UNENE Graduate Course
Reactor Thermal-Hydraulics Design and Analysis
McMaster University
Whitby
March 11-12, March 25-26,
April 8-9, April 22-23, 2006

Thermal Efficiency

Dr. Nik Popov

Thermal Efficiency – Inlet Pressure

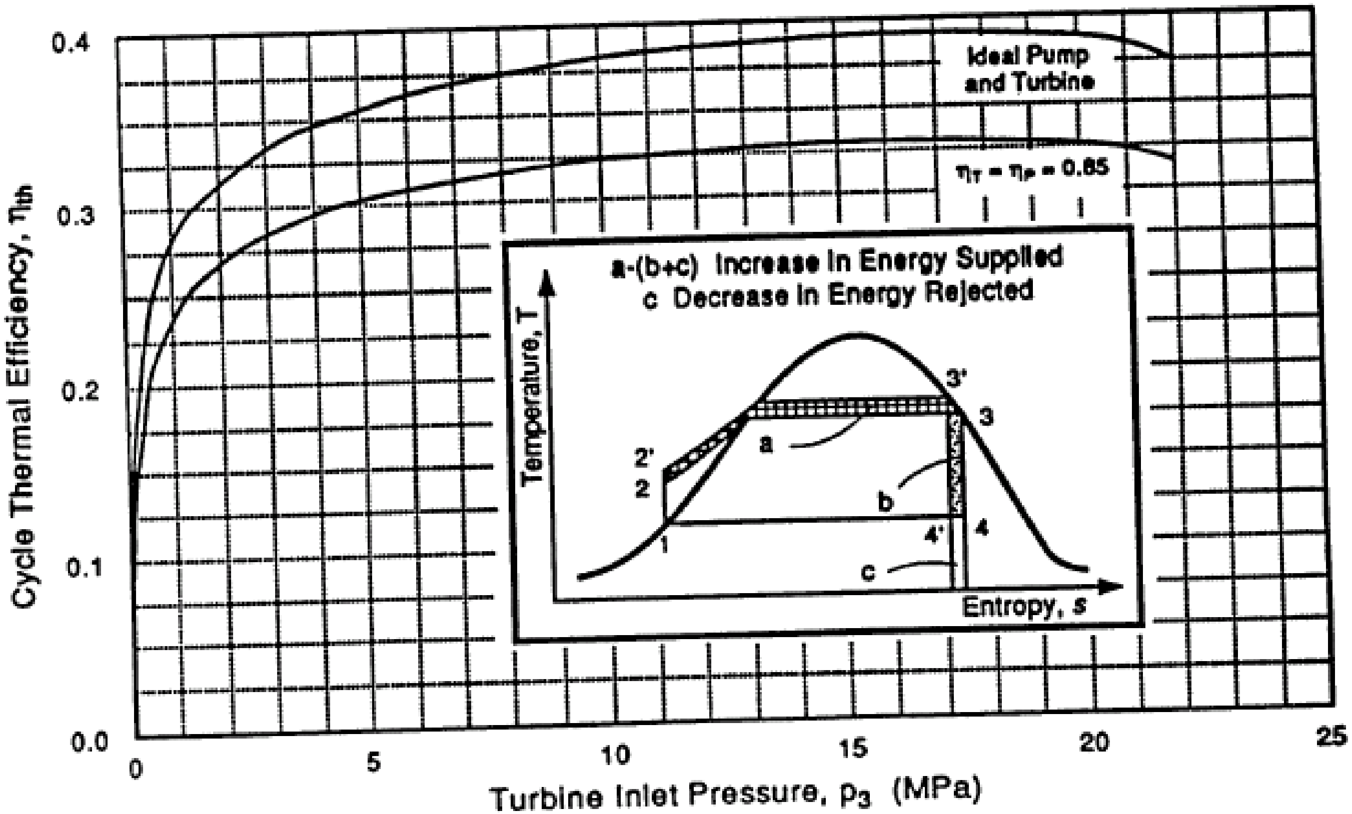


Figure 6-13 Thermal efficiency of Rankine cycle using saturated steam for varying turbine inlet pressure. Turbine inlet: saturated vapor. Exhaust pressure: 7kPa.

