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Design and Analysis of Deep Drawing Tool For Aluminum Cup

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Abstract

Deep drawing is important method for production of small components like automobile, hollowcups, different home appliances as well as large components like bodies and doors, turbine blades etc. The raw material undergoes different sheet metal operations like shearing, blanking, piercing, bending deep drawing etc. For these operations different dies and punches are used. Also a redrawing operation is used. We used aluminum 1mm thick sheet to punch gasket of 50mm inner dia and 70mm outer dia. The traditional techniques for design of dies for sheet metal operation used In industry are experimental and expensive methods. Using analytical methods we can calculate various design parameters and forces required or the sheet metal operation and can be verified using COMPUTER AIDED DESIGN such as PROE, CATIA, SOLID WORKS and FINITE ELEMENT ANALYSIS by using ANSYS which will reduces the time for development of die.

Keywords: Deep Draw; Formability; Simulation; ANSYS; Mild Steel

1. Introduction

From sheet metal particular shaped components are produced from press tools called deep draw tool. The shape of a component depends on the shape of drawtool. A sheet metal is formed with the help of punch and die. A sheet metal blank is drawn in to a forming die with the help of a punch. This process is called deep drawing when the depth of the component exceeds its diameter. The traditional techniques for design of dies for sheet metal. Operation used In industry are experimental and expensive methods.

Using analytical methods we can calculate various design parameters and forces required or the sheet metal operation and can be verified using COMPUTER AIDED DESIGN such as PROE, CATIA , SOLID WORKS and FINITE ELEMENT ANALYSIS by using ANSYS which will reduce the time for development of dies. The earlier research work published by various authors on LDR revealed that the punch load is proportional tool blank size as shown in Figure.1

2. Methodology

A hydraulic press has been used to produce the aluminium cup with the help of deep draw tool. With the help of shank, a punch is held in the top plate whereas die is held in the bottom plate. Then the blank is placed in the first stage die and clamped with the help of blanking pad. The component is drawn which is the first stage of the cup for making the final component with the help of second stage punch and die. The circular blank is cut from the sheet with the help of circular cutting machine or blanking tool made separately or by laser cutting.

In second step the tool punch and die is placed in press then the second stage drawing operation is completed. Finally the wrinkled portion of the flange is removed by trimming.

2.1 Deep Draw Tool Setup

The deep drawing tool is highly skilled task. It involves a number of activities which start with determination of blank size, selection of process and tool parameters. the tool setup is shown in figure 2.

A deep draw tool consists of the following:

- First and second stage punch
- First and second stage die
- Blank holder
- Punch holders/ two nos.
- Die holder two nos.
- Guide plate
- Rubber pad spring

Load on blank holder can be varied by applying compressive force over the rubber pad or open coiled helical spring housed over the blank holder with the help of tightening the nut provided for it. The testing can easily determine the blank force applied on the blank holder as the spring index is already known.

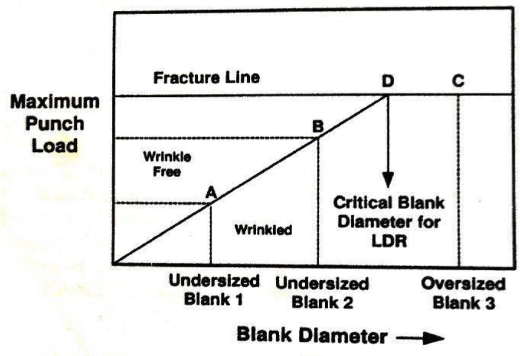


Figure 1. Punch limit load at different blank [1].

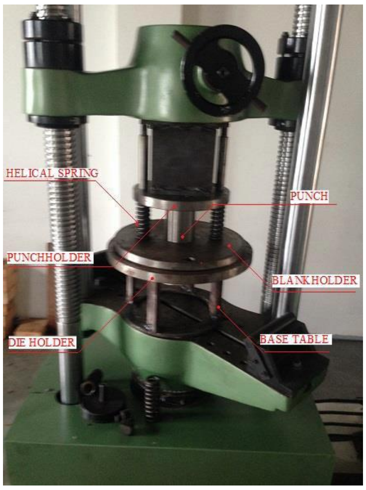


Figure 2. Deep drawing tool setup

3 Problem Statement

3.1 Parameters of Draw Tool

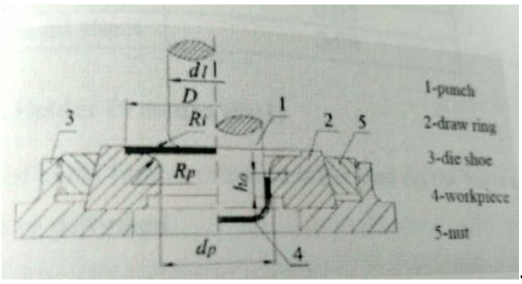


Figure 3 Parameter of Draw Tool

Where,

D=blank diameter

d 1=inside work piece diameter after the first drawing operation

T=material thickness

Rp=draw ring

Ri=punch radius

dp=outside work piece diameter after the first drawing operation

The radius of draw ring

Rp=0.8[(D-d1)X T]0.5………………(1)

