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SELF STUDY MODULE

Entropy a new state variable

Objective

Entropy balance, concept of reversibility, quality of energy

Vocabulary

Heat: Energy in transit due to a temperature difference. Heat is transferred to bring objects to a thermal equilibrium.

Work: Energy in transit due to motion, due to a pressure difference. Mechanical equilibrium is reached through work.

Entropy: A state variable that will enable us to see if the processes are possible, if they are reversible, what is their direction. The term is of Greek origin meaning, the change within.

Balance equations

The general mass conservation law $\frac{dm}{dt} = \sum_{in} m_i - \sum_{out} m_j$

The general conservation of energy or the first law of thermodynamics

$$\frac{dU}{dt} = \sum_{in} m_i h_i - \sum_{out} m_j h_j + \dot{Q} + \dot{W}_S - P\frac{dv}{dt}$$

The entropy balance has a generation term

$$\frac{dS}{dt} = \sum_{in} m_i s_i - \sum_{out} m_j s_j + \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

Calculate

1. A gas in piston and cylinder assembly is heated at constant volume from T_1 to T_2. Derive the equation that will allow you to determine the entropy change for this process for a
    a. monoatomic ideal gas.
    b. diatomic ideal gas.
2. A gas in piston and cylinder assembly is heated at constant pressure from T_1 to T_2. Derive the equation that will allow you to determine the entropy change for this process for a
    a. monoatomic ideal gas
    b. diatomic ideal gas
3. Air is confined in a piston and cylinder assembly, is in thermal equilibrium with its environment under ambient conditions. The piston exerts a pressure on the gas through the pressure of the ambient, and an additional 50 kg weight is exerting additional pressure through 100 cm^2 area of the interface between the piston and the gas. Rework this problem to find the entropy generation during the rapid removal of the weight.
4. Determine the maximum efficiency of an ideal power cycle operating between the high temperatures given below and a common cold temperature T_C=300 K. Based on your answers, comment on the quality of the heat available at each of these T_H temperatures.
    a. T_H=5000 K
    b. T_H=1000 K
    c. T_H=500 K
    d. T_H=350 K

Bibliography

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