Operaciones de Embutido

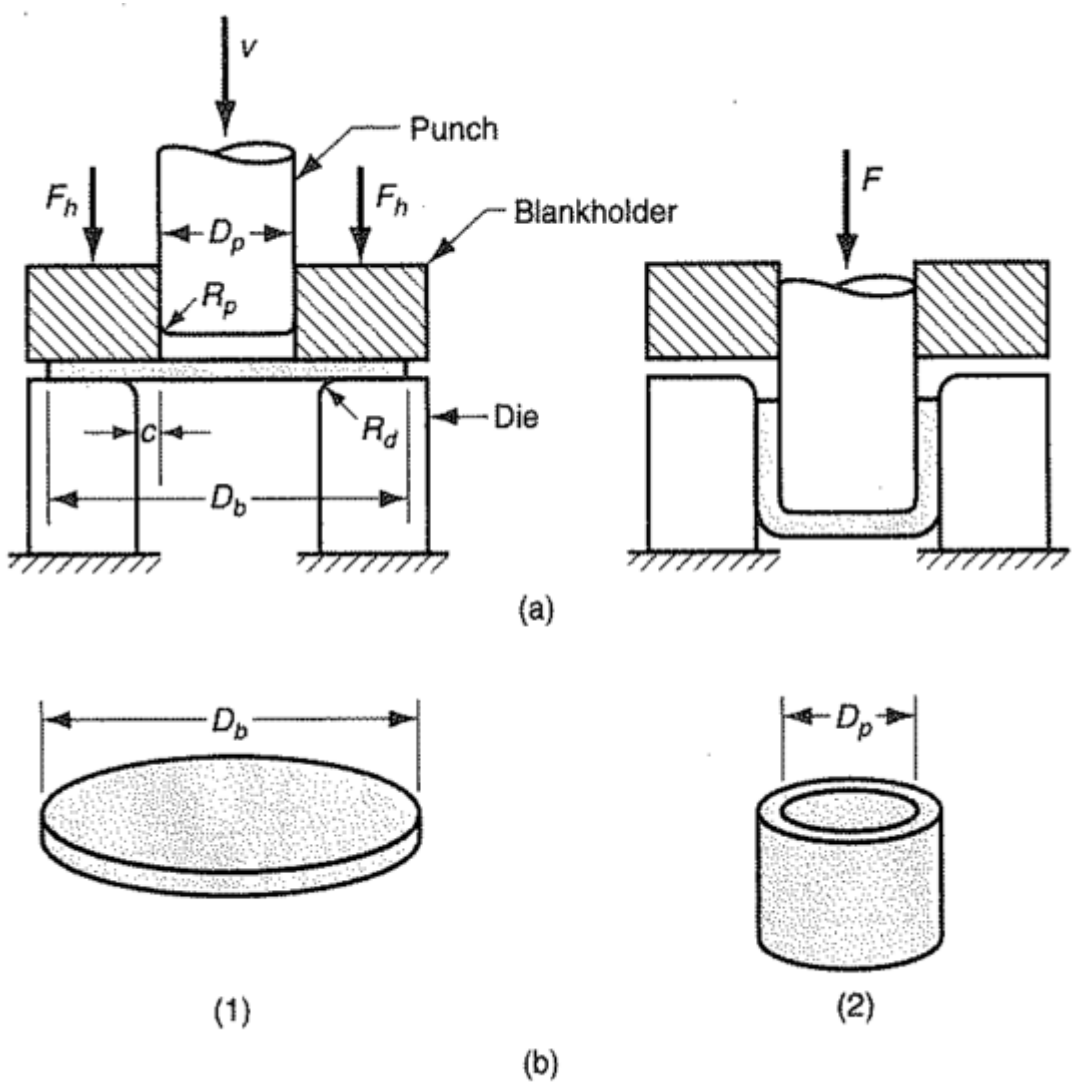
- **Embutido**
- **Reembutido**
- **Reembutido Inverso**
- Embutido de Piezas no cilíndricas
- Embutido sin Sujetador

