Preface

This book has arisen from my many years of experience in the automotive industry. It is intended for advanced undergraduates in mechanical engineering, research scientists, and practicing engineers working on automotive turbochargers. It could be also used as an aero and vibroacoustics textbook in colleges and universities, and as a practical handbook of Aero and Rotordynamics in turbocharger industries.

Aero and Vibroacoustics of Automotive Turbochargers is a widely interdisciplinary working field dealing with noise source generation and airborne noise propagation from turbochargers to the environment. First, it involves *thermodynamics of turbomachinery* to design the turbocharger and to determine its working conditions. Second, it involves *aerodynamics* and the study of flow dynamics and instabilities of rotating stall and surge in compressors, which lead to aerodynamic noise. These are self-excited vibration noises rather than the response of external excitation noise sources. Third, it involves *fluid and rotordynamics* to study the unbalance whistle due to rotor unbalance, and self-excitation flow instabilities of oil whirls in rotating floating ring bearings, leading to the constant tone (howling). Both noise types are called rotordynamic noise. Lastly, it involves the *noise propagation computation* based on the Lighthill's analogy to investigate the airborne noise of turbochargers in passenger vehicles. However, some mathematical backgrounds in vector, matrix, and tensor analysis are required to comprehend this interdisciplinary working field of Aero and Vibroacoustics.

Airborne noise has recently become a much more important topic in passenger cars next to CO_2 reduction, and reducing fuel consumption. In recent years, engine noise has become relatively quiet so that other noise sources now become audible in passenger vehicles. Drivers and passengers want to use online communications via Internet and mobile phones, or relax with audio and video infotainment media without any external noise disturbance during driving. Therefore, airborne noise level in the cabin is required to be as low as possible. Moreover, car frames made of light metals and light periphery components have been used to reduce the vehicle mass, and to save fuel consumption and reduce emissions. Under these circumstances, induced noise of turbochargers excites the periphery components

neighboring the turbocharger, leading to additional airborne noises in the car cabin and environment. The root causes of different airborne noise types in turbochargers, such as pulsation, rotational, growling, whining noise, unbalance whistle, constant tone, crackling noise, high-order harmonic noise, and wear noise are thoroughly studied. Both active and passive measures are recommended to reduce the airborne noise levels in passenger vehicles.

Despite all my careful efforts, there may be some unpredictable errors in this book. I would be very grateful to receive your feedback and hints of errors. Therefore, readers of this book need to have a thorough analysis before applying it to their individual applications, and take their own responsibilities for possible damages.

I am grateful to Dr. Martin Knopf, the executive director of Bosch Mahle Turbo Systems (BMTS) in Stuttgart, for all his support and encouragement. Especially, I am also indebted to my colleague Daren Bolbolan for reviewing this book, and giving me constructive and helpful suggestions. In addition, I would like to acknowledge Dr. Jan-Philip Schmidt at Springer in Heidelberg for proofing mathematical derivations and for editing this book; Mrs. Heather King also at Springer and Dr. Shine David at SPS (P) Ltd. for invaluable recommendations and helps in publishing this book.

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