Thermal Efficiency – Outlet Pressure

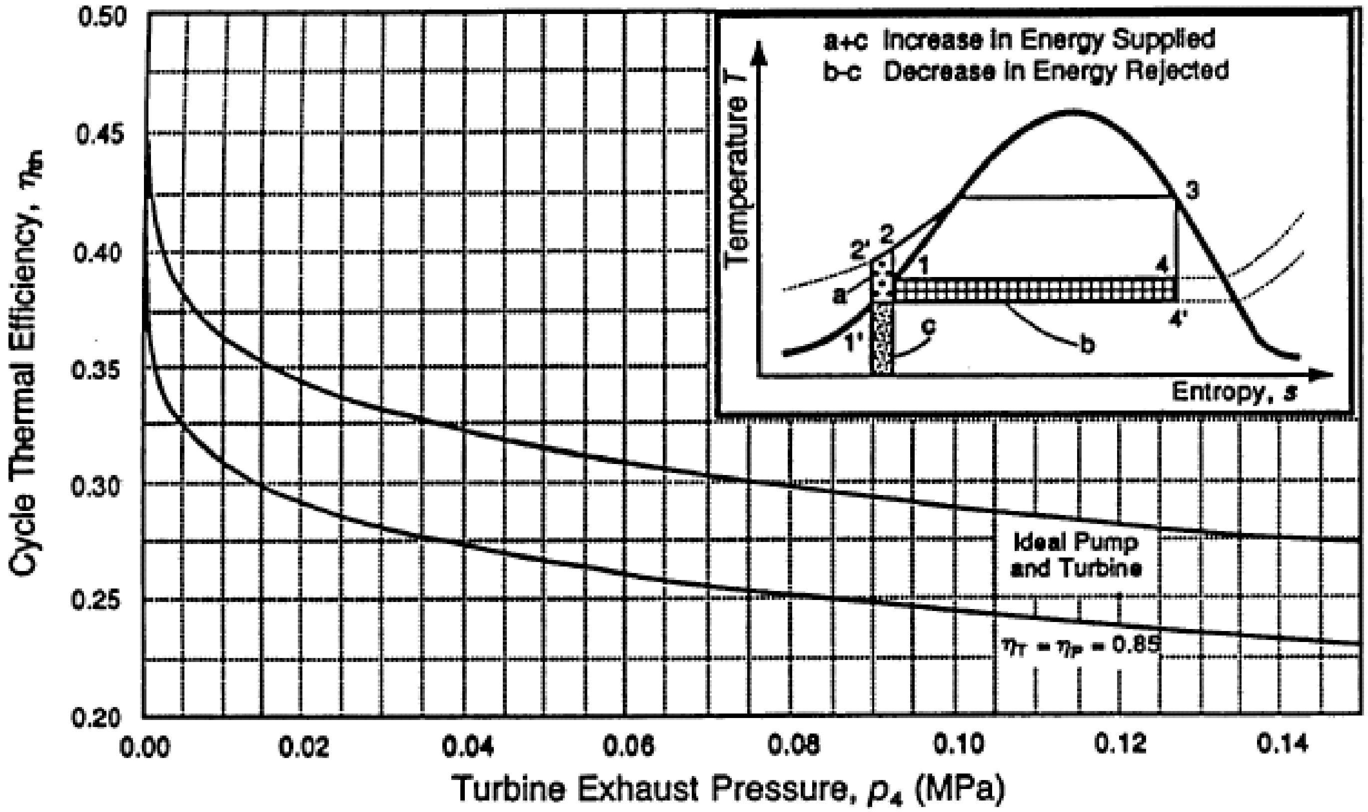
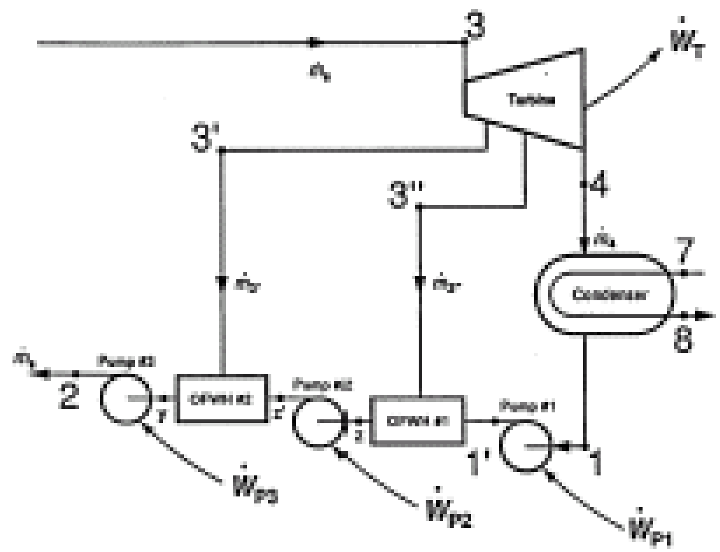
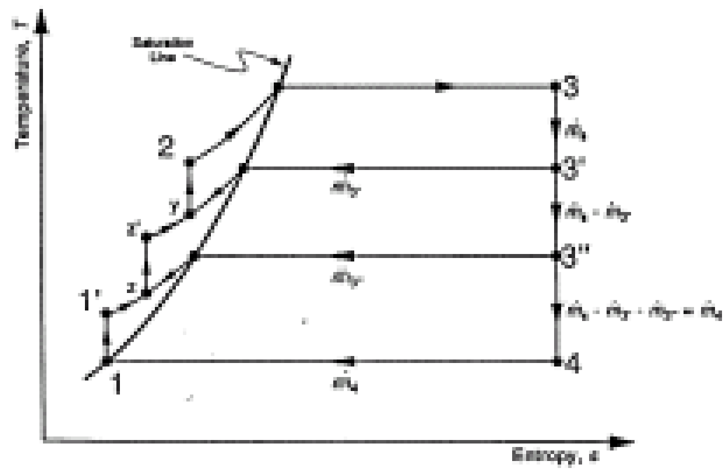