Embutido

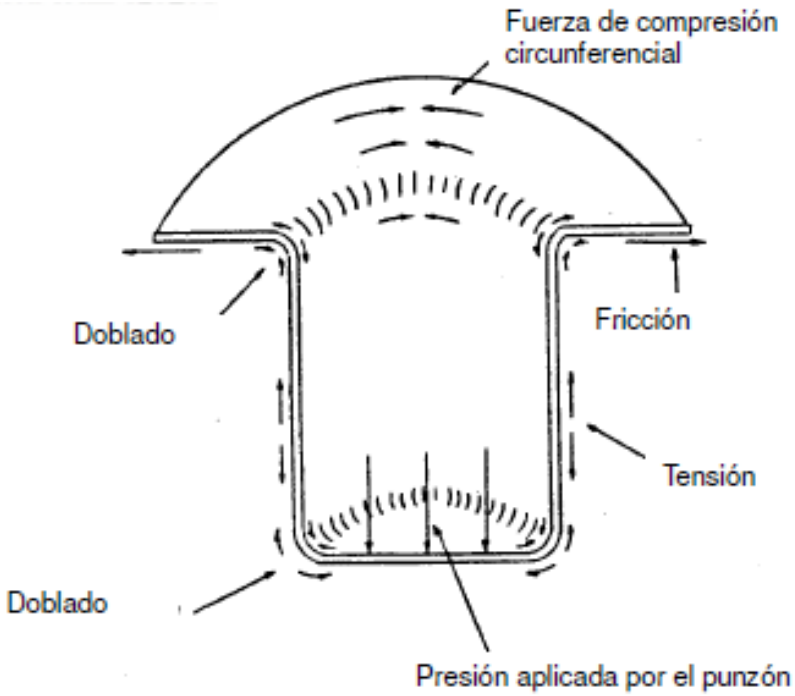
Operación de conformado de láminas para obtener piezas que puedan contener líquidos (cerradas).

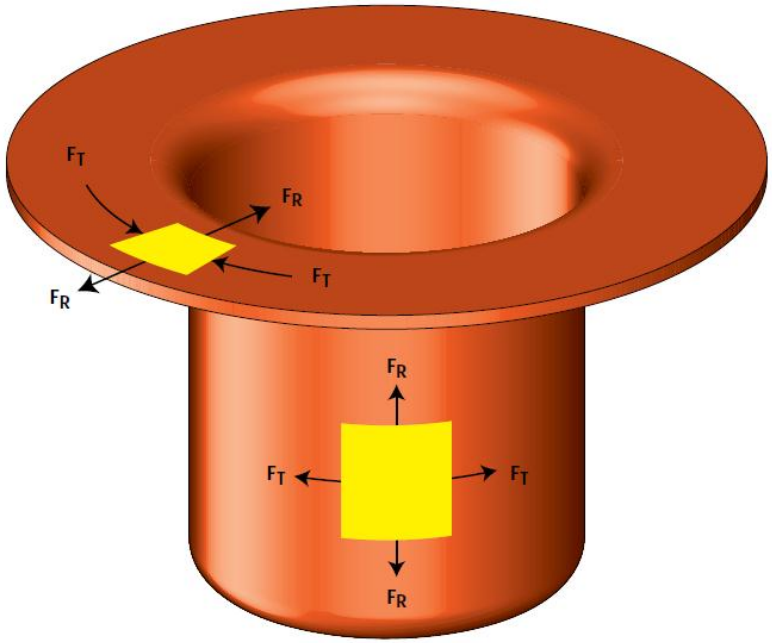
Ejemplo: Cacerolas, Fuentes, Piletas de cocina, Carter de motores, etc.

