## THE SUMMARY OF Ph.D. DISSERTATION

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Title

## DEVELOPMENT OF FUNDAMENTAL EQUATIONS OF STATE FOR THERMODYNAMIC PROPERTIES OF HFC REFRIGERANTS

## Abstract

Fundamental equations of state for hydrofluorocarbon (HFC) refrigerants were developed due to several percents of uncertainty of the specific heat in the gaseous phase near saturation and completely different behavior of the third virial coefficient in the existing equations of state. The fundamental equations of state expressed in Helmholtz free energy for the purpose of representing the right thermodynamic consistencies were developed with taking consideration of a physical background in addition to available experimental information. Development of a computer program including evolution process and genetic rule as genetic algorithm was conducted for finding high efficiency of optimization process on the thermodynamic modeling.

The dissertation is divided into eight chapters. In Chapter 1, the present situation on refrigerants and the thermodynamic properties is introduced, and the latest state of the art on the existing equations of state is described in advance. It is then closed with the research background and the research purpose and scope. Chapter 2 explains the thermodynamic relations among physical properties and the relations with the Helmholtz free energy function on the basis of the thermodynamics. In the next chapter, literature survey and selection of experimental data on HFC refrigerants in single phase and at saturation are described. The paradigm and consideration on the theoretical background that should be considered into the thermodynamic modeling are described in Chapter 4. Preparation of the derived data for compensating shortage of experimental data and the optimization procedure and genetic rule for thermodynamic modeling are also explained in this chapter. Chapter 5 describes thermodynamic formulation of ancillary equations for saturation properties with simultaneous optimization of four HFC refrigerants to express into a common functional form. The ancillary equations have functions of temperatures for representing vapor pressure and saturated-liquid and saturated-vapor densities, respectively. In Chapter 6, development of the fundamental equations of state, thermodynamic formulation, and their assessment for PVT and caloric properties in single phase and at saturation are described. Their reliabilities in fluid phase including region where no experimental data exist are assessed. The discussions, which cover consistency of the fundamental equations of state with intermolecular potential models, characteristics of the ideal curves for wide-range thermodynamic surface at extreme pressures and temperatures, and relation of the optimization procedure to thermodynamic consistency, are conducted in Chapter 7. Finally, the result of the study is summarized in Chapter 8.