DATE | | SHEET NO.

Experiment no. 2 :- Deep Drawing

- **Aim of the experiment :-**

To learn the forming characteristics of sheet metal specimen with Deep Drawing Operation.

- **Objective :-**

(i) To do the deep drawing experiments of brass (or any metallic specimen) with the help of compression Testing machine.

(ii) To correlate the initial and final dimensions of the job.

(iii) To determine the deep drawing ratio of the material.

(iv) To determine the deep drawing load.

(v) To measure the thickness variation in the critically deep cup.

(vi) To study the nature of load displacement curve.

Equipment used :-

Deep drawing die, constant clearance blank holder, Punch, Compression Testing machine, blank (metallic sample), LVDT (Linear variable Differential Transducer), Load cell (Pressure transducer). Torque range, screw guage, vernier calipers, divider, screw driver, etc.

Theory :-

Deep drawing is a sheet metal drawing process in which a sheet metal blank is radially drawn into a forming die by mechanical action of the punch. It is thus a shape transformation process with material retention. The process is considered "deep" drawing transformation process. when the depth of the drawn part exceeds its diameter. This is achieved by redrawing the part through series of dies. The operation is carried out one pass with punch and dies as shown in fig.1. The material initially flat flanges of the blanks flows to form the walls of the cup. Due too the shrinkage of the outer periphery, circumferential compressive stress develops which might thicken the sheet or cause local buckling (wrinkling). The flange region (sheet metal in die shoulder area) experiences a radial drawing force and a tangential compressive stress develops ~~which~~ due to the material retention property. These compressive stresses (hoop stresses) result in flange wrinkles (wrinkles of the first order). wrinkles can be prevented by using a blank holder, the function of which is to facilitate controlled material flow into the die radius.

For all forming processes, some important solid material's properties are involved here.

Ductility :- is the ability of material to deform under tensile stress, this often characterised by the material's ability to be streched into wire.

Malleability :- is the ability of material to deform under compressive stress, this is often characterised by the materials property to form a thin sheet by hammering or rolling.

Formability :- Is the ability of material to undergo plastic deformation without being damaged. The mechanical properties are aspects of plasticity. the extent to which a solid material can be plastically deformed without fracture.

Drawing ratio :-

Fracture occurs in the wall of the cup when the forces necessary to draw the material from under the blank holder is more than what can be sustained by the wall of the cup, as the force has to be transmitted from the punch to the under-formed blank through the cup walls.

The limiting drawing ratio (LDR) i.e., β_0 is defined as the ratio of the maximum blank diameter (D_{max}) that can be safely drawn into a cup without flange to the punch diameter (d_p). The ratio of blank diameter (d_j) and the punch diameter (d_p) is called drawing ratio (β).

$$\beta_0 = \frac{D_{max}}{d_p} \qquad \beta = \frac{d_j}{d_p} \quad \text{and}$$