Mecánica del Embutido

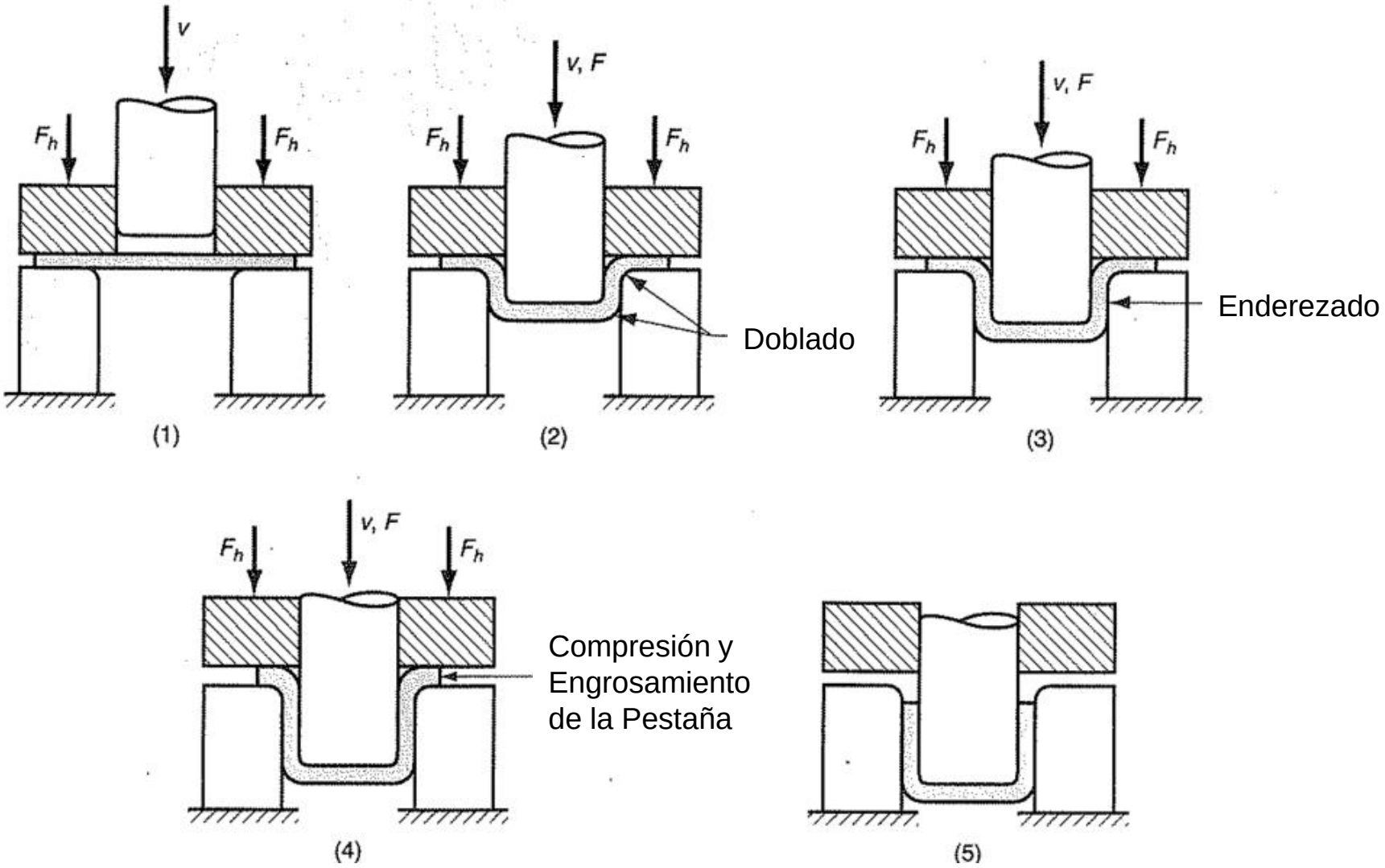


Tensiones durante el Embutido





Deformaciones durante el Embutido



Variaciones del espesor luego del Embutido

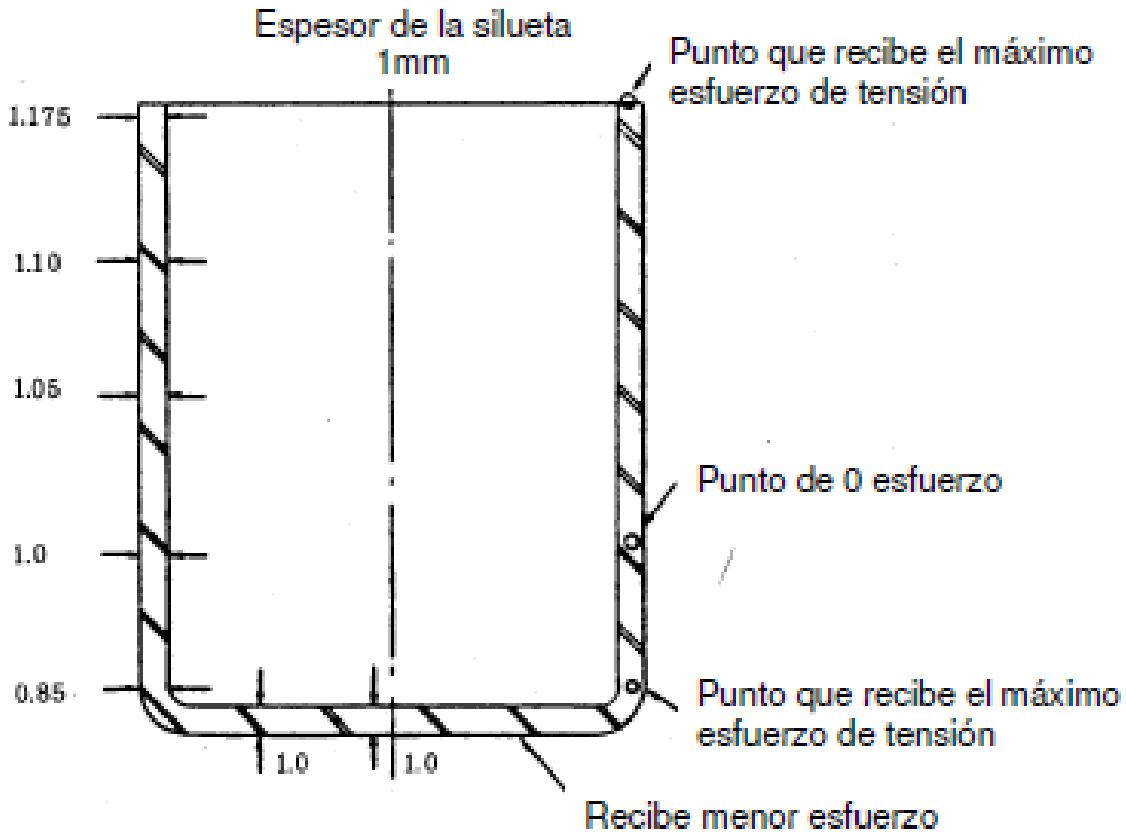
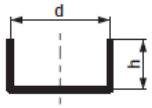
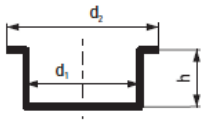
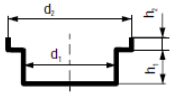
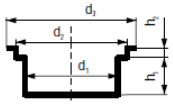
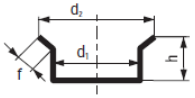
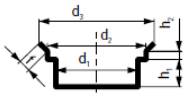
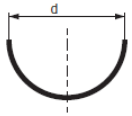
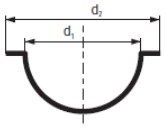
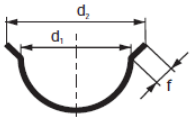
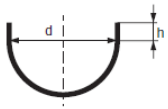


