ME 201
Thermodynamics

Cycle Analysis Guide

Basic Principles

Three basic types of thermal cycles

Control Volume Power or Propulsion Cycles
Closed System Power or Propulsion Cycles
Control Volume Refrigeration Cycle

All three systems have

Heat Added $q_{in}$
Heat Rejected $q_{out}$
Net Work Output $w_{net}$

First Law for any complete cycle is

$$w_{net} = q_{in} - q_{out}$$

Net Power or heat transfer rate is given by

$$\dot{W}_{net} = \dot{m} \cdot w_{net}$$
$$\dot{Q}_{in} = \dot{m} \cdot q_{in}$$

System performance is characterized by

Thermal Efficiency: $\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{in}}$  (for power cycles)

Coefficient of Performance: $\text{COP} = \frac{\dot{Q}_{in}}{\dot{W}_{net}}$  (for refrigeration cycles)

To characterize best performance compare to Carnot cycle
Carnot Cycle Thermal Efficiency:  \[ \eta_{\text{Carnot}} = 1 - \frac{T_L}{T_H} \]

Carnot Cycle COP for Refrigerator:  \[ (\text{COP})_{\text{Carnot}} = \frac{1}{\frac{T_H}{T_L} - 1} \]

**Procedure of Cycle Analysis**

1. The plant layout is sketched as a block diagram. The devices or processes are placed and connected according to the plant description.

2. The nodes between the devices or processes are numbered. These nodes represent the various states of the working fluid as it passes through the cycle.

3. A table is constructed with the following headings:

   **Assuming a compressible substance as the working fluid in a control volume plant**

<table>
<thead>
<tr>
<th>Node</th>
<th>T</th>
<th>P</th>
<th>Fluid Phase</th>
<th>h</th>
<th>s</th>
<th>( \dot{m} )</th>
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   **Assuming an ideal gas as the working fluid in a control volume plant using the ideal gas tables**

<table>
<thead>
<tr>
<th>Node</th>
<th>T</th>
<th>P</th>
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<th>( \phi )</th>
<th>( \dot{m} )</th>
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   **Assuming an ideal gas as the working fluid in a control volume plant using the constant specific heat equations**

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Assuming an ideal gas as the working fluid in a closed system plant using the ideal gas tables

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<tr>
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Assuming an ideal gas as the working fluid in a closed system plant using the constant specific heat equations

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4. With the given operating conditions and plant description, all known thermodynamic information is entered on the table.

5. Using the state postulate and the working fluid property tables or equations, all obtainable thermodynamic information is added to the table.

6. The system is traversed, device by device or process by process, analyzing the fluid as it passes through each device or process. This analysis provides additional fluid properties, which when used in conjunction with step #5 systematically completes the table.

7. If there is insufficient information to fix the state at the node, continue on to the next node. After the cycle has been traversed, repeat the traversing until the state at each node is fixed.

8. With the completed table, plant information (such as thermal efficiency and work produced) is calculated.