Preface

Environmental pollution has been one of the most significant threats faced by mankind in the last decades. It affects severely the whole planet, resulting in millions of premature deaths every year, degradation of the human life level, and considerable financial burden on individuals and the whole society. Passenger cars, light- and heavy-duty trucks and buses, and non-road equipment, i.e., vehicles powered by fossil-fueled internal combustion engines, are among the major contributors to the anthropogenic-related environmental issues, particularly in large cities. The authorities, having acknowledged this fact from the early 50s, proceeded to various measures, such as legislation of gradually stricter emission limits, cleaner fuels, inspection and maintenance tests.

Many books have been published in the last decades dealing with vehicular-related environmental issues. A lot of these books have focused on emission limits and emission legislation in general. Others deal with pollutant emissions analyzing their production mechanisms; additionally, a significant portion has been concerned with after-treatment control. None of these subjects are dealt with in this book. In contrast, it seems that there has been no book dealing exclusively with certification cycles, i.e., the test schedules employed at type approval level to test the vehicle, being representative of the concerned vehicle's or engine's duty cycle. Instead, with few exceptions, driving cycles have been presented in the past mainly as 'accompanying text' to manuscripts dealing with pollutant regulations and emission limits. Since, to the best of the author's knowledge, no comprehensive analysis of drive cycles has ever been attempted, this is the gap in the open literature that the present book aims to fill.

In the following chapters, an effort has been made to cover all possible subjects related to drive cycles, namely describe what a test cycle is, how it is constructed, and provide detailed historical information on the development of the most influential certification test schedules employed in the past. Moreover, the shortcomings of the various cycles with respect to their representativeness (in terms of driving activity and emission results) will be highlighted, as well as their most important technical specifications. The book also aims to combine this information with typical performance and emission results from real vehicles operation, in order

for the reader to draw a more complete picture on how the vehicle/engine behaves during a test cycle regarding development of engine speed, torque, power, as well as pollutant emissions. The results that will be presented stem from both (experimentally validated) simulations and experiments. Moreover, an extensive part of the book is dedicated to engine-dynamometer cycles, for heavy-duty and non-road engines/vehicles, which have been dealt with in the past even more scarcely.

It should be pointed out that it has never been the intention to provide an exhaustive list of all test cycles or their technical specifications. This holds true as regards the numerous non-legislated test schedules. For legislated cycles, on the other hand, a detailed presentation of all of them will be provided. Owing to the availability of large amount of data regarding U.S., European, and (recently developed) worldwide regulations, these cycles will be presented in more detail, particularly vis-à-vis their historical background. On the other hand, owing to language limitations and reluctance of the relevant authorities in Japan to provide background information, the analysis of Japanese test cycles will be considerably shorter. The discussion of drive cycles will be primarily from a mechanical engineer's point of view and only secondarily from a traffic engineering perspective.

The book is organized as follows: Chap. 1 serves as an introduction to driving cycles and test procedures in general. Test cycles are defined and classified with the focus on why certification cycles for all kinds of vehicles should be transient. A description of the main attributes follows for all cycle types (chassis and engine, modal and transient). Emphasis is given here on representativeness issues, also providing and analyzing various cycle metrics. The procedure followed when constructing a driving cycle is also discussed at the end of the chapter. Chapters 2 and 3 provide details on driving cycles for passenger cars and light-duty trucks, which form the biggest and oldest category (Chap. 2), and motorcycles (Chap. 3). These have been exclusively of the chassis-dynamometer type. Test cycles for heavy-duty engines/vehicles are discussed in Chap. 4. An interesting characteristic for these test schedules is that both chassis and engine-dynamometer cycles have been employed in the past, the latter on a stationary or transient form. All of them are discussed in detail. Chapter 5 deals with non-road engines/vehicles, such as those utilized in agricultural and construction equipment, marine and locomotive applications. The relevant cycles here are exclusively of the engine-dynamometer type. Lastly, Chap. 6 serves as an introduction to the experimental procedure during vehicle or engine certification in the laboratory, discussing the driving cycle test. Various topics are dealt with such as type approval issues, dynamometers, the coast-down test, and, primarily, the experimental setup and the equations used to calculate emissions and fuel consumption during the cycle execution in the laboratory.

One inherent feature of test cycles is their numerous technical specifications. These are provided collectively in the Appendix, for the most important schedules, and on a relatively detailed basis. It was intentional to not incorporate many 'numbers' inside the text. In any case, some technical specifications are important to supply context, particularly when comparing cycles; such comparisons form an

important component of the book. In order to understand the basis under which these technical characteristics have been derived, the interested reader is advised to check initially the introductory text in the Appendix, where the exact equations/logic is provided.

Although the biggest part of the book deals with driving cycles, i.e., those executed on a chassis-dynamometer where the whole vehicle is under test, it was decided to title the book 'Driving and Engine Cycles' so as to cover the second important category as well, namely engine-dynamometer cycles, which are also discussed in detail.

The present book is intended to serve as a reference for engineers and researchers, but it should also be useful to students as a supplementary text on exhaust pollution courses. Although for much of its length, it does not require specific technical knowledge and can be rather easily conceived by most people involved in the research and study of engine emissions and fuel economy, it is expected that the reader is already familiar with emission regulation matters and with some basic aspects of internal combustion engines operation.

Lastly, and bearing in mind that the broad subject of emission legislation is constantly evolving, the reader should always have in mind that a regulation valid when preparing this book (2016) might have been superseded at the time of reading it.

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