WIRE DRAWING

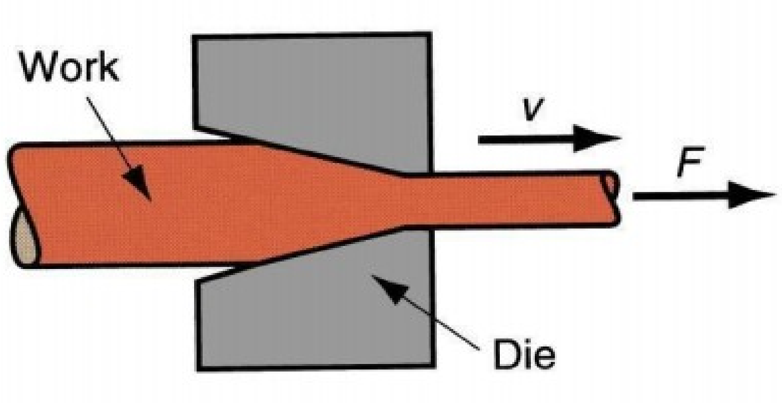
- A wire by definition, is circular with small diameters so that it is flexible. The process of wire drawing is to obtain wires from rods of bigger diameter through a die.

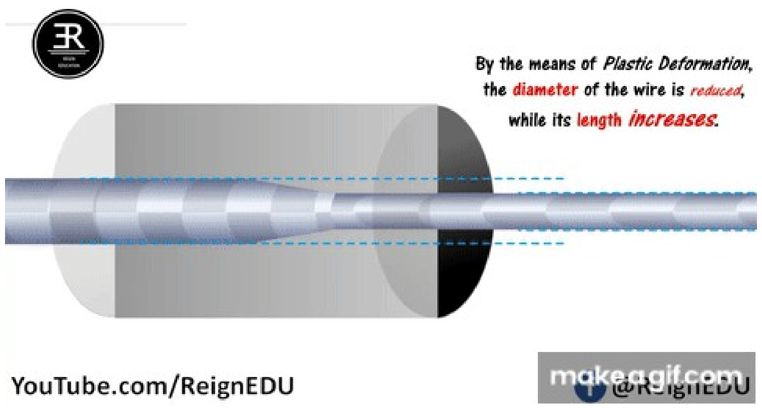
- The wiredrawing die is of conical shape.

- The end of the rod or wire, which is to be further reduced is made into a point shape and inserted through the die opening.

- This end is then gripped on the other side with a gripper, which would then pull the wire through the die. The wire thus drawn is then coiled round a power reel.

- Wire drawing is always a cold-working process.





SHEET METAL DRAWING

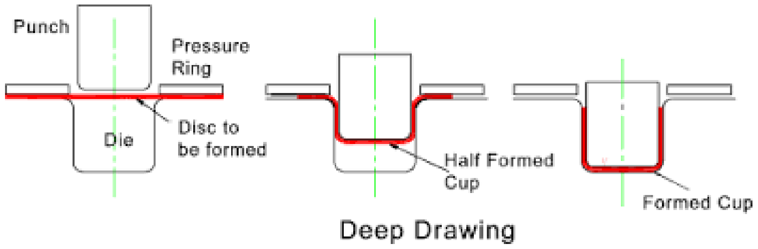
- Sheet metal is generally considered to be a plate with thickness less than about 5 mm.

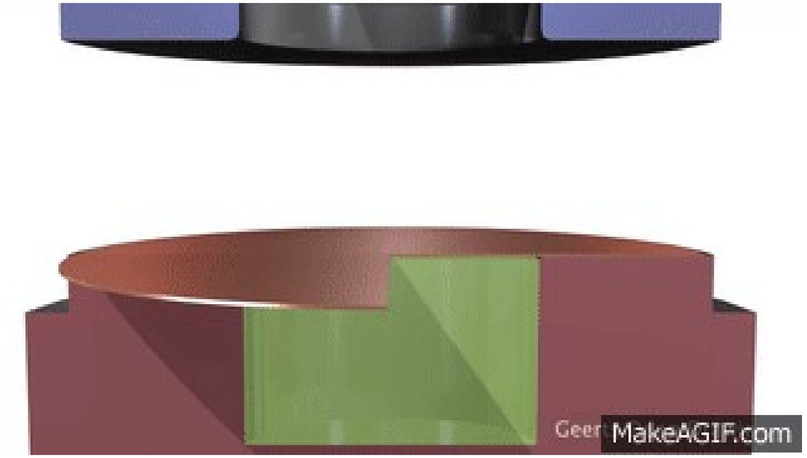
- Sheet metal operations are mostly cold working operations that manufacture low cost parts with very high volumes and at a fast rate.

- Sheet metal drawing is the process of making cups, shells and similar articles from metal sheet blanks.

- The blank is first kept on the die plate. The punch slowly descends on the blank and forces it to take the cup shape formed by the end of the punch, by the time it reaches the bottom of the die.

