(i) **GIVEN**

- Diffuser
  - >> air (ideal gas) @ steady state
  - >> $T_1 = 270\,K$, $V_1 = 180\,m/s$, $T_2 = ?$, $V_2 = 48.4\,m/s$

FIND

T_2, exit temp.

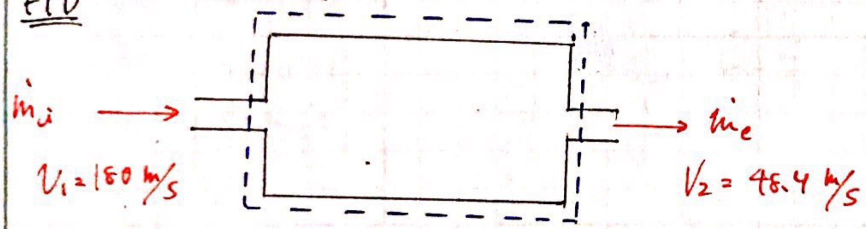
ASSUMP

- SSSF
- Uniform flow
- open sys
- $\Delta PE = 0$
- ideal gas
- well insulated ($\dot{Q} = 0$)
- $\dot{W} = 0$

EQN

- $\cancel{\left.\frac{dm}{dt}\right|_{sys}}^{\,0} = \sum \dot{m}_i - \sum \dot{m}_e$
- $\cancel{\left.\frac{dE}{dt}\right|_{sys}}^{\,0} = \cancel{\dot{Q}}^{\,0} - \cancel{\dot{W}}^{\,0} + \sum_i \dot{m}(h + \cancel{pe}^{\,0} + ke) - \sum_e \dot{m}(h + \cancel{pe}^{\,0} + ke)$
- $pv = R_{air} T$

EFD



SOLN at the inlet and outlet $m_i = m_e \Leftrightarrow \dot{m}_i = \dot{m}_e$ ... (i)

and from "ideal gas table" $h_1 = 270.0\,kJ/kg$

$$\frac{1}{2} m_i v_1^2 - \frac{1}{2} m_e v_2^2 + m_i h_1 - m_e h_2 = 0$$

$\because$ (i)

$$h_2 = \frac{v_1^2}{2} - \frac{v_2^2}{2} + h_1$$

$$= \frac{1}{2}\left[(180^2) - (48.4)^2\right] J/kg + 270 \times 10^3\, J/kg$$

$$\cong 285082\ J/kg \cong 285.1\ kJ/kg$$

from the table the corresponding temperature is

$$\boxed{T_2 = 285\,K}$$

(Q1)
GIVEN

\# turbine
>> steam/vapor @ steady state

* $p_1 = 2MPa$, $T_1 = 360°C$, $V_1 = 100 m/s$
* saturated vapor exits $p_2 = 0.1 MPa$, $V_2 = 50 m/s$
* inlet $h = 3m$ higher than outlet.
* mass flow rate $\equiv \frac{dm}{dt} = 15 kg/s$
* power $\equiv \dot{W} = 7 MW$

FIND

(a) area of inlet $\equiv A_i$
(b) rate of heat transfer $\equiv \dot{Q}$, in kW

ASSUMP

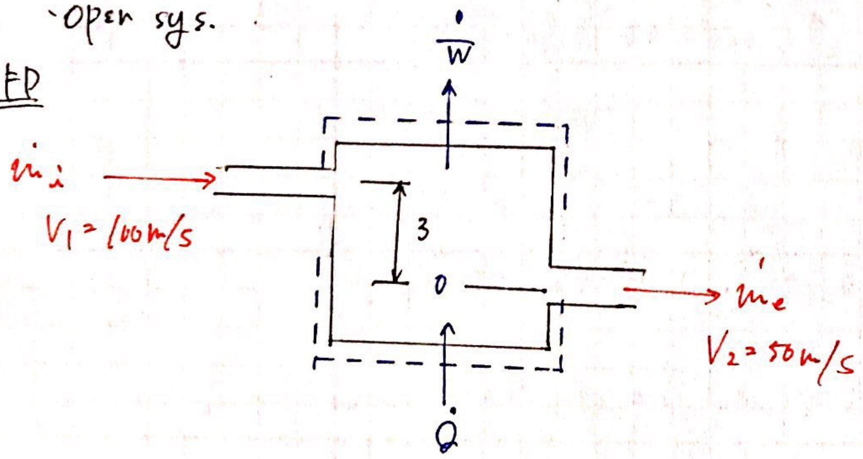
- SSSF
- uniform flow
- steady state
- $g = 9.81 m/s^2$
- open sys.

