1 Objective

Design a technological process of cutting/drawing/redrawing to make the following aluminium sheet metal cylindrical component.

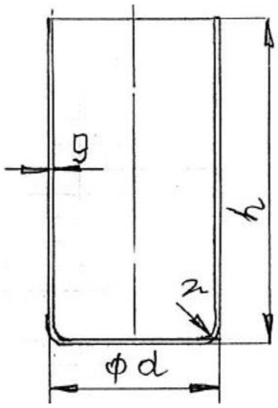


Figure 1 Aluminium sheet metal cylinder

The dimensions are given below:

Table 1 Dimensions of aluminium sheet metal cylinder

d	h	r	g
mm	mm	mm	mm
98	150	4	2

2 Blanking (cutting) operation design

2.1 Blank diameter D

2.1.1 Assumptions

- Thickness of the component and the blank is equal.
- Trimming allowance of h'=0.08h.

2.1.2 Calculation

We know that,

$$Blank\ diameter = \sqrt{d^2 + 4dh}$$

After putting the values,

$$Blank\ diameter = \sqrt{98^2 + 4 \times 98 \times 150} = 261.5\ mm$$

We have following formula trim allowance,

$$Trim\ allowance = 0.08h = 0.08 \times 150 = 12\ mm$$

Considering bottom inner radius,

Considering bend angle = 1 degree.

Hence,

$$Length\ required\ for\ bend\ angle\ =\ 2 \times \left(\frac{\pi}{180} \times 4\right) = 0.14\ mm$$

Taking into account the bottom inner radius r and assuming trimming allowance,

$$Final\ blank\ diameter$$
$$= blank\ diameter + trim\ allowance +\ Length\ required\ for\ bend\ angle$$

$$Final\ blank\ diameter, D = 261.5 + 12 + 0.14 = \mathbf{273.64\ mm}$$

2.2 Calculation of cutting force

We have,

$$R_{\ cut} = 200\ MPa$$

Force required for cutting,

$$F_{cut} = lgR_{\ cut}$$

l is length of cut edge.

Hence, after putting the values,

$$F_{cut} = (\pi \times D)gR_{\ cut} =\ (\pi \times 273.64) \times 2 \times 200 = \mathbf{343.87\ kN}$$

2.3 Cutting clearance between the cutting punch and the die

Cutting clearance can be calculated as,

$$Cutting\ clearance, c = cutting\ allowance\ \times g$$

Assuming cutting allowance = 0.075

Hence,

$$Cutting\ clearance, c = 0.075\ \times 2 = 0.15\ mn$$

3 Drawing & redrawing operation design

3.1 Calculation of $(m_1)_{min}$, $(m_2)_{min}$ and $(m_3)_{min}$

$$Relative\ thickness = \left(\frac{g}{D}\right) \times 100 = \frac{2}{273.64} \times 100 = 0.73$$

By interpolating between the table values, available in Table 1 and Table 2,

	Relative thickness (g/D)x100		
	1	**0.73**	0.5
$(m_1)_{min}$	0.53	**0.54**	0.56
$(m_2)_{min}$	0.74	**0.75**	0.76
$(m_3)_{min}$	0.76	**0.77**	0.78
$(m_4)_{min,\ we}$	0.78	**0.79**	0.80
$(m_5)_{min}$	0.80	**0.81**	0.82

3.2 Number of operations required

$$m_{tot} = \frac{(d-g)}{D} = \frac{(98-2)}{273.64} = 0.35$$

After multiplying initial three drawing/redrawing coefficient, we can satisfy the conditions

$$(m_1)_{min} \times (m_2)_{min} \times (m_3)_{min} < m_{tot}$$

Hence number of operation required = three.

3.3 Choice of m_1, m_2 and m_3

We can select,

$$m_1 = (m_1)_{min} = 0.54$$

$$m_2 = (m_2)_{min} = 0.75$$

And,

$$m_3 = \frac{m_{tot}}{(m_1)_{min} \times (m_2)_{min}} = 0.864$$

3.4 Dimensions of cup

We have internal radius,

- In drawing operation (m_1) = 1.5r = 6 mm.
- In first redrawing operation (m_2) = 1.5r = 5 mm.
- In last redrawing operation (m_3) = r = 4 mm.

3.4.1 Drawing operation

We have,

$$m_1 = \mathrm{d}_1/\mathrm{D} = 0.54$$

After putting the value,

$$\mathrm{d}_1 = 0.54 \times D = 147.77\ mm$$

Assuming the same surface area & bend angle = 1 degree

$$D = \sqrt{d_1{}^2 + 4d_1 h}$$

Hence,

$$h = \frac{D^2 - d_1{}^2}{4d_1} = \frac{D^2 - d_1{}^2}{4d_1} = \frac{273.64^2 - 147.77^2}{4 \times 147.77} = 89.74\ mm$$

3.4.2 First redrawing operation

We have,

$$m_2 = \mathrm{d}_2/\mathrm{d}_1 = 0.75$$

After putting the value,

$$\mathrm{d}_2 = 0.75 \times \mathrm{d}_1 = 110.83\ mm$$

Assuming the same surface area & bend angle = 1 degree

$$\mathrm{d}_1 = \sqrt{\mathrm{d}_2{}^2 + 4\mathrm{d}_2\, h_1}$$

Hence,

$$h_1 = \frac{\mathrm{d}_1{}^2 - \mathrm{d}_2{}^2}{4\mathrm{d}_2} = \frac{147.77^2 - 110.83^2}{4 \times 110.83} = 21.55\ mm$$

