ترمودینامیک ۲

جلسه اول (نمونه)

احمدرضا غلامرضاپور

خلاصه مطالب

THE RANKINE CYCLE

1–2: Reversible adiabatic pumping process in the pump

2–3: Constant-pressure transfer of heat in the boiler

3–4: Reversible adiabatic expansion in the turbine (or other prime mover such as a steam engine)

4–1: Constant-pressure transfer of heat in the condenser

خلاصه مطالب

یادآوری ترمودینامیک ۱

قانونی که در ترمودینامیک برای مسائل مختلف نوشته می‌شود، قوانین بقا است:

Inputs + Generations = Rate of Changes + Outputs + Destructions

- برای جرم، تولید و تخریب صفر، تنها ورود و خروج جریان جرمی:

$$\sum \dot{m}_i = \frac{d}{dt}m + \sum \dot{m}_e$$

- برای انرژی، تولید و تخریب صفر، ورود و خروج هم به صورت جریان جرمی و هم به صورت کار و حرارت:

- $\sum \dot{m}_i \left(h_i + \frac{v_i^2}{2} + gz_i\right) + \dot{Q} = \frac{d}{dt}E_{st} + \dot{W} + \sum \dot{m}_e \left(h_e + \frac{v_e^2}{2} + gz_e\right)$

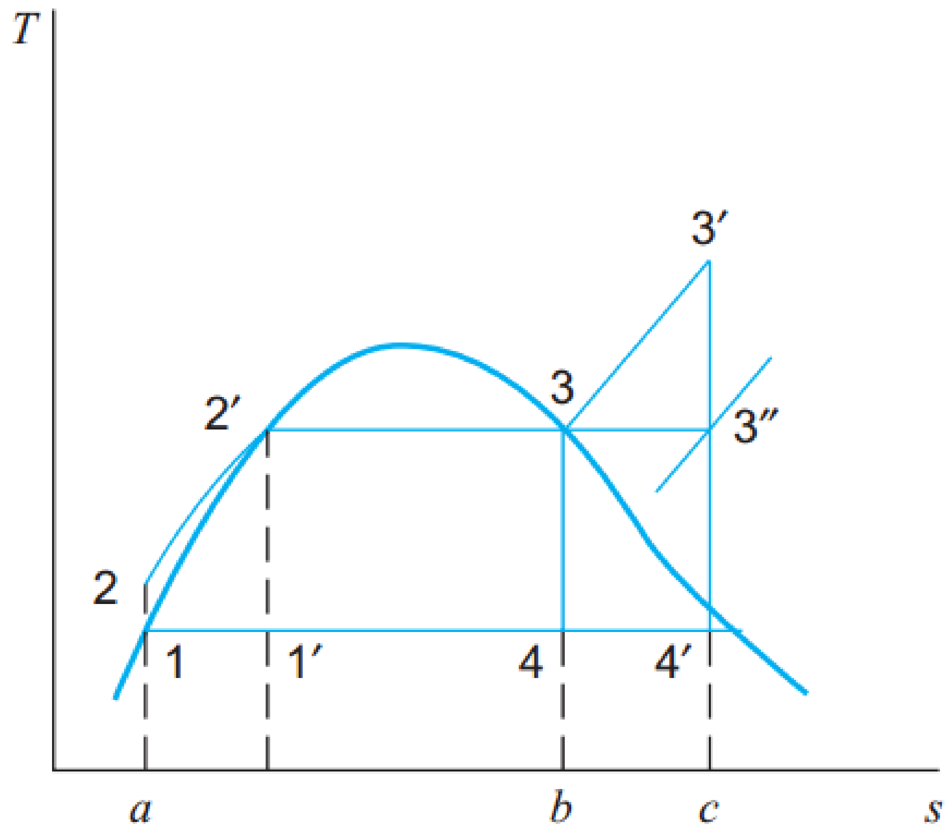
خلاصه مطالب

In the Rankine cycle the vapor is superheated at constant pressure, process 3–3’.

