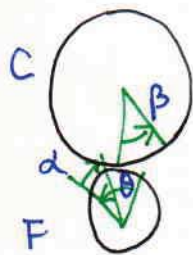


3) (2) Vista frontal
F, C

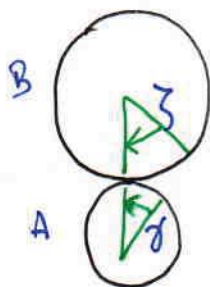


θ : ángulo de torsión F inicial
 α : ángulo de restitución elástica en F
 β : ángulo de torsión inducido en C

$$\Rightarrow D_1 \alpha = D_2 \beta \Rightarrow \alpha = \frac{D_2}{D_1} \beta$$

(2)

Vista frontal
A, B

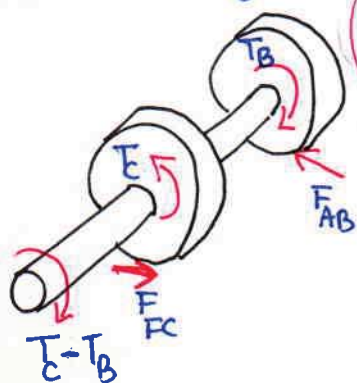


γ : ángulo de torsión inducido en A
 ζ : ángulo de torsión inducido en B

$$\Rightarrow \zeta = \frac{D_1}{D_2} \gamma$$

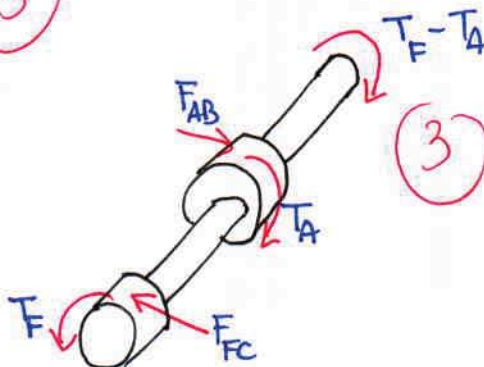
(2)

DCL eje MCB



(3)

DCL eje FAK



(3)

F_{FC} , F_{AB} fuerzas contactos engranajes

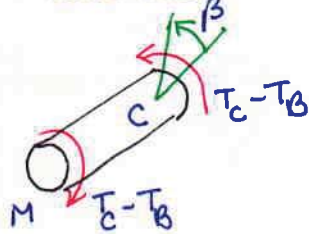
De los diagramas anteriores se tiene

14

$$\textcircled{3} \left. \begin{aligned} T_C &= F_{FC} \frac{D_2}{2} & T_B &= F_{AB} \frac{D_2}{2} & T_F &= F_{FC} \frac{D_1}{2} & T_A &= F_{AB} \frac{D_1}{2} \end{aligned} \right\} \textcircled{\Delta}$$

torsión eje MCB

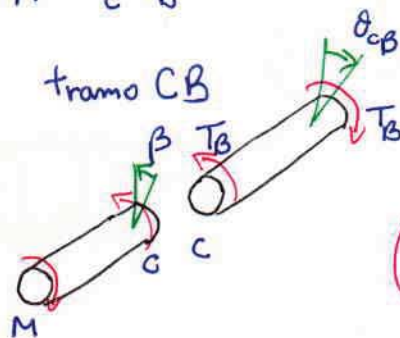
tramo MC



$$\Rightarrow \beta = \frac{(T_C - T_B) l}{GJ}$$

$$\Rightarrow \gamma = \beta - \theta_{CB}$$

tramo CB

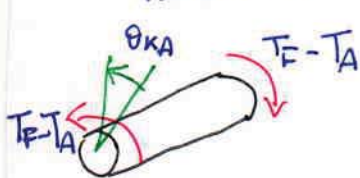


$$\theta_{CB} = \frac{T_B L}{GJ}$$

$$\textcircled{2} \gamma = \frac{(T_C - T_B) l}{GJ} - \frac{T_B L}{GJ} \quad \textcircled{***}$$

