MET 350 Foster Grubbs

Test #2

Problem 1

Purpose |

To determine the thermal efficiency and specific net work for the original cycle.

Drawings and Diagrams |

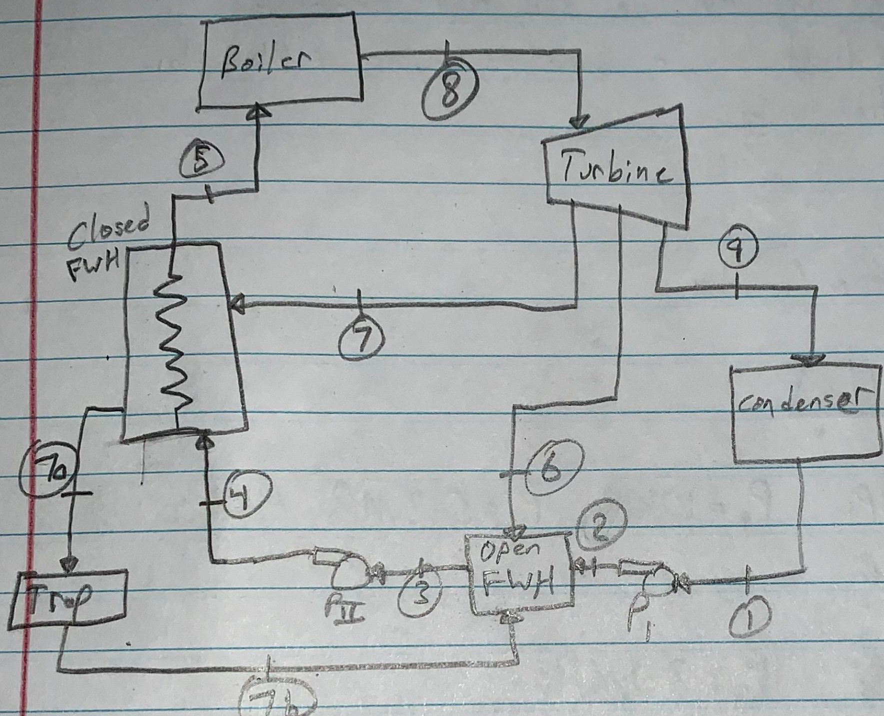

fig 1. Diagram of the plant

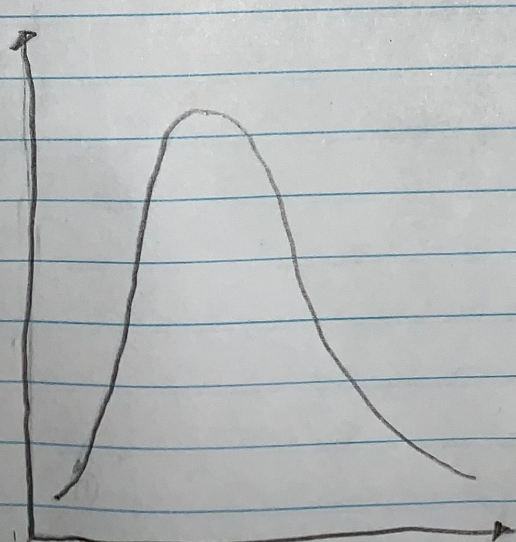

fig 2.

P-V diagram of the cycle

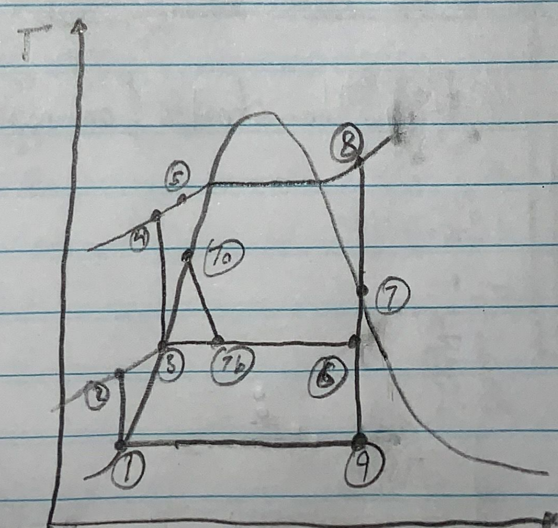

fig 3.

