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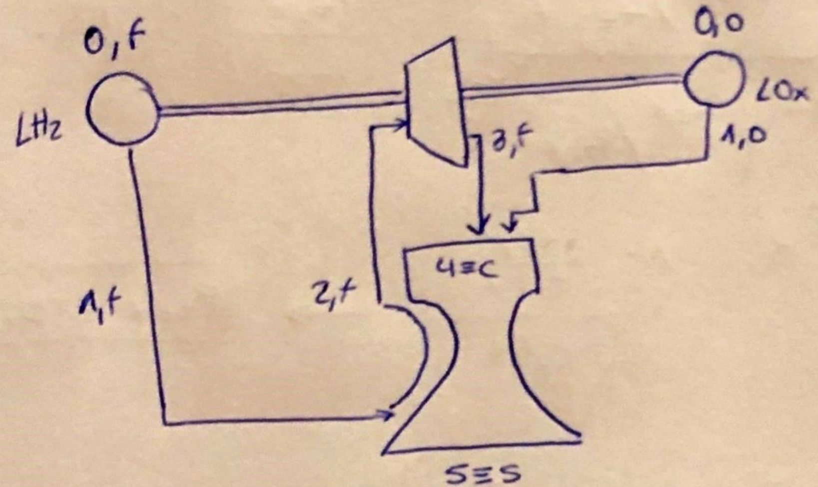
PROBLEMAS PEL - SEMANA 11

(1)



DATOS

$O/F = 6:1$

$\eta_t = 0{,}68$

$\eta_b = 0{,}6$

$\eta_{mec} = 0{,}88$

$\Delta p_{b,f} = 80\,bar$

$\Delta p_{b,o} = 40\,bar$

$Q_{comb}(298{,}15K) = 9\ MJ/s$

$\eta_{comb} = 1$

$T_{t2,f} = 325K$

$T_{t1,o} = 100K$

Perdidas $P_{t,f}$ en refrigeración: 15%

$(C_{D,Airy})_0 = 5{,}5cm^2$

$A_S = 184{,}5cm^2$

$\varepsilon = 30:1$

GASES IDEALES Y CAL. PERF

LÍQUIDOS IDEALES

(1) $P_{t3,f}$ y $T_{t3,f}$

Acoplamiento mecánico: $\eta_{mec}\dot{w}_t = \dot{w}_{b,o} + \dot{w}_{b,f}$

$$\dot{w}_{b,o} = \dot{m}_o \frac{\Delta p_{b,o}}{\eta_{b,o}\,\rho_o} = 6\dot{m}_f \cdot \frac{40\ bar \times 10^5}{0{,}6 \cdot (1140\ kg/m^3)} = 35087{,}72\,\dot{m}_f$$

$$\dot{w}_{b,f} = \dot{m}_f \frac{\Delta p_{b,f}}{\eta_{b,f}\,\rho_f} = \dot{m}_f \cdot \frac{80 \times 10^5}{0{,}6\,(71\ kg/m^3)} = 187.793{,}43\,\dot{m}_f$$

$$\dot{w}_t = \frac{(\dot{w}_{b,o} + \dot{w}_{b,f})}{\eta_{mec}} = 253.274{,}03\,\dot{m}_f$$

TURBINA:

$$\dot{w}_t = \underset{\dot{m}_f}{\dot{m}_t}\, c_p\,(T_{te} - T_{ts})$$

$$c_{p,f} = \frac{R\gamma}{\gamma - 1} = 19004{,}34$$

$$\dot{w}_t = \dot{m}_f\, c_p\,(T_{t2,f} - T_{t3,f})$$

$$253.274{,}03\,\cancel{\dot{m}_f} = \cancel{\dot{m}_f} \cdot 19004{,}34\,(325 - T_{t3,f})$$

$$\boxed{T_{t3,f} = 311{,}67\ K}$$

②

Sabemos que $P_{t2,f} \simeq \Delta P_{b,f} \cdot 0{,}85 = 68$ bar

$$\eta_t = \frac{1 - T_{t3,f} / T_{t2,f}}{1 - \left(P_{t3,f} / P_{t2,f}\right)^{\frac{\gamma-1}{\gamma}}}$$

$$1 - \left(\frac{P_{t3,f}}{P_{t2,f}}\right)^{\frac{\gamma-1}{\gamma}} = \frac{1 - \frac{T_{t3,f}}{T_{t2,f}}}{0{,}68} \longrightarrow \boxed{P_{t3,f} = 51{,}17 \text{ bar}}$$

② T_c, c^* (T inyección: T_{t3} fuel y T_{t1} oxidante)

$$T_e = \frac{\dot m_{ox} C_{p\,ox} T_{t1} + \dot m_f C_{pf} T_{t3}}{\dot m_{ox} C_{p\,ox} + \dot m_f C_{pf}}$$

$C_{p,f} = 19004{,}34$ J/kg K

$C_{p,o} = 1187{,}7$ J/kg K

$\dot m_{ox} = 6 \dot m_f$

$$= \frac{\cancel{\dot m_f}\left[6 \cdot C_{p\,ox} T_{t1} + C_{pf} T_{t3}\right]}{\cancel{\dot m_f}\left[6 C_{p\,ox} + C_{pf}\right]} = \boxed{253{,}94 \text{ K}}$$

$$1 = \eta_q \; Q_{comb} = \frac{1 + (O/F)}{\min\left\{(O/F), (O/F)_{ST}\right\}} C_{p,p} \left(T_c - T_e\right)$$

