SUMMARY OF Ph.D. DISSERTATION

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Title

A Study on Further Improvement of Transient Hot-Wire Technique for Simultaneously Measuring the Thermal Conductivity and Thermal Diffusivity of Liquids, and Application to Various Hydrocarbons

Abstract

The thermal conductivity λ and thermal diffusivity κ of liquids, which rule the heat transfer phenomenon, are intrinsically important properties in thermal power engineering and related science. The technology to measure these properties has been studied, and, the transient hot-wire (THW) method is now regarded as the most reliable and accurate technique for measuring the thermal conductivity of fluid (or liquid) with the recent progress of the electronic technology. However the technique is not perfect to precisely and reliably measure thermal conductivity. The THW method has the benefit of permitting simultaneous measurement of the thermal diffusivity with the thermal conductivity. In this study, the THW method is re-investigated in order to measure, simultaneously and accurately, the thermal conductivity and thermal diffusivity, and the system are developed and tested with materials such as Toluene, *n*-Heptane, etc. as reference. Further, the system is applied to the measurement of a total of 53 hydrocarbon liquid materials (including three deuterated hydrocarbons), and heat capacities (volumic-: $c_p\rho$, specific-: c_p, molar-: $C_{m,p}$) are conducted using the relationship $c_p\rho=\lambda/\kappa$ and $C_{m,p} = c_p/M_r$ (density: ρ, molar mass: M_r). Results are compared with literature values and examined regarding such points as the relationship of thermophysical properties with sound velocity and the effect of deuterium substitution. The uncertainty of the system and also measured data are estimated to be better than 0.4 % for thermal conductivity and than 1.8 % for the thermal diffusivity (with a coverage factor of $k_p = 2$; $p = 95$ %).

Chapter 1 summarizes the background and the objectives.

Chapter 2 introduces the theoretical aspects of heat conduction with the definition of thermophysical properties, proposes the techniques to measure the thermophysical properties making use of the similarity between electric and heat conduction phenomena, and then outlines previous studies on techniques including the THW method.

Chapter 3 describes the theoretical and experimental investigation of the THW method to measure reliably and precisely λ and κ as the core of the study.

Chapter 4 describes the confirmation of the newly proposed system with the measurement of Toluene, *n*-Heptane, *n*-Pentane, and *iso*-Pentane.

Chapter 5 describes the measurement results applied to a total of 53 hydrocarbon liquid materials (including three deuterated hydrocarbons: Toluene-d_8, Cyclohexane-d_{12}, and Benzene-d_6), and heat capacities ($c_p\rho$, c_p, and $C_{m,p}$), and the comparison with the previously obtained data, and also refers to the relationship of thermophysical properties with sound velocity and the effect of deuterium substitution.

Chapter 6 summarizes the results of this study.