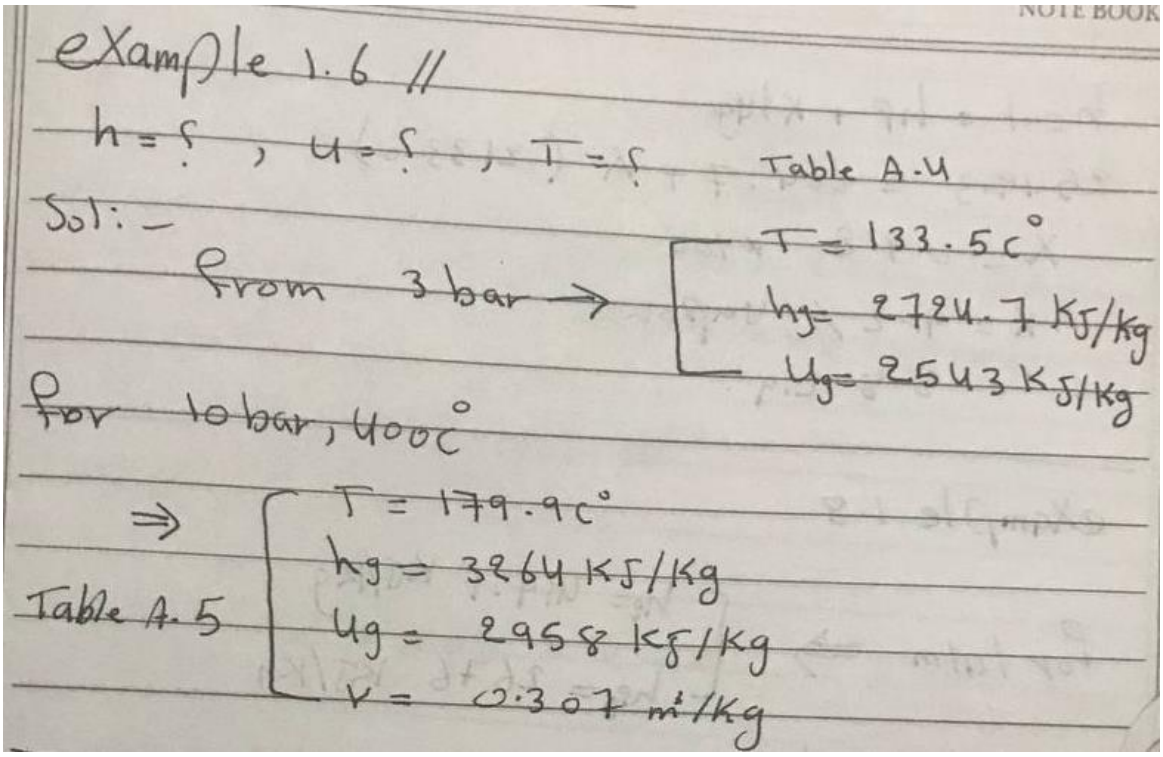
Example 1.6 Use of a Steam Table

Use steam tables in the appendix to determine the temperature, specific Internal energy and specific enthalpy of saturated steam at 3.0 bar. What is the state of the steam at 10 bar and 400°C? (i.e., is it saturated or superheated steam?)

