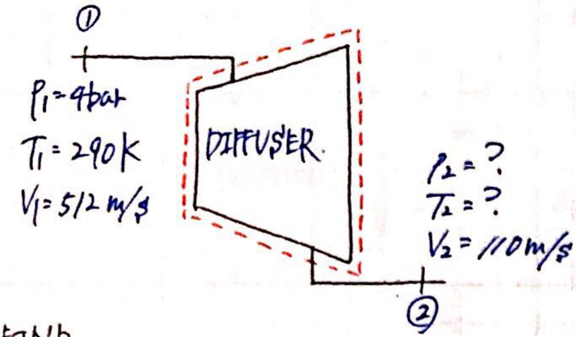
<i>

GIVEN & <EFD> AIR



FIND

(a) P_2, T_2 when $k = 1.4$

(b) using data from table

ASSUMP

open sys, SSSF, 1-DUF, $\dot{Q} = 0$, $\Delta pE = 0$, $\dot{W} = 0$, $\Delta S = 0$ (isentropic), ideal gas

EQN

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

$$\cancel{\frac{ds}{dt}\Big|_{sys}}^{0} = \cancel{\sum \frac{\dot{Q}}{T}}^{0} + \sum_i \dot{m} s_i - \sum_e \dot{m} s_e + \cancel{\dot{\sigma}_{gen}}^{0}, \quad \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}, \quad Pv = R_{air} T$$

$$R_{air} = 0.287\ kJ/kg\text{-}K$$

SOLN

$$\dot{m}_1 = \dot{m}_2 = \dot{m} \quad \cdots ①$$

$$0 = \dot{m}\left(h_1 + \frac{V_1^2}{2} - h_2 - \frac{V_2^2}{2}\right) \quad \cdots ②$$

(a)

from table $h_1 = 290.1\ kJ/kg$

using ②

$$h_2 = h_1 + \frac{V_1^2}{2} \times 10^{-3} - \frac{V_2^2}{2} \times 10^{-3}$$

$$= 290.1\ kJ/kg + (512\ m/s)^2 \times \frac{10^{-3}}{2} - (110\ m/s)^2 \times \frac{10^{-3}}{2} = 415.022\ kJ/kg$$

from table $\boxed{T_2 = 415K}$

and

$$P_2 = P_1\left(\frac{T_2}{T_1}\right)^{\frac{k}{k-1}} = (4\ bar)\left(\frac{415K}{290K}\right)^{\frac{1.4}{0.4}} \cong 14.02 \qquad \boxed{P_2 = 14.0\ bar}$$

(b) if $T_2 = 415K$ from tables

$P_{r1} = 1.2311$

interpolation $P_{r2} = (415K - 410K)\dfrac{(4.522 - 4.153)}{(420K - 410K)} + 4.153 = 4.3375$

then

$$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}} \Leftrightarrow P_2 = P_1\left(\frac{P_{r2}}{P_{r1}}\right) = (4\ bar)\left(\frac{4.3375}{1.2311}\right) \cong \boxed{14.0\ bar}$$

<P>

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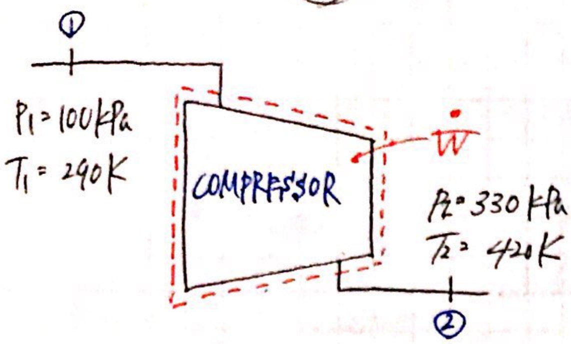

FIND
(a) specific work, w, kJ/kg
(b) $\frac{\dot{\sigma}_{gen}}{\dot{m}}$, kJ/kg-K
(c) isentropic efficiency η

ASSUMP
open sys, SSSF, 1-DUF, $\dot{Q}=0$, $\Delta PE = \Delta KE = 0$, ideal gas

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

$\cancel{\frac{dS}{dt}\Big|_{sys}}^{0} = \cancel{\sum \frac{\dot{Q}}{T}}^{0} + \sum_i \dot{m}_i s_i - \sum_e \dot{m}_e s_e + \dot{\sigma}_{gen}$, $P v = R_{air} T$ ($R_{air} = 0.287$ kJ/kg-K)

SOLN
$\dot{m}_1 = \dot{m}_2 = \dot{m}$ ... ①
$\dot{w} = h_1 - h_2$ ... ②
$\frac{\dot{\sigma}_{gen}}{\dot{m}} = s_2 - s_1 = s_2^o - s_1^o - R \ln \frac{P_2}{P_1}$ ... ③

from table
$h_1 = 290.1$ kJ/kg $s_1^o = 1.669$ kJ/kg-K
$h_2 = 421.4$ kJ/kg $s_2^o = 2.042$ kJ/kg-K

(a)
$\because$ ② $\dot{w} = 290.1\,kJ/kg - 421.4\,kJ/kg = -131.3\,kJ/kg \cong \boxed{-131\,kJ/kg}$

(b) $\because$ ③
$\frac{\dot{\sigma}_{gen}}{\dot{m}} = 2.042\,kJ/kg\text{-}K - 1.669\,kJ/kg\text{-}K - (0.287\,kJ/kg\text{-}K) \ln\left(\frac{330\,kPa}{100\,kPa}\right) \cong \boxed{0.030344\,kJ/kg\text{-}K}$

(c) if $\Delta s = 0$
using ③ $s_{2s}^o = s_1^o + R \ln \frac{P_2}{P_1} = 1.669\,kJ/kg\text{-}K + (0.287\,kJ/kg\text{-}K) \ln\left(\frac{330\,kPa}{110\,kPa}\right)$
$\cong 2.0117$
the corresponding (Temp.) $\longrightarrow$ enthalpy h_{2s} will be
interpolating $h_{2s} = (2.0117\,kJ/kg\text{-}K - 1.993\,kJ/kg\text{-}K) \frac{(411.2 - 401.1)\,kJ/kg}{(2.018 - 1.993)\,kJ/kg\text{-}K} + 401.1\,kJ/kg$
$\cong 408.65$ kJ/kg
$\therefore \dot{w}_{isentropic} = h_1 - h_{2s} = (290.1 - 408.65)\,kJ/kg = -118.55\,kJ/kg$

then $\eta = \frac{\dot{w}_{isentropic}}{\dot{w}} = \frac{-118.55\,kJ/kg}{-131.3\,kJ/kg} \cong 0.9029$ $\boxed{\eta = 90.3\,\%}$