$C_{p,H_2O} = 2111{,}09$ J/kg K

$2H_2 + O_2 \longrightarrow 2H_2O$ estequiométrico $\longrightarrow (O/F)_{st} = \frac{1 \times M_{O_2}}{2 \times M_{H_2}} = 8$

$$T_c = T_e + \frac{Q_{comb} \min\{6, 8\}}{(1+6)\, C_{p,H_2O}} = \boxed{3908{,}11 \text{ K}}$$

$$c^* = \frac{\sqrt{R T_c}}{\Gamma(\gamma)} = \boxed{2023{,}4 \text{ m/s}}$$

$R_{H_2O} = 461{,}9$ J/kg K

$$\Gamma(\gamma) = \sqrt{\gamma} \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}} = 0{,}664$$

3 P_c, $\dot{m}_{b,o}$ y $\dot{m}_{b,f}$

$$c^* = \frac{P_c A_g}{\dot{m}} = \frac{P_c A_g}{\dot{m}_{ox}(1+1/6)} \quad (1)$$

$$(\dot{m}_{iny})_o = (C_D A_{iny})_{ox} \rho_l v_{iny} \longrightarrow v_{iny} = \frac{(\dot{m}_{iny})_{ox}}{(C_D A_{iny})_{ox} \cdot \rho_l}$$

$$\Delta P_{iny} = \frac{1}{2} \cancel{\rho_l} \frac{(\dot{m}_{iny})^2_{ox}}{(C_D A_{iny})^2_{ox} \rho_l^{\cancel{2}}} = (P_{iny})_o - P_c$$

$$(\dot{m}_{iny})_{ox} = \sqrt{2(\Delta P_{b,o} - P_c)(C_D A_{iny})^2_{ox} \rho_l} \quad (2)$$

Juntando (1) y (2):

$$\dot{m}_{ox} = \frac{P_c A_g}{\frac{7}{6} c^*} = \sqrt{2(\Delta P_{b,o} - P_c)(C_D A_{iny})^2 \rho_l}$$

$$\boxed{P_c = 30{,}57 \text{ bar}}$$

$$\dot{m} = \frac{P_c A_g}{c^*} = 27{,}87 \text{ kg/s}$$

$$\dot{m}_{ox} = \frac{6}{7}\dot{m} = \boxed{23{,}89 \text{ kg/s}}$$

$$\dot{m}_f = \frac{1}{7}\dot{m} = \boxed{3{,}98 \text{ kg/s}}$$

4 ε, I_{sp} a 7500 m ($T_{amb} = 239{,}4$ K, $P_{amb} = 38{,}5$ kPa

- calculamos P_s/P_c:

$$\varepsilon = \frac{\Gamma(\gamma)}{\left(\frac{P_s}{P_c}\right)^{1/\gamma}\sqrt{\frac{2\gamma}{\gamma-1}\left[1-\left(\frac{P_s}{P_c}\right)^{\frac{\gamma-1}{\gamma}}\right]}} = 30 \Longrightarrow \frac{P_s}{P_c} = 2{,}25 \times 10^{-3}$$

- calculamos C_E:

$$C_E = \Gamma(\gamma)\sqrt{\frac{2\gamma}{\gamma-1}\left[1-\left(\frac{P_s}{P_c}\right)^{\frac{\gamma-1}{\gamma}}\right]} + \varepsilon\left(\frac{P_s}{P_c} - \frac{P_{amb}}{P_c}\right) = 1{,}415$$

- calculamos E :

$$C_E = \frac{E}{P_c A_g} \Longrightarrow E = C_E \cdot P_c \cdot A_g = \boxed{79{,}82\ KN}$$

- Calculamos I_{sp}:

$$I_{sp} = C_E\, C^* = \boxed{2863{,}11\ m/s} \sim 291{,}86\, s$$

5 Determinar si hay desprendimiento según Stark.

$$P_{det} = \frac{\pi\, P_{amb}}{3\, M_{det}} \longrightarrow M_{det} = \frac{\pi\, P_{amb}}{3 P_{det}}$$

$$\frac{P_c}{P_{det}} = \left(1 + \frac{\gamma-1}{2} M_{det}^2\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{P_c}{P_{det}} = \left(1 + \frac{\gamma-1}{2}\, \frac{\pi^2 P_{amb}^2}{9 P_{det}^2}\right)^{\frac{\gamma}{\gamma-1}} \Longrightarrow P_{det} = 9395\ Pa$$

$$P_s = P_c\,(2{,}25 \times 10^{-3}) = 7042\ Pa$$

Como $P_{det} > P_s \longrightarrow$ hay desprendimiento.

Para saber en que área: (A^*) :

$$\frac{A^*}{A_g} = \frac{1}{M_{det}} \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}} \left[1 + \frac{\gamma-1}{2} M^2\right]^{\frac{\gamma+1}{2(\gamma-1)}}$$

$$M_{ed} = 4{,}26 \Longrightarrow \boxed{A^* = 4470\ cm^2}$$