

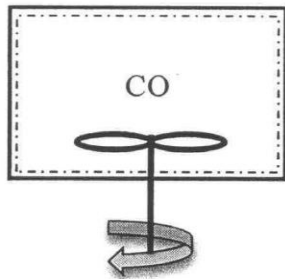
PROBLEM 2.67

Known: Carbon monoxide (CO) is contained in a rigid tank with a paddle wheel that transfers energy to the air at a constant rate of 14 W for 1 h. During the process, the specific internal energy of the carbon monoxide increases.

Find: Determine the specific volume at the final state, in m^3/kg ; the energy transfer by work, in kJ; and the energy transfer by heat transfer, in kJ, with direction.

Schematic and Given Data:

$$\begin{aligned}V &= 1 \text{ m}^3 \\m &= 4 \text{ kg} \\ \Delta u &= 10 \text{ kJ/kg} \\ \dot{W} &= -14 \text{ W} \\ \Delta t &= 1 \text{ h}\end{aligned}$$



Engineering Model:

- (1) The carbon monoxide within the tank is the closed system.
- (2) The tank is rigid, therefore $V_1 = V_2$.
- (3) The system experiences no change in potential and kinetic energy.

Analysis:

- (a) The mass and volume remain constant in the process due to assumptions (1) and (2), therefore

$$v = \frac{V}{m} = \frac{1 \text{ m}^3}{4 \text{ kg}} = 0.25 \frac{\text{m}^3}{\text{kg}}$$

←

- (b) To evaluate W , in kJ, integrate the following

$$\int_0^{1\text{h}} \dot{W} dt = \int_0^{1\text{h}} (-14 \text{ W}) dt = (-14 \text{ W})(1 \text{ h}) \left| \frac{3600 \text{ s}}{1 \text{ h}} \right| \left| \frac{1 \text{ J}}{1 \text{ W}} \right| \left| \frac{1 \text{ kJ}}{1000 \text{ J}} \right| = -50.4 \text{ kJ}$$

←

The minus sign for W indicates that energy is added to the system by work, as expected.

- (c) To evaluate Q , in kJ, use the closed system energy balance

$$\Delta KE + \Delta PE + \Delta U = Q - W$$

$$Q = \Delta U + W = m\Delta u + W = (4 \text{ kg}) \left(10 \frac{\text{kJ}}{\text{kg}} \right) + (-50.4 \text{ kJ}) = -10.4 \text{ kJ}$$

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Energy is removed from the system through heat transfer.

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