Figura 1.4: Variación del espesor del material en caso del embutido de vaso con fondo plano

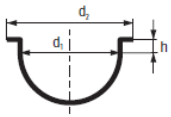
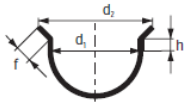
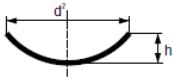
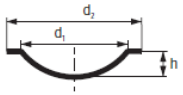
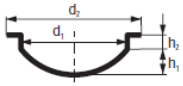
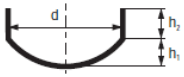
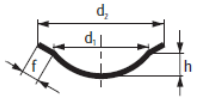
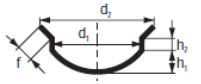
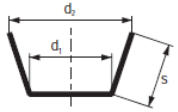
Calculo del desarrollo (Diámetro del Disco Primitivo)

Container shape *(cross-section)* rotationally symmetrical shapes		Blank diameter D =
1		$\sqrt{d^2 + 4 \cdot d \cdot h}$ *
2		$\sqrt{{d_2}^2 + 4 \cdot d_1 \cdot h}$ *

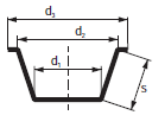
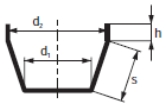
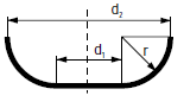
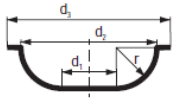
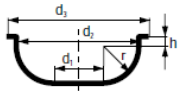
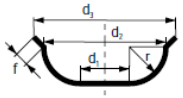
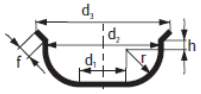
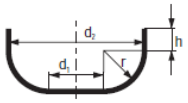
Container shape *(cross-section)* rotationally symmetrical shapes		Blank diameter D =
3		$\sqrt{{d_2}^2 + 4 \cdot (d_1 \cdot h_1 + d_2 \cdot h_2)}$ *
4		$\sqrt{{d_3}^2 + 4 \cdot (d_1 \cdot h_1 + d_2 \cdot h_2)}$ *
5		$\sqrt{{d_1}^2 + 4 \cdot d_1 \cdot h + 2 \cdot f \cdot (d_1 + d_2)}$ *
6		$\sqrt{{d_2}^2 + 4 \cdot (d_1 \cdot h_1 + d_2 \cdot h_2) + 2 \cdot f \cdot (d_2 + d_3)}$ *
7		$\sqrt{2 \cdot d^2} = 1.414 \cdot d$
8		$\sqrt{{d_1}^2 + {d_2}^2}$
9		$1.414 \cdot \sqrt{{d_1}^2 + f \cdot (d_1 + d_2)}$
10		$1.414 \cdot \sqrt{d^2 + 2 \cdot d \cdot h}$

* *Containers with small (bottom) radii r < 10 mm*

Calculo del desarrollo (Diámetro del Disco Primitivo)

