Sharif University of Technology
School of Mechanical Engineering
Center of Excellence in Energy Conversion

Advanced Thermodynamics

Lecture 10

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- Exergy=available reversible work
- Simultaneous invocation of the first and second laws.
- The two laws combined: exergy destruction
- The losses can be measured in units of entropy.
- Lost available work (lost exergy)
  - **Entropy generation maximization**
  - **2nd law analysis**
  - **Exergy analysis**
  - **Energetic cast analysis (exergo-economic analysis)**
  - **Thermo-economic analysis**

- What is exergy analysis?
- What is 2^{nd} law analysis?
- What is 1^{st} law analysis?
- Applying this tool for
  - Improve the efficiency of power generation
  - Improve the efficiency of a residential heat pump
  - Reduce the size of a heat exchanger
  - Design an efficient fuel cell

- Exergy (availability)
- From the definition of exergy or availability, it may be concluded that a system will deliver the maximum possible work when it undergoes through a reversible process from the initial to the state of equilibrium with the surrounding.
- Relation between irreversibility (entropy generation) and one-way destruction of available work.
- Considering the possibility of changing the design (the internal functioning) of the system to maximize the work transfer rate.

- For a system:

$$\text{second law} \rightarrow \Delta S = \sum \frac{Q}{T} + S_{gen}$$

- For a control volume:

$$\text{Clausius ineq.} \rightarrow \Delta S \geq \frac{dQ}{T}$$

$$\text{second law} \rightarrow \Delta S = S(t+\Delta t) - S(t) =$$

$$S_{C.V.}(t+\Delta t) - S_{C.V.}(t) + m_{out}S_{out} - m_{in}S_{in}$$

$$\Rightarrow S_{C.V.}(t+\Delta t) - S_{C.V.}(t) = \sum \frac{Q}{T} + S_{gen} + m_{in}S_{in} - m_{out}S_{out}$$

$$\text{or} \quad \frac{dS_{C.V.}}{dt} + \sum \dot{m}_{out}S_{out} - \sum \dot{m}_{in}S_{in} = \sum \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

- $\dot{S}_{gen}$ = the rate of entropy production in the C.V.

- For cycles:

$$\text{second law} \rightarrow \Delta S = \sum \frac{Q}{T} + S_{gen}$$

$$\text{for heat engines } \Delta S = 0 \rightarrow S_{gen} = -\sum \frac{Q}{T} =$$

$$\Rightarrow \boxed{S_{gen} = \frac{Q_L}{T_L} - \frac{Q_H}{T_H}}$$

- If the process within the heat engines be reversible:

$$\Rightarrow \frac{Q_L}{T_L} = \frac{Q_H}{T_H}$$

- which defines Temperature Scale.