

Thermodynamics
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Lecture 35
Ideal Gas – Part 3

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- Calculate R , C_p , C_v for Nitrogen

$$N_2$$

$$\gamma = \frac{D+2}{D} = \frac{5+2}{5} = \frac{7}{5} = 1.4$$

$$R = \frac{\bar{R}}{M} = \frac{8314.5 \text{ J/(kmolK)}}{28 \text{ kg/kmol}} = 296.9 \text{ J/(kgK)}$$

$$C_v = \frac{R}{\gamma-1} = 742.3 \text{ J/(kgK)}$$

$$C_p = C_v + R; \quad C_p = \gamma C_v = 1039 \text{ J/(kgK)}$$

Monatomic
 $\gamma = \frac{D+2}{D} = \frac{3}{3} = 1.67$



We looked at the concepts of ideal gas and pure substance.

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- The number of degrees of freedom may change with temperature because the vibrational mode gets excited at high temperatures
- As temperature increases, the fraction of molecules with vibrational excitation will increase and this results in D (and so γ , C_p and C_v) varying as functions of temperature



We also saw that the number of degrees of freedom may change with temperature. The vibrational modes get excited at higher temperatures making the number of degrees of

freedom (D) a function of temperature. Hence, C_p , C_v and γ (ratio of specific heats) for a gas may change with temperature.

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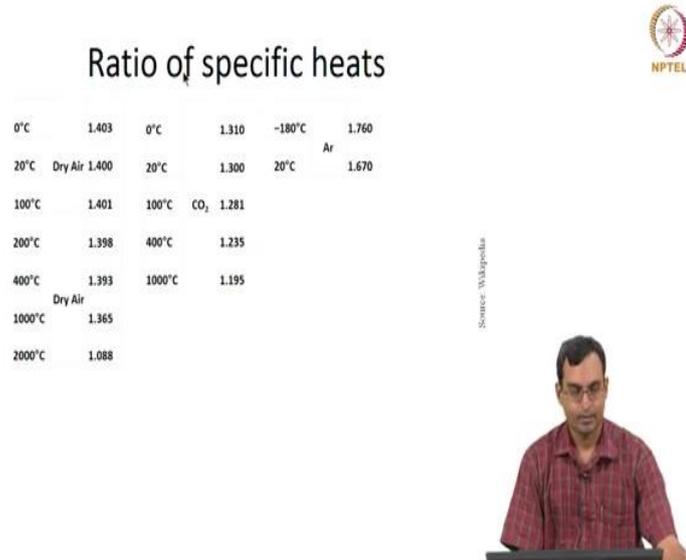


Figure 1.

Figure 1 shows typical values of γ for typical gases.

As the temperature increases, the values of C_p and C_v for dry air individually increase, whereas the value of γ reduces. For a triatomic gas such as CO_2 , the value of γ at 20 °C is 1.3. However, this value decreases as the temperature increases. A similar trend is seen in the case of argon.

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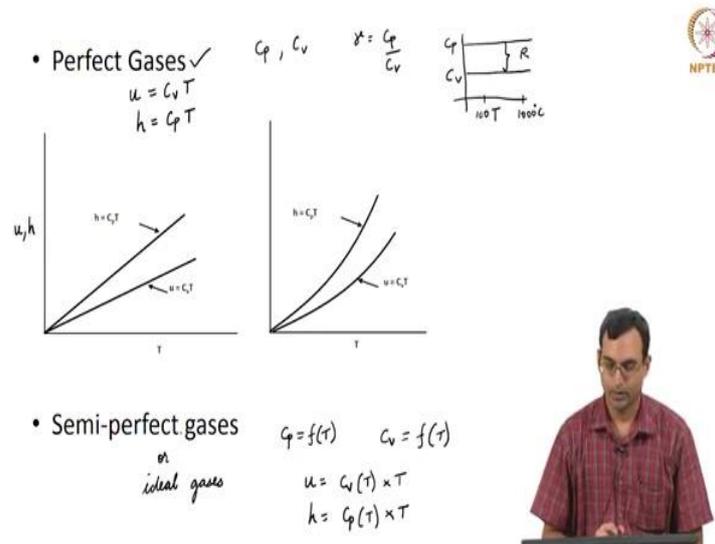


Figure 2.

For a perfect gas, C_p and C_v are constant. They do not change with temperature. The plot of C_p or C_v versus temperature is a line parallel to T axis. Since C_p and C_v are constant, their ratio γ is also constant. The difference between C_p and C_v , which is the specific gas constant R , is also constant. Such a gas is often called calorically perfect gas. For an ideal gas, specific internal energy $u = C_v T$ and specific enthalpy $h = C_p T$, where T is temperature. If C_p and C_v are constant, the plots of u or h versus T are straight lines passing through origin (see Fig. 2).

For a semi-perfect gas (which is another name for an ideal gas), C_p and C_v are functions of temperature only. Now, $h = C_p(T)T$ and $u = C_v(T)T$. Hence, the plots of u or h versus T are no longer straight lines (see Fig. 2).