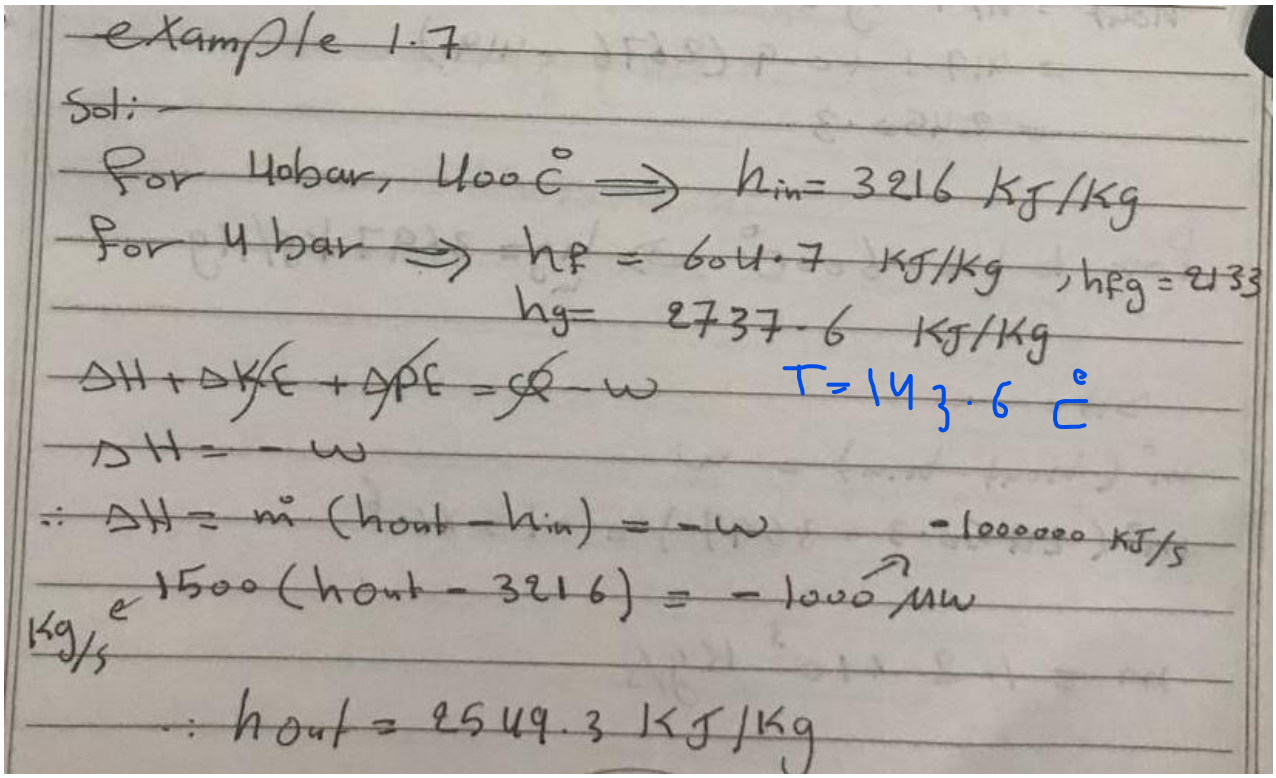


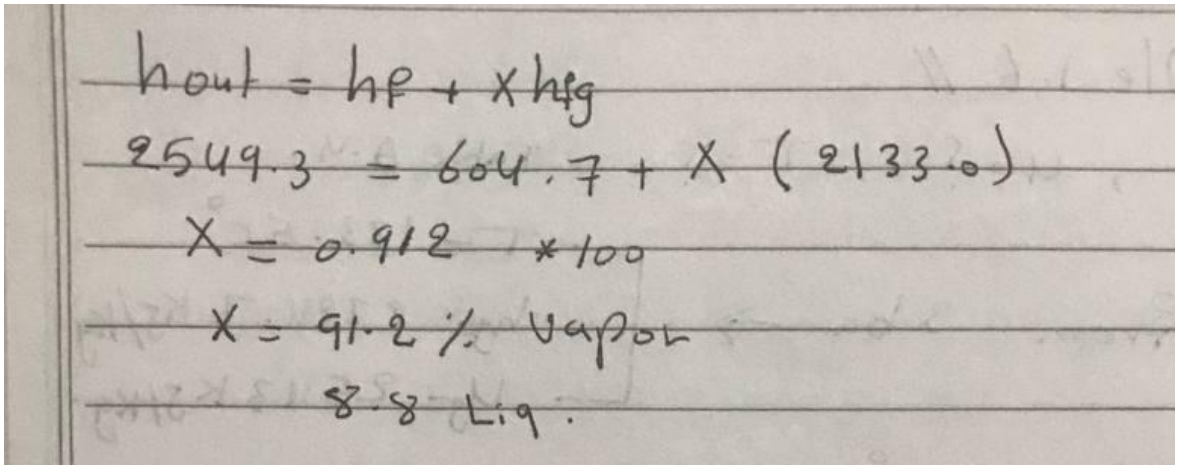
1.1.4 Steam Turbine

Steam turbines are open systems used to generate electricity; in most cases, the turbine operates adiabatically. The exit pressure of turbine is lower than the inlet pressure. Turbines produce work; by contrast, work should be provided to a compressor or a pump. The following examples explain the possible operations for a steam turbine.

