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13.05.19

ME 263

Thermodynamics Term Project

# Vapor Power Cycle

As our system is a cycle, every step is in steady state. Meaning that, energy change rate will be zero. So, for every step we can write down the equations below.

$$\dot{m}h_1 + \dot{w}_{pump} = \dot{m}h_2$$

$$\dot{m}h_2 + \dot{Q}_{in} = \dot{m}h_3$$

$$\dot{m}h_3 = \dot{m}h_4 + \dot{w}_{turb}$$

$$\dot{m}h_4 = \dot{Q}_{out} + \dot{m}h_1$$

We write what is given to us and what we can get from tables. We assume that at the outlet of the condenser, fluid is Saturated Liquid. Because, even if it is not 100% saturated, for Compressed Liquid model, entalphy of SL is almost equal to CL at the same temperature.

| STEP | T (°C) | P (BAR) | STATE | X | ENTROPY | ENTALPHY |
|---|---|---|---|---|---|---|
| 1 | g.f.t | 0.7 | Saturated Liquid | - | g.f.t | g.f.t |
| 2 | | 10 | g.f.t | | $=s_1$ | g.f.t |
| 3 | 700 | 10 | Super-Heated Steam | - | g.f.t | g.f.t |
| 4 | g.f.t | 0.7 | g.f.t | g.f.t | $= s_3$ | g.f.t |

*g.f.t = get from tables (XSteam for this case)*

$$\eta = \frac{\dot{w}_{turb} - \dot{w}_{pump}}{\dot{Q}_{in}}$$

$$\dot{w}_{turb} = \dot{m}(h_3 - h_4)$$

$$\dot{w}_{pump} = \dot{m}(h_2 - h_1)$$

$$\dot{Q}_{in} = \dot{m}(h_3 - h_2)$$

$$\eta = \frac{h_1 - h_2 + h_3 - h_4}{h_3 - h_2} = \frac{h_1 - h_4}{h_3 - h_2} + 1$$

Giving these equations to MATLAB, we can calculate entalphy values with XSteam. For 10 bar turbine pressure and 0.7 bar condenser pressure, values are given below in the table.

| h1 (kJ/kg) | h2 (kJ/kg) | h3 (kJ/kg) | h4 (kJ/kg) | Thermal Efficiency (η) |
|---|---|---|---|---|
| 376.68 | 377.65 | 3924.1 | 3015.4 | 0.2559 |

When we draw the T-S diagram for given cycle we get Figure 1.

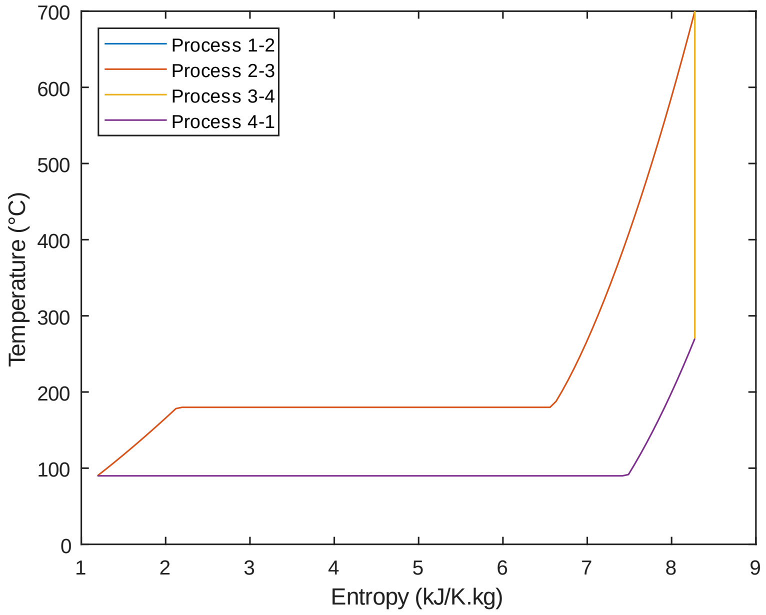



*Figure 1*

To determine phases at every process we need to see saturation dome. From Figure 2 we can get which at phase our working fluid is.