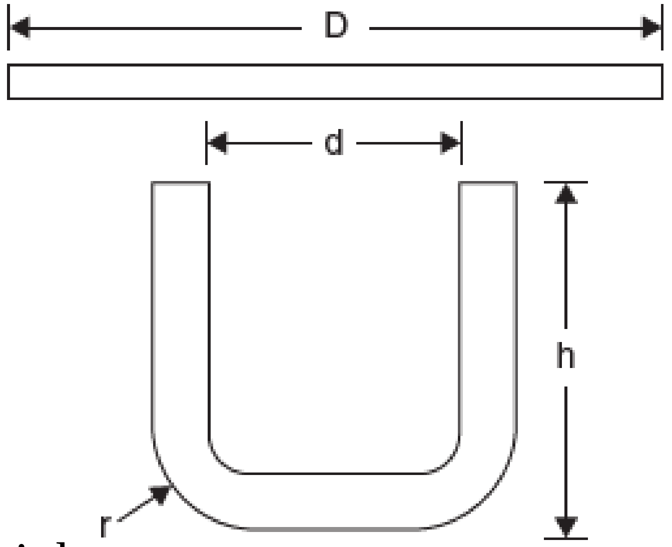
- Shallow drawing is defined as where the cup height is less than half the diameter. Otherwise it is referred to as deep drawing.





Deep Drawing

Deep drawing or drawing is defined as process for the making of cup-shaped parts from flat sheet metal blanks. The blank is first heated to provide necessary plasticity for working. The heated blank is then placed in position over the die or cavity. The punch descends and pushes the metal through the die to form a cup. So this process is also known as cupping (Figure)



Blank Diameter

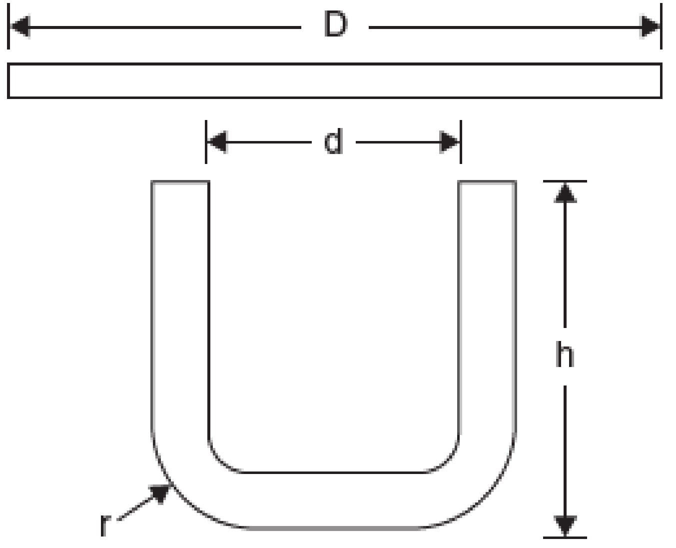
If D is the blank diameter in mm, r is the corner radius (in mm), h is the height of the shell as shown in Figure. Then for thin shells whose wall thickness is t and bottom thickness is T,

Deep Drawing

$$D = \sqrt{d^2 + 4dh}; \quad \text{for } 20 \le \frac{d}{r}$$

$$D = \sqrt{d^2 + 4dh - 0.5r}; \quad \text{for } 15 \le \frac{d}{r} < 20$$

$$D = \sqrt{d^2 + 4dh - r}; \quad \text{for } 10 < \frac{d}{r} < 15$$



If wall thickness t is not equal to bottom thickness T which is also the blank thickness. Since, volume before and after drawing is equal. Therefore, $D = \sqrt{d^3 + 4dh\frac{t}{T}}$.

To find a blank diameter for a shell of irregular C/S equal the weight before and after when a sample is available.

$$D = 1.1284\sqrt{\frac{w}{WT}};$$

where W = Weight of finished shells (g), and w = Weight of metal per cubic mm

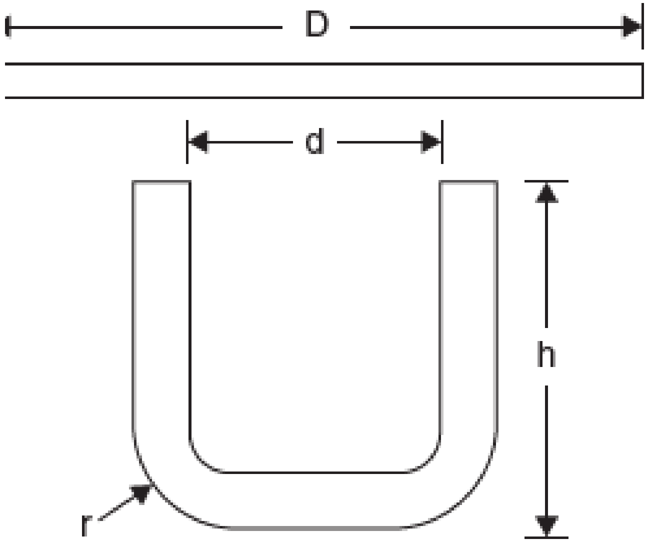
Deep Drawing

Number of Draws

The number of draws is based on the ratio of height and diameter of the cup as given in Table :