EQN

$$\cancel{\frac{dm}{dt}}\Big|_{sys}^{0} = \sum \dot{m}_i - \sum \dot{m}_e$$

$$\cancel{\frac{dE}{dt}}\Big|_{sys}^{0} = \dot{Q} - \dot{W} + \sum_i \dot{m}(h+pe+ke) - \sum_e \dot{m}(h+pe+ke)$$

EFD



SOLN

(a) from the saturation table @ p_1 $T_1 > T_{sat}$ so looking at the superheated vapor table @ p_1, T_1

$$v_1 = 0.14115 \ m^3/kg, \ u_1 = 2877.6 \ kJ/kg, \ h_1 = 3159.9 \ kJ/kg$$

also for p_2 with saturation table.

$$T_2 = 100°C, \ v_2 = 1.6718 \ m^3/kg, \ u_2 = 2506.0 \ kJ/kg, \ h_2 = 2675.6 \ kJ/kg$$

Scanned with CamScanner

from these data if area of inlet and outlet are A_1, A_2 respectively

and
$$\begin{cases} \left(A_1V_1 \frac{m^3}{s}\right) = \left(\dot{m}_i v_1 \frac{kg}{s}\cdot\frac{m^3}{kg}\right) & \cdots (i) \\ \left(A_2V_2 \frac{m^3}{s}\right) = \left(\dot{m}_e v_2 \frac{kg}{s}\cdot\frac{m^3}{kg}\right) & \cdots (ii) \\ \dot{m}_i = \dot{m}_e = 15 \ kg/s & \cdots (iii) \end{cases}$$

$\because$ (i) & (iii) $A_1 = \frac{\dot{m}_i v_1}{V_1} = \frac{15 \cdot 0.14115}{100} m^2 \approx 0.02117 \ m^2$

$$\boxed{A_1 = 0.0212 \ m^2}$$

(b) from General Energy Balance EQN.

$$\dot{Q} = \dot{W} + \sum_e \dot{m}(h_2 + pe_2 + ke_2) - \sum_i \dot{m}(h_1 + pe_1 + ke_1)$$

since $\dot{m}\cdot\Delta pe = \dot{m}(g\cdot 0 - gh)$

$$= \left(15\frac{kg}{s}\right)\left(-9.81\frac{m}{s^2}\cdot 3m\right) = -441.45 \ W \approx -0.4415 \ kW$$

$$\dot{m}\cdot\Delta ke = \frac{\dot{m}}{2}(V_2^2 - V_1^2)$$

$$= \left(\frac{15}{2}\frac{kg}{s}\right)(50^2 - 100^2)\frac{m^2}{s^2} = -56250 \ W \approx -56.25 \ kW$$

$$\dot{W} = 7\times10^6 \ W$$

$$\dot{m}\Delta h = \left(15\frac{kg}{s}\right)(h_2 - h_1)\frac{J}{kg}$$

$$= \left(15\frac{kg}{s}\right)(2675.6 - 3159.9)\times10^3\frac{J}{kg} \approx -7265 \ kW$$

$$\therefore \dot{Q} = (7000 - 7265 - 56.25 - 0.4415)\ kW$$

$$\approx -321.69 \ kW$$

$$\boxed{\dot{Q} = -322 \ kW}$$