Design & Analysis of Die & Punch used for Deep Drawing Operation for Daulat Industries, Gaddi Godam, Nagpur

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Abstract— In this paper, in a deep drawing operation carried in Daulat Industries, Gaddi godam, Nagpur, a sheet metal called blank is placed on a die cavity, held in position using a holding plate or holding ring and pressed against the die cavity using a solid punch. The sheet metal attains the shape of the die cavity with flat bottom. Both die and punch should be provided with corner radius in order to avoid shearing of the sheet. Very limited and small amount of work for design improvement in shape of die, improvement in defects and analysis on suitable die punch shape has been observed and there is still a need for further work. At present the company is not able to produce their product with the mentioned qualities. The company is not equipped with the CAD and FEA techniques because of which they lack the qualities in their product and results in failure. By generating appropriate design in CAD and simulate by using FEA techniques on their product we will be able to improve the qualities (i.e. weight, strength, density, and corrosion resistance) which will ultimately benefit the company and reduce their time and effort.

Key words: Embossing, Deep Drawing, Manufacturing Simulation

I. Introduction

Sheet metal fabrication plays an important role in the metal manufacturing world. Sheet metal is used in the production of materials ranging from tools, to hinges, automobiles etc.. Sheet metal fabrication ranges from deep drawing, stamping, forming, and hydro forming, to high-energy-rate forming (HERF) to create desired shapes. Cup drawing or deep drawing is one of the widely used sheet metal forming operations. Cup shaped objects, utensils, pressure vessels, gas cylinders, cans, shells, kitchen sinks etc. are some of the products of deep drawing.

In this process, a sheet metal called blank is placed on a die cavity, held in position using a holding plate or holding ring and pressed against the die cavity using a solid punch. The sheet metal attains the shape of the die cavity with flat bottom. Both die and punch should be provided with corner radius in order to avoid shearing of the sheet. During drawing of sheet into the die, there is thickening of the sheet upto 12%. Therefore, clearance is provided between the punch and die. The radial clearance therefore is equal to the sheet thickness plus the thickening of sheet. Punch pushes the bottom of the sheet into the die cavity. The flat portion of the sheet under the holding plate moves towards the die axis, then bends over the die profile. After bending over the die profile the sheet unbends to flow downward along the side wall.

The vertical portion of the sheet then slips past the die surface. More metal is drawn towards the centre of the die in order to replace the metal that has already flown into the die wall. Friction between holding plate and blank and that between die and blank has to be overcome by the blank during its horizontal flow.

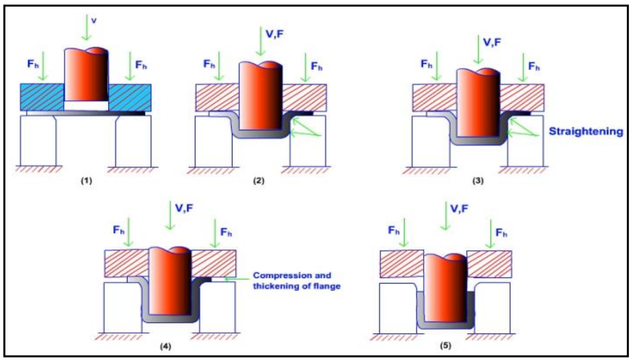
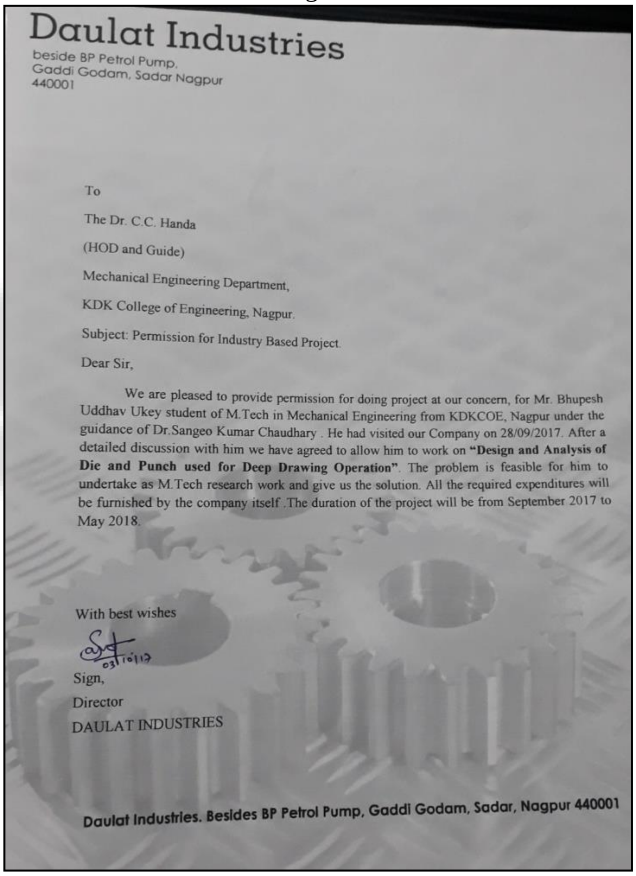


