Problem Set No. 9

Due: Friday, March 11, 2011

Objective: To understand and perform calculations involving fundamental thermodynamic relations and potentials (U, H, A, G, and S), and applying PVT models, C_P models, and data from steam tables for open and closed processes. To understand and perform calculations for open and cyclical processes with applications to power plants and process equipment.

Note: Numerical values for some problems have been changed from those in the book.

Problem 45 (*survey question)*

If you could trade time spent on one topic for another this quarter, which topic would you reduce and which would you increase?

Problem 46 (*Smith, van Ness, Abbott, 6.14k, page 242)*

Calculate Z, H^R, and S^R by the Lee-Kessler correlation for nitrogen at $150\ K$ and $50\ bar$.

Problem 47 (*Smith, van Ness, Abbot, 6.34, page 244)*

A rigid vessel of $2\ m^3$ capacity contains $0.02\ m^3$ liquid water and $1.98\ m^3$ of water vapor at $101.33\ kPa$. How much heat must be added to the contents of the vessel so that the liquid water is just evaporated?

Problem 48 (*Smith, van Ness, Abbott, 7.35a, page 285)*

A compressor operates adiabatically with air entering at $T_1 = 25$ °C and $P_1 = 101.33\ kPa$, with a molar flowrate of $\dot{n} = 100\ mol/s$. The discharge pressure is $P_2 = 375\ kPa$ and the compressor efficiency is $\eta = 0.75$. Estimate the power requirement of the compressor and the temperature of the discharge stream. Assume air can be modeled as an ideal gas with $C_P = (7/2)R$.

Problem 49 (*Smith, van Ness, Abbott, 7.46, page 287)*

A boiler house produces a large excess of low-pressure steam at $50\ psig$ and 5 °F of superheat (i.e., °F higher than the boiling temperature at that pressure). An upgrade is proposed that would first run the low-pressure steam through an adiabatic steady-flow compressor, producing medium-pressure steam at $150\ psig$. On the attached Mollier diagram (next page), indicate the initial state of the gas and draw an arrow for the direction of the process in:

(a) an ideal compressor

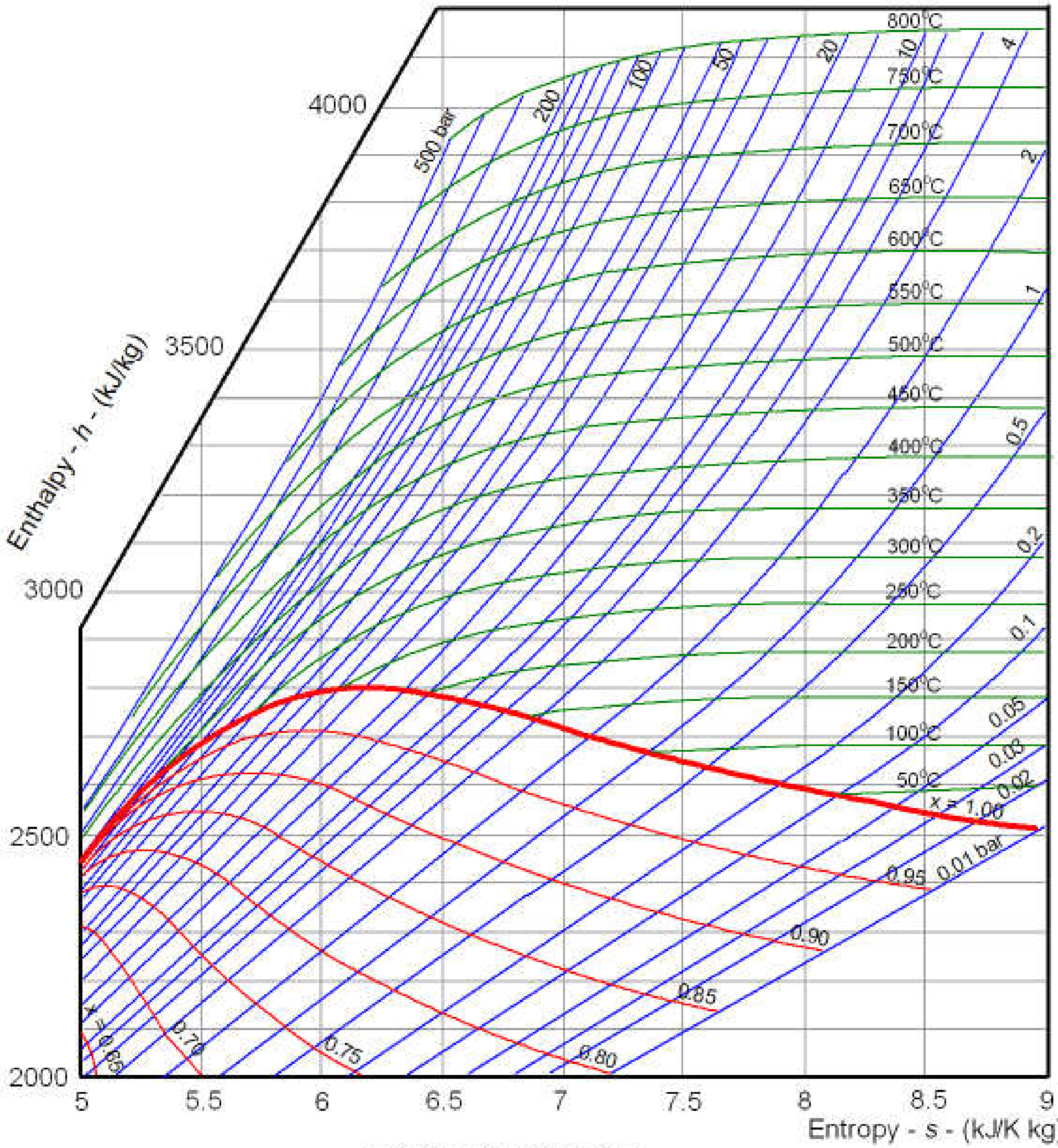
(b) a nonideal compressor

Is there cause for concern, in either case above, that the compression could result in the formation of liquid water, damaging the compressor?

Problem 50 (*Smith, van Ness, Abbott, 8.3e, page 312)*

A steam power plant operates on the cycle of Figure 8.4. For the following set of operating conditions, determine the steam flow rate, the heat-transfer rate in the boiler, and the thermal efficiency of the plant.

$P_1 = P_2 = 8500\ kPa$
$T_2 = 600\ °\mathrm{C}$
$P_3 = P_4 = 10\ kPa$
$\eta(\mathrm{turbine}) = 0.80$
$\eta(\mathrm{pump}) = 0.80$
$\mathrm{power\ rating} = 70{,}000\ \mathrm{kW}$



engineeringtoolbox.com