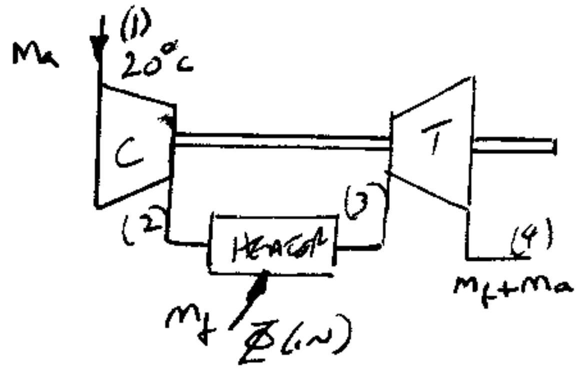
Q6 2000



$r_p = 10$ $T_1 = 293K$
$T_3 = 1173K$

GAS CONSTANTS AIR

$R_a = R_0/\tilde{m} = 287\ J/kgK$

$C_{pa} = 1.004\ kJ/kgK$

$\gamma_a = 1.4$

GAS CONSTANTS (TURBINE)

$R_g = R_0/32 = 259.81\ J/kgK$

$C_{pg} = 1.2\ kJ/kgK$

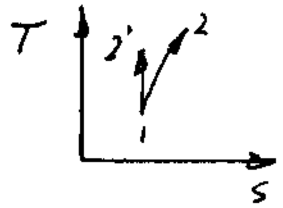
$C_{vg} = C_{pg} - R_g = 1200 - 259.81 = 940.2\ J/kgK$

$\gamma_g = C_{pg}/C_{vg} = 1200/940.2 = 1.276$

COMPRESSOR $T_2' = 293 \times 10^{\frac{\gamma}{\gamma-1}}$

$T_2 = 293 \times 10^{.286} = 566\ K$

ISENTROPIC EFFICIENCY



$\eta_{is} = \dfrac{T_2' - T_1}{T_2 - T_1}$ $0.88 = \dfrac{566 - 293}{T_2 - 293}$

$T_2 = 603.2\ K$

$\Phi(in) = M_g C_{pg} T_3 - M_a C_{pa} T_2$

USING FUEL CALORIFIC VALUE

$\Phi(in) = M_f \times 45000$ $M_g = M_a + M_f$

$45000 M_f = (M_a + M_f) \times 1.2 \times 1173 - M_a \times 1.004 \times 603.2$

$45000 = \left(\dfrac{M_a}{M_f} + 1\right) \times 1.2 \times 1173 - \dfrac{M_a}{M_f} \times 1.004 \times 603.2$

$45000 = 1407.6\ M_a/M_f + 1407.6 - 605.5\ M_a/M_f$

$43592 = 802\ M_a/M_f$ $M_a/M_f = \underline{\underline{54.35}}$

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TURBINE

$$p_2 = 10 \times 1 = 10\,\text{bar}$$

$$p_3 = 90\% \times p_2 = 9\,\text{bar} \qquad r_p = 9$$

$$T_4' = T_3 \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}} = 1173 \left(\frac{1}{9}\right)^{.276/1.276} = 729\,K$$

ISENTROPIC EFFICIENCY

$$\eta_{is} = \frac{T_3 - T_4}{T_3 - T_4'} \qquad 0.9 = \frac{1173 - T_4}{1173 - 729}$$

$$T_4 = 773.6\,K$$

$$\text{Power out} = M_g\, C_{pg} (T_3 - T_4)$$

$$P(\text{out}) = M_g \times 1.2 \times (1173 - 773.6) = 479.2\, M_g$$

COMPRESSOR

$$P(\text{in}) = M_a\, C_{pa} (T_2 - T_1) =$$
$$= M_a \times 1.004 (603.2 - 293)$$
$$= 311.4\, M_a$$

NETT POWER

$$P_{nett} = 479.2\, M_g - 311.4\, M_a$$

$$\Phi(\text{in}) = 45000\, M_f$$

EFFICIENCY

$$\eta_{th} = \frac{P_{nett}}{\Phi_{in}} = \frac{499.2\, M_g - 311.4\, M_a}{45000\, M_f}$$

$$M_g = M_a + M_f \qquad m_a = 54.35\, m_f \qquad m_g = 55.35\, M_f$$

$$\eta_{th} = \frac{479.2 \times 55.35 M_f - 311.44 \times 54.35 M_f}{45000\, M_f}$$

$$\eta_{th} = \frac{9612}{45000} = 0.214 \text{ or } 21.4\%$$

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CARNOT EFFICIENCY

$$\eta_c = 1 - \frac{T_{COLD}}{T_{HOT}}$$

$$= 1 - \frac{293}{1173} = 0.75 \text{ or } 75\%$$