Preface

Many engineering applications are based on vapor compression cycle, a complex thermodynamic process that cannot be directly described by low-order differential equations (ODEs). Such systems have been studied extensively from the viewpoint of numerical simulation. However, the optimization, control, and fault diagnosis of such systems is a relatively new subject, which has been developing steadily over the last decades, inspired partially by research advances in the modeling methodology of moving-boundary method.

This book presents, in a unified framework, recent results on the output tracking, energy optimization, and fault diagnosis for the air conditioning system used on on-road vehicles. The intent is not to include all of the developments on this subject but, through a focused exposition, to introduce the reader to the tools and methods that we can employ to improve the current control strategies on product system. A second objective is to document the occurrence and significance of model-based optimization and control in automotive air conditioning system, a large class of applications that have received limited attention in the existing literature, in contrast to building heating, ventilation, and air conditioning (HVAC) system.

The book is intended primarily as a reference for engineers interested in optimization and control of thermofluid system and the mathematical modeling of engineering applications.

More specifically, the book focuses on typical layout of automotive air conditioning system. The book is organized into four sections. Part I focuses on control-oriented model development. Chapter 1 introduces the traditional modeling approach of the thermodynamics of heat exchangers in a passenger compartment. Chapter 2 exemplifies the model development process of an industrial project for automotive air conditioning system in heavy-duty trucks. Chapter 3 details the model order reduction method used in building HVAC system that might shed light on the difficulty of deriving low-order control-oriented models. Part II focuses on control design for output tracking of cooling capacity and superheat temperature, two critical requirements on system performance. Chapter 4 presents the recent development of robust control of parameter-varying model, a promising framework that could be used to describe the air conditioning system dynamics at different cooling loads. Chapter 5 utilizes the H infinity synthesis technique to design local controller ensuring the trajectories of the two outputs tracked. Chapter 6 utilizes the mu synthesis technique to improve the tracking performance when both parameter and system uncertainties exist. Chapter 7 details the theory of mean-field control that is proved to improve building HVAC efficiency significantly. Chapter 8 details a specific optimal control theory for constrained nonlinear systems. Both theories have promising applications in the problem of output tracking in automotive air conditioning system. Part III focuses on the problem of electrified vehicle energy management when the air conditioning load is considered. Chapter 9 presents the recent development of energy management strategy for hybrid electric vehicles when multiple-objective conflict and trade-off are required. Chapter 10 utilizes embedded method to design optimal operation sequence for mechanical clutch connecting the crankshaft and compressor in vehicles with conventional powertrain. Chapter 11 utilizes hybrid minimum principle to design the optimal operation sequence when phase change material is stored in an evaporator. Chapter 12 details controllers for cruising control of hybridized powertrain. Part IV focuses on the fault diagnosis of automotive air conditioning system. Chapter 13 presents the recent development of fault detection and isolation methods, as well as their applications to vehicle systems. Chapter 14 utilizes H infinity filter to detect and isolate a variety of fault types, such as actuator fault, sensor fault, and parameter fault. Chapter 15 evaluates the performance of automated fault detection and diagnosis tools developed for building HVAC system.

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