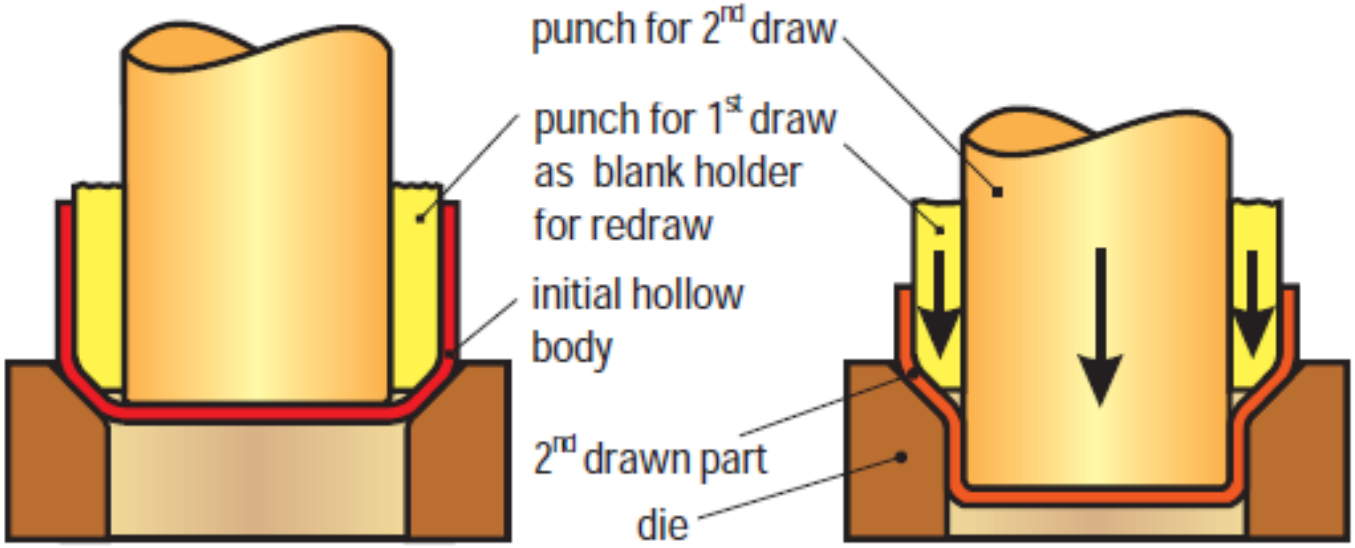
	Container shape *(cross-section)* rotationally symmetrical shapes	Blank diameter D =
11		$\sqrt{d_1^2 + d_2^2 + 4 \cdot d_1 \cdot h}$
12		$1.414 \cdot \sqrt{d_1^2 + 2 \cdot d_1 \cdot h + f \cdot (d_1 + d_2)}$
13		$\sqrt{d^2 + 4 \cdot h^2}$
14		$\sqrt{d_2^2 + 4 \cdot h^2}$
15		$\sqrt{d_2^2 + 4 \cdot (h_1^2 + d_1 \cdot h_2)}$
16		$\sqrt{d^2 + 4 \cdot (h_1^2 + d \cdot h_2)}$
17		$\sqrt{d_1^2 + 4 \cdot h^2 + 2 \cdot f \cdot (d_1 + d_2)}$
18		$\sqrt{d_1^2 + 4 \cdot [h_1^2 + d_1 \cdot h_2 + 0.5 \cdot f \cdot (d_1 + d_2)]}$
19		$\sqrt{d_1^2 + 2 \cdot s \cdot (d_1 + d_2)}$ *

* *Containers with small (bottom) radii r < 10 mm*

	Container shape *(cross-section)* rotationally symmetrical shapes	Blank diameter D =
20		$\sqrt{d_1^2 + 2 \cdot s \cdot (d_1 + d_2) + d_3^2 - d_2^2}$ *
21		$\sqrt{d_1^2 + 2 \cdot [s \cdot (d_1 + d_2) + 2 \cdot d_2 \cdot h]}$ *
22		$\sqrt{d_1^2 + 6.28 \cdot r \cdot d_1 + 8 \cdot r^2}$ or $\sqrt{d_2^2 + 2.28 \cdot r \cdot d_2 - 0.56 \cdot r^2}$
23		$\sqrt{d_1^2 + 6.28 \cdot r \cdot d_1 + 8 \cdot r^2 + d_3^2 - d_2^2}$ or $\sqrt{d_3^2 + 2.28 \cdot r \cdot d_2 - 0.56 \cdot r^2}$
24		$\sqrt{d_1^2 + 6.28 \cdot r \cdot d_1 + 8 \cdot r^2 + 4 \cdot d_2 \cdot h + d_3^2 - d_2^2}$ or $\sqrt{d_3^2 + 4 \cdot d_2 \cdot (0.57 \cdot r + h) - 0.56 \cdot r^2}$
25		$\sqrt{d_1^2 + 6.28 \cdot r \cdot d_1 + 8 \cdot r^2 + 2 \cdot f \cdot (d_2 + d_3)}$ or $\sqrt{d_2^2 + 2.28 \cdot r \cdot d_2 + 2 \cdot f \cdot (d_2 + d_3) - 0.56 \cdot r^2}$
26		$\sqrt{d_1^2 + 6.28 \cdot r \cdot d_1 + 8 \cdot r^2 + 4 \cdot d_2 \cdot h + 2 \cdot f \cdot (d_2 + d_3)}$ or $\sqrt{d_2^2 + 4 \cdot d_2 \cdot (0.57 \cdot r + h + 0.5 \cdot f) + 2 \cdot d_3 \cdot f - 0.56 \cdot r^2}$
27		$\sqrt{d_1^2 + 4 \cdot (1.57 \cdot r \cdot d_1 + 2 \cdot r^2 + d_2 \cdot h)}$ or $\sqrt{d_2^2 + 4 \cdot d_2 \cdot (0.57 \cdot r + h) - 0.56 \cdot r^2}$

