Acoustics of Automotive Turbocharger

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