Module 3: "Thin Film Hydrodynamics"

Lecture 18: ""

The Lecture Contains:

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Effect of Temperature at Constant Pressure

CASE 1:

Again, consider the same system (the liquid drop). (fig:4.9)

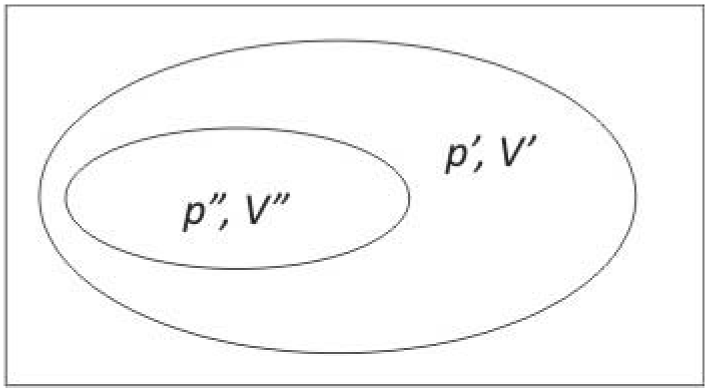

Fig:4.9:

Gibbs Duhem equation

$\bar{S}' - \bar{S}"dT + \bar{V}"dp" = 0$

and $dp"$ can be written as

$dp" = d\left(\frac{2\gamma}{r}\right)$ while $\bar{S}' - \bar{S}"$ can be written as $\Delta\mathrm{H}/\mathrm{T}$

where $\Delta\mathrm{H}$ is the latent heat of vaporization

$$\int_{T_0}^{T_s} \frac{\Delta H_V}{T}\,dT + \bar{V}" \int_{r=\infty}^{r} d\left(\frac{2\gamma}{r}\right) = 0$$

$$\ln\frac{T_S}{T_0} = -\frac{2\gamma\bar{V}"}{\Delta H_V r}$$

$$\Longrightarrow T_S < T_0$$

$\Rightarrow$ For isobaric condition we have to subcool the vapor to condense it.

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CASE 2: Vapor bubble (“) in liquid (‘)

$\mathrm{dp}' = 0$ for isobaric condition

$$-\bar{S}' - \bar{S}" \, dT = \bar{V}" dp"$$

Assuming vapor to be ideal,

$$\frac{\Delta H_V}{T} dT = \frac{RT dp"}{p"}$$

$$\int_{T_0}^{T_s} \frac{\Delta H_V}{T^2} dT \int_{p_0}^{p"} \frac{R dp"}{p"} \text{(Clausius clapyron equation)}$$

$$\Delta H_V \left(\frac{1}{T_0} - \frac{1}{T_S}\right) = R \ln\left(\frac{p"}{p_0}\right) \quad (4.25)$$

$$\Delta H_V \left(\frac{1}{T_0} - \frac{1}{T_S}\right) = R \ln\left(\frac{p' + {}^{2\gamma}/_{r}}{p_0}\right)$$

$$\mathrm{p}_0 = \mathrm{p}'$$

$$\Rightarrow \ \Delta H_V \left(\frac{1}{T_0} - \frac{1}{T_S}\right) = R \ln\left(\frac{p_0 + {}^{2\gamma}/_{r}}{p_0}\right) > 0 \quad (4.26)$$

$$\Rightarrow T_S > T_0$$

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$\Rightarrow$ For vaporization, we have to superheat the liquid.

For water

$\Delta H_V = 36.29\ kJ/mol$

$T_0 = 176°C$

$\gamma = 39.1$

$r = 1000\ A° \Rightarrow T_s = 176°C$

$r = 1000\ A° \Rightarrow T_s = 272°C$

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