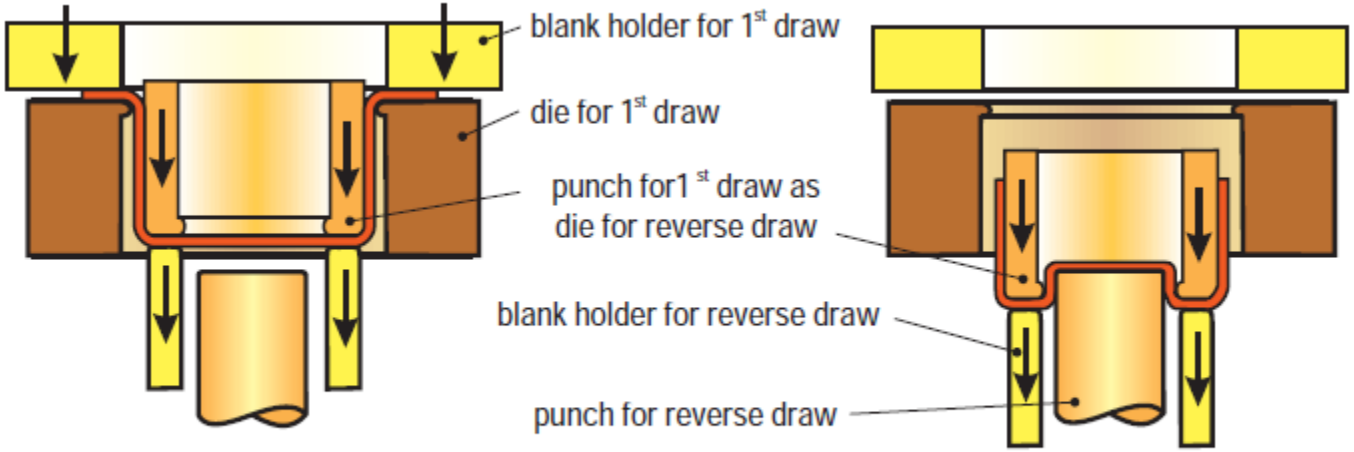
* *Containers with small (bottom) radii r < 10 mm*