Figure 6-14 Thermal efficiency of Rankine cycle for a saturated turbine inlet state for varying turbine outlet pressure. Turbine inlet: 7.8 MPa saturated vapor.

Thermal Efficiency – Open Configuration





Thermal Efficiency – Open Configuration

OPEN FEED WATER HEATERS

$$W_T = \dot{m}_5 (h_5 - h_3) + (\dot{m}_5 - \dot{m}_{3'})(h_{3'} - h_{3''}) + \dot{m}_4 (h_{3''} - h_4)$$

$$h_2 = \frac{\dot{m}_{3''} h_{3''} + \dot{m}_4 h_{4'}}{\dot{m}_{3''} + \dot{m}_4} = \frac{\dot{m}_{3''} h_{3''} + \dot{m}_4 h_{4'}}{\dot{m}_5 - \dot{m}_{3'}}$$

$$h_Y = \frac{\dot{m}_{3'} h_{3'} + (\dot{m}_5 - \dot{m}_{3'}) h_{x'}}{\dot{m}_5}$$

Thermal Efficiency – Closed Configuration

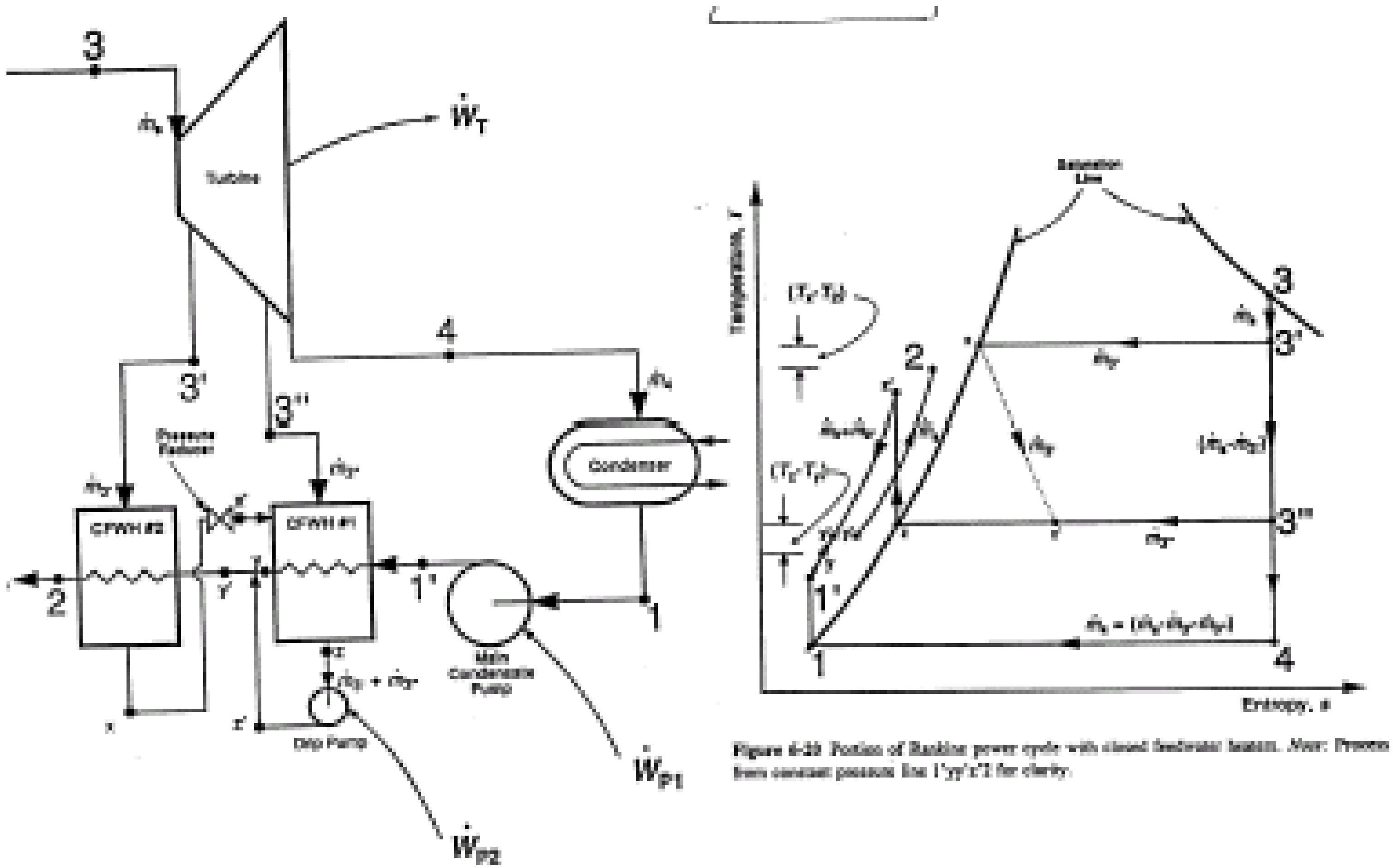


Figure 6-39 Portion of Rankine power cycle with closed feedwater heaters. Note: Process from constant pressure line 1'yy'z'2 for clarity.

Thermal Efficiency – Closed Configuration

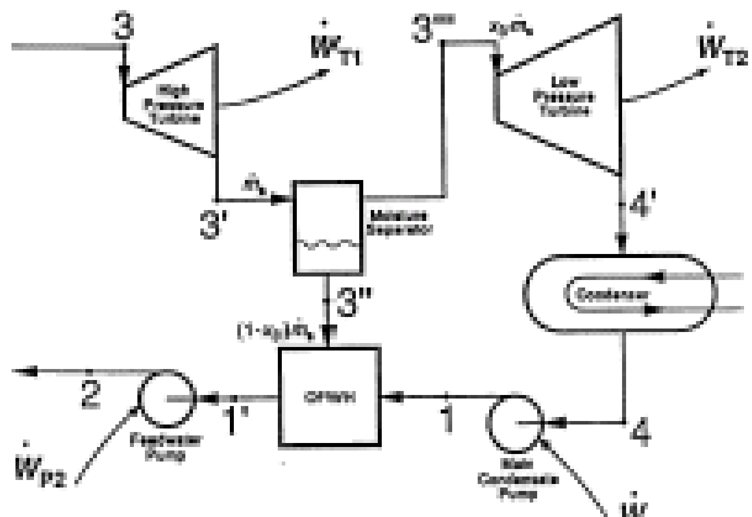
CLOSED FEED WATER HEATERS

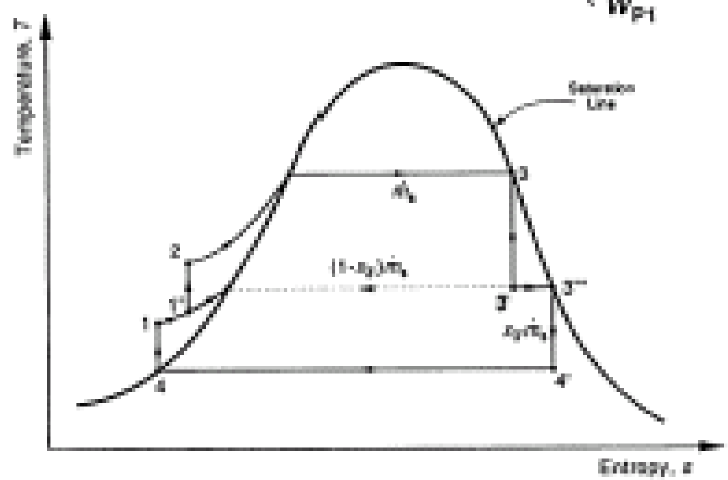
$$h_Y = \frac{\dot{m}_{3''} h_{3''} + \dot{m}_4 h_{4'} + \dot{m}_{3'} h_{X'} - (\dot{m}_{3'} + \dot{m}_{3''}) h_X}{\dot{m}_4}$$

