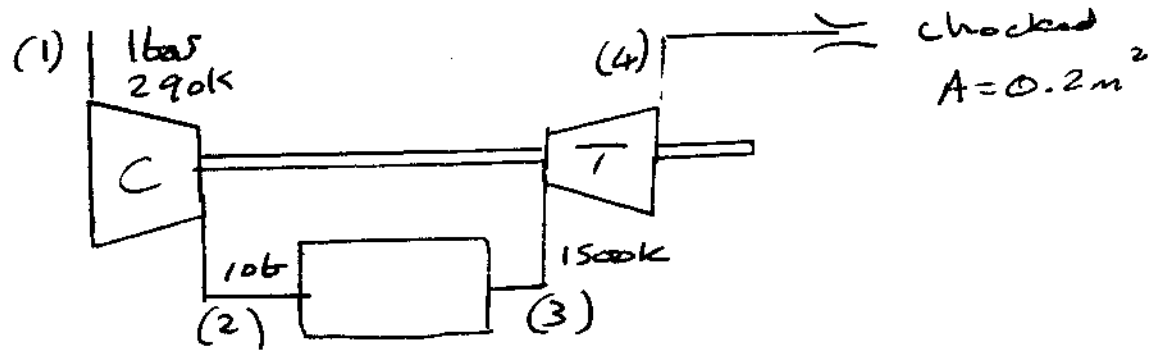
Q2 2002



$T_2' = T_1 r_p^{\frac{\gamma-1}{\gamma}} = 290(10)^{0.286} = 560.3\,K$

$\eta_{IS} = 0.9 = \frac{560.3 - 290}{T_2 - 290}$ $\quad T_2 = 590.3\,K$

COMPRESSOR

$Power = \dot{m} C_p \Delta T = \dot{m} C_p (590.3 - 290)$

$= 300.3\, \dot{m} C_p$

TURBINE

$Power = \dot{m} C_p \Delta T = \dot{m} C_p (1500 - T_4)$

EQUATE $\quad 300.3\, \dot{m} C_p = \dot{m} C_p (1500 - T_4)$

$T_4 = 1199.7\,K$

$\eta_{IS} = 0.92 = \frac{1500 - 1199.7}{1500 - T_4'}$ $\quad T_4' = 1174\,K$

$T_4 = T_3 r_p^{-(\frac{\gamma-1}{\gamma})}$ $\quad 1174 = 1500\, r_p^{-.286}$

$r_p^{-.286} = \frac{1174}{1500} = 0.782$ $\quad r_p = 2.35$

$2.35 = P_3/P_4 = 10/P_4$ $\quad P_4 = 10/2.35$

$P_4 = 4.245$ bar

CHOCKED NOZZLE

$T_5/T_4 = 2/(\gamma+1) = 0.833$ $\quad T_5 = 1000\,K$

IF CHOCKED, EXIT VELOCITY IS SONIC

$$\text{Velocity} = a = \sqrt{\gamma R T_s}$$

$$a = \sqrt{1.4 \times 287 \times 1000} = 633.8 \text{ m/s}$$

VOLUME FLOW RATE = AREA × VELOCITY

$$V = Aa = 0.2 m^2 \times 633.8 \text{ m/s}$$

$$V = 126.77 \text{ m}^3/\text{s}$$

CRITICAL PRESSURE RATIO $r_c = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}} = 0.528$

$$p_s = 0.528 \times 4.245$$

$$= 2.242 \text{ bar}$$

$$\text{MASS} = \frac{pV}{RT} = \frac{2.242 \times 10^5 \times 126.77}{287 \times 1000}$$

$$\text{MASS} = 99 \text{ kg/s}$$

$$\text{THRUST} = m \Delta \text{velocity} + A \Delta p$$

$$= 99 \times (633.8 - 0) + 0.2(2.742 - 1) \times 10^5$$

$$= 62746 \text{ N} + 34840 \text{ N}$$

$$= \underline{97.6 \text{ kN}}$$