Solution 1

Calcule de V_e

$$Cp_a = \frac{\gamma_a . r}{\gamma_a - 1} \quad \Rightarrow r = 287\ j/KgK$$

$$M = \frac{V_e}{\sqrt{\gamma . r . T_e}} \quad \Rightarrow V_e = 261.43\, m/s$$

Transformation e~~1,1'~~ →

De l'équation d'énergie

$$T_{1'} = T_e + \frac{1}{2.Cp}.V_e^2 \quad \Rightarrow T_{1'} = 244K$$

$$\eta_d = \frac{T_1 - T_e}{T_{1'} - T_e} \quad \Rightarrow T_1 = 242.32K$$

$$\frac{P_1}{P_e} = \left(\frac{T_1}{T_e}\right)^{\frac{\gamma}{\gamma-1}} \quad \Rightarrow P_1 = 29.7KPas$$

Transformation 1'2,~~2'~~ →

$$\frac{P_2}{P_{1'}} = \left(\frac{T_2}{T_{1'}}\right)^{\frac{\gamma}{\gamma-1}} = r_c \quad \Rightarrow T_2 = 574.26K$$

$$\eta_c = \frac{T_2 - T_{1'}}{T_{2'} - T_{1'}} \quad \Rightarrow T_{2'} = 623.6K$$

Selon l'équation d'énergie, la puissance du compresseur est :

$$\dot{W}_c = \dot{m}_a . Cp_a . (T_{2'} - T_{1'}) \quad \Rightarrow \dot{W}_c = 1.144\ .10^7 W$$

La soufflante transformation 1'~~2s,~~→2's

$$\frac{P_{2s}}{P_{1'}} = \left(\frac{T_{2s}}{T_{1'}}\right)^{\frac{\gamma}{\gamma-1}} = r_s \quad \Rightarrow T_{2s} = 279K$$

$$\eta_s = \frac{T_{2s} - T_{1'}}{T_{2's} - T_{1'}} \quad \Rightarrow T_{2's} = 284K$$

Equation d'énergie $\dot{W}_s = \dot{m}_{as} . Cp_a . (T_{2's} - T_{1'}) \quad \Rightarrow \dot{W}_s = 2.429\ .10^6 W$

Transformation 2' → 3 (chambre de combustion) $T_3 = ?$

Transformation 3 → 4,4' $\dot{W}_T = \dot{W}_c + \dot{W}_s \quad \Rightarrow \dot{W}_T = 1.387\ .10^7 W$

$$\dot{W}_T = \dot{m}_{a(p)}.Cp_g.(T_3 - T_{4'}) \Rightarrow (T_3 - T_{4'}) = 409.12K \qquad (1)$$

$$\frac{P_4}{P_3} = \left(\frac{T_4}{T_3}\right)^{\frac{\gamma_g}{\gamma_g - 1}} = r_s$$

Mélange à pression constante

$$P_4 = P_s \; P_{2's} = P_{2s} \qquad P_{2s} = r_s.P_{1'} = 47.52KPas \Rightarrow P_4 = 47.52KPas$$

$$P_3 = P_2 = P_{2'}$$

$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma_g - 1}{\gamma_g}} \Rightarrow \frac{T_3}{T_4} = 1.9 \qquad (2)$$

$$\eta_T = \frac{T_3 - T_{4'}}{T_3 - T_4} \Rightarrow (T_3 - T_4) = 449.6K \qquad (3)$$

A partir des équations 1,2 ,3 :

$$T_3 = 949.12K$$
$$T_{4'} = 540K$$
$$T_4 = 499.53K$$

Transformation 4’~~5,5’~~▸la tuyère

Equation d’énergie

$$V_5 = \sqrt{2.Cp_m.(T_{4m} - T_{5'})}$$

Second $Cp_s.\dot{m}_{a,s}.T_s$

Primaire $Cp\ .\dot{m}_a.T_4$

Donc $Cp_m.\left(\dot{m}_{a,p} + \dot{m}_{a,s}\right).T_{4,m} \quad Cp_m = 1067.25\,j/KgK$

