ME 201
Thermodynamics

Conservation of Energy Guide

The most general equation for the conservation of energy is

$$\frac{d}{dt}(m \cdot e) = \sum_{\text{inflows}}(\dot{m}_{in} \cdot e_{in}) - \sum_{\text{outflows}}(\dot{m}_{out} \cdot e_{out}) + \dot{Q} - \dot{W}_{sh} - \dot{W}_{bnd}$$

The time derivative portion represents the change in energy within the system. The two summations represent the inflow and outflow of energy as it is carried along with the inflow and outflow of mass. The net heat transfer in is represented by Q. If Q is negative it is then heat out or if we have heat out then we can let that be negative Q. The shaft work and boundary work terms represent net work out of the system, so they are negative for work into the system.

The system energy, e in the time derivative, consists of thermal energy, kinetic energy, and potential energy on a per mass basis or

$$e = u + \frac{\vec{V}^2}{2} + gz$$

The flow energy, e_{in} or e_{out} in the summations, consists of thermal energy, flow energy, kinetic energy, and potential energy on a per mass basis or

$$e_{\text{in or out}} = h + \frac{\vec{V}^2}{2} + gz$$

where we have used the enthalpy, h, to represent the combined thermal and flow energy.

We can write work and heat transfer in three different fashions:

Total: Use capital and will have units of energy, kJ or Btu
Rate: Use capital with dot over variable and will have units of power, kW or Btu/hr
Specific: Use lower case and will have units of energy per mass, kJ/kg or Btu/lbm

We can relate these three forms as shown below:

Total Work or Heat Transfer

$$W = \Delta t \cdot \dot{W} = m \cdot w$$

$$Q = \Delta t \cdot \dot{Q} = m \cdot q$$

Power or Heat Transfer Rate

$$\dot{W} = \frac{W}{\Delta t} = \dot{m} \cdot w$$

$$\dot{Q} = \frac{Q}{\Delta t} = \dot{m} \cdot q$$

Specific Work or Heat Transfer

$$w = \frac{W}{m} = \frac{\dot{W}}{\dot{m}}$$

$$q = \frac{Q}{m} = \frac{\dot{Q}}{\dot{m}}$$