Subsequent deep drawing ratio,

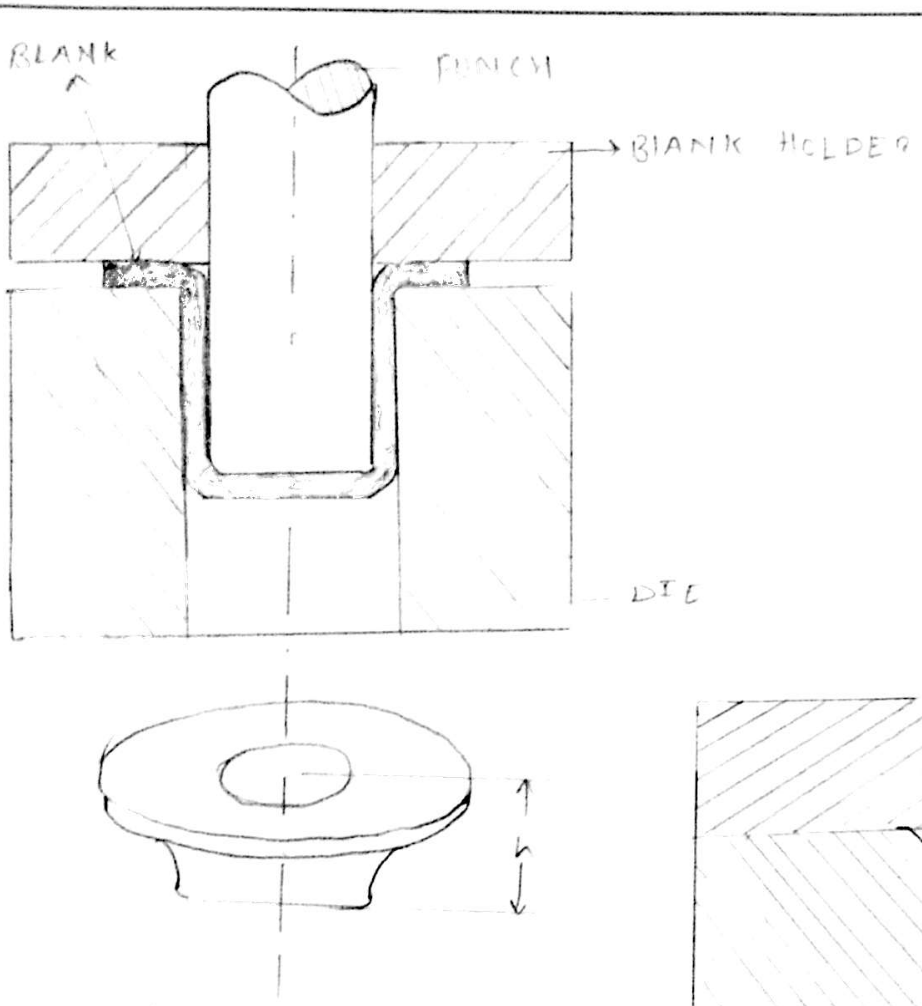
$$\beta_F = \frac{D_F}{d_i}.$$

Drawing force :-

The force on the punch required to produce a cup is the summation of the ideal force of deformation, the frictional forces and the force required to produce ironing (if present).

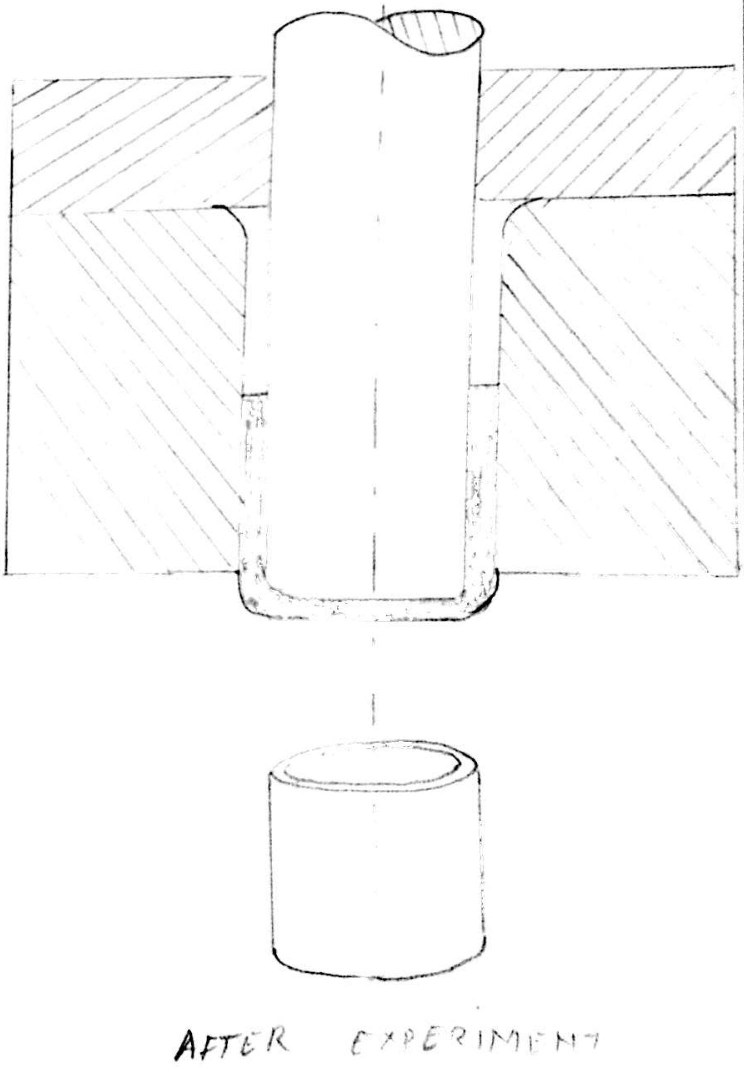
The drawing force depends upon the material property, its dimension (desired shape and size). The drawing force can be calculated using the following equation for cylindrical shell (or cup shape).

