

## Conservation of Energy

1. Define, illustrate, and compare and contrast the following terms and concepts:

### Work-Energy Principle

relation to conservation of linear momentum

### Energy

internal energy

specific internal energy:  $u$

mechanical energy

gravitational potential energy

specific gravitational potential energy:  $gz$

kinetic energy

specific kinetic energy:  $V^2/2$

spring energy

### Work

mechanism for transferring energy

mechanical work vs. thermodynamic work

work ( $W$ ) vs. power ( $\dot{W}$ )

path function

reversible (quasiequilibrium) work vs. irreversible work  
types

compression/expansion ( $pdV$ ) work

shaft work

elastic (spring) work

electric work/power

dc power

ac power:

effective vs maximum values

power factor

### Heat transfer

mechanism for transferring energy

heat transfer ( $Q$ ) vs. heat transfer rate ( $\dot{Q}$ )

adiabatic surface or boundary

path function

types of heat transfer

conduction

convection

Newton's law of cooling

convection heat transfer coefficient

thermal radiation

## Application of Accounting Principle to Energy

rate of accumulation of energy within the system

$$\text{amount of energy } E_{\text{sys}} = \int_V e \rho dV$$

where the specific energy is defined as  $e = u + (V^2)/2 + gz$

transport rate of energy by heat transfer:  $\dot{Q}$  ---- Heat transfer rate

transport rate of energy by work at non-flow boundaries:  $\dot{W}$  ----- Power

transport rate of energy by work at flow boundaries:

$$\boxed{\sum (pv)\dot{m}_{in} - \sum (pv)\dot{m}_{out}} \text{----- Flow Power}$$

transport rate of energy mass flow:  $\boxed{\sum \dot{m}(u + \frac{V^2}{2} + gz)_{in} - \sum \dot{m}(u + \frac{V^2}{2} + gz)_{out}}$

## Rate form of Conservation of Energy

$$\boxed{\frac{dE_{\text{sys}}}{dt} = \dot{Q}_{\text{Net},in} + \dot{W}_{\text{Net},in} + \sum (h + \frac{V^2}{2} + gz)\dot{m}_{in} - \sum (h + \frac{V^2}{2} + gz)\dot{m}_{out}}$$

where  $h = u + pv$  is a new property called enthalpy

## Substance models

Ideal gas with room-temperature specific heats

Incompressible substance with room-temperature specific heats

## Thermodynamic cycles

Definition ( three parts)

Classifications

On Final Exam

Working fluid: single vs two-phase

Structure: Closed, periodic vs Closed-loop, steady-state

Purpose: Power vs Refrigeration vs Heat Pump cycles

Measures of Performance

General definition

Power cycles  $\rightarrow$  Thermal efficiency –  $\eta$

Refrigeration cycle  $\rightarrow$  Coefficient of Performance –  $\text{COP}_{\text{ref}}$

Heat pump cycles  $\rightarrow$  Coefficient of Performance –  $\text{COP}_{\text{hp}}$

- Given a mechanical system consisting of particles, apply the Work-Energy Principle where appropriate to solve problems where changes in mechanical energy (kinetic, potential, and spring) can be balanced with mechanical work done on the system.
- Given a closed or open system and sufficient information about the properties of the system, apply conservation of energy to determine changes in energy (rates of change) within the system and heat transfers (heat transfer rates) and work transfers of energy (power) with the surroundings.

4. Given sufficient information, determine the change in specific internal energy  $\Delta u$  and the change in  $\Delta h$  for a substance that can be modeled using one of the following substance models:
  - Ideal gas with room-temperature specific heats
  - Incompressible substance with room-temperature specific heatsand use this information in conjunction to meet Objective 3 above.
5. Given the indicated information calculate the associated work or power for a system:
  - Given a relation between system pressure and system volume, calculate the compression/expansion work done on the system.
  - Given a torque and a rotational speed for a shaft, calculate the shaft power transmitted by the shaft.
  - Given an electric current and the corresponding voltage difference across the terminals, calculate the electric power supplied to or by the system. (You should be able to perform this calculation for both DC and AC systems.)
7. Given a numerical value for a typical energy or power quantity, make the appropriate unit conversions to change the units to the requested values, e.g. convert  $\text{ft}^2/\text{s}^2$  to Btu/lbm.
8. List the appropriate assumptions to recover the mechanical energy balance from the general conservation of energy equation.