T-s diagram of the cycle

Foster Gribbs

Problem 1

Sources

Cengel + Boles, Thermodynamics - An Engineering Approach. 8th edition. Mc Graw Hill, 2015.

Design Considerations

- Pumps and turbine are not isentropic
- No heat loss in connections, pipes, or fluid flow friction losses

Materials

- Steam (water

Data + Variables

$P_8 = 3.0 MPa$ $P_9 = 10 kPa$ $P_7 = 0.8 MPa$ $P_6 = 100 kPa$

$T_8 = 400°C$

$P_2 = 100 kPa$ $P_4 = 3.0 MPa$

Procedure + Calculations

Getting the states (on next page)

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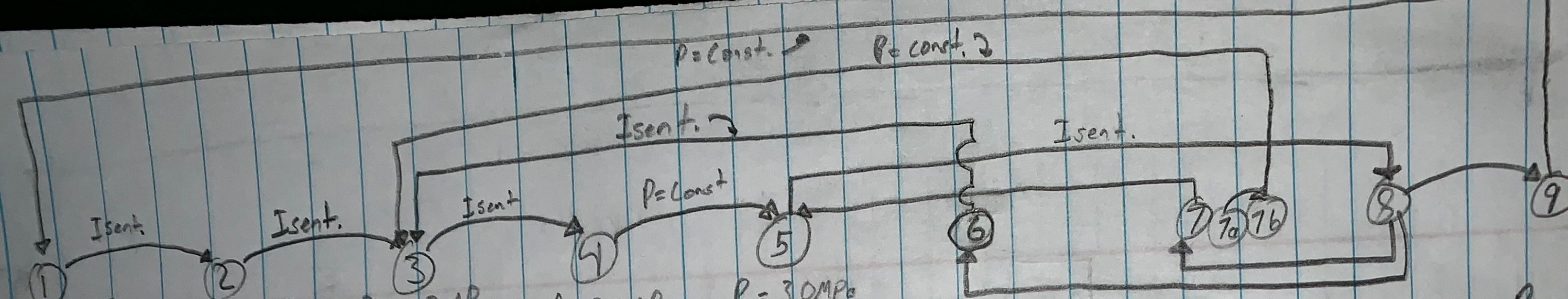
Problem 1
Procedure + Calculations



$P_1 = 10kPa$

From table A-5:
$v_f = 0.001010 \frac{m^3}{kg}$
$h_1 = 191.81 \frac{kJ}{kg}$

$w_{PI} = v_1(P_2 - P_1)$
$\Rightarrow w_{PI} = 0.909 \frac{kJ}{kg}$

$h_2 = h_1 + w_{PI}$
$\Rightarrow h_2 = 191.901 \frac{kJ}{kg}$

$P_2 = 100kPa$

$P_3 = 0.8MPa$
$h_3 = 721.1 \frac{kJ}{kg}$
$v_3 = 0.001115 \frac{m^3}{kg}$

$w_{PII} = v_3(P_4 - P_3)$
$\Rightarrow w_{PII} = 2.45 kJ/kg$
$h_4 = h_3 + w_{PII}$
$\Rightarrow h_4 = 723.55 \frac{kJ}{kg}$

