PBC2

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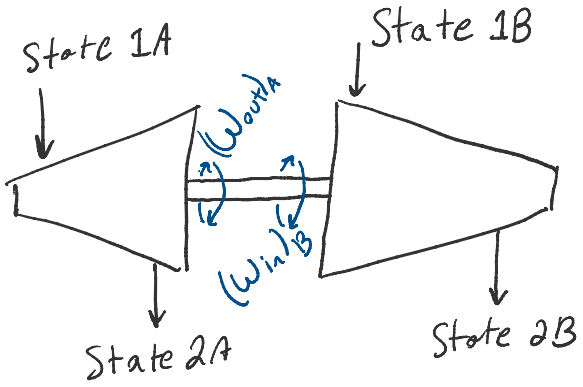


a)

Turbine

State 1	State 2
$T_1 = 400^\circ C = 673K$	$T_2 = 100^\circ C = 373K$
$P_1 = ?$	$P_2 = 100\ kPa$
$V_1 = 29\ m/s$	$V_2 = 5\ m/s$
$A_1 = 0.25\ kPa$	

$$E_{out} = E_{in}$$
$$W_{out} + KE_{out} + H_{out} = KE_{in} + H_{in}$$
$$-W_{out} = \Delta H + \Delta KE$$
$$-W_{out} = \dot{m}(\Delta h + \Delta ke)$$

$\therefore 300 \leq \Delta T \leq 500 \rightarrow \Delta h = c_p(T_2 - T_1)$ (Table A2b)

$$\frac{c_p - 1.029}{523 - 500} = \frac{1.040 - 1.029}{550 - 500}$$

$$c_p = 1.034\ kJ/kg \cdot K$$

$$P_{1A} V_{1A} = R_{air} T_{1A}$$
$$v = R_{air} T / P$$

$$P_{1A}\underline{v}_{1A} = R_{air}T_{1A}$$

$$\underline{v}_{1A} = R_{air}T_{1A}/P_{1A}$$

$$\dot{m}_A = \frac{A_{1A}V_{1A}}{\underline{v}_{1A}} = \frac{P_{1A}A_{1A}V_{1A}}{R_{air}T_{1A}}$$

$$(\dot{W}_{out})_A = -\frac{P_{1A}A_{1A}V_{1A}}{R_{air}T_{1A}}\left(C_p(T_{2A}-T_{1A}) + \frac{\frac{1}{2}(V_{2A}^2 - V_{1A}^2)}{1000}\right) \quad (1)$$

Compressor

State 1	State 2	
$T_{1B} = 150°C$	$T_{2B} = 500°C$	@ 100 kPa, $T_1 > T_{sat}$ ∴ superheated
$P_{1B} = 100\ kPa$	$P_{2B} = 2\ MPa$	$h_{1B} = 2776.6\ kJ/kg$ from Table A6
$V_{1B} \doteq 0\ m/s$	$V_{2B} = 100\ m/s$	@ 2 MPa, $T_{2B} > T_{sat}$
$\dot{m}_B = 10\ kg/s$		$h_{2B} = 3468.3\ kJ/kg$ from Table A6

$$E_{in} = E_{out}$$

$$H_{in} + KE_{in} + \dot{W}_{in} = H_{out} + KE_{out}$$

$$(\dot{W}_{in})_B = \dot{m}_B\left[(h_{2B}-h_{1B}) + \frac{1}{2}(V_{2B}^2 - V_{1B}^2)\right]$$

$$(\dot{W}_{in})_B = \dot{m}_B\left((h_{2B}-h_{1B}) + \frac{\frac{1}{2}(V_{2B}^2 - V_{1B}^2)}{1000}\right) \quad (2)$$

$$\bigstar\ (\dot{W}_{in})_B = (\dot{W}_{out})_A = \dot{W}$$

$$\dot{W} = \dot{m}_B\left((h_{2B}-h_{1B}) + \frac{\frac{1}{2}(V_{2B}^2 - V_{2B}^2)}{1000}\right) = -\frac{P_{1A}A_{1A}V_{1A}}{R_{air}T_{1A}}\left(C_p(T_{2A}-T_{1A}) + \frac{\frac{1}{2}(V_{2A}^2 - V_{1A}^2)}{1000}\right)$$

$$\dot{W} = (10)\left((3468.3-2776.6) + \frac{\frac{1}{2}(100^2 - 0^2)}{1000}\right)$$

$$\boxed{\dot{W} = 6967\ kW}$$

h) $\dot{W} = -P_{1A}A_{1A}V_{1A}/(R_{air}T_{1A})\left(1 + \frac{1}{2}(V_{2A}^2 - V_{1A}^2)\right)$

b) $\dot{\omega} = -\frac{P_{1A} A_{1A} V_{1A}}{R_{air} T_{1A}} \left(C_p (T_{2A} - T_{1A}) + \frac{\frac{1}{2}(V_{2A}^2 - V_{1A}^2)}{1000} \right)$

$$6967 = -\frac{P_{1A}(0.25)(20)}{(0.287)(400+278)} \left[1.034(100-400) + \frac{1}{2000}(5^2 - 20^2) \right]$$

$$6967 = P_{1A}(8.0348)$$

$$\boxed{P_{1A} = 867.099 \text{ kPa}}$$

c) $\dot{m}_B = \frac{A_{2B} V_{2B}}{\underline{V}_{2B}}$

$$A_{2B} = \frac{\dot{m}_B \underline{V}_{2B}}{V_{2B}} = \frac{(10)\underline{V}_{2B}}{100} = \frac{\underline{V}_{2B}}{10}$$

@ $P_{2B} = 2 \text{ MPa}$, $500^\circ C > T_{sat}$ ∴ superheated

$$\underline{V}_{2B} = 0.17568 \text{ m}^3/\text{kg}$$

$$A_{2B} = 0.17568/10 = \boxed{0.017568 \text{ m}^2}$$

d)

$$\underline{V}_{1A} = R T_{1A}/P_{1A} = (0.287)(400+273)/867.099$$

$$\underline{V}_{1A} = 0.2228 \text{ m}^3/\text{kg}$$

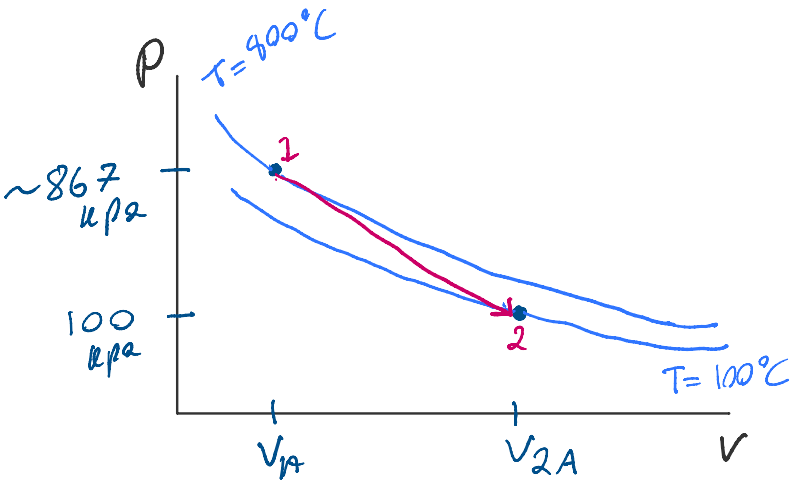
$$\underline{V}_{2A} = R T_{2A}/P_{2A} = (0.287)(100+273)/100$$

$$\underline{V}_{2A} = 1.0705 \text{ m}^3/\text{kg}$$

Turbine

Compressor

Turbine



Compressor