



Complete, fold and seal
(see note 2 below)

SURNAME: Baxter

FORENAME(S): Connor

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

[illegible]

Q5. Static lift = 12m $\dot{Q} = 10 \text{ l/s}$ or $0.01 \text{ m}^3/\text{s}$ $L = 30\text{m}$
 $\phi = 100\text{mm}$ $\mu = 0.001136 \text{ kg/ms}$

1. $Re = \frac{\rho v D}{\mu} = \frac{1000 \times 4.07 \times 0.1}{0.001136}$ where $v = \frac{\dot{Q}}{CA}$
 $C = \frac{\dot{Q}}{A}$
 $C = \frac{0.01}{(\frac{\pi}{4} \times 0.1^2)}$
 $C = 4.07 \text{ m/s}$
 $Re = 299264.7$
 $\therefore$ Turbulent as $Re > 4000$

Primary losses using Darcy equation.

$h_f = \frac{4 f L v^2}{2 g d}$ $K = 0.15$ for Galvanised steel
 $\therefore$ relative roughness = $\frac{K}{d} = \frac{0.15}{100} = 0.0015$

$f = 0.0056$ from moody diagram.

$\therefore h_f = \frac{4 \times 0.0056 \times 0.3 \times 4.07^2}{2 \times 9.81 \times 0.1}$
 $= 0.0139$

Secondary losses

$h_f = \sum K \left(\frac{v^2}{2g} \right)$
 $= [0.2 \times 1 + (4 \times 0.9) + 1 + 0.5] \left(\frac{4.07^2}{2 \times 9.81} \right)$
 $= 5.3 \left(\frac{4.07^2}{2 \times 9.81} \right)$
 $= 1.104$

$\therefore$ Total losses = $1.1 + 0.0139 = 1.1139$.

Pumping Power = $\dot{Q} \times \rho g h$
 for desired flow

$$= \frac{0.01}{1000} \times 1000 \times 9.81 \times 12$$

$$= 1.1772 \text{ kW or } 1.177 \text{ MW}$$

Using the affinity equation

$$\frac{h_1}{h_2} = \frac{Q_1^2}{Q_2^2}$$

$$\frac{1.1139}{h_2} = \frac{0.008}{0.012}$$

$$h_2 = \frac{0.012 \times 1.1139}{0.008}$$

$$h_2 = 1.67 \text{ @ } Q = 0.012$$

At $Q = 0.004$,

$$\frac{h_1}{1.1139} = \frac{0.004}{0.008}$$

$$h_1 = \frac{0.004}{0.008} \times 1.1139$$

$$h_1 = 0.557$$

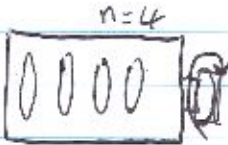
①

②

③

4

Q4.



$$N = 2500$$

$$T = 220 \text{ Nm}$$

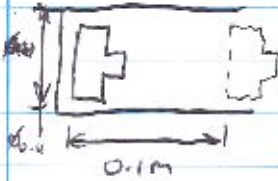
$$\text{Air/fuel} = 14/1$$

$$\text{SEC} = 0.364 \text{ kg/kWh}$$

$$P_{\text{atm}} = 1.01 \text{ bar}$$

$$T = 15^\circ\text{C or } 288 \text{ K}$$

$$C_v = 44,200 \text{ kJ/kg}$$



$$i) \eta_{\text{bte}} = \frac{\text{Brake Power}}{m_f \times C_v} \quad \text{where } BP = T \cdot \omega$$

$$= \frac{220 \times 2500 \times 2\pi}{2 \times 60}$$

$$= 28797 \text{ or } 28.8 \text{ kW}$$

$$\text{Also, } m_f = BP \times \text{SEC}$$

$$= \frac{28.8}{3600} \times 0.364$$

$$= 0.029 \text{ kg}$$

$$\therefore \eta_{\text{bte}} = \frac{28.8 \times 10^3}{0.029 \times 44200} \times 100\%$$

$$= 22.5\%$$

$$ii) \text{Volumetric efficiency} = \frac{\text{Mass of fuel + mass of air}}{\text{Swept volume}} = 44.5\%$$

$$m_f = 0.029 \text{ kg}$$

$$\therefore m_{\text{air}} = 14/1 \times 0.029 \times 14$$

$$= 0.406 \text{ kg}$$

$$\text{Total mass} = 0.406 + 0.029 = 0.435 \text{ kg}$$

$$PV = MRT, \quad V = \frac{MRT}{P}, \quad V = \frac{0.435 \times 287 \times 288}{1.01 \times 10^5} = 0.356 \text{ m}^3$$

$$\text{per cylinder} = \frac{0.356}{4} = 0.089 \text{ m}^3$$

$$\text{Swept volume} = (0.055^2 \times \pi) \times 0.1 \times \frac{2500}{2 \times 60}$$
$$= \boxed{0.02 \text{ m}^3}$$