$P_4 = 3.0MPa$
$h_4 = 723.55 \frac{kJ}{kg}$

$P_5 = 3.0MPa$
$h_5 = 3230.8 \frac{kJ}{kg}$
$s_5 = 6.9211 \frac{kJ}{kg \cdot K}$

$q_H = h_5 - h_4$
$\Rightarrow 2507.25 \frac{kJ}{kg}$

$P_6 = 100kPa$
$h_6 = 2891.6 \frac{kJ}{kg}$
$s_6 = 6.9211 \frac{kJ}{kg \cdot K}$

$s_7 = s_6 = s_5 = 6.9211 \frac{kJ}{kg \cdot K}$

$P_7 = 0.8MPa$
$s_7 = 6.9211 \frac{kJ}{kg \cdot K}$
$s_{f7} = 0.6492 \frac{kJ}{kg \cdot K}$
$s_{fg7} = 7.501 \frac{kJ}{kg \cdot K}$

$x_7 = \frac{s_7 - s_{f7}}{s_{fg7}}$

$\Rightarrow x_7 = 0.83614$

$h_7 = h_{f7} + x_7 h_{fg7}$
$\Rightarrow h_7 = 2192.55 \frac{kJ}{kg}$

$P_8 = 3.0MPa$
$T_8 = 400°C$

$P_9 = 10kPa$

Extraction

$(1-x)h_2 + xh_6 = h_3$
$\Rightarrow x = \frac{h_3 - h_2}{h_6 - h_2}$
$\Rightarrow 0.19598 = x$

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Problem 1

Procedure + Calculations (cont.)

Using the information from the states; we need to find the work of the turbine.

$$w_{Turb} = \frac{\dot{W}_{Turb}}{\dot{m}_5} = h_5 - h_6 + (1-x)(h_6 - h_7)$$

$$\Rightarrow 3230.82 - 2891.6 + (1 - 0.19598)(2891.6 - 2192.55)$$

$$\Rightarrow w_{Turb} = 901.27 \frac{kJ}{kg}$$

Now that we know turbine work, we can use the work of the pumps and turbine to calculate net work.

$$w_{net} = w_{Turb} - w_{PI}(1-x) - w_{PII}$$

$$\Rightarrow 901.27 - 0.798(1 - 0.19598) - 2.45$$

$$\boxed{\Rightarrow w_{net} = 898.2 \frac{kJ}{kg}}$$ — specific net work of the cycle

Thermal efficiency can be calculated using the formula

$$\eta_{th} = \frac{w_{net}}{q_H}$$ now that we know net work.

$$\Rightarrow \frac{898.2}{2507.25}$$

$$\boxed{\eta_{th} = 0.3582 \Rightarrow 35.82\%}$$ — thermal efficiency of the cycle

Foster Grub

Problem 2

Purpose

To determine the thermal efficiency and specific net work of the plant when the line connecting the first extraction point and the Closed FWH (state 7) malfunctions.