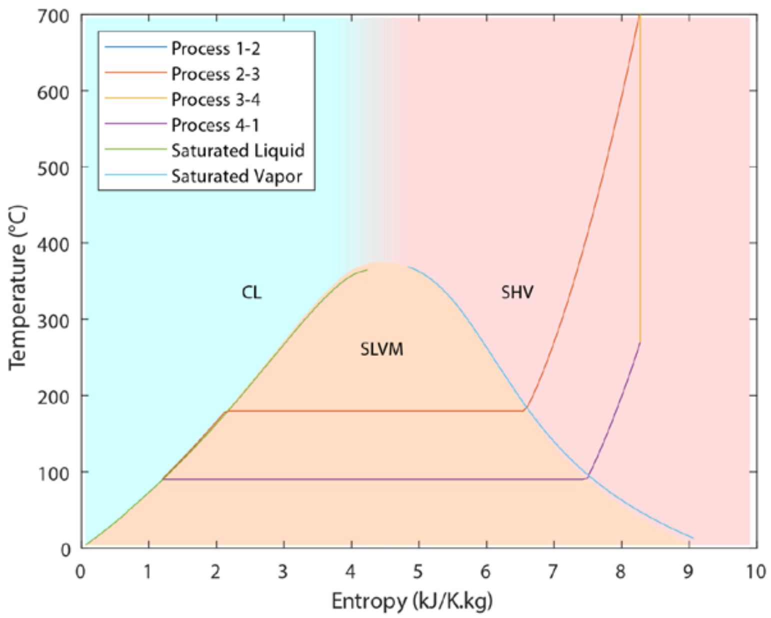


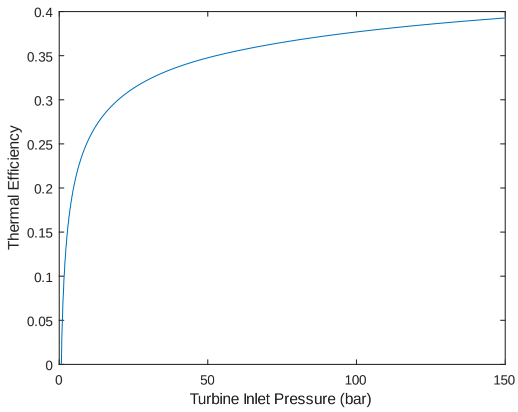

*Figure 2*

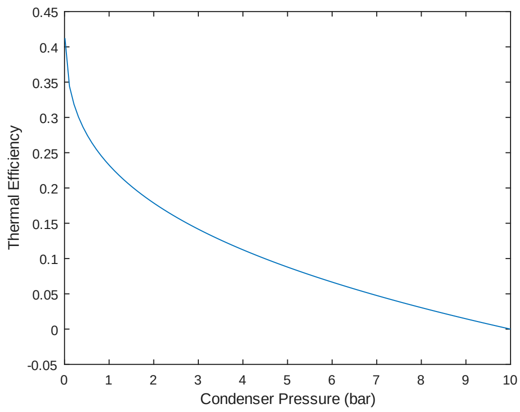
| PROCESS | 1-2 | 2-3 | 3-4 | 4-1 |
|---|---|---|---|---|
| STATE | Saturated Liquid | Saturated Liquid → Superheated Vapor | Superheated Vapor | Superheated Vapor → Saturated Liquid |

Using the MATLAB code, we can calculate efficiencies of different input values.

| TURBINE PRESSURE (BAR) | CONDENSER PRESSURE (BAR) | THERMAL EFFICIENCY |
|---|---|---|
| 60 | 0.7 | 0.3556 |
| 80 | 0.7 | 0.3677 |
| 100 | 0.7 | 0.3769 |
| 120 | 0.7 | 0.3842 |
| 140 | 0.7 | 0.3901 |
| 10 | 0.3 | 0.3027 |
| 10 | 0.5 | 0.2760 |
| 10 | 0.7 | 0.2559 |
| 10 | 0.9 | 0.2396 |
| 10 | 1.1 | 0.2257 |

As we can see from table, if we increase turbine pressure, thermal efficiency increases too. However, if we increase condenser pressure, thermal efficiency decreases. If we plot these data to graph, we get the figures below. (While plotting data, condenser pressure is constant at 0.7 bar and turbine inlet pressure at 10 bar.)




Another option to increase the efficiency is increasing turbine inlet temperature. When we plot the data of changing temperature we get the graph below.