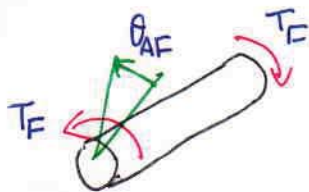
torsión eje FAK

Tramo A-K



$$\Rightarrow \theta_{KA} = \frac{(T_F - T_A) l}{GJ}$$

Tramo AF



$$\Rightarrow \theta_{AF} = \frac{T_F L}{GJ}$$

$$\underbrace{\text{ángulo total en F}}_{\theta - \alpha} = \theta_{KA} + \theta_{AF}$$

5) luego

$$\theta - \alpha = \frac{(T_F - T_A)l}{GJ} + \frac{T_F l}{GJ}$$

☆☆☆

①

De las figuras anteriores se tiene $\theta_{KA} = \gamma$, luego de
⊛ y ⊛⊛ se tiene

① $\gamma = \frac{D_1}{D_2} \frac{(T_F - T_A)l}{GJ}$, por lo que ⊛⊛⊛ queda como

⊙ $\frac{D_1}{D_2} \frac{(T_F - T_A)l}{GJ} = \frac{(T_C - T_B)l}{GJ} - \frac{T_B l}{GJ}$

②

De ⊛⊛ y ⊛ se tiene

$$\alpha = \frac{D_2}{D_1} \frac{(T_C - T_B)l}{GJ}, \text{ por lo que } \textcircled{\text{☆☆}} \text{ queda como}$$

⊙ $\theta - \frac{D_2}{D_1} \frac{(T_C - T_B)l}{GJ} = \frac{(T_F - T_A)l}{GJ} + \frac{T_F l}{GJ}$

②

De ⊙ en ⊙ y ⊙ tenemos dos ecuaciones para
 F_{AB} , F_{FC} y se obtiene

$$F_{FC} = \frac{2D_1 GJ [D_2^2(l+L) - D_1^2 l] \theta}{L [l(D_2^4 - D_1^4) + D_1^2 D_2^2 (2l+L)]} = 26275.1 \text{ N}$$

①

$$F_{AB} = \frac{2D_1 (D_2^2 - D_1^2) GJ l \theta}{L [l(D_2^4 - D_1^4) + D_1^2 D_2^2 (2l+L)]} = 5385.58 \text{ N}$$

①

luego de (A) se tiene

(6)

$$T_C = 5255.02 \quad T_B = 1077.12 \quad T_F = 1970.63$$

$$T_A = 403.919 \text{ Nm}$$

(2)

Para el eje MCB tramo MB

$$\textcircled{1} \quad z_{\max} = \frac{(T_C - T_B) d/2}{J} = 170.223 \text{ MPa}$$

tramo CB

$$\textcircled{1} \quad z_{\max} = \frac{T_B d/2}{J} = 43.8857 \text{ MPa}$$

Para el eje FAK tramo AK

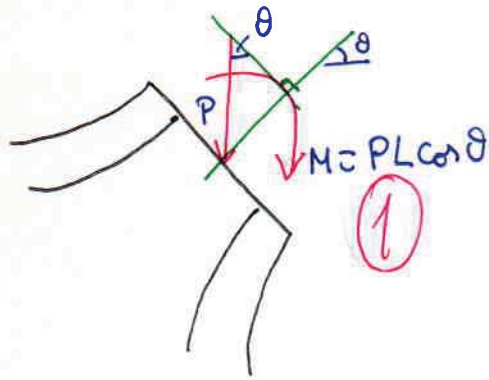
$$\textcircled{1} \quad z_{\max} = \frac{(T_F - T_A) d/2}{J} = 63.8337 \text{ MPa}$$

tramo AF

$$z_{\max} = \frac{T_F d/2}{J} = 80.2908 \text{ MPa}$$

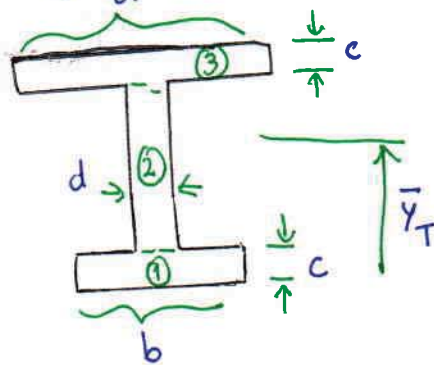
7]