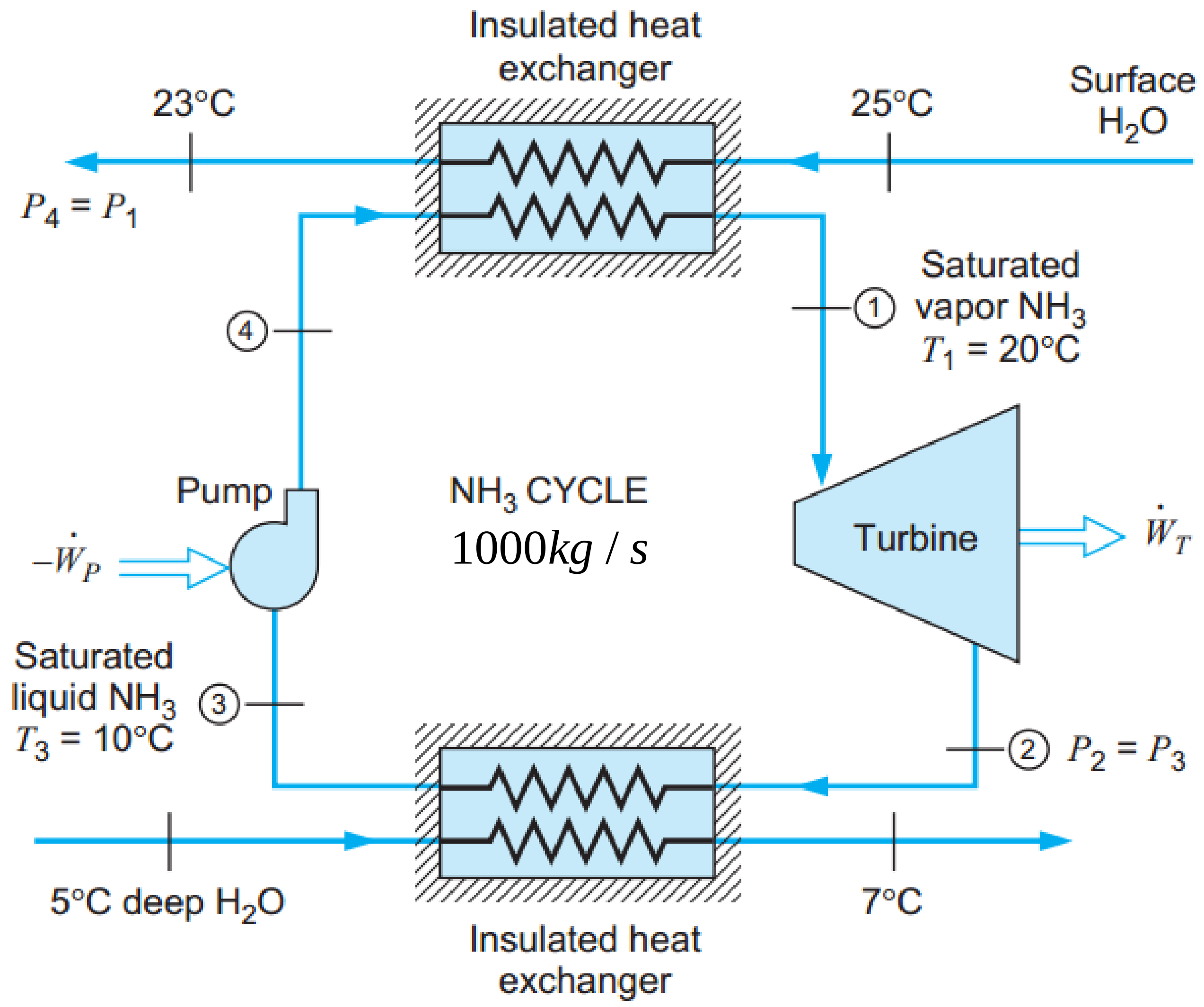
if the moisture in the low-pressure stages of the turbine exceeds about 10%,

not only is there a decrease in turbine efficiency,

but erosion of the turbine blades may also be a very serious problem.



