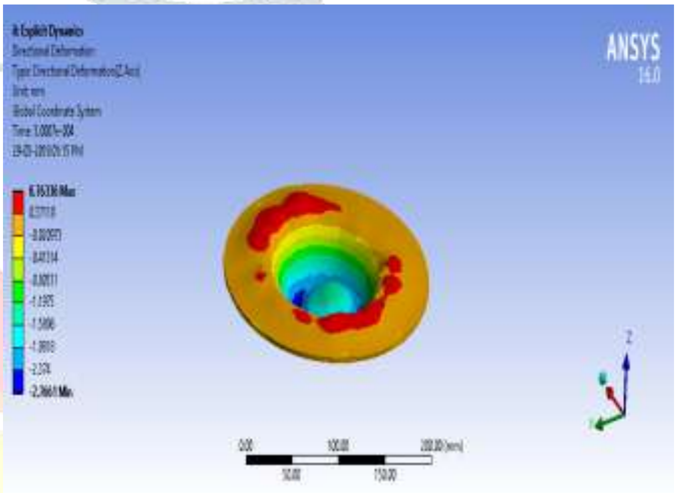


Figure 19: Directional deformation of 3mm blank

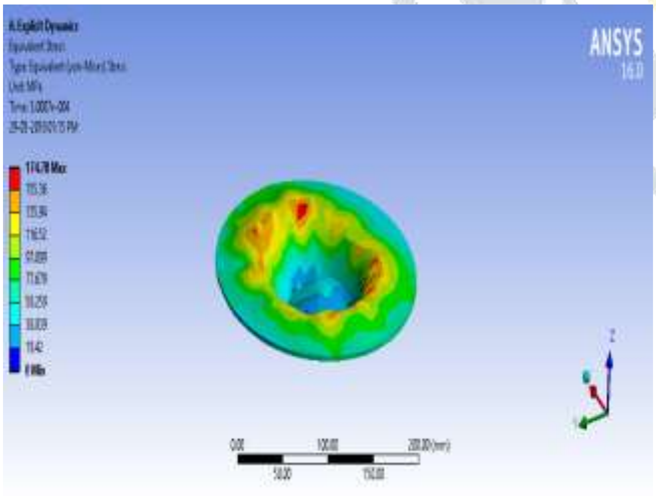


Figure 20: Von misses stress of 3mm blank

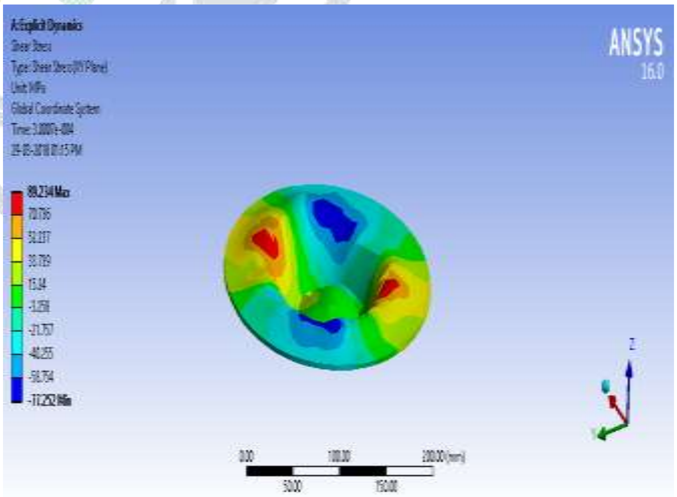


Figure 21: Shear stress of 3mm blank

5.4. Plate Thickness 3mm And With Adding Friction Coefficient 0.30.

