TIO SOLUTIONS BY WAITZ

FIRST FIND SPEED OF SOUND $a = \sqrt{\gamma RT} = \sqrt{1.4 \cdot 287 \cdot 220K}$

$a = 297 \text{ m/s}$

AND MACH #

$$M = \frac{c}{a} = \frac{250}{297} = 0.84$$

a) STAGNATION TEMPERATURE AT COMPRESSOR INLET (IN REFERENCE FRAME OF AIRPLANE)

$$\frac{T_{T_1}}{T_1} = 1 + \frac{\gamma - 1}{2} M^2 = 1.14 \quad \therefore \boxed{T_{T_1} = 251K}$$

b) $$\frac{P_{T_1}}{P_1} = \left(\frac{T_{T_1}}{T_1}\right)^{\gamma/\gamma-1} = 1.59 \quad \therefore \boxed{P_{T_1} = 79.4 kPa}$$

c) STAGNATION TEMPERATURE RATIO ACROSS TURBINE

T_{T_3} = COMBUSTOR EXIT STAGNATION TEMP = $6\left(T_{T_2}\right)$

$T_{T_3} = 6(251k) = 1506K$

TURBINE SHAFT WORK DRIVES COMPRESSOR

$\therefore \quad |W_{S_T}| = |W_{S_C}|$

SFEE $-W_s = C_p \Delta T$ FOR COMP. & TURBINE = 0 SINCE ADIABATIC $\quad h_{T_{OUT}} - h_{T_{IN}} = C_p\left(T_{T_{OUT}} - T_{T_{IN}}\right)$

$\therefore \quad |W_{S_T}| = C_p\left(T_{T_3} - T_{T_4}\right) = |W_{S_C}| = C_p\left(T_{T_2} - T_{T_1}\right)$

SOLVE FOR COMPRESSOR FIRST. WE KNOW $T_{T_1} = 251K$

ALSO GIVE $\frac{P_{T_2}}{P_{T_1}} = 12$. THEN SINCE Q-S, ADIAB.

$$\frac{T_{T_2}}{T_{T_1}} = \left(\frac{P_{T_2}}{P_{T_1}}\right)^{\gamma-1/\gamma}$$

SO $\frac{T_{T_2}}{T_{T_1}} = 2.03$ SO $T_{T_2} = 510.5K$

BACK TO SSFE: $(1506K - T_{T_4}) = (510.5K - 251K)$

$$T_{T_4} = 1246.5K$$

$$\therefore \boxed{\frac{T_{T_4}}{T_{T_3}} = 0.83}$$

d) STAGNATION PRESSURE RATIO

$$\frac{P_{T_4}}{P_{T_3}} = \left(\frac{T_{T_4}}{T_{T_3}}\right)^{\gamma/\gamma-1} \boxed{= 0.52}$$