$$h_{Y'} = \frac{\dot{m}_4 h_Y + (\dot{m}_{3'} + \dot{m}_{3''}) h_{X'}}{\dot{m}_5}$$

$$h_2 = \frac{\dot{m}_{3'} (h_{3'} - h_{X'}) + \dot{m}_5 h_{Y'}}{\dot{m}_5}$$

Thermal Efficiency – Moisture Separation





Thermal Efficiency – Open Configuration

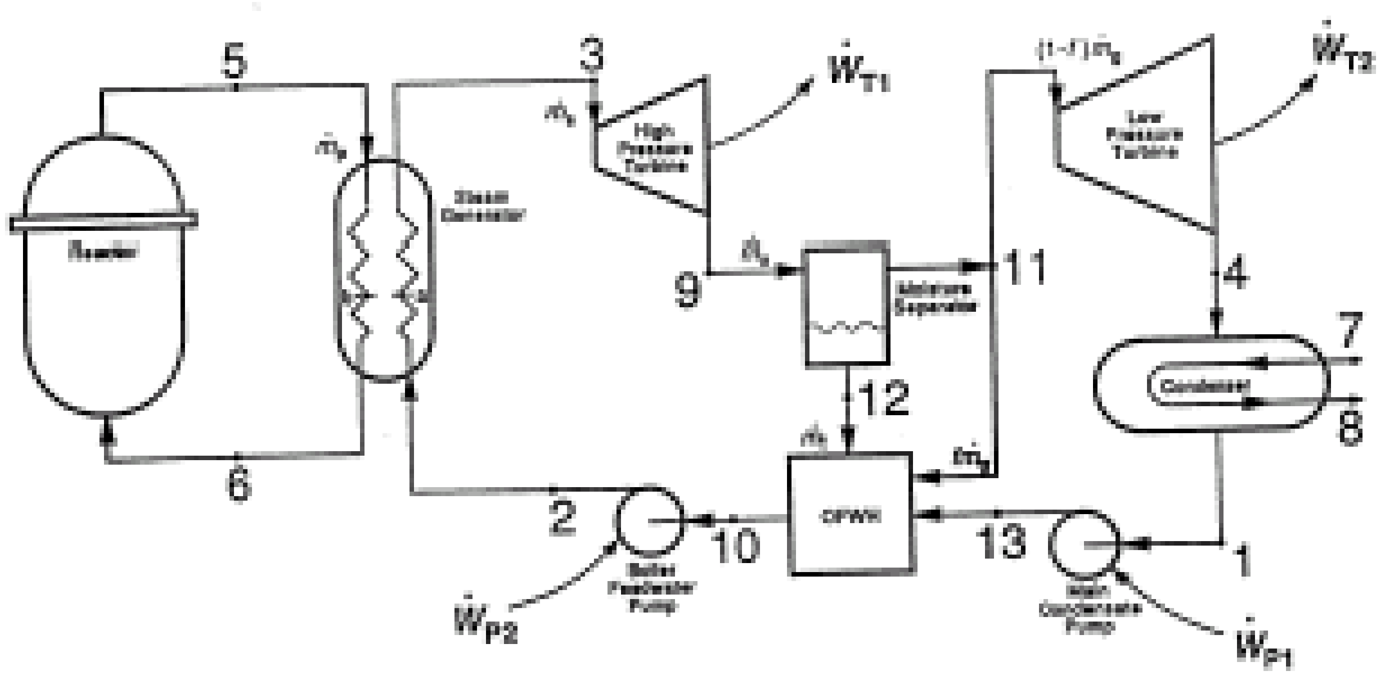
MOISTURE SEPARATION

$h_{3''} = h_f \text{ (at } P_{3'}) \qquad (1 - X_{3'})\,\dot{m}_s \qquad \text{saturated}$

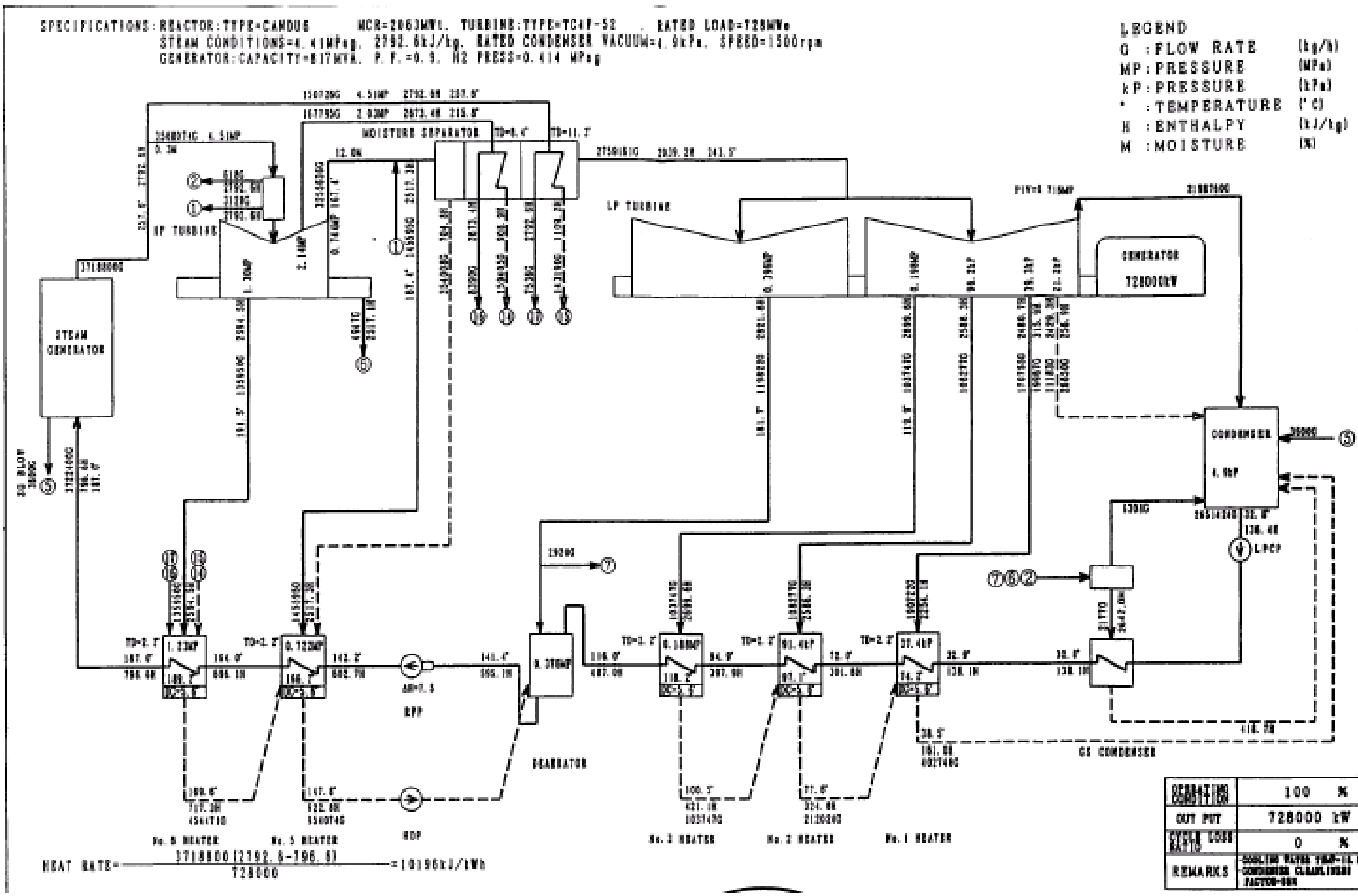
$h_{3''} = h_g \text{ (at } P_{3'}) \qquad X_{3'}\,\dot{m}_s \qquad \text{saturated}$

$$h_{1'} = \frac{h_{3''}(1 - X_{3'})\,\dot{m}_s + h_1 X_{3'}\,\dot{m}_s}{\dot{m}_s}$$

Thermal Efficiency – Simple PWR



Thermal Efficiency – CANDU 6



Questions?