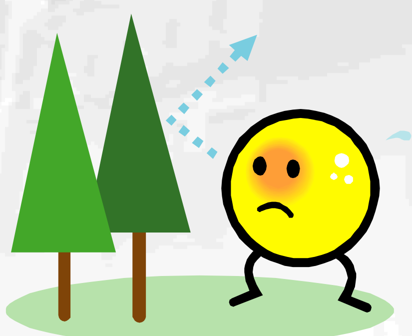
. Methods of Decreasing Temperature (I)

Decreasing Temperature by Adiabatic Throttling—J-T Effect

1. Adiabatic throttle process

- When a hydraulic resistance part, such as throttle valve, a porous plug, or a capillary tube restrictor, is implemented in a gas stream, and the gas flows adiabatically through the resistance part without performing any external work or any velocity change at the system boundary, this process is called adiabatic throttle process.
- The process was first investigated by J.P. Joule and W.
- Thomson (Lord Kelvin), and is called Joule-Thomson process.

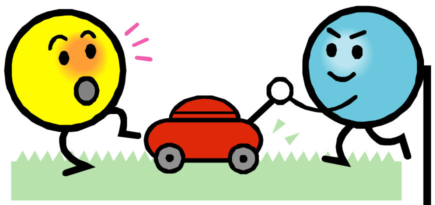


2. The Joule-Thomson effect

- The change of temperature with respect to a change in a Joule-Thomson process is the Joule-Thomson (Kelvin) coefficient:

$$\mu_{J-T} = \left(\frac{\partial T}{\partial P}\right)_H$$

- For an ideal gas, the enthapy is only the function of temperature ; it does not vary with pressure



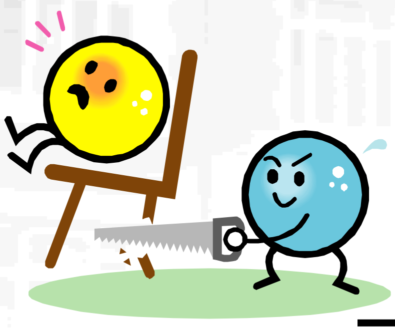
Refrigeration Technology

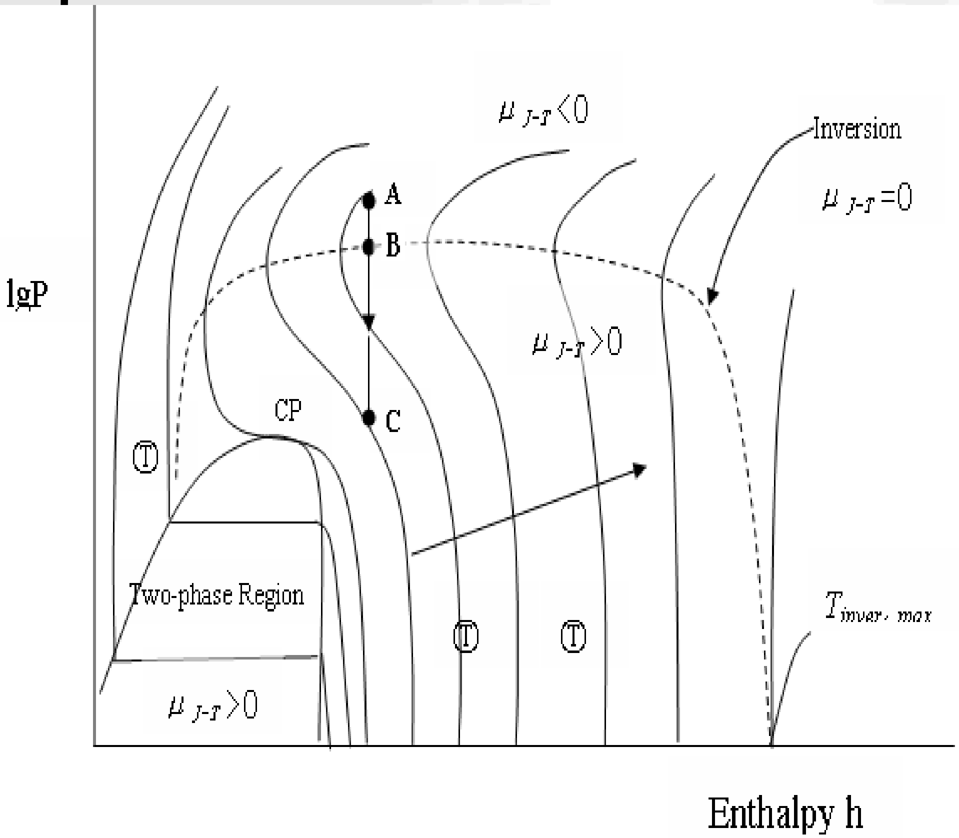
- In an adiabatic throttle process, the gas pressure is reduced (P2<P1), and thus
- If $\mu_{J-T} = (\frac{\partial T}{\partial P})_H > 0$, the temperature of the gas is reduced,T2<T1 , which produces a cooling effect;
- $\mu_{J-T} = (\frac{\partial T}{\partial P})_H < 0$,the temperature of the gas is raised, T2>T1, which produces a heating efect;
- $\mu_{J-T} = (\frac{\partial T}{\partial P})_H = 0$, the temperature of the gas has no change, i.e., T2=T1

3. Adiabatic throttling in real gas region

- For all real gases, the value of μ_{J-T} will equal zero at some point, which is called the inversion point and Joule-Thomson inversion temperature, which is the temperature where the coefficient μ_{J-T} changes sign (i.e., where the coefficient equals zero).

- The Joule-Thomson inversion temperature depends on the pressure of the gas before expansion.





Fig, The Joule-Thomson Effect (ABC)
on a logarithmic pressure and enthalpy diagram

- Fig.3-2 shows the isotherms and the inversion locus on the pressure-enthalpy diagram with pressure to a logarithmic scale.
- The isotherms at low pressure tend towards the vertical, indicating the approach to ideal gas behaviour.
- Adiabatic throttling at low pressure produces negligible change of temperature.
- The inversion locus comes down towards zero pressue at the maximum inversion temperature $T_{inver,\max}$