③

Vista corte A-A \rightarrow moviendo P a la nueva posición

$$\Rightarrow V = -P \cos \theta$$

Propiedades de área



$$\bar{y}_T = \frac{\bar{y}_1 A_1 + \bar{y}_2 A_2 + \bar{y}_3 A_3}{A_1 + A_2 + A_3}$$

$$\bar{y}_1 = \frac{c}{2}$$

$$A_1 = bc$$

$$\bar{y}_2 = \frac{h}{2}$$

$$A_2 = (h - 2c)d$$

$$\bar{y}_3 = h - \frac{c}{2}$$

$$A_3 = ac$$

$$\Rightarrow \bar{y}_T = 0.0464815 \text{ m}$$

①

$$I_T = \bar{I}_1 + \bar{I}_2 + \bar{I}_3$$

$$\bar{I}_1 = \frac{bc^3}{12} + A_1 (\bar{y}_T - \frac{c}{2})^2$$

$$\bar{I}_2 = \frac{d(h-2c)^3}{12} + A_2 (\bar{y}_T - \frac{h}{2})^2$$

$$\bar{I}_3 = \frac{ac^3}{12} + A_3 (h - \frac{c}{2} - \bar{y}_T)^2$$

$$\Rightarrow I_T = 8.3863 \times 10^{-7} \text{ m}^4$$

②

Esfuerzo de corte por corte puro

$$Z_{xy} = \frac{V}{It} \int_y g \xi dA$$

$$g = h - \bar{y}_T \quad (1)$$

Se tiene

$$\text{Para } -\bar{y}_c + c < y < h - c - \bar{y}_T$$

$$t = d \quad dA = d d\xi \quad (1)$$

$$\text{Para } h - c - \bar{y}_T < y < h - \bar{y}_T$$

$$t = a \quad dA = a d\xi \quad (1)$$

$$\text{Para } -\bar{y}_T < y < -\bar{y}_T + c$$

$$t = b \quad dA = b d\xi \quad (1)$$

$$\text{Zona (1) } -\bar{y}_T < y < -\bar{y}_T + c$$

$$Z_{xy}(y) = -\frac{P \cos \theta}{I_T b} \int_y g \xi dA$$

$$\begin{aligned} \text{pero } \int_y g \xi dA &= \int_y^{-\bar{y}_T + c} \xi b d\xi + \int_{-\bar{y}_T + c}^{h - c - \bar{y}_T} \xi d d\xi \\ &+ \int_{h - c - \bar{y}_T}^{h - \bar{y}_T} \xi a d\xi \end{aligned} \quad (1)$$

9]

$$\Rightarrow Z_{xy}(y) = -\frac{P \cos \theta}{I_T b} \frac{1}{2} \left\{ b [(c - \bar{y}_T)^2 - y^2] \right. \\ \left. + d [(h - c - \bar{y}_T)^2 - (c - \bar{y}_T)^2] \right. \\ \left. + a [(h - \bar{y}_T)^2 - (h - c - \bar{y}_T)^2] \right\} \quad (1)$$

$$\Rightarrow Z_{xy}(y) = -1.1155 \cdot 10^7 + 5.16334 \cdot 10^9 y^2 \quad (1)$$

Zona (2) $-\bar{y}_T + c < y < h - c - \bar{y}_T$

$$\Rightarrow Z_{xy}(y) = -\frac{P \cos \theta}{I_T d} \int_y^g \xi dA \quad (1)$$

$$\int_y^g \xi dA = \int_y^{h-c-\bar{y}_T} \xi d d\xi + \int_{h-c-\bar{y}_T}^{h-\bar{y}_T} \xi a d\xi$$

$$\Rightarrow Z_{xy}(y) = -\frac{P \cos \theta}{I_T d} \frac{1}{2} \left\{ d [(h - c - \bar{y}_T)^2 - y^2] \right. \\ \left. + a [(h - \bar{y}_T)^2 - (h - c - \bar{y}_T)^2] \right\} \quad (1)$$

$$\Rightarrow Z_{xy}(y) = -1.7581 \cdot 10^7 + 5.16334 \cdot 10^9 y^2 \quad (1)$$

Zona ③ $h - c - \bar{y}_T < y < h - y_T$

(1)

$$Z_{xy}(y) = -\frac{P \cos \theta}{I_T a} \int_y^{h - \bar{y}_T} \xi a d\xi$$

$$= -\frac{P \cos \theta}{2 I_T} [(h - \bar{y}_T)^2 - y^2]$$

$$= -5.80096 * 10^6 + 5.16334 * 10^9 y^2$$

(1)