

Powertrain

Series Editor: Helmut List

Robert Fischer · Ferit Küçükay · Gunter Jürgens
Rolf Najork · Burkhard Pollak

The Automotive Transmission Book

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Edited by Helmut List

Scientific Advisory Board

R. Bastien, C. Beidl, H. Eichlseder,
H. Kohler, J. Li, R. Reitz

For decades, the series “The internal combustion engine” edited by Hans List was an indispensable reference work for engineers in practice and students at universities. With regard to the fast pace of technology, I decided to create a new series in 2002 and publish it under the title “Powertrain”. This title focuses on the role of today’s internal combustion engines as components of propulsion systems.

In the years 2013 and early 2014, a new series was discussed, and the decision made to publish it under the same title “Powertrain”, but with a new layout and a new Scientific Advisory Board. This series will again show the holistic context of the individual components of a powertrain. It is anticipated that 15 to 20 books will be published. In particular, the English language editions will be promoted next to the German editions.

In this series, the classification was made according to the present areas of responsibility in the industry.

This book series will focus especially on the state of knowledge in the various fields in the industry, starting from the basics and describing the necessary background information. In particular, the new elements of future propulsion systems and their mutual influence and system considerations will be addressed. In addition to the technical content, methods and processes for new developments and their boundary conditions are presented. The circumstances of different economies and their respective requirements will be set out in concepts.

This book series provides both students at universities and colleges as well as practitioners in the industry with a guidebook from which they can acquire the accumulated experience of the authors’ knowledge.

I thank the authors who have agreed to share their knowledge in these books and have invested their efforts in writing them. I also want to thank our publisher, Springer, for their cooperation. I am very grateful to the Scientific Advisory Board, which stood by me in both the division of the very broad subject area as well as in the selection of authors. The members of the board are: R. Bastien, Vice President Renault; C. Beidl, Professor, Technische Universität Darmstadt; H. Eichlseder, Professor, Graz University of Technology; H. Kohler, Vice President Daimler; J. Li, Vice President FAW; and R. D. Reitz, Professor, University of Wisconsin, Madison.

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Rolf Najork • Burkhard Pollak

The Automotive Transmission Book

With contributions by
Gerhard Kokalj, Björn Wultsch, Christian Hörsken,
Tobias Kassel, Artur Plötner

Robert Fischer
AVL List GmbH
Graz, Austria

Rolf Najork
Heraeus Holding GmbH
Hanau, Germany

Ferit Küçükay
Institute of Automotive Engineering
Technical University Braunschweig
Braunschweig, Germany

Burkhard Pollak
pi3 GmbH
Weinheim, Germany

Gunter Jürgens
Inst. f. Maschinenelemente
Technical University Graz
Graz, Austria

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Preface

Transmission technology has significant impact on fuel consumption, drivability, weight, and cost of vehicles. The relevance of these properties increased recently; and interacting with the entire powertrain and vehicle, the transmission becomes increasingly important.

For a long period, little innovation has been applied to transmission technology. Generally, until the beginning of the 80's of the previous century, just manual transmissions and step automatic transmissions with planetary gear sets and hydraulic control dominated the transmission market. Automatic transmissions focused on the operational comfort. Neither fuel economy nor sportiveness could compete with manual transmissions.

Evolutionary steps towards more gear ratios, for both, manual and automatic transmissions, were motivated by drivability and fuel economy. A first major leap in innovation was the introduction of electronic control to supplement the hydraulic control of conventional automatic transmissions. The additional degrees of freedom and functionalities aimed to improve comfort and interaction with the internal combustion engine. One of the features was an improved control of the torque converter lockup clutch for reduced fuel consumption.

In the 1990's transmission technology—especially the step automatic transmissions—was challenged by the introduction of continuous variable transmissions for higher torque applications. This led to massive redesigns and optimizations for step automatic transmissions and as a consequence, the benefits of the newly introduced continuous variable transmissions vanished and were finally overcompensated. Step automatic transmissions regained their leading position. Further, competition was created by the introduction of dual clutch transmissions. Automatic shifting transmissions are also demanded in markets which had traditionally been dominated by manual transmissions. As dual clutch transmissions allow reutilization of manufacturing equipment installed for manual transmissions, they are major driver of this change.

The competition between the different transmission types was and is very beneficial. Modern automatic shifting transmissions can outperform manual transmissions in both, fuel economy and drivability.

Also the evolution of engine technology drives changes. Engines torques increase and fuel economy map flatten, which lead to new requirements for modern transmissions. Automatic shifting transmissions offer broader range of potentials to meet these requirements.

A further boost for transmission technology is given by the introduction of hybrid propulsion. Further degrees of freedom combining transmission, electric motor, and internal combustion engines lead to multiple architectures and solutions. It has to be considered and understood that the different measures to improve fuel economy are not cumulative; adding up the different potentials is not possible. Utilizing the methods of systems engineering allows us to find optimal solutions and it is required to include the entire system during the design process to realize the potentials.

This explains the importance of transmission technology. Yet, does it justify another transmission book as there are plenty good ones already available?

We consider three levels of competencies in transmission technology: know, how to execute transmission designs, know, how to design transmissions and the competence to apply system engineering methodology on transmission concepts and designs. We believe the first two levels are well represented in existing publications.

Our desire is to focus on the latter in this transmission book. The competencies on transmission systems and accordingly the development methodology is our motivation. This starts deriving the needs for transmission technologies in automotive applications and includes the interactions with surrounding systems of the powertrain, the entire vehicle, and the environment of the vehicle. Introducing the multiple components and subsystems on an abstract level provides an ageless competence applicable for traditional, state-of-the-art, and future transmission technologies. We would be honoured if we motivate the investigation and realization of new transmission concepts with this book.

We would like to thank various experts, especially from AVL, GETRAG, Institut für Fahrzeugtechnik der TU Braunschweig und Institut für Maschinenelemente und Entwicklungsmethodik der TU Graz for their contributions in discussions, executing reviews, and giving proposals. Special thanks to Dipl.-Ing. Gerhard Kokalj, Dipl.-Ing. Björn Wultsch, Dr.-Ing. Tobias Kassel, Dr.-Ing Dipl. Math. Christian Hörsken and Dipl.-Ing Artur Plötner for their support in coordinating the efforts and valuable discussions and reviews on the manuscript of this book on top of their daily businesses.

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