ES 202
Fluid and Thermal Systems

Lecture 17:
More on properties and phases
(1/21/2003)

Road Map of Lecture 17

- Continue exercise on property table (water)
- Common procedure in phase determination
  - saturation table
- More on Compressed Liquid Approximation
- Practice with data interpolation
  - linear
  - bi-linear
- Special models
  - constant pressure process
  - constant volume process

What is the common starting point?

- Review question: In the procedure of phase determination of a substance, what is the common starting point?
  - the saturation table
- It serves as a reference region which helps you to decide if you are in
  - compressed (subcooled) liquid region
  - two-phase region
  - superheated vapor region
- If the substance is in the two-phase region, the knowledge of quality (mass fraction of vapor in the mixture) is critical in completely identifying the state of the mixture.

More on Compressed Liquid Approximation

- As introduced yesterday, the compressed liquid approximation can be expressed as:

$$u(T,P) \cong u_f(T)$$

$$v(T,P) \cong v_f(T) \qquad \text{(weak function of } T\text{)}$$

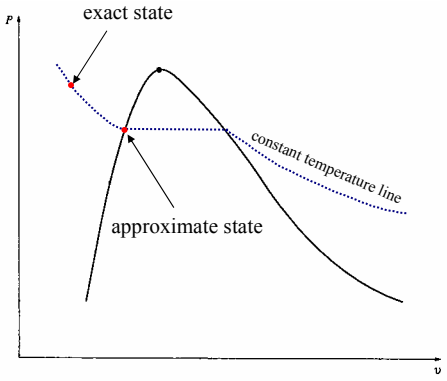
$$s(T,P) \cong s_f(T)$$

$$h(T,P) \cong u_f(T) + Pv_f(T) = h_f(T) + \left[P - P_{sat}(T)\right]v_f(T)$$

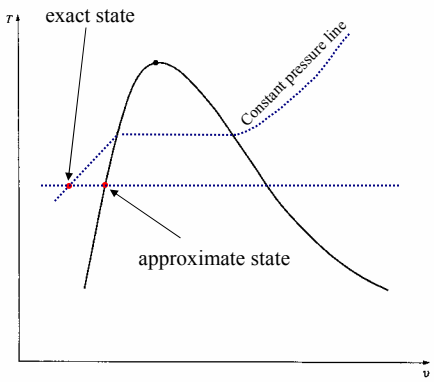
- It can be interpreted as weak dependency of most properties on pressure in the compressed liquid region.
- Hence, most properties can be approximated by their saturated liquid values at the specified temperature.

Compressed Liquid Approximation on Phase Diagrams

P-v diagram



T-v diagram

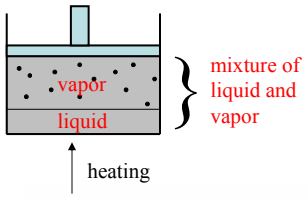


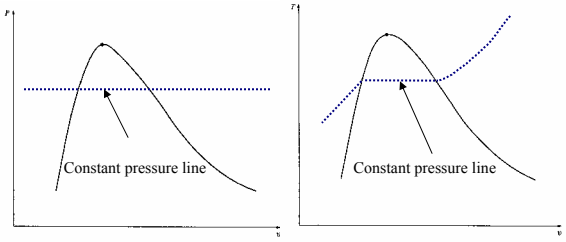
Data Interpolation

- The property tables only tabulate discrete values for pressure or temperature as the independent property.
- If you are interested in values which do not fall on the tabulated data points, interpolation within the "sandwich" interval will be necessary.
- Since the property tables report data at small intervals, linear interpolation should be adequate for most purposes.
  - Example: specify T (not tabulated) and x in two-phase region
- If both independent, intensive thermodynamic properties do not fall on the tabulated data points, bi-linear interpolation is necessary to completely specify the thermodynamic states.
  - Example: specify P and T in superheated vapor region (both not tabulated)

Constant Pressure Process

- Imagine a heating process in a cylinder with a constant weight as a lid (closed system; control mass)
- Since pressure is constant, you only need one more independent, intensive property to specify the state.
- Trace the process on
  - *P-v* diagram
  - *T-v* diagram





Constant Volume Process

- Imagine a heating process in a rigid enclosure (closed system; control mass)
- Since volume is constant, specific volume is constant throughout the process.
- Trace the process on
  - *P-v* diagram
  - *T-v* diagram