Drawings and Diagrams

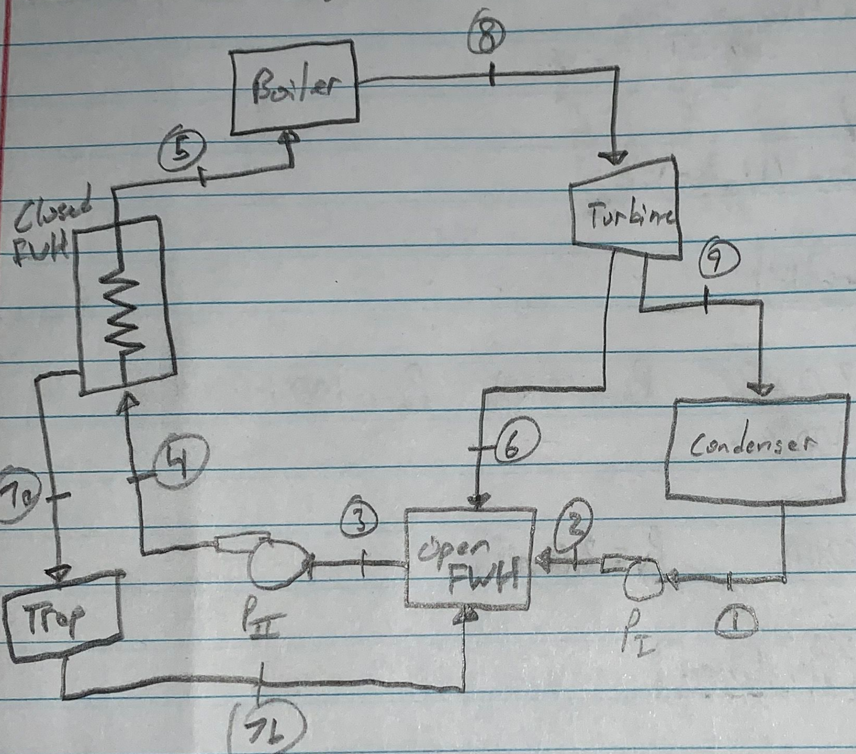

Fig. 1 Diagram of the Plant

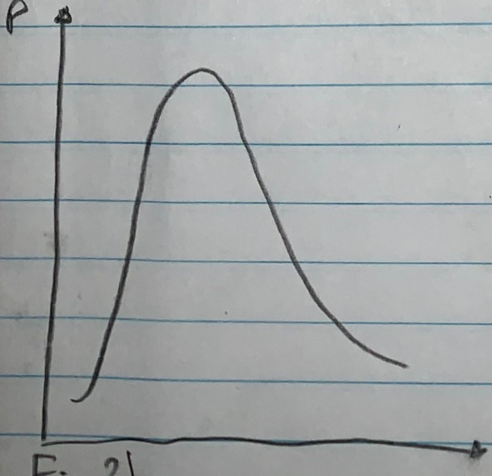

Fig. 2

P-V Diagram of the Cycle

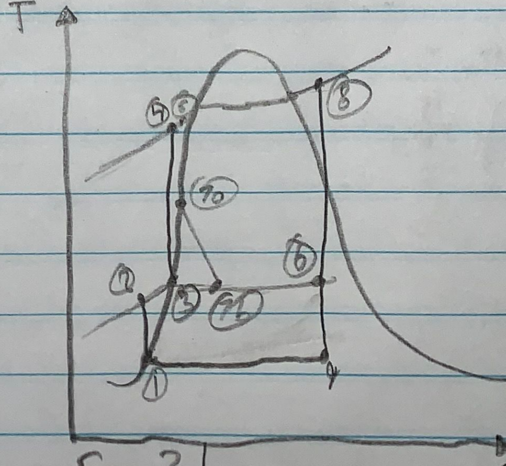

Fig. 3

T-s Diagram of the Cycle

Foster Grubbs

Problem 2

Sources|

Cengel + Boles, Thermodynamics - An Engineering Approach 8th Edition, Mc Graw Hill, 2015

Design Considerations|

- Pumps + turbine are not isentropic
- No heat loss in connections, pipes or fluid flow friction loss

Materials|

- Steam (Water)

Data and Variables|

$P_8 = 3.0\ MPa$ $P_9 = 10\ KPa$ $P_6 = 100\ kPa$
$T_8 = 400°C$

$P_2 = 100\ kPa$ $P_4 = 3.0\ MPa$

Procedure + Calculations|

Getting the states (on next page)