The height of the cylindrical part of the draw ring(ho)

ho=(3X5)Xt…………(3)

The clearance between the walls of the punch and the die

C=T+k(10T)0.5……………(4)

C=clearance

T=material thickness

k=coefficient

Table 1.Material and coefficient

Material	Coefficient k
Steel sheet	0.7
Aluminum sheet	0.02
Other metal sheet	0.04

3.2 Blank Holder Pressure (Pd1)

The value of blank holder pressure is decided on the basis of sheet metal material which is to be formed.

Table 2.Material and blank holder pressure.

Material	Pressure	
	Lb/in^2	Mpa
Deep-drawing steel	300-450	1-3
Low-carbon steel	500	3-5
Aluminum and aluminum alloys	120-200	0.85-1.4
Aluminum alloys, special	500	3.5
Stainless steel, general	300-750	2-5
Stainless steel, austenite	1000	7
Copper	175-250	1.25-1.75
Brass	200-300	1.40-2.0

The blank holder force can be calculated by the

Following formula:

Fd1= $\pi/4$ [D2-d12] Pd1…………….(5)

DRAW FORCE- draw force required for the operation is given by

Pdraw =A St ncln(Ec)……………….(6)

Where

A=$\pi d1t$

A=area of cross section of a shell

T= thickness of sheet metal

St=ultimate tensile strength of material

E=cupping strain factor

nc- deformation efficiency of drawing process

the cupping strain factor E gives us the actual strain in the

Metal created by its elongation during the deep-drawing process, it is calculated by

E={(D/d1)+1]X0.5…………….(7)

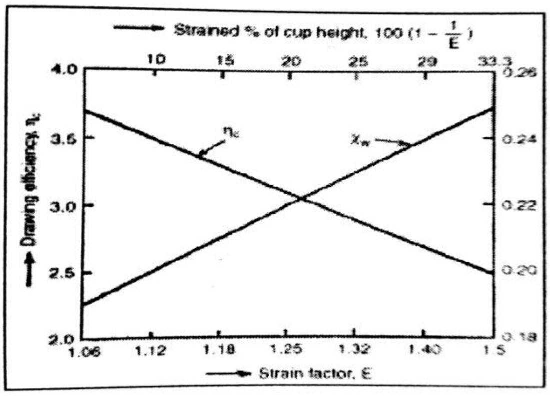


Figure.4 deformation efficiency of drawing process (nc)

4. Design Calculations.

Input parameters

Table3Sheet metal (input part) details

.	EDD-513
Dimension	110mmX110mmX0.8mm thick
Ultimate tensile strength (S_t)	260Mpa
Yield strength (S_y)	165Mpa

4.1 Press data

Shut height-340mm

Clamping slot dimension-8mm(thick)X 30mm(width)X20mm(depth)forM8 clamping bolt, pitch of clamp slots from center of press is 20mm.Front to back maximum size-150mmLeft to right maximum size-100mmNumber of strokes perminute-20Make unioMaximumcapacity-160 tonNo cushion pins for blank-holder Travel of blank-holder as per shape of output component.

As the depth of drawn component is 20mm, blank-holder travel is kept 26mm for proper holding 1mm before the start of operation.

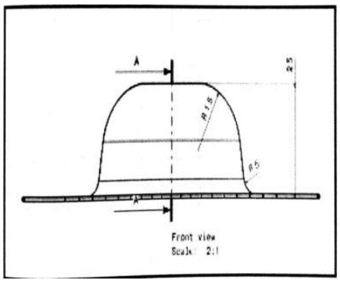


Figure 5 various parameters

Blank diameter (D)-120mm

Punch diameter (d1)-70mm

Thickness of sheet (T)-1mm

Draw ring radius (Rp)-

Rp=0.8X [(D-d1)XT] 0.5

=5.65mm

=6mm

Clearance value between punch and cavity (C)-

C=T+k$\sqrt{10\ XT}$

=0.99 mm

=1mm

Cavity diameter (d0)-

D0=70+0.99

=70.99 mm

=71 mm

Blank holder pressure (P) is decided based on the finite element analysis of metal flow. From method plan report and table 2 the value is selected as 1.17 Mpa.

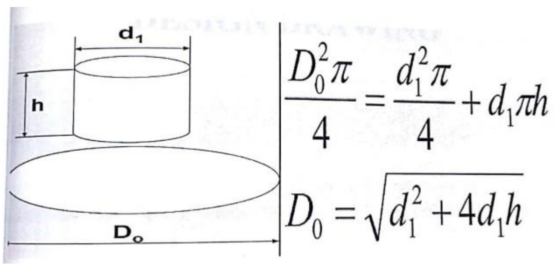
Blank-holder force (Pd1).

