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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

Table 1.Material and coefficient

Material	Coefficient k
Steel sheet	0.7
Aluminum sheet	0.02
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.

Material	Pressure		
	Lb/in ²	Мра	
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	

Table 2.Material and blank holder pressure.

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

 $E = \{ (D/d1) + 1 \} X 0.5 \dots (7)$





4. Design Calculations.

Input parameters

Table3Sheet metal (input part) details

	EDD-513		
Dimension	110mmX110mmX0.8mm		
	thick		
Ultimate	260Mpa		
tensile strength			
(\mathbf{S}_{t})			
Yield strength	165Mpa		
$(\mathbf{S}_{\mathbf{y}})$			

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

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

=12.345KN

4.2 Blank diameter Calculations



Where d=70 and h=50 $\pi \div 4X(70)^2 + \pi X70X50 \div \pi \div 4 = db^2$ db² = 14435.55 db = 120

5. Design Drawing

Blank Holder:		Bottom Plate		
TOP VIEW				
Large Die:	La	rge Punch		
FIGHT VIEW		VID Ø 100 Ø 70 Ø 18.26 TOP VIEW ISOMETRIC VIEW ISOMETRIC VIEW ISOMETRIC VIEW FRONT VIEW ISOMETRIC VIEW		
Medium Sized Pu	inches:			
PRI Cava Der				
Medium Punch Size		Assembly		

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 DD						
NAME OF THEFT	<u>UFENTIE5</u>	MAILD SIEEL MIN MY		<u>CAST INUN</u>	<u>CAST IKON</u> MN	
		MIN MX		IVIIN	MN MX	
Young's modulus		200E6 pa		115E9 pa	115E9 pa	
Poisson ratio		0.3		0.3		
Shoor stross		23 7277	1 7686	1 63337	21 31/1	
Shear stress		23.1211	4.7000	4.03337	21.3171	
ast a s		1= 1000				
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-missos stross		0.862E-0.3	54 298	0.938F-0.3	48 7146	
V UV-IIIISSES SU ESS		0.00212-0.5	54.270	0.75012-0.5	40./140	
	DIE	11				
MAXIMUM	DIE	5.114×10^{-11}		9.38	9.38 \times 10 ⁻¹¹	
DEFORMATION						
	PUNCH	5.7×10^{-11}		7.33×10^{-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.

References

- [1] Jain, M., J. Allin, and M. J. Bull. "Deep drawing characteristics of automotive aluminum alloys." Materials Science and Engineering: A Vol.256, No.1, pp.69-82, 1998.
- [2] Popli, D., & Gupta, M. (2018). Investigation of machining rate and roughness for rotary ultrasonic drilling of Inconel 718 alloy with slotted diamond metal bonded tool. International Journal of Manufacturing Research, 13(1), 68-95.
- [3] G. Behrens, F. O. Trier, H. Tetzel and F. Vollertsen, "Influence of tool geometry variations on the limiting drawing ratio inmicrodeep drawing ", International Journal of Material Forming Vol.9, No.2, pp.253-258, 2016.
- [4] Xiao-bo Fan, Zhu-bin He, Wen-xuan Zhou and Shi-jian Yuan. "Formability and strengthening mechanism of solutiontreated Al–Mg–Si alloy sheet under hot stamping conditions" Journal of Materials Processing Technology Vol.228,pp.179-185, 2016.

- [5] Pourboghrat, Farhang, SenthilkumarVenkatesan, and John E. Carsley. "LDR and hydroforming limit for deep drawing ofAA5754 aluminum sheet." Journal of Manufacturing Processes Vol.15 No.4, pp.600-615, 2013.
- [6] Wen-yu Ma, Bao-yu Wang, lei Fu, Jing Zhou and Ming-dong Huang. "Influence of process parameters on deep drawing of AA6111 aluminum alloy at elevated temperatures"
- [7] Lucian Lazarescu, IoanNicodim, and Dorel Banabic."Evaluation of drawing force and thickness distribution in the deep-drawing process with variable blank-holding. In Key Engineering Materials", Trans Tech Publ. Vol.639, pp.33-40,2015.
- [8] Demirci, Halil Ibrahim, CemalEsner, and Mustafa Yasar. "Effect of the blank holder force on drawing of aluminum alloysquare cup: Theoretical and experimental investigation." Journal of materials processing technology Vol. 206, No.1pp.152-160, 2008.
- [9] A. C. S. Reddy, S. Rajesham, and P. R. Reddy. "Experimental and simulation study on the warm deep drawing of AZ31.