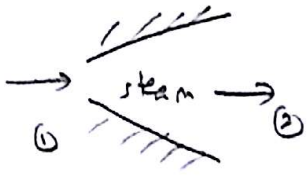
MMEM 1413

HW 7.50 Fundamentals - Sonntag

A diffuser is a steady-state, steady flow device in which a fluid flowing at high velocity is decelerated in such a way that the pressure increases during the process. Consider a diffuser in which steam enters at 200 kPa, 200°C, with a velocity of 700 m/s and exits with a velocity of 70 m/s. Assuming that the process is reversible and adiabatic, what are the exit pressure and temperature of the steam?



$\vec{V}_2 = 70$ m/s

$P_1 = 200$ kPa

$T_1 = 200°C$

$\vec{V}_1 = 700$ m/s

$T_2 = ?$

$P_2 = ?$

reversible, adiabatic

$\therefore s_2 = s_1$

1st. Law

$$\cancel{\dot{Q}} - \cancel{\dot{W}} = \sum_{out} \dot{m}\left(h + \cancel{ke} + \cancel{pe}\right) - \sum_{in} \dot{m}\left(h + \cancel{ke} + \cancel{pe}\right)$$

$$0 = \left(h_2 + \frac{\vec{V}_2^2}{2}\right) - \left(h_1 + \frac{\vec{V}_1^2}{2}\right)$$

P_1, T_1 $\Big\}$ $h_1 = 2870.5$ kJ/kg

$s_1 = 7.5066$ kJ/kg·K $= s_2$

$$\rightarrow h_2 = \left(2870.5 \frac{kJ}{kg} + \frac{700^2}{2} \times \frac{1}{1000} \frac{kJ}{kg}\right) - \frac{70^2}{2000}$$

$$= 3113.05 \frac{kJ}{kg}$$

known $h_2 = 3113.05$ kJ/kg, $s_2 = 7.5066$ kJ/kg·K $\Big\}$ can get P_2 & T_2, needs trial & error since not explicitly listed in table.

Phase of state 2?

Set $s_2 = s_g$ and compare with saturated table.

Closest values: $s_g = 7.4791$; $h_{g_a} = 2600.1$

or $s_g = 7.5445$; $h_{g_b} = 2651.9$

since $h_2 > h_{g_a}$ & h_{g_b} / $\left.\begin{matrix} s_2 \\ h_2 \end{matrix}\right\}$ superheated

or

Set $h_2 = h_g$ & compare with sat. table.

Sat table values only up to 2804.2 ∴ superheated.

- State 2 is superheated; trial & error with superheated table.

We notice that the combination of $h = 3113$ & $s = 7.5066$ occurs in the lower pressure values of the table (between 0.5 MPa & 0.6 MPa) between 300°C and 350°C.

- Trial & error can be performed with repeated interpolations varying both pressure and temperature.