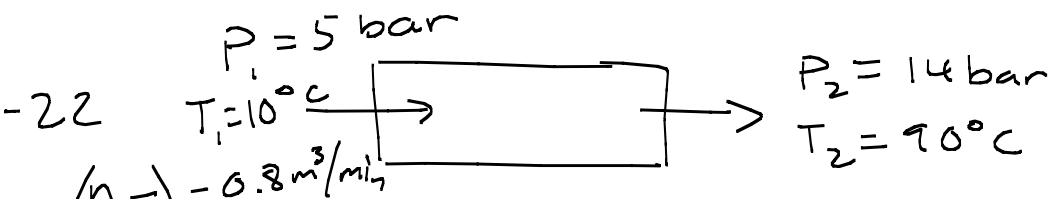
Problem 3



Given :- Compressor with R-22

- diameter of the inlet = 4cm
- diameter of the exit = 2cm
- The heat transfer rate from the compressor to the surroundings is 5% of the power input
- $\Delta PE = 0$

Determine: The power input

Mass Rate Balance

$$\dot{m}_1 = \dot{m}_2 = \dot{m}$$

Energy Rate Balance

$$0 = \dot{Q}_{cv} - \dot{W}_{cv} + \dot{m}\left[(h_1 - h_2) + \frac{1}{2}(v_1^2 - v_2^2) + g(z_1 - z_2)\right]$$

($g(z_1 - z_2) \approx 0$)

$$\dot{Q}_{cv} = 0.05\,\dot{W}_{cv}$$

Table A-9 @ $P_1 = 5\ bar, T_1 = 10°C \Rightarrow h_1 = 257.22\ kJ/kg, v_1 = 0.04934\ m^3/kg$

$P_2 = 14\ bar, T_2 = 90°C \Rightarrow h_2 = 306.60\ kJ/kg, v_2 = 0.02217\ m^3/kg$

$$\dot{m} = \frac{(Av)_1}{v_1} = \frac{0.8\ m^3/min\left(\frac{1\ min}{60\ sec}\right)}{0.04934\ m^3/kg} = \underline{0.2702\ kg/s}$$

$$A_1 = \frac{\pi}{4}(0.04m)^2 = 1.257 \times 10^{-3}\ m^2$$

$$A_2 = \frac{\pi}{4}(0.02m)^2 = 3.14 \times 10^{-4}\ m^2$$

$$V_1 = \frac{(AV)_1}{A_1} = \frac{0.8\ m^3/min\left(\frac{1}{60}\right)}{1.257 \times 10^{-3}\ m^2} = 10.61\ m/s$$

$$\dot{m} = \frac{(AV)_2}{v_2} \Rightarrow V_2 = \frac{\dot{m} v_2}{A_2} = \frac{(0.2702\ kg/s)(0.02217\ m^3/kg)}{3.14 \times 10^{-4}\ m^2}$$

$$V_2 = 19.08\ m/s$$

$$0 = 0.05\dot{W}_{cv} - \dot{W}_{cv} + (0.2702\,kg/s)\Big[(257.22\,kJ/kg - 306.60\,kJ/kg) + \frac{1}{2}\left((10.61\,m/s)^2 - (19.08\,m/s)^2\right)\left(\frac{1\,kJ}{1000\,J}\right)$$

$$\boxed{\dot{W}_{cv} = -14.08\ kW}$$