Example 1.7 Steam Table and Turbine Work

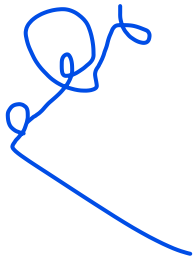
Steam at a rate of 1500 kg/s enters a turbine at 40 bar and 400°C. It comes out of the turbine as wet steam at 4 bar. The turbine operates adiabatically and produces 1000 MW of work. What is the temperature of the steam leaving the turbine? What is the mass fraction of vapor in the stream leaving the turbine?





Example 1.8 Steam Turbine

Steam enters a turbine at a pressure of 10.0 bar (absolute) and a temperature of 600°C. The steam leaving the turbine is at 1 atm (absolute) pressure and is of 90% quality (90 wt% steam, 10 wt% liquid). How much steam has to go into the turbine to yield 1.5 × 106 kW of shaft work?



example 1.8

For 1atm $\Rightarrow$ $\begin{cases} h_f = 419.1 \text{ KJ/Kg} \\ h_{fg} = 2676 \text{ KJ/Kg} \end{cases}$

$h_{out} = h_f + x h_{fg}$

$= 419.1 + 0.9 (2676 - 419)$

$= 2450.3$

For 10 bar, 600C° $\Rightarrow h_{g_{in}} = 3697 \text{ KJ/Kg}$

$\Delta H = -W$

$\dot{m} (h_{out} - h_{in}) = -W$

$\dot{m} (2450.3 - 3697) = -1.5 \times 10^6$

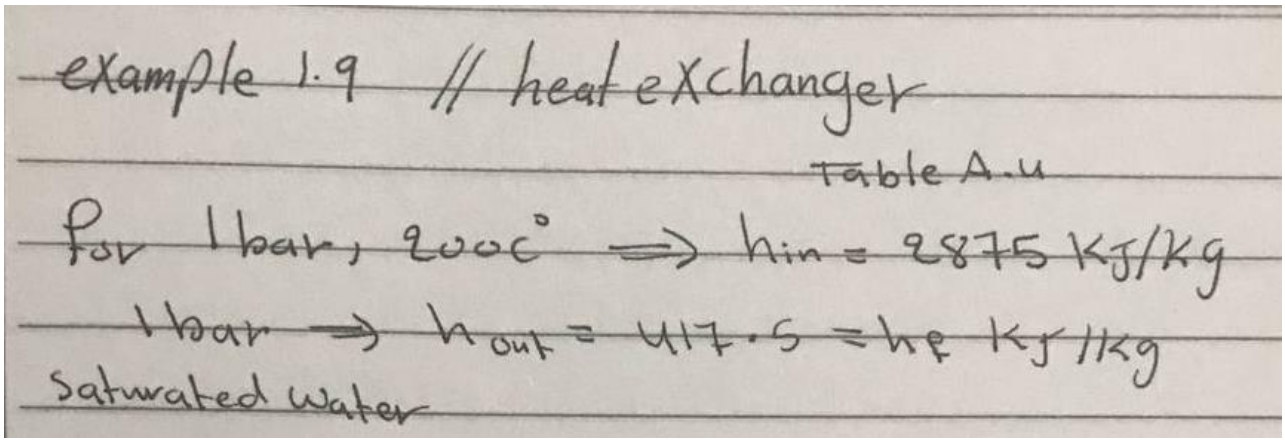
$\dot{m} = 1.2 \times 10^3 \text{ Kg/s}$

1.1.5 Heaters and Coolers

Heaters and coolers such as shell and tube heat exchangers are open systems employed to cool down or heat up certain fluid streams. In most cases, the external surface of heaters and coolers is insulated and heat is just transferred between the cold and hot streams across the walls of the exchanger tubes. The following example illustrates the use of heat exchangers for cooling and heating purposes.

Example 1.9 Heat Exchanger

Steam at a rate of 60 kg/h, at 200°C, and 1 bar enters the tube side of a shell and tube heat exchanger. The steam is used to heat cold water flowing on the shell side; the steam leaves as saturated liquid. Neglect pressure drop of the steam on the tube side and the water on the shell side of the heat exchanger. How much heat must be transferred from the steam to the water side?



$\Delta H + \Delta KE + \Delta PE = Q - W$

$\Delta H = Q$

$= m \Delta h = \dot{m} (h_{out} - h_{in})$

$\therefore Q = 60 \text{ kg/h} \left(417.5 - 2875 \right) \text{kJ/kg}$

$= -147,450 \text{ kJ/h}.$