Abstract

At the end of the 19$^{\text{th}}$ Century, the invention of the Internal Combustion Engine (ICE) marked the beginning of our current lifestyle. Soon after the first ICE patent, the importance of increasing air pressure upstream the engine cylinders was revealed. At the beginning of the 20$^{\text{th}}$ Century turbo-machinery developments (which had started time before), met the ICE what represented the beginning of turbocharged engines. Since that time, the working principle has not fundamentally changed. Nevertheless, stringent emissions standards and oil depletion have motivated engine developments; among them, turbocharging coupled with downsized engines has emerged as the most feasible way to increase specific power while reducing fuel consumption.

Turbocharging has been traditionally a complex problem due to the high rotational speeds, high temperature differences between working fluids (exhaust gases, compressed air, lubricating oil and cooling liquid) and pulsating flow conditions. To improve current computational models, a new procedure for turbochargers characterization and modelling has been presented in this Thesis. That model divides turbocharger modelling complex problem into several sub-models for each of the non-recurring phenomenon; i.e. heat transfer phenomena, friction losses and acoustic non-linear models for compressor and turbine. A series of ad-hoc experiments have been designed to aid identifying and isolating each phenomenon from the others. Each chapter of this Thesis has been dedicated to analyse that complex problem proposing different sub-models.

First of all, an exhaustive literature review of the existing turbocharger models has been performed. Then a turbocharger 1-D internal Heat Transfer Model (HTM) has been developed. Later geometrical models for compressor and turbine have been proposed to account for acoustic effects. A physically based methodology to extrapolate turbine performance maps has been developed too. That model improves turbocharged engine prediction since turbine instantaneous behaviour moves far from the narrow operative range provided in manufacturer maps. Once each separated model has been developed and validated, a series of tests considering all phenomena combined have been performed. Those tests have been designed to check model accuracy under likely operative conditions.

The main contributions of this Thesis are the development of a 1-D heat transfer model to account for internal heat fluxes of automotive turbochargers; the development of a physically-based turbine extrapolation methodology; the several tests campaigns that have been necessary to study each phenomenon isolated from others and the integration of experiments and models in a comprehensive characterization procedure designed to provide 1-D predictive turbocharger models for ICE calculation.