$$\boxed{F = \sigma_z \, 2\pi r_p t}$$



DURING EXPERIMENT

FIG-2



AFTER EXPERIMENT

FIG-3

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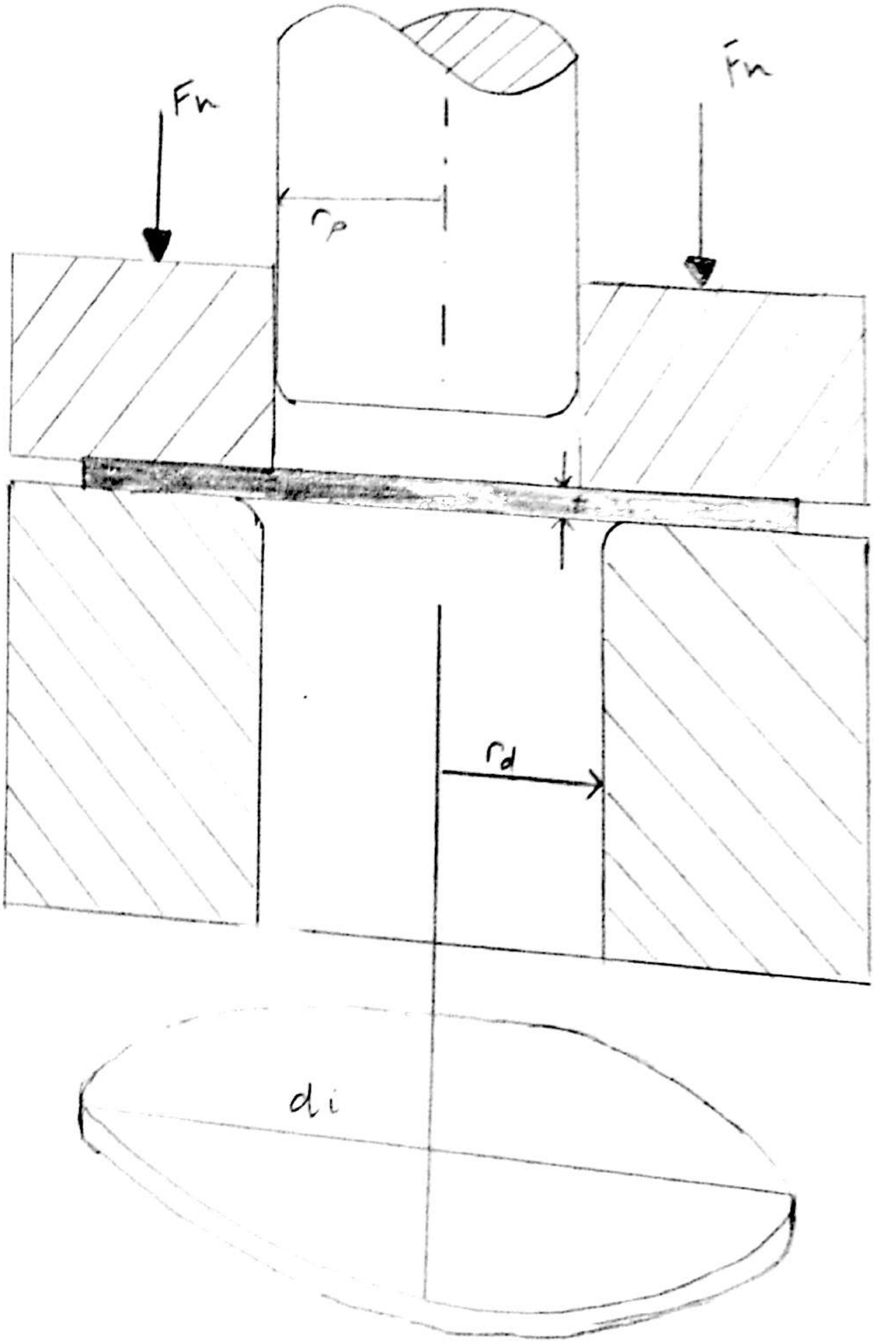