Table Number of Draws in Deep Drawing

h/d	Up to 0.7	0.7–1.5	1.5–3.0	3.0–7.0
Number of draws	1	2	3	4



where h, depth of cup; d, shell diameter; D, blank diameter.

$$\text{Percentage reduction} = \frac{D-d}{D} \times 100$$

Both the factors limit the reduction percentage; top limit for the first draw is in between 45 and 48% reduction. It is 30% for the second draw and is 20% for the third and subsequent draws. Total reduction should not be increased beyond 70–75%; it should be annealed and reduction may again start at the maximum percentage, number of draws does not exceed 3–4 in this way.

Deep Drawing - Numerical

A metal sheet of a thickness of 0.8 mm is to be drawn in a cup of circular cross-section with a diameter of 40 mm and height of 60 mm. The radius of the corner is given as 2 mm. The reduction ratio is 50 % for the first, 30 % for the second, and 16 % for the next successive draws. What will be the number of steps required to draw the cup?

Given Parameters

- Final Cup Diameter, $d = 40 \text{ mm}$
- Cup Height, $h = 60 \text{ mm}$
- Corner Radius, $r = 2 \text{ mm}$
- Sheet Thickness, $t = 0.8 \text{ mm}$ (This is used for reference but is not needed for the D calculation based on the provided geometry formulas.)

Deep Drawing - Numerical

Deep Drawing - Numerical

Calculation

$$D^2 = (40)^2 + 4(40)(60) - (2)(40)$$

$$D^2 = 1600 + 4(2400) - 80$$

$$D^2 = 1600 + 9600 - 80$$

$$D^2 = 11200 - 80$$

$$D^2 = 11120 \text{ mm}^2$$

$$D = \sqrt{11120} \approx \mathbf{105.45} \text{ mm}$$

The required **Initial Blank Diameter ($D_{initial}$)** is approximately 105.45 mm.

Deep Drawing - Numerical

Step 2: Determine the Number of Draws

The process starts with an initial blank diameter $D_0 \approx 105.45 \text{ mm}$ and must end with a final cup diameter $d_{final} = 40 \text{ mm}$.

The diameter after each draw (D_i) is calculated using the diameter of the previous draw (D_{i-1}) and the given reduction ratio (R_i):

$$R_i = \frac{D_{i-1} - D_i}{D_{i-1}} \implies D_i = D_{i-1}(1 - R_i)$$

Deep Drawing - Numerical

Draw 1 (Reduction Ratio, $R_1 = 50\%$ or 0.50):

$$D_1 = D_0(1 - R_1)$$

$$D_1 = 105.45 \text{ mm} \times (1 - 0.50)$$

$$D_1 = 105.45 \text{ mm} \times 0.50 = \mathbf{52.73} \text{ mm}$$

Since $D_1(52.73 \text{ mm})$ is greater than $d_{final}(40 \text{ mm})$, a second draw is required.

Adjusting the Final Draw

The target cup diameter is 40 mm. We must ensure the final draw results in exactly 40 mm. Since the diameter after Draw 1 is $D_1 = 52.73 \text{ mm}$, Draw 2 must reduce this to 40 mm.

Required Reduction for Draw 2 ($R_{2,\text{required}}$):

$$R_{2,\text{required}} = \frac{D_1 - d_{final}}{D_1} \times 100$$

$$R_{2,\text{required}} = \frac{52.73 \text{ mm} - 40 \text{ mm}}{52.73 \text{ mm}} \times 100$$

$$R_{2,\text{required}} = \frac{12.73}{52.73} \times 100 \approx \mathbf{24.14\%}$$

The required final reduction (24.14%) is **less than** the maximum allowable reduction for the second draw (30%). Therefore, the second draw can achieve the final 40 mm cup diameter.

Draw 2 (Reduction Ratio, $R_2 = 30\%$ or 0.30):

$$D_2 = D_1(1 - R_2)$$

$$D_2 = 52.73 \text{ mm} \times (1 - 0.30)$$

$$D_2 = 52.73 \text{ mm} \times 0.70 = \mathbf{36.91} \text{ mm}$$

*Since $D_2(36.91 \text{ mm})$ is **less** than the target final diameter $d_{final}(40 \text{ mm})$, this means that the 30% reduction is too large and overshoots the final size.*

📝 Conclusion

The cup can be drawn in **2 steps (draws)**:

1. **Draw 1:** Reduces the blank from $\approx 105.45 \text{ mm}$ to 52.73 mm (50% reduction).
2. **Draw 2:** Reduces the cup from 52.73 mm to the final 40 mm (24.14% reduction).

APPLICATIONS OF METAL FORMING

- Automotive Manufacturing: Automobile body panels
- Aerospace Engineering: Airplane fuselage, wings and engine components
- Construction: Pipelines