3.4.3 Last redrawing operation

We have,

$$m_3 = \mathrm{d}_3/\mathrm{d}_2 = 0.864$$

After putting the value,

$$d_3 = 0.864 \times d_2 = 95.76\, mm$$

Assuming the same surface area & bend angle = 1 degree

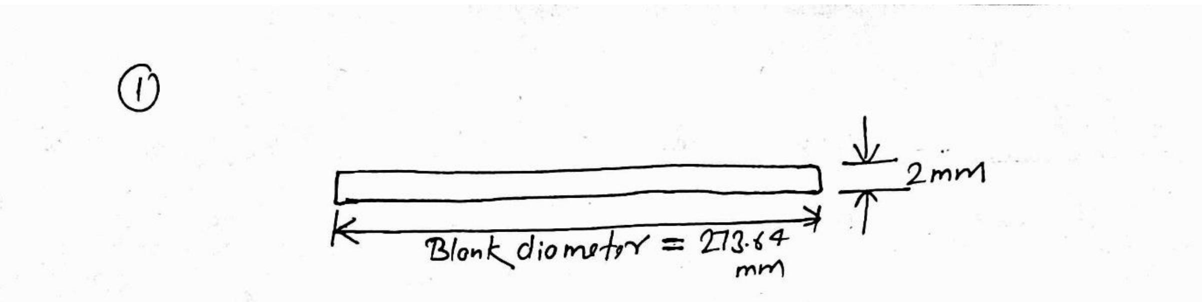
$$d_2 = \sqrt{d_3{}^2 + 4d_3\, h_2}$$

Hence,

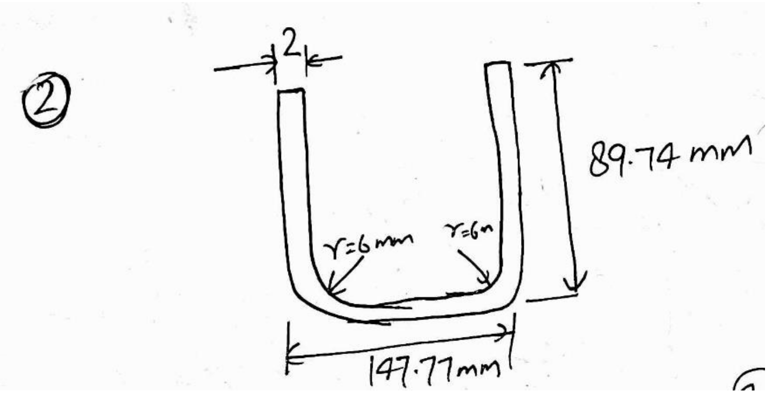
$$h_2 = \frac{d_2{}^2 - d_3{}^2}{4d_3} = \frac{110.83^2 - 95.76^2}{4 \times 95.76} = 8.12\, mm$$

3.5 Diagram of product after each stage

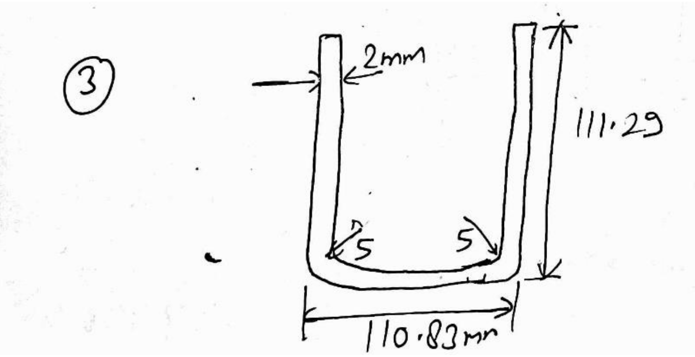
3.5.1 Product after Blanking (cutting)



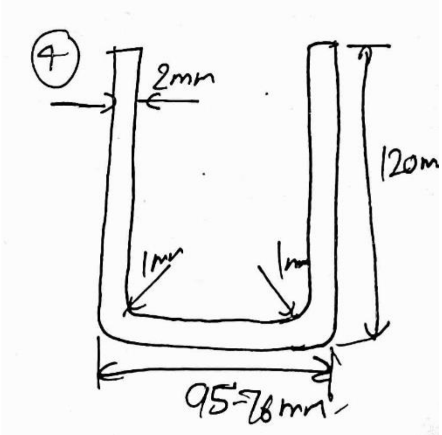
3.5.2 Product after drawing



3.5.3 Product after first redrawing



3.5.4 Product after last redrawing



3.6 Requirement of blank holder

3.6.1 For drawing

For drawing: $100g/D \leq 5\ (1 - m_1)$

After putting values, it satisfy the condition hence blank holder is required.

3.6.2 For 1st redrawing

For redrawing: $100g/d1 \leq 1/m2$

After putting values, it does not satisfy the condition hence blank holder is not required.

3.6.3 For 2ndt redrawing

For redrawing: $100g/d2 \leq 1/m3$

After putting values, it does not satisfy the condition hence blank holder is not required.

3.7 Setup sketch at different steps