Fig. 1:



Daulat Industries
beside BP Petrol Pump,
Gaddi Godam, Sadar Nagpur
440001

To
The Dr. C.C. Handa
(HOD and Guide)
Mechanical Engineering Department,
KDK College of Engineering, Nagpur.
Subject: Permission for Industry Based Project
Dear Sir,

We are pleased to provide permission for doing project at our concern, for Mr. Bhupesh Uddhav Ukey student of M.Tech in Mechanical Engineering from KDKCOE, Nagpur under the guidance of Dr.Sangeo Kumar Chaudhary . He had visited our Company on 28/09/2017. After a detailed discussion with him we have agreed to allow him to work on **"Design and Analysis of Die and Punch used for Deep Drawing Operation"**. The problem is feasible for him to undertake as M.Tech research work and give us the solution. All the required expenditures will be furnished by the company itself .The duration of the project will be from September 2017 to May 2018.

With best wishes
Sign,
Director
DAULAT INDUSTRIES

Daulat Industries. Besides BP Petrol Pump, Gaddi Godam, Sadar, Nagpur 440001

Fig. 2:

II. Data Accumulation

- Cup diameter (d) = 60mm
- Cup height (h) = 31mm
- Cup thickness (t) = 1mm
- 2mm deep feature with 38mm diameter,
- 10mm center hole and 4mm mounting holes can be drilled with drilling machine
- Material specification of product
- yield stress = 275 MPa2. Data Accumulation

GRADE	Tensile Strength Mpa (kg/mm²) min	ELONGATION (%) MIN. (Guage length 50 mm) Thickness (mm)					
		≥ 0.25 < 0.40	≥ 0.40 < 0.60	≥ 0.60 <1.00	≥ 1.0 < 1.6	≥ 1.6 < 2.5	≥ 2.5
D	275 (28)	32	34	36	37	38	39
DD	275 (28)	34	36	38	39	40	41
EDD	275 (28)	36	38	40	41	42	43

Table 1: Mechanical Properties

Fig. 3: Product to be drawn

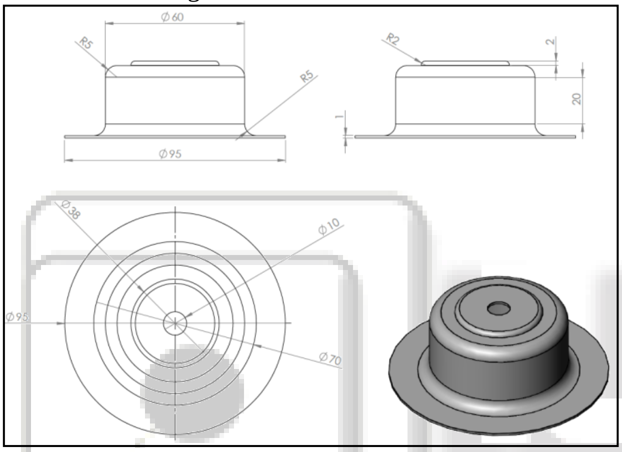


Fig. 4: Detailing of final product

III. DESIGN INFLUENCING FACTORS

A. Corner Radius of Punch

Though there is no set rule for the provision of corner radius on the punch, it is customary to provide a radius of four to ten times the blank thickness.

Too small a corner radius makes for the excessive thinning and tearing of the bottom of the cup. Ideally, the punch radius should be the same as the corner radius of the required cup, because it takes its form.

B. Draw Radius of Die

Since the draw radius on die does not contribute to the cup shape, it can be made as large as possible. Higher the radius, higher would be the freedom for the metal to flow. Too high a radius causes the metal to be released early by the blank holder and thus lead to edge wrinkling. Too small a radius causes the thinning and tearing of the side walls of the cups.

C. Clearance

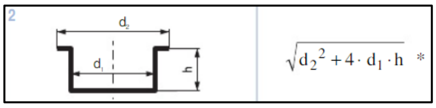
Ideally, the clearance between punch and die should be same as the blank thickness. But the blank gets thickened towards the edge because of the metal flow and hence, the actual clearance provided is slightly higher to account for this thickening. An allowance in the range of 7 to 20% of the blank thickness is provided depending on the cup material and cup dimensions

D. Blank Holder Pressure

If too much force is applied to the blank, the punch load will be increased (because of the increase in friction), and this increase will lead to fracture of the shell wall.

