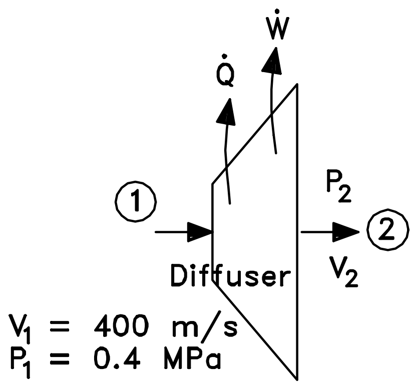
Problem: 7-24

Given: Steam entering an adiabatic diffuser at 400 m/s as a saturated vapor at 0.4 MPa.

Find: Maximum possible discharge pressure.



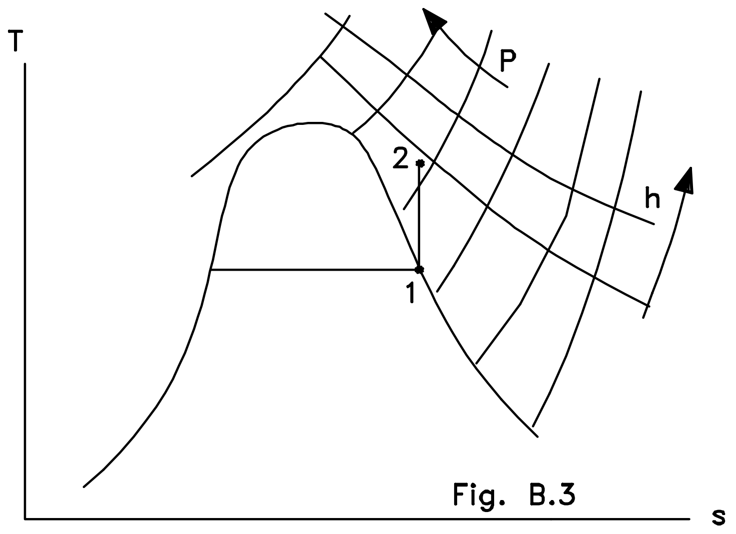


Fig. B.3

From the $T-s$ plot, we see that in the superheat region (which is where state 2 will be), as s increases, P decreases. Thus for the maximum discharge pressure we want the minimum entropy.
But from the second law

$$P_s \geq 0 \quad \Rightarrow \quad s_2 \geq s_1$$

Therefore for maximum P_2,

$$s_2 = s_1$$

Following a line of constant entropy, we see that as h increases, P increases. Therefore we want h_2 to be as high as possible. A first law energy balance gives:

$$\dot{m}(h_1 + \frac{1}{2}V_1^2 + \cancel{pe_1}) = \dot{m}(h_2 + \frac{1}{2}V_2^2 + \cancel{pe_2}) + \cancel{\dot{Q}}^{\,0} + \cancel{\dot{W}}^{\,0}$$

For maximum h_2, $V_2 = 0$.
Then

$$h_2 = h_1 + \frac{1}{2}V_1^2$$

From Tables:

$$\begin{aligned} h_1 &= 2738.5\ kJ/kg \\ s_1 = s_2 &= 6.8967\ kJ/kg \cdot K \end{aligned}$$

$$\begin{aligned} h_2 = h_1 + \frac{1}{2}V_1^2 &= 2738.5\ kJ/kg + \frac{1}{2}\left(\frac{400\ m/s}{10^3}\right)^2 \\ &= 2918.5\ kJ/kg \end{aligned}$$

Therefore state 2 is defined by:

$$\begin{aligned} h_2 &= 2818.5\ kJ/kg \\ s_2 &= 6.8967\ kJ/kg \cdot K \end{aligned}$$

Interpolating Table B.16:

$$\boxed{P_{2_{max}} = 0.601\ MPa} \quad \Leftarrow$$