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\textsuperscript{nd} law analysis?

What is 1\textsuperscript{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:

\[ \dot{\Delta}S = \sum Q \frac{1}{T} + S_{gen} \]

For a control volume:

Clausius ineq. \( \Rightarrow \Delta S \geq \frac{\delta Q}{T} \)

second law \( \Rightarrow \Delta S = S(t + \Delta t) - S(t) = \)

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

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

or \[ \frac{dS_{C.V.}}{dt} + \sum n_{\xi_{out}} S_{out} - \sum n_{\xi_{in}} S_{in} = \sum \frac{\delta \xi}{T} + S_{gen} \]

\[ \dot{S}_{gen} \] = the rate of entropy production in the C.V.
For cycles:

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

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

\[ S_{gen} = \frac{Q_L}{T_L} - \frac{Q_H}{T_H} \]

If the process within the heat engines be reversible:

\[ \Rightarrow \frac{Q_L}{T_L} = \frac{Q_H}{T_H} \]

which defines Temperature Scale.