

AE 209 THERMODYNAMICS

QUIZ 6

Air enters the compressor of a gas-turbine plant at ambient conditions of 100 kPa and 25°C with a low velocity and exits at 1 MPa and 437 °C with a velocity of 80 m/s. The compressor is cooled at a rate of 1200 kJ/min, mass flow rate of the air is 0.5 kg/s. Determine the given power input to the compressor. Use air tables (Table A-17 or table 2.4.3)

Answer:

$$\left. \begin{aligned} T_1 = 25 \text{ } ^\circ\text{C} = 298 \text{ K} &\rightarrow h_1 = 298,18 \text{ kJ/kg} \\ T_2 = 437 \text{ } ^\circ\text{C} = 710 \text{ K} &\rightarrow h_2 = 724,04 \text{ kJ/kg} \end{aligned} \right\} \text{From Table}$$

$$\dot{E}_{in} - \dot{E}_{out} = \Delta E = 0 \text{ (Steady Flow Process)}$$

$$\dot{E}_{in} = \dot{E}_{out}$$

$$\dot{W}_{in} + \dot{m} \left(h_1 + \frac{V_1^2}{2} \right) = \dot{Q}_{out} + \dot{m} \left(h_2 + \frac{V_2^2}{2} \right)$$

$$\dot{W}_{in} - \dot{Q}_{out} = \dot{m} \left(h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} \right)$$

$$\dot{W}_{in} - \frac{1200}{60} \frac{\text{kJ}}{\text{s}} = 0,5 \frac{\text{kg}}{\text{s}} \left(724,04 - 298,18 \frac{\text{kJ}}{\text{kg}} + \frac{80^2 - 0^2}{2} \frac{\text{m}^2}{\text{s}^2} \right)$$

$$= 0,5 \frac{\text{kg}}{\text{s}} \left(425,86 \frac{\text{kJ}}{\text{kg}} + 3200 \frac{\text{m}^2}{\text{s}^2} \right)$$

$$= 212,93 \frac{\text{kJ}}{\text{s}} + \underbrace{1600 \frac{\text{kg} \cdot \text{m}^2}{\text{s}^3}}_{\frac{\text{J}}{\text{s}}}$$

$$\dot{W}_{in} - 20 \text{ kW} = 212,93 \text{ kW} + 1,6 \text{ kW}$$

$$\dot{W}_{in} = 214,53 \text{ kW} + 20 \text{ kW} = \underline{\underline{234,53 \text{ kW}}}$$