IV. DESIGN CALCULATIONS

A. Blank Diameter



$$D = \sqrt{d2^2 + 4d1.h}$$

where,
D = blank diameter
d2 = 95mm (outer diameter of cup with ears)
d1 = 60mm (diameter of cup)
h = 33mm (height of cup)

$$D = \sqrt{95^2 + 4 \times 60 \times 33} = 130\text{mm}$$

B. Die Corner Radius

$$Rd = 0.8\sqrt{(D - d)t}$$

Rd = die corner radius
D = blank diameter
d = 38mm (inside cup diameter)
t = 1mm (thickness of cup)

$$Rd = 0.8 \times \sqrt{(130 - 38)1} = 7.6\text{mm}$$

C. Clearance between Wall of Punch & Die Cavity

$$c = t + k\left(\sqrt{10t}\right)$$

c = clearance
t = 1mm (material thickness)
k = coefficient (Table 1.1)

MATERIAL	Coefficient k
Steel sheet	0.07
Aluminum sheet	0.02
Other metal sheet	0.04

Table 1.1: Value of Coefficient k for Different Material

$$c = 1 + 0.07 \times \left(\sqrt{10 \times 1}\right) = 1.22\text{mm}$$

D. Dimensions of Punch & Die

If the outside diameter of the final piece must be within a certain tolerance, the Die diameter (dp) is equal to the minimum outside diameter of the final piece, and the punch diameter is less than the Die diameter by 2c.

The Die and Punch are assigned working tolerances (tp, t2), given in Table 1.2, where d is the nominal diameter of the final piece and T is the thickness of the work material.

d (mm)	Tol.	MATERIAL THICKNESS T (mm)									
		0.25	0.35	0.50	0.60	0.80	1.0	1.2	1.5	2.0	2.5
10 to 50	+tp	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.11	0.13	0.15
	-ti	0.01	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.10
51 to 200	+tp	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.12	0.15	0.18
	-ti	0.01	0.02	0.00	0.04	0.05	0.06	0.07	0.08	0.10	0.12
201 to 500	+tp	0.03	0.04	0.05	0.06	0.08	0.10	0.12	0.14	0.17	0.20
	-ti	0.01	0.02	0.03	0.04	0.06	0.07	0.08	0.09	0.12	0.14

Table 1.2: work tolerances of Die and Punch

1) The Nominal Die Diameter

$$dp = do - \Delta$$

dp = nominal Die diameter
do = 60mm (outer diameter of final product)
Δ = tolerance (0.09+0.06/2=0.075)

$$dp = 60 - 0.075 = 59.925mm$$

2) Maximum Die diameter

$$dpmax = dp + tp$$

dpmax = Max. Die diameter
dp = 59.925mm (nominal Die diameter)
tp = 0.09 (work tolerance of die)

$$dpmax = 59.925 + 0.09 = 60.015mm$$

3) The Nominal Punch Diameter

$$di = dp - 2c$$

di = Nominal Punch diameter
dp = 59.925mm (nominal Die diameter)
c = 1.22mm (clearance)

$$di = 59.925 - 2 \times 1.22 = 57.485mm$$

4) Minimum Punch diameter

$$dimin = di - ti$$

dimin = Minimum Punch diameter
di = 57.485mm (nominal punch diameter)
ti = 0.06 (work tolerance of punch)

$$dimin = 57.485 - 0.06 = 57.425mm$$

E. Blank Holder Force

Blank-holder pressure (P) is decided based on the finite element analysis of metal flow. From table 3 the value is selected as 1.53MPa

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, austenitic	1000	7
Copper	175-250	1.25-1.75
Brass	200-300	1.40-2.0

Table 3:

$$Pd1 = P \text{ X area of sheet metal holding}$$
$$= 1.53 \text{ X} \frac{\pi}{4} [D^2 - d^2]$$
$$= 1.53 \text{ X } \frac{\pi}{4} [130^2 - 57.485^2]$$
$$= 16.74 \text{ kN}$$

Pd1 = Blank Holder Force
P = blank holder pressure
D = 130mm (Blank Diameter)
d = 57.485mm (punch diameter)

F. Draw Force (F)

$$F = \pi dT(UTS)\left[\frac{D}{d} - 0.7\right]$$

D = 130mm (Blank Diameter)
d = 57.485mm (punch diameter)
UTS = 275 MPa
T = 1 mm

$$F = \pi \times 57.485 \times 1(275)\left[\frac{130}{57.485} - 0.7\right]$$
$$F = 77.5 \text{ KN}$$

G. Total Ram Force Required (T) = Draw Force + Blank Holder Force

= F + Pd1
= 77.5 + 16.74
= 94.24 KN

V. CONCLUSION

Within these paper, work involves the deep drawing parameters optimization. The detailed study of deep drawing and embossing, various affecting parameters has assisted us to gain deeper knowledge. By performing simulation of a deep drawing process company will be directly benefited as the work will help them to improve quality to reduce both time and effort. In this study design calculations of deep drawing process is presented based on the data gathered.

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