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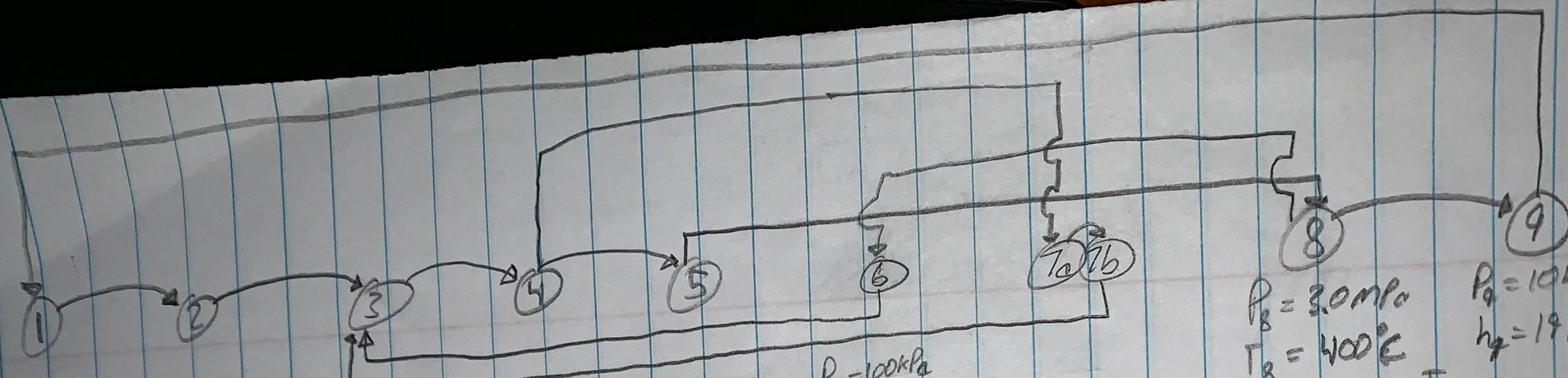
Problem 2

Procedure + Calculations



$P_1 = 10\,kPa$ $\quad P_2 = 100\,kPa$

$v_f = 0.001010\,\frac{m^3}{kg}$

$h_1 = 191.81\,\frac{kJ}{kg}$

$W_{PI} = v_1(P_2 - P_1)$

$\Rightarrow W_{PI} = 0.909\,\frac{kJ}{kg}$

$h_2 = h_1 + W_{PI}$

$\Rightarrow h_2 = 191.901\,\frac{kJ}{kg}$

$P_3 = 0.8\,MPa$ $\quad P_4 = 3.0\,MPa$

$h_3 = 721.1\,\frac{kJ}{kg}$

$v_3 = 0.00115\,\frac{m^3}{kg}$

$W_{PII} = v_3(P_4 - P_3)$

$\Rightarrow W_{PII} = 2.45\,\frac{kJ}{kg}$

$h_4 = h_3 + W_{PII}$

$\Rightarrow h_4 = 723.55\,\frac{kJ}{kg}$

$P_6 = 100\,kPa$

$h_6 = 2891.6\,\frac{kJ}{kg}$

$P_8 = 3.0\,MPa$

$T_8 = 400°C$

$h_8 = 3231\,\frac{kJ}{kg}$

$P_9 = 10\,kPa$

$h_9 = 191.81\,\frac{kJ}{kg}$

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Problem 2

Procedures + Calculations (cont.)

Calculating turbine work

$W_{turb} = h_5 - h_6$

$\Rightarrow 3230.82 - 2891.6$

$\Rightarrow W_{turb} = 339.22 \frac{kJ}{kg}$

Calculating net work

$W_{net} = W_{Turb} - W_{PI}(1-x) - W_{PII}$

$\Rightarrow 339.22 - 0.798(1 - 0.19598) - 2.45$

$\boxed{\Rightarrow W_{net} = 336.128 \frac{kJ}{kg}}$ - specific net work of the cycle

calculating thermal efficiency

$\eta_{th} = \frac{W_{net}}{q_H}$

$\Rightarrow \frac{336.128}{2507.25}$

$\eta_{th} = 0.13406 \Rightarrow \boxed{13.406\%}$ - thermal efficiency of the cycle

Foster [illegible]

Summary

Overall, the first case is much more efficient than the second case having a thermal efficiency of 35.82% versus an efficiency of 13.406% for the second case.

Analysis

Since the efficiency for the second case is so low, comparitively, the malfunctioning control valve needs to be fixed as soon as possible.