$$T_{4m} = \frac{Cp_s.\dot{m}_s.T_s + Cp_p.\dot{m}_p.T_4}{Cp_m.\left(\dot{m}_s + \dot{m}_p\right)} \Rightarrow T_{4m} = 369K$$

$$\frac{P_5}{P_{4m}} = \left(\frac{T_5}{T_{4m}}\right)^{\frac{\gamma_m}{\gamma_m - 1}} \Rightarrow T_5 = 279K$$

$$\eta_{ty} = \frac{T_{4m} - T_{5'}}{T_{4m} - T_5} \Rightarrow T_{5'} = 325.9K$$

$$V_5 = 303.34\,m/s$$

$$F = \left(\dot{m}_s + \dot{m}_p \right)\left(V_s - V_e\right) \;\Rightarrow\; F = 3772N$$

Solution 2

Equation d'énergie

$$W + Q = \Delta h + \Delta E_c + \Delta E_p$$

$$0 = \dot{m}\left(Cp.\Delta T + \frac{1}{2}\left(V_s^2 - V_e^2\right)\right)$$

$$V_s = \sqrt{2.Cp.\left(T_e - T_s\right)} \Rightarrow V_s = \sqrt{2.Cp.T_e.\left(1 - \frac{T_s}{T_s}\right)}$$

$$Cp = \frac{\gamma . r}{\gamma - 1}$$

$$\left(\frac{T_s}{T_e}\right) = \left(\frac{P_s}{P_e}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow V_s = \sqrt{\frac{2.\gamma.r}{\gamma - 1}.T_e.\left(1 - \left(\frac{P_s}{P_e}\right)^{\frac{\gamma-1}{\gamma}}\right)}$$

Solution3

Transformation 0 $\rightarrow$ 1

$$\frac{T_1}{T_0} = \left(\frac{P_1}{P_0}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow T_1 = 442.43K$$

$$\eta_{dif} = \frac{T_1 - T_0}{T_{1'} - T_0} \Rightarrow T_{1'} = 454K$$

Transformation 1'2 $\rightarrow$

$$Cp = \frac{\gamma . r}{\gamma - 1} = 1008\, j/KgK$$

$$Q_{12} = \dot{m}_c . P_c^i = \dot{m}_a . Cp.\left(T_2 - T_{1'}\right) \Rightarrow T_2 = 3888K$$

$$\frac{P_1}{P_0} = \frac{T_2}{T_3} \Rightarrow \frac{T_1}{T_0} = \frac{T_2}{T_3} \Rightarrow T_3 = \frac{T_0 . T_2}{T_1} = 1959.72K$$

Transformation 23,3' $\rightarrow$

$$\eta_{ty} = \frac{T_2 - T_{3'}}{T_2 - T_3} \Rightarrow T_{3'} = 2056.11K$$

$$V_3 = \sqrt{2.Cp.(T_2 - T_{3'})} = 1921.74\, m/s$$

$$F = \dot{m}_a .(V_3 - V_0) \Rightarrow V_0 = V_3 - \frac{F}{\dot{m}_a} = 125.58\, m/s$$

Solution 4

$$T_1 = T_0 + \frac{V_0^2}{2.Cp} = 361.8K$$

$$\frac{P_1}{P_e} = \frac{P_2}{p_3} \Rightarrow \frac{T_1}{T_e} = \frac{T_2}{T_3} \Rightarrow T_3 = \frac{T_2.T_0}{T_1} = 836.08K$$

$$V_3 = \sqrt{2.Cp.(T_2 - T_3)} = 726.52\, m/s$$

Le débit massique d'air :

$$F = \dot{m}_a .(V_3 - V_0) \Rightarrow \dot{m}_a = \frac{F}{V_3 - V_0} = 32.27\, Kg/s$$

Le débit massique du carburant :

$$Q_{12} = \dot{m}_c .P_c^i = \dot{m}_a .Cp.(T_2 - T_1) \Rightarrow \dot{m}_c = 0.34\, Kg/s$$

