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Introduction To Electric Vehicle Engineering Explains History And Design Concepts

Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, *Third Edition*, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press Taylor & Francis Group, 2018, 546 pages, glossy hardback, ISBN-13: 978-1-4987-6177-2.

Reviewed by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

This book surveys the technology of land-based vehicles with electric propulsion. Two of the authors are electrical and electronics engineering professors and the other two are in mechanical engineering. The lead author, Prof. Ehsani, is at Texas A&M U. and director of the Advanced Vehicle Systems Research Program. Whether this book belongs in the power electronics section of the library (under batteries or electrochemistry) or in the automotive engineering section required some consideration that landed it in the automotive section of my library. The book contains a large amount of mechanical engineering, though all of it is related to electric or hybrid vehicle drive trains (propulsion).

The first four chapters are tutorial, covering background concepts of vehicle history leading to electric vehicles (EVs), air pollution, global warming, petroleum resources and some history of EVs, which stretches back to the late 19th century. Basic concepts of vehicle propulsion and braking are followed by internal combustion (IC) engine fundamentals, expressed mainly through thermodynamic cycles. Alternative fuels to gasoline or diesel fuel are covered: ethanol, compressed natural gas, and hydrogen.

Hybrid vehicles combine both electric motor and IC engine mechanical power sources. In the serial scheme, the IC engine drives a generator which drives the electric motors driving the wheels, directly or through a differential. In the parallel scheme, the two combine mechanically in the vehicle transmission, the topic of chapter 4.

Chapter 5, on "Electric Vehicles" and chapter 6, "Hybrid Electric Vehicles," describe the overall design schemes or configurations, and the performance requirements in mechanical terms. We finally arrive at something that looks like power electronics—and mainly motor-drive electronics—in chapter 7.

In this chapter, basic electric machine concepts are covered along with block-diagram-level explanations of converters and motor drives. This is followed by a more-detailed explanation of induction motors including field-oriented control. Some of the rotor sensing methods for induction motors are presented, though overall, the presentation is not intended to be a book—only a chapter or two—on electric machines. Permanent magnet synchronous motors are also presented, and with some emphasis and a good review of winding-sensed or "sensorless" methods for detecting rotor phase.

Chapter 7 continues with sections on switched reluctance motors (SRM) which produce torque based on variations within their electric cycle of winding inductance. This section also has an emphasis on sensorless control, including observer-based methods and artificial neural networks. The chapter concludes with an overview of SRM design.

Chapters 8 and 9 return to mechanical considerations of drivetrain design followed by two chapters on mechanical control. These chapters with a mechanical emphasis nevertheless are not far from the ongoing electric propulsion theme. Chapter 12 overviews hybrid drivetrain design.

Chapter 13 turns to electrochemistry and covers relevant battery technologies, including the one that is optimal for off-grid stationary electric systems, nickel-iron, because of its long cycle life. It is not chosen as optimal for vehicles, however, because weight and energy density are higher-priority considerations than for battery-banks in buildings. One of the main problems discussed is transient power which exceeds what a battery bank can deliver, and by shunting them with double-layer ("ultra") capacitors, or even high-speed flywheels, peak power can be delivered in short bursts.

Chapter 14 is heavily mechanical but quite important: regenerative braking, which converts mechanical kinetic energy of the vehicle into electric energy used to recharge the batteries.

Chapters 15 and 16 are about fuel cells, which can be thought of simply as batteries with a chemical flow process. Instead of being a thermodynamic system, the battery as fuel-cell stack becomes a control volume. Fuel cells are a newer technology and have various problems and limitations in their current state of

development. The book discusses *direct methanol fuel cells* but does not even mention ethanol fuel cells, ethanol being a safer fuel to handle (as many of us even drink modest amounts of it) and can be made from renewable biosources. Hydrogen as a fuel has a high energy density but has many disadvantages in storage, safety, and handling. Despite its lower energy density, ethanol seems like a more practical engineering solution. However, there are almost no fuel-cell passenger vehicles on the market.

The remaining chapters, 17 through 20, are automotive engineering design topics, about off-road vehicles, hybrid electric vehicle engine design optimization, powertrain optimization, and a final chapter on an optimizing computer program. Within these chapters is a comparison of the 2011 Toyota Corolla and the 2011 Toyota Prius Hybrid. The Appendix is of related interest, a technical overview of the Toyota Prius. Any engineer who owns a Prius would find this appendix interesting in that it has sufficient detail to provide insights into how the Prius was designed. The 22-page double-column index completes the book.

About The Author

Dennis Feucht has been involved in power electronics for over 30 years, designing motor-drives and power converters. He has an instrument background from Tektronix, where he designed test and measurement equipment and did research in Tek Labs. He has lately been working on projects in theoretical magnetics and power converter research.

To read Dennis' reviews of other texts on power supply design, magnetics design and related topics, see How2Power's Power Electronics Book Reviews.

To read articles on the design of power converters for electric vehicles and hybrid vehicles, see the How2Power Design Guide, locate the Application category and select Automotive.