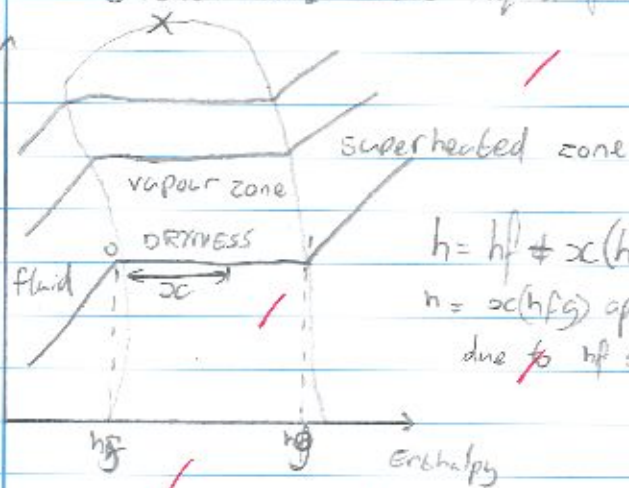
x

5

12

critical Point where liquid flashes into steam

Q3 a)
temp



$$h = h_f + x(h_{fg})$$

$$x = \frac{h - h_f}{h_{fg}} \text{ approx}$$

due to h_f so small

From the temperature-enthalpy diagram, we can see that at higher pressures the temperature increases while also shortening the duration of each phase until the critical point is reached where the pressure is around 2212 bar and the fluid flashes into steam, leaving no vapor zone.

b) $P_1 = 30 \text{ bar}$ $T = 350^\circ \text{C}$ $v = 0.16 \text{ m}^3$ $PV^{1.3} = C$
 $P_2 = 6 \text{ bar}$

c) $m = \frac{v}{v_g} = \frac{0.16}{0.0905} = 1.77 \text{ kg}$

v_g from table = 0.0905
 @ 30 bar 350°C

ii) ~~From table~~

From table, $h_g = 3117 \text{ kJ/kg}$

$$P_1 V_1 = P_2 V_2$$

$$V_2 = \frac{P_1 V_1}{P_2}$$

$$V_2 = \frac{30 \times 0.0905}{6}$$

$$= 0.22 \text{ kJ/kg}$$

$$x = 0.9$$

iii) $W = \frac{P_1 V_1 - P_2 V_2}{n-1}$

$$= \frac{30 \times 0.0905 - 6 \times 0.22}{0.3} = 465 \text{ kJ}$$

~~specific work~~

Q2

$$Q = 100 \text{ l/s or } 0.1 \text{ m}^3/\text{s} \quad P = 900$$



$$P_1 = 400 \text{ kN/m}^2$$

$$D_{in} = 0.12 \text{ m}$$

$$D_{out} = 0.1 \text{ m}$$

$$P_{friction} = 1.2 \text{ m}$$

Bernoulli Equation

$$\frac{P_1}{\rho g} + \frac{1}{2} \frac{C_1^2}{g} + \underbrace{mgh_1}_{=0} = \frac{P_2}{\rho g} + \frac{1}{2} \frac{C_2^2}{g} + \underbrace{mgh_2}_{\text{assume 1}}$$

$$Q = C_1 A_1$$

$$Q = C_2 A_2$$

$$C_1 = \frac{Q}{A_1}$$

$$C_2 = \frac{Q}{A_2}$$

$$= \frac{0.1}{(0.06^2 \times \pi)}$$

$$= \frac{0.1}{(0.05^2 \times \pi)}$$

$$C_1 = 8.84 \text{ m/s} \quad \checkmark$$

$$C_2 = 12.73 \text{ m/s}$$

$$\therefore \frac{400 \text{ kN}}{900 \times 9.81} + \frac{8.84^2}{2 \times 9.81} + 0 = \frac{P_2}{900 \times 9.81} + \frac{12.73^2}{2 \times 9.81} + 9.81 \times 12$$

$$45.31 + 3.98 = \frac{P_2}{8829} + 8.26 + 117.72$$

$$49.29 = \frac{P_2}{8829} + 125.98$$

$$\therefore P_2 = (49.29 - 125.98) 8829$$

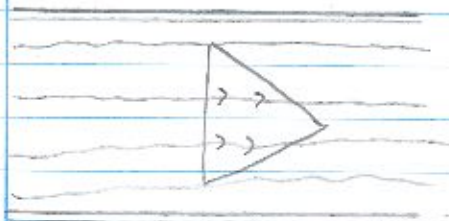
$$= 677 \text{ kN}$$

(4)

(6)

- b) The critical Reynolds numbers ~~may~~ state that any Re value below 2000 will see a system with laminar flow, an Re value of above 4000 will be purely turbulent flow while any number between will see a mixture of both.

Laminar Flow



Turbulent Flow



(6)