FIG 1

BEFORE EXPERIMENT

TABLE :1 SAMPLE THICKNESS AND DIAMETER

SAMPLE No.	THICKNESS (mm)			AVERAGE THICKNESS (mm)
1	0.52	0.60	0.58	0.57

SAMPLE NO.	DIAMETER (mm)			AVERAGE DIAMETER (mm)
1	64.92	66.18	66.02	65.71

TABLE :2 LOAD AND DISPLACEMENT

SAMPLE - 1	
CUP HEIGHT (h) (mm)	APPLIED LOAD (P) (kgf)
0.0	20
0.5	20
1.0	70
1.5	160
2.0	282
2.5	364
3.0	448
3.5	530
4.0	608

4.5	684
5.0	768
5.5	840
6.0	914
6.5	990
7.0	1054
7.5	1120
8.0	1174
8.5	1218
9.0	1254
9.5	1280
10.0	1300
10.5	1310
11.0	1302
11.5	1266
12.0	1212
12.5	1040
12.8	898
12.9	918
13.0	926

TABLE : 4 INNER, OUTER DIAMETERS AND HEIGHT OF CUP

Die corner radius, r_{cd} = 5.25 mm

Punch corner radius, r_{cp} = 4.25 mm

Punch diameter, d_p = 36.75 mm

SAMPLE NO.	OUTER DIAMETER D_F (mm)			AVG. OUTER DIAMETER D_F (mm)	DEPTH OF CUP h (mm)			AVG. DEPTH OF CUP, h (mm)
1	53.16	54.72	54.28	54.05	13.50	12.60	11.90	12.67

SAMPLE NO.	INNER DIAMETER D_i (mm)			AVG. INNER DIAMETER D_i (mm)
1	33.18	32.20	33.52	32.97

CALCULATIONS:

LDR (Limiting Drawing Ratio) β_0 $= \dfrac{D_{max}}{d_p} = \dfrac{65.71}{36.75} = 1.788$

subsequent drawing ratio β_F $= \dfrac{D_F}{d_i} = \dfrac{54.05}{32.97} = 1.639$

Drawing Force F $= \sigma_z . 2\pi r_p t = 275 \times 10^6 \times 2\pi \times \dfrac{36.75}{2} \times 0.57 \times 10^{-6}$ [redacted]

$= 18097.34$ [redacted] N

$= 1846.66$ kgf

RESULTS :

SAMPLES	SAMPLE -1
LDR, β_0	1.788
Subsequent Drawing Ratio, β_F	1.639
Calculated Drawing Force, F	1846.66 kgf
Experimental fracture load P_{max}	1310 kgf
Variations, $F \sim P_{max}$	536.66 kgf

Discussion:

1. How will the depth of cup with its diameter ratio >1 can be drawn?

Ans→ By using deep drawing process the depth of cup with its diameter ratio >1 can be drawn.

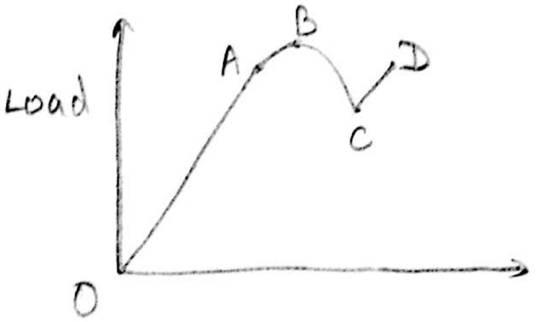
2. Would lubricant improve the deep drawing ratio?

Ans→ Yes lubricant would improve the deep drawing ratio. It reduces the coefficient of friction between the metal and blank, thus enhancing easy flow of metal.

3. How annealing can influence on deep drawing operation?.

Ans→ Annealing relieves the metal from internal stress. If internal stresses will be present in the material then ~~toe~~ more force is required for a particular displacement in comparison to the case when the internal stress is not present in the material.
So, annealing enhances the deep drawing operation.

4. Plot the displacement vs applied Load graphs and discuss the nature of the curves.



The force first increase linearly. Then it followed a curve from A to B and reached a maximum value of 1310 at point B. Then force decreased from B to C & after that increased to D.

5) What is the function of blank holder?

Ans → A deep drawn part's quality is affected significantly by the flow of metal into the die cavity. The force is exerted by blank holder on the sheet supplies a restraining force which controls the metal flow. This restraining action is largely applied through friction.

DISPLACEMENT VS APPLIED LOAD