La consommation spécifique du carburant :

$$CSC = \frac{\dot{m}_c}{F} = 0.34\ .10^{-4}\, Kg/Ns$$

Solution5

Le Diffuseur

$$\frac{1}{2}.(V_1^2 - V_0^2) + Cp.(T_1 - T_0) = 0 \quad avec\ V_1 \langle\langle V_0 \quad \Rightarrow T_1 = 328.55K$$

$$\frac{P_1}{P_0} = \frac{P_2}{P_3} \Rightarrow \frac{T_1}{T_0} = \frac{T_2}{T_3} \Rightarrow T_3 = \frac{T_2.T_0}{T_1} = 831K$$

La tuyère : la vitesse d'éjection est :

$$V_s = \sqrt{2.Cp.(T_2 - T_3)} = 581.37\, m/s$$

Le débit massique d'air :

$$F = \dot{m}_a .(V_s - V_0) \Rightarrow \dot{m}_a = \frac{F}{V_s - V_0} = 33.46\, Kg/s$$

$$\dot{Q}_{1,2} = \dot{m}_c .P_c^i = \dot{m}_a .Cp.(T_2 - T_1) \Rightarrow \dot{m}_c = 0.356\,Kg/s$$

La consommation spécifique du carburant :

$$CSC = \frac{\dot{m}_c}{F} = 4.296\ .10^{-5}\ Kg/N.s$$

Solution 6

Transformation e $\longrightarrow$ 1,1'

$$\frac{P_1}{P_e} = \left(\frac{T_1}{T_e}\right)^{\frac{\gamma}{\gamma-1}} = r \quad \Rightarrow T_1 = 425.04K$$

$$\eta_d = \frac{T_1 - T_e}{T_{1'} - T_e} \quad \Rightarrow T_{1'} = 433.73K$$

De l'équation d'énergie

$$V_e = \sqrt{2.Cp.(T_{1'} - T_e)} \quad \Rightarrow V_e = 660.93\,m/s$$

$$\eta_{th,P} = \eta_g = \frac{F.V_e}{\dot{m}_c .P_c^i} \quad \Rightarrow \dot{m}_c = 2.4418\,Kg/s$$

$$x = \frac{\dot{m}_a}{\dot{m}_c} = 15 \quad \Rightarrow \dot{m}_a = 36.62\,Kg/s$$

$$F = \dot{m}_g .V_s - \dot{m}_a .V_e \quad \Rightarrow V_s = 2462.84\,m/s$$

Solution 7

$$T_1 = T_0 + \frac{V_0^2}{2.Cp_a} \quad \Rightarrow T_1 = 271.2K$$

$$\eta_d = \frac{T_{1'} - T_0}{T_1 - T_0} = 0.9 \quad \Rightarrow T_{1'} = 269.6K$$

$$\frac{P_1}{P_0} = \left(\frac{T_{1'}}{T_0}\right)^{\frac{\gamma}{\gamma-1}} = 1.21$$

Pour le compresseur

$$\frac{T_{2'}}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \quad \Rightarrow T_{2'} = 508K$$

$$\eta_c = \frac{T_{2'} - T_1}{T_2 - T_1} = 0.9 \quad \Rightarrow T_2 = 537.35K$$

$$W_c = Cp_a.(T_2 - T_1) \quad \Rightarrow W_c = 267.5Kj / Kg$$

$$\frac{P_3}{P_4} = \frac{P_2}{P_0} = \frac{P_2}{P_1}.\frac{P_1}{P_0} = 10.89$$

Donc

$$\frac{T_{4'}}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{\gamma_g - 1}{\gamma_g}} \quad \Rightarrow T_{4'} = 618.46K$$

$$\eta_T = \frac{T_4 - T_3}{T_{4'} - T_3} = 0.93 \quad \Rightarrow T_4 = 653.77K$$

Travail produit par la turbine

$$W_T = Cp_g.(T_3 - T_4) \; W_T = 539.6Kj / Kg$$

Travail net de l'hélice

$$W_h = (W_T - W_c).\eta_{mécanique} \quad \Rightarrow W_h = 266.658Kj / Kg$$

$$Q = Cp_m.(T_3 - T_2) \quad \Rightarrow Q = 6.31\ .10^5 W$$

$$\eta_{th} = \frac{W_h}{Q} \quad \Rightarrow \eta_{th} = 42.2\%$$