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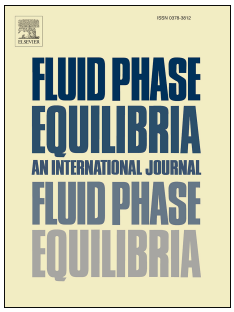

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Modeling Investigation on the Thermal Conductivity of Saturated Vapor

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Abstract

A general analytical equation to predict thermal conductivity of saturated vapors has been expressed. It was started with a global energy transfer equation which rearranged by molecular heat capacity and density. Then we replaced speed of sound and a new parameter as characteristic length of energy, Λ, instead of heat transfer velocity and mean free path, respectively. The values of Λ for ideal gases showed a linear correlation to molar volume with a material dependent slope behind the σ (molecular diameter) parameter. However, considering different materials in the saturated vapor state, say 14, including monatomic and polyatomic as non-polar, polar and polar-protic substances concluded a linear relation for Λ value versus reduced molar volume. It is noticeably found that for saturated vapor the Λ value and then the final equation for thermal conductivity can be considered independent of material type.

Keywords: Characteristic length; Thermal conductivity; Speed of sound; Saturated vapor.

Introduction

The mechanisms of heat transfer by heat conduction have been studied extensively [1–17], and some models such as thermal radiation and diffusion of molecules, elastic phonon and electron have been proposed to the present time. Probably several mechanisms simultaneously affect the final thermal conductivity of material [18]. Thermal conductivity of mono-atomic and poly-atomic molecules in the ideal gas state has almost been obtained using statistical mechanics approach, precisely. For example by an assumption of hard sphere model with symmetrical spherical mono-atomic molecules the resulting equation for thermal conductivity, λ, is defined as follows [13]

$$\lambda = \frac{5}{6}\left(\frac{k_B T}{\pi m}\right)^{1/2} \frac{C_v^{molecule}}{\sigma^2} \qquad (1)$$

where k_B, T, m, σ and $C_v^{molecule}$ are Boltzmann's constant, absolute temperature, the mass of one molecule, molecular diameter and molecular heat capacity at constant volume, respectively. However, the models for polyatomic gases contain internal and transitional portions with complicated relations. Also, these relations may only predict the diluted polyatomic gas states and release poor issue for a saturated vapor. Enskog presented different mechanisms for thermal conductivity of a diluted gas and compressed gas, for the first time [19]. The famous correlations for thermal conductivity of purely saturated vapors include individual coefficients for each material or group which is more obvious for liquids due to their un-homogenous transitional mechanism.