Reembutido



▲ **Fig. 2.1.11** Multiple-draw deep drawing with telescopic punch

Embutido Inverso

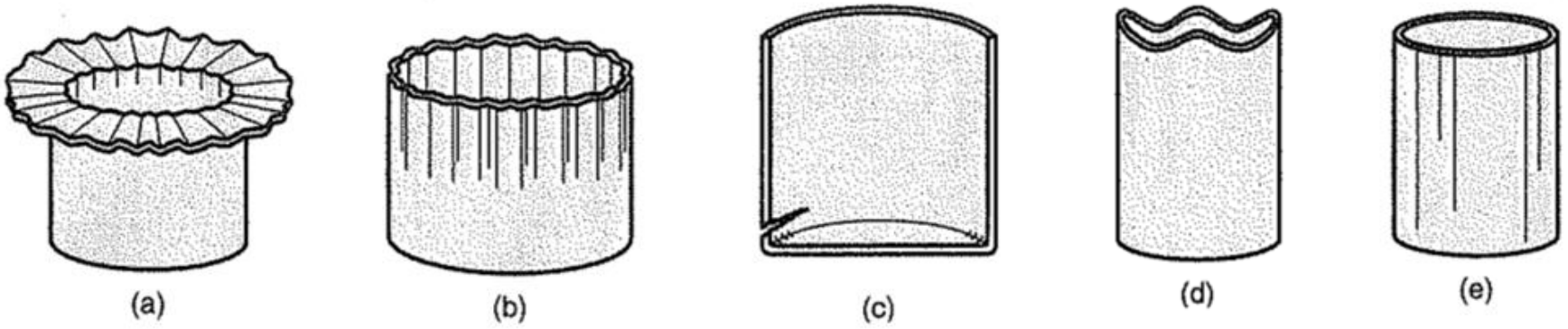


▲ **Fig. 2.1.12** Reverse drawing

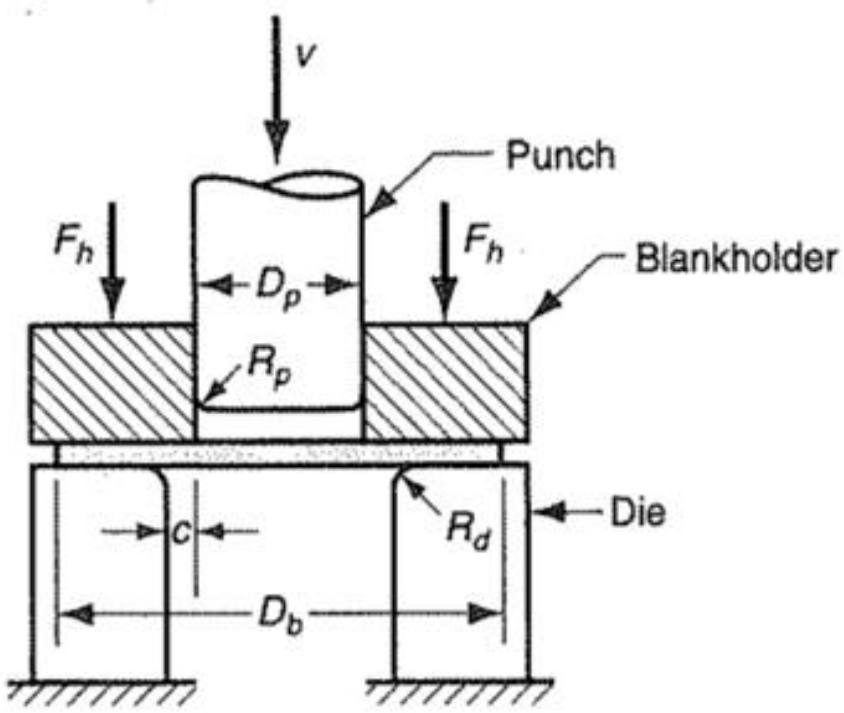
Embutido de Piezas no Cilíndricas

Defectos de Piezas Embutidas

(a) Arrugamiento en la pestaña;
(b) Arrugamiento en la pared;
(c) Desgarrado;
(d) Orejeado;
(e) Rayado superficial;



Consideraciones para el Diseño de una Matriz de Embutido



- Radio de embutido $\mathbf{R_d = 6t}$ (valor recomendado para embutidos exigidos, puede ser menor para embutidos menos severos)
- Radio de la nariz del punzón $\mathbf{R_p = 5t}$ (idem anterior)
- Luz entre matriz y punzón **c = 1,1t**