Pd1= PX area of sheet metal holding

=1.17 X[120(2)-($\pi/4$)$X70(2)$]

=12.345KN

4.2 Blank diameter Calculations



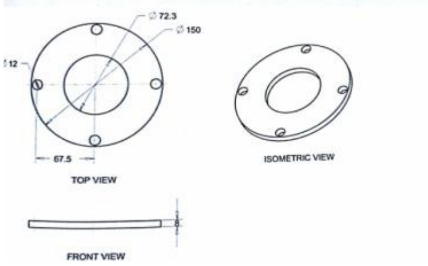
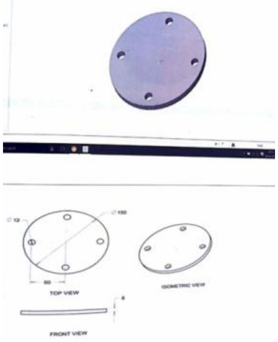
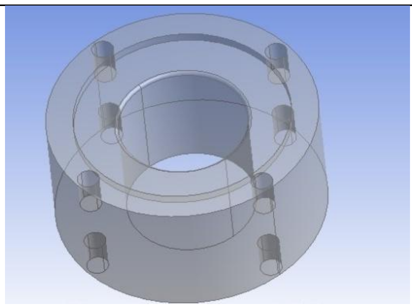
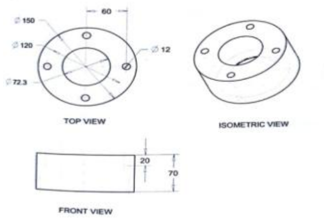
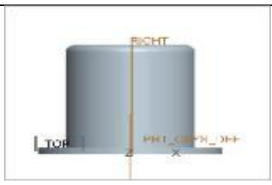
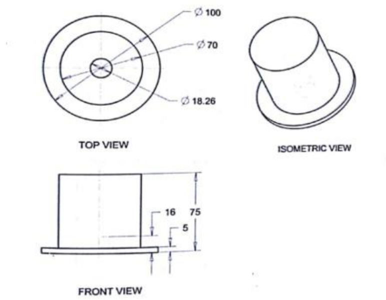
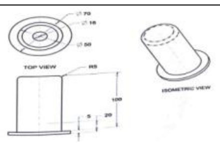
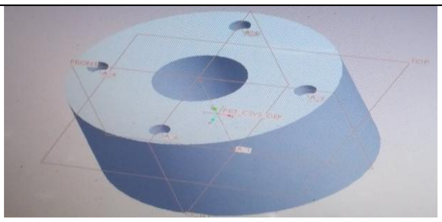
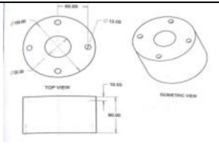
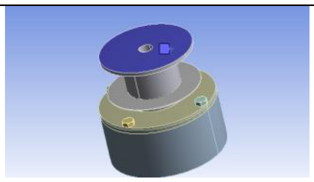
Where d=70 and h=50

$\boldsymbol{\pi \div 4X(70)^2 + \pi X70X50 \div \pi \div 4 = db^2}$

db^2 = 14435.55

db = 120

5. Design Drawing

<table>
<tr><th colspan="2">Blank Holder:</th><th>Bottom Plate</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><th>Large Die:</th><th colspan="2">Large Punch</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><th colspan="2">Medium Sized Punches:</th><th></th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><th colspan="2">Medium Punch Size</th><th>Assembly</th></tr>
<tr><td></td><td></td><td></td></tr>
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6. Analysis Report and Result Discussion:

6.1. Total Deformations:

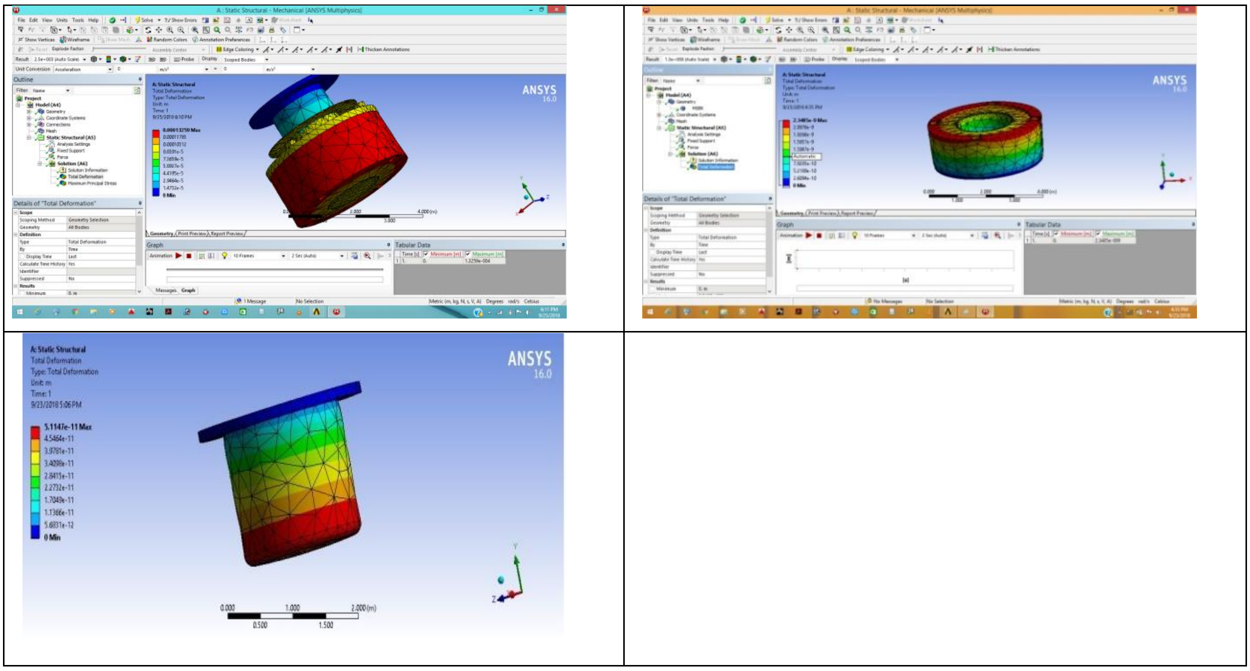

Figure 7. Total Deformation Analysis

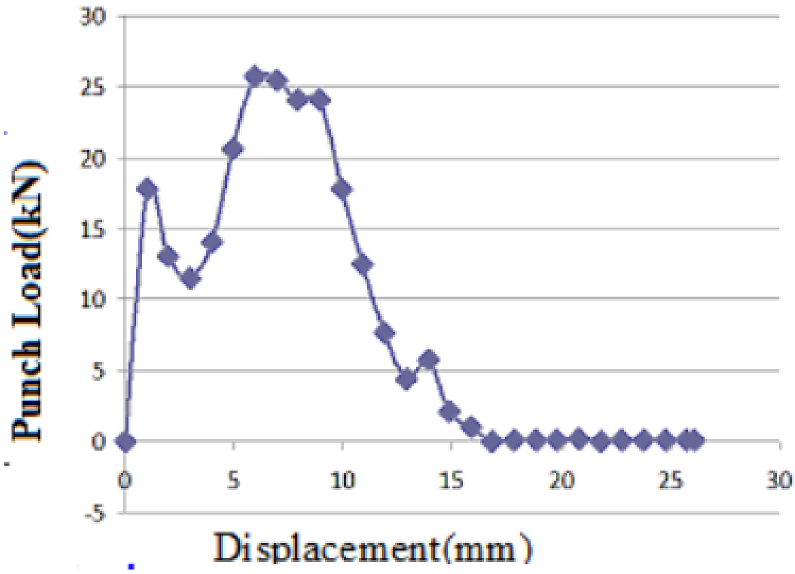

***Figure* 8 .Punch load vs. punch displacement curve for 50 mm diameter (simulation)**

NAME OF THE PROPERTIES		MAILD STEEL MIN	MX	CAST IRON MN	MX
Young's modulus		**200E6 pa**		**115E9 pa**	
Poisson ratio		**0.3**		**0.3**	
Shear stress		**23.7277**	**4.7686**	**4.63337**	**21.3141**
1^{st}principle stress		**17.4392**	**55.5029**	**23.4577**	**70.9248**
3^{rd}principle stress		**70.3419**	**16.4325**	**58.1371**	**22.985**
Vov-misses stress		**0.862E-0.3**	**54.298**	**0.938E-0.3**	**48.7146**
MAXIMUM DEFORMATION	**DIE**	5.114×10^{-11}		9.38×10^{-11}	
	PUNCH	5.7×10^{-11}		7.33×10^{-11}	

7. Conclusion

In this project I have designed the deep drawing tool for aluminum cup and structural analysis is done and results are shown above.

I have done stress, strain and the maximum deflection analysis using ANSYS on deep drawing tool made of MS (Mild steel). As the result show, Mild steel has more strength to withstand higher loads.

I have also done analysis on both the soft tool (MS) a hard tool (CI) and concluded as MS is suitable for mass production.

Hence, by end of this project I can say that all objectives of this project are fulfilled and Mild steel (MS) can sustain more loads and metal flow is good in this deep drawing tool.

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