Thermodynamics paper

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Name:

Instructions:

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Problem 1

Air flows steadily and isothermally at $27^\circ\ C$ along a horizontal pipe of constant crosssectional area 100 cm^2. At point A the pressure is $3\ bar$ and the mean velocity is $160\ m/s$. At point B the pressure is $2\ bar$.

a. Calculate the velocity at point B, assuming air is an ideal gas [4].

b. Find the heat-transfer per kg of air between the two points [5].

c. Assuming the flow is from A to B, calculate the increase in specific entropy due to irreversibility. Suggest a physical cause for the irreversibility, and comment on the validity of the assumption that the flow is from A to B. Use an R value of 287 $J/(kg \cdot K)$ [5].

b. Water flows through an insulated pump. On the assumption that the flow is reversible, use the steady-flow energy equation along with the equation $\Delta h = \frac{\Delta p}{\rho}$ to show that the pump power is given by

$$\dot{W}_p = \frac{\dot{m}}{\rho}\left[(p_2 - p_1) + \frac{1}{2}\rho\left({v_2}^2 - {v_1}^2\right)\right]$$

where $\dot{m}$ is the mass flow rate, p_1 and v_1 are the pressure and velocity at the inlet, and p_2 and v_2 are the pressure and velocity at the outlet. You may neglect changes in potential energy. [5]

Problem 2

a. Use the first law of thermodynamics, in the form $dq = du + pdv$ to show that for a reversible adiabatic process, the incremental change in specific enthalpy is $dh = vdp$. Hence show that when an incompressible fluid undergoes a reversible adiabatic process, the total change in specific enthalpy is given by the expression below $\Delta h = \frac{\Delta p}{\rho}$. [5]

c. Why will the flow not be reversible in practice? [2]