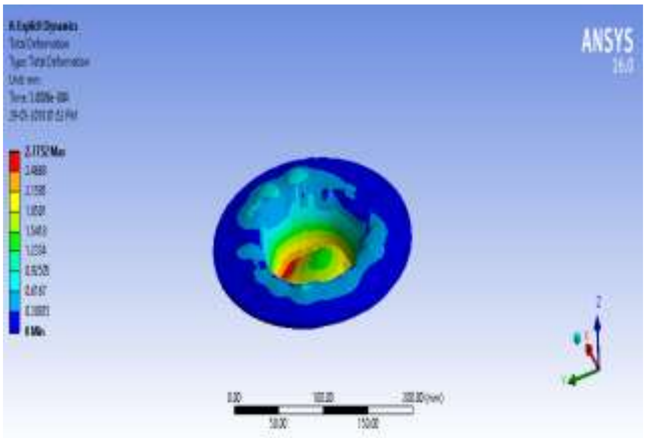


Figure 22: Total deformation of 3mm blank

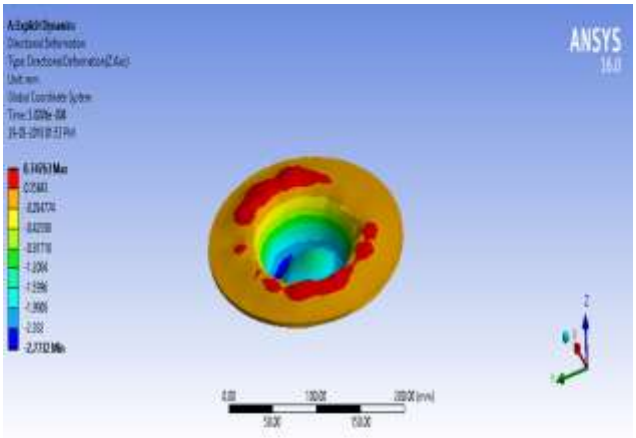


Figure 23: Directional deformation of 3mm blank

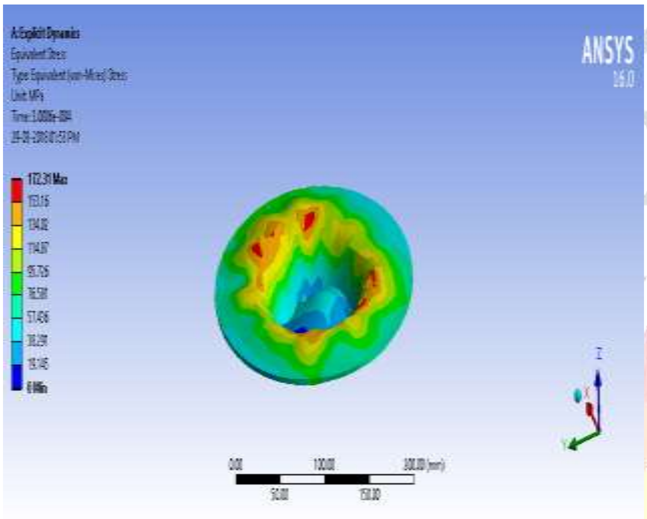


Figure 24: Von misses stress of 3mm blank.

