Lecture 6:
Energy balance of closed system
Examples

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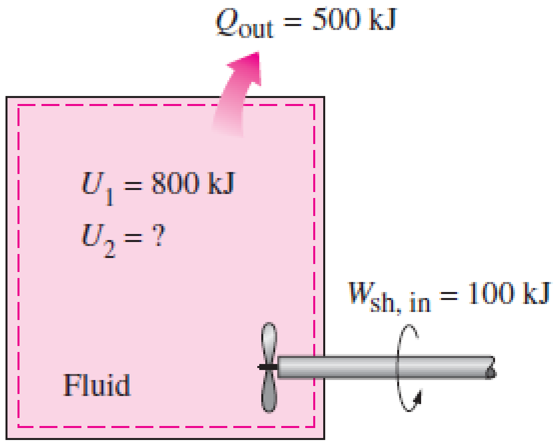
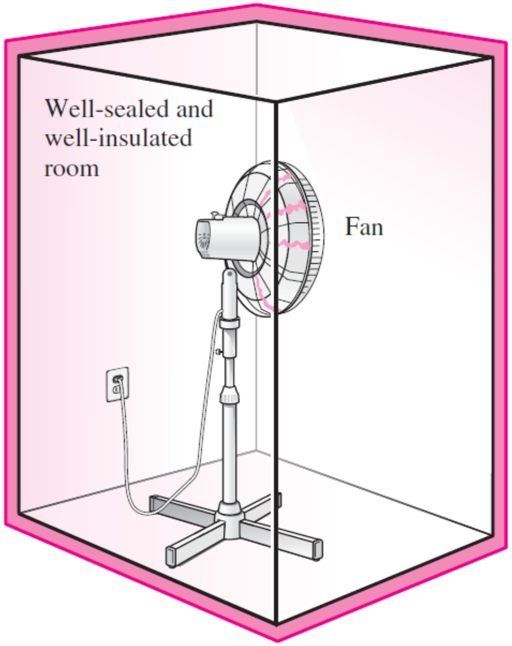
Example 1— —Cooling of a Hot Fluid in a Tank

- A rigid tank contains a hot fluid that is cooled while being stirred by a paddle wheel. Initially, the internal energy of the fluid is 800 kJ. During the cooling process, the fluid loses 500 kJ of heat, and the paddle wheel does 100 kJ of work on the fluid. Determine the final internal energy of the fluid.
- Neglect the energy stored in the paddle wheel.
- Known: U_1 , Q , W_{in}
- Find: U_2



Example 2

- A 5-hp fan is used in a large room to provide for air circulation. Assuming a well-insulated, sealed room determine the internal energy increase after 1 h of operation.



Example 3

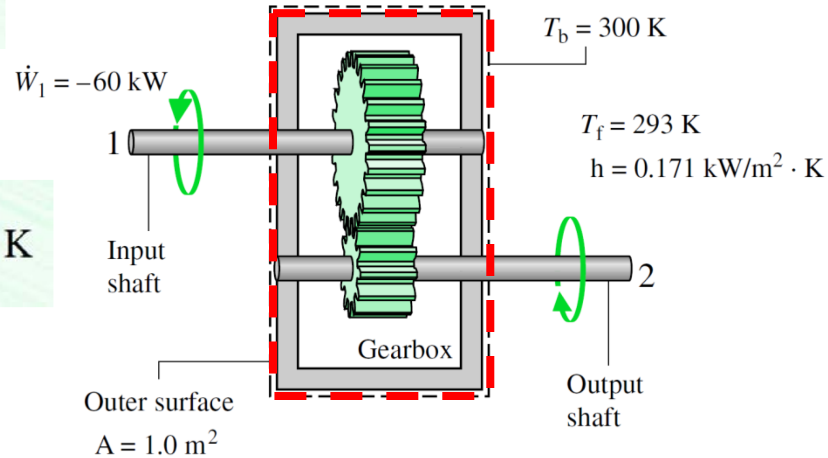
- A fan that consumes 20 W of electric power when operating is claimed to discharge air from a ventilated room at a rate of 0.25 kg/s at a discharge velocity of 8 m/s . Determine if this claim is reasonable.

Example 4

During steady-state operation, a gearbox receives 60 kW through the input shaft and delivers power through the output shaft. For the gearbox as the system, the rate of energy transfer by convection is

$$\dot{Q} = -\mathrm{h}A(T_b - T_f)$$

where $\mathrm{h} = 0.171\ \mathrm{kW/m^2 \cdot K}$ is the heat transfer coefficient, $A = 1.0\ \mathrm{m^2}$ is the outer surface area of the gearbox, $T_b = 300\ \mathrm{K}$ (27°C) is the temperature at the outer surface, and $T_f = 293\ \mathrm{K}$ (20°C) is the temperature of the surrounding air away from the immediate vicinity of the gearbox. For the gearbox, evaluate the heat transfer rate and the power delivered through the output shaft, each in kW.



Assumption:

1. closed system, 2. steady state, 3. Heat transfer by convection

$$\dot{Q} = -\mathrm{h}A(T_b - T_f) = -\left(0.171 \frac{\mathrm{kW}}{\mathrm{m^2 \cdot K}}\right)(1.0\ \mathrm{m^2})(300 - 293)\ \mathrm{K}$$

$$\boxed{\dot{Q} = -1.2\ \mathrm{kW}}$$

$$\cancel{\frac{dE}{dt}}^{0} = \dot{Q} - \dot{W} \quad \text{or} \quad \dot{W} = \dot{Q}$$

$$\dot{W} = \dot{W}_1 + \dot{W}_2 \qquad \dot{W}_1 + \dot{W}_2 = \dot{Q}$$

$$\dot{W}_1 = -60\ \mathrm{kW}$$

$$\dot{W}_2 = \dot{Q} - \dot{W}_1 = (-1.2\ \mathrm{kW}) - (-60\ \mathrm{kW})$$

$$\boxed{\dot{W} = +58.8\ \mathrm{kW}}$$

Home work

- For next class, please read the text book:
  - » **2.6 and all the examples in the text book 2.3-2.5**

- **Next Wednesday one 20-minutes quiz**