Preface

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Energy-Efficient Train Operation

A System Approach for Railway Networks

Springer

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Preface

Rail transport is developing rapidly across the world due to the merits of safety, convenience, and comfort. Although rail transport is environmentally friendly compared to other transport modes including road and air, the amount of energy consumption in the rail transport system can still be improved considering its large scale of operation and high frequency of train services. Reducing energy consumption also contributes to reducing energy costs and achieving decarbonisation. The railway sector is aiming at energy-saving measures in many fields, in which reducing the energy consumption of train operations gets much attention. For this reason, this book focuses on energy-efficient train operations. In this book, the principles and methods of energy-efficient train operation will be introduced to provide railway companies with a set of energy-saving methods that can be applied in practice. This book also provides a systematic introduction for researchers and students in the field of energy-efficient train operation, helping them to understand this field quickly and master the basic theoretical methods.

This book consists of eight chapters. Chapter 1 reviews energy consumption data and the main relevant projects in recent years. In addition, a classification is given for energy-efficient train operation research. Chapter 2 introduces the relationship between train operation and energy consumption under different energy-efficient strategies. This relationship will serve as the basis for the energy-efficient optimisation methods in the subsequent chapters. Four types of optimisation methods for energy-efficient train operation are proposed from Chaps. 3 to 6. In Chap. 3, the driving strategy optimisation method for a single train is introduced. Chapter 4 considers energy-efficient train timetabling for mainline railway corridors, including multiple stops and heterogeneous trains. Optimisation of timetables taking into consideration the regenerative braking energy for metro systems is presented in Chap. 5. To make full use of regenerative braking energy, Chap. 6 discusses the main technologies, modelling, and control methods of energy storage systems. Because traction power network modelling plays a significant role in validating energy-efficient train operations, Chap. 7 then presents the simulation of electric railway systems, which integrates the train movement model and railway power network

model. Finally, basic conclusions about energy-efficient train operation methods and recommendations for further research are given in Chap. 8.

The main authors of this book are Shuai Su, Zhongbei Tian, and Rob Goverde. Professor Shuai Su is the deputy director of the Frontier Science Center of the Smart High-Speed Rail System at Beijing Jiaotong University. He has led projects concentrating on improving the energy efficiency of train operations. Moreover, he is a senior member of the Chinese Association of Automation and also a member of the TRB Annual Rail Transit Systems Committee. Dr. Zhongbei Tian has been working on railway traction power system modelling and analysis, energy-efficient train control, and energy system optimisation for more than ten years. He is now a Lecturer in Railway Power Systems at the University of Birmingham and an Honorary Lecturer at the University of Liverpool. His research has been implemented in projects across the world, including Network Rail, Edinburgh Tram in the UK, Madrid Metro in Spain, SMRT in Singapore, and Beijing and Guangzhou Metro in China. Professor Rob Goverde is a Professor of Railway Traffic Management and Operations and Director of the Digital Rail Traffic Lab at the Delft University of Technology. His research concentrates on the planning and management of railway traffic systems, including digitalised and automated train operations based on energy-efficient train trajectory optimization. He has wide experience from participation in many European railway projects and is President of the International Association of Railway Operations Research (IAROR) and Fellow of the Institution of Railway Signal Engineers.

The contributions of each author are listed as follows. Professor Shuai Su worked on Chaps. 1, 2, 5, and 8. Dr. Zhongbei Tian worked on Chaps. 1, 2, 7, and 8. Professor Rob Goverde worked on Chaps. 1, 2, 4, and 8. In addition, international experts were invited to contribute to chapters in the book. Xiao Liu is the co-author of Chap. 1. Xuekai Wang is the co-author of Chaps. 2 and 5. Peter Pudney is the author of Chap. 3. Gerben Scheepmaker is the co-author of Chap. 4. Gonzalo Sánchez-Contreras, Adrián Fernández Rodríguez, Antonio Fernández-Cardador, and Asunción Cucala are the authors of Chap. 6. We also like to thank all the support from students and experts of railway companies for this book.

It is, therefore, our pleasure to present this compendium. We hope that this book will support the railways all over the world to increase their contribution to clean mobility.

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