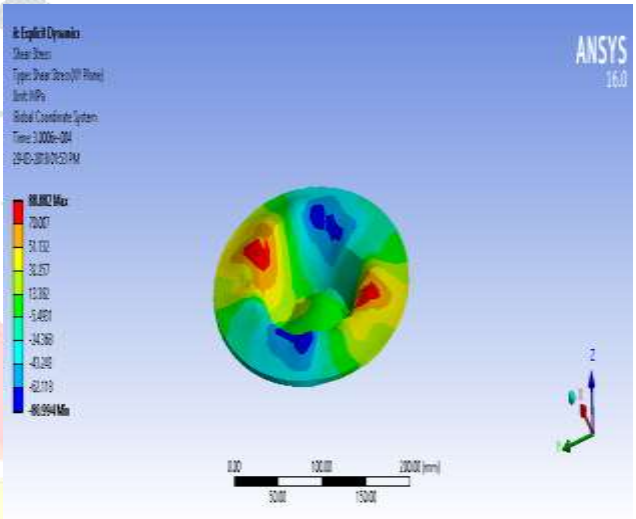


Figure 25: Shear stress of 3mm blank

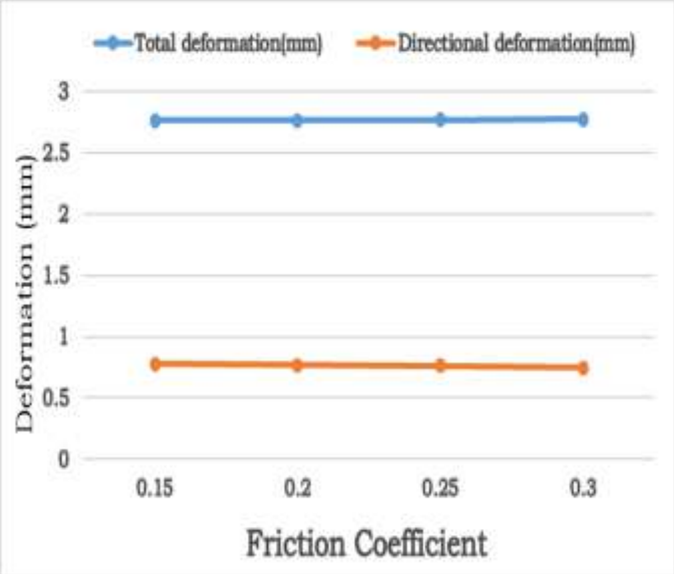
VI. RESULTS & CONCLUSION

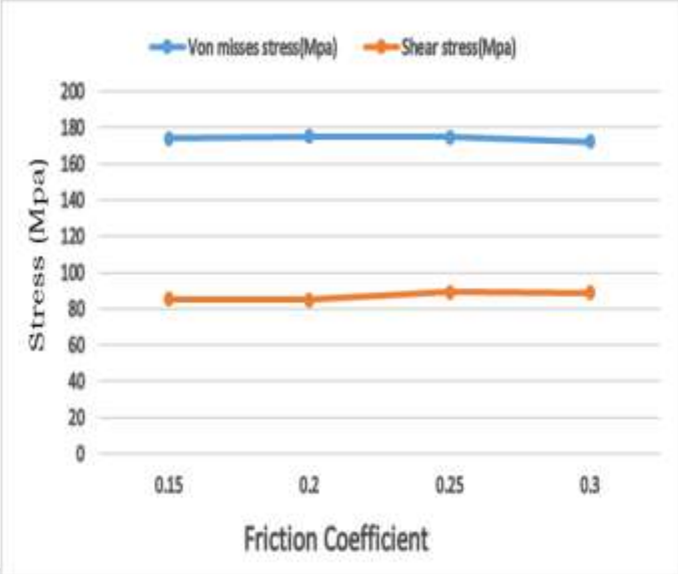
Table 4: Comparison of Blank Thickness with Friction Coefficient

Type of parameter	Blank thickness (mm)	Friction Coefficient			
		0.15	0.20	0.25	0.3
Total deformation(mm)	3	2.76	2.764	2.768	2.775
Directional deformation(mm)(z axis)	3	0.78	0.77	0.763	0.747
Von misses stress(Mpa)	3	174.05	175	174.78	172.31
Shear stress(Mpa)	3	85.29	85.11	89.23	88.88
Factor of safety	3	1.58	1.57	1.57	1.60

From the above table by comparing von misses stress and total deformation by considering a peak value with the blank thickness with 3mm the results is 0.2 friction coefficient is considered. The von misses stress are in allowable limit for all the friction coefficient among that the friction coefficient 0.2 is considered as a peak result for von misses stress which is 175 MPa and total deformation is 2.76 mm. So, from the results and comparison we can say that deliabretly the blank with 3mm thickness and friction coefficient 0.2 will be sustained better.

A graph is drawn by comparing all the parameters





Graph 1: comparing total deformation and directional deformation thickness 3mm and with friction coefficient

Graph 2: comparing von misses stress and shear stress for blank for blank thickness 3mm and with friction coefficient

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