سوال ۱



a. Determine the turbine power output and the pump power input for the cycle.

b. Determine the mass flow rate of water through each heat exchanger.

c. What is the thermal efficiency of this power plant?

پاسخ

a) C.V. Turbine. Assume reversible and adiabatic.

$$s_2 = s_1 = 5.0863 = 0.8779 + x_2 \times 4.3269 \quad => \quad x_2 = 0.9726$$

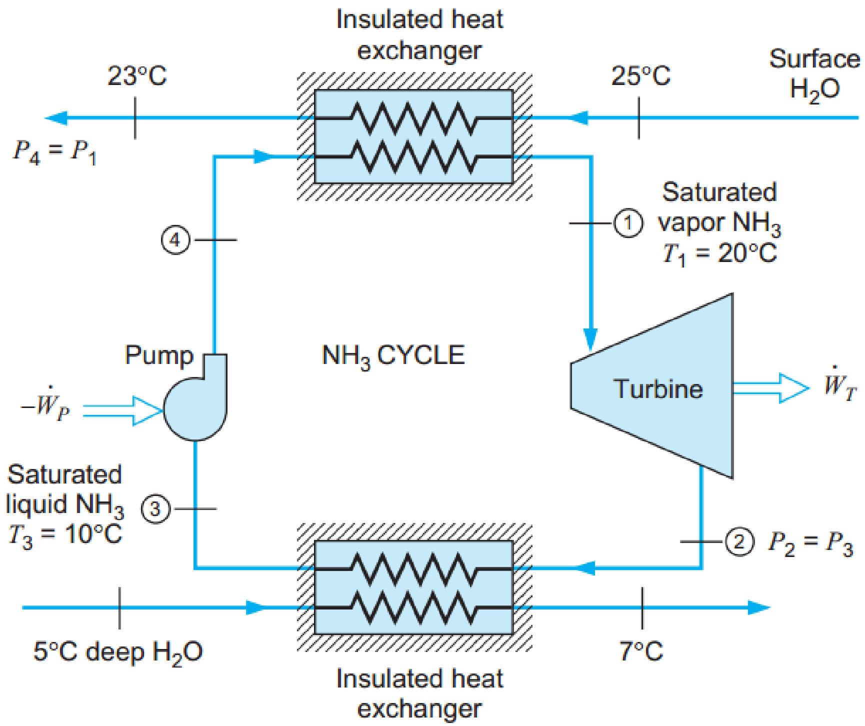
$$h_2 = 227.08 + 0.9726 \times 1225.09 = 1418.6 \text{ kJ/kg}$$

$$w_T = h_1 - h_2 = 1460.29 - 1418.6 = 41.69 \text{ kJ/kg}$$

$$\dot{W}_T = \dot{m}w_T = 1000 \times 41.69 = \mathbf{41\ 690\ kW}$$

Pump: $w_P \approx v_3(P_4 - P_3) = 0.0016(857 - 615) = 0.387$ kJ/kg

$$\dot{W}_P = \dot{m}w_P = 1000 \times 0.387 = \mathbf{387\ kW}$$



پاسخ

b) Consider condenser heat transfer to the low T water

$$\dot{Q}_{\text{to low T H2O}} = 1000(1418.6 - 227.08) = 1.1915\times10^6 \text{ kW}$$

$$\dot{m}_{\text{low T H2O}} = \frac{1.1915\times10^6}{29.38 - 20.98} = \mathbf{141\,850\ kg/s}$$

$$h_4 = h_3 + w_P = 227.08 + 0.39 = 227.47 \text{ kJ/kg}$$

Now consider the boiler heat transfer from the high T water

$$\dot{Q}_{\text{from high T H2O}} = 1000(1460.29 - 227.47) = 1.2328\times10^6 \text{ kW}$$

$$\dot{m}_{\text{high T H2O}} = \frac{1.2328\times10^6}{104.87 - 96.50} = \mathbf{147\,290\ kg/s}$$

c) $$\eta_{TH} = \dot{W}_{NET}/\dot{Q}_H = \frac{41\,690 - 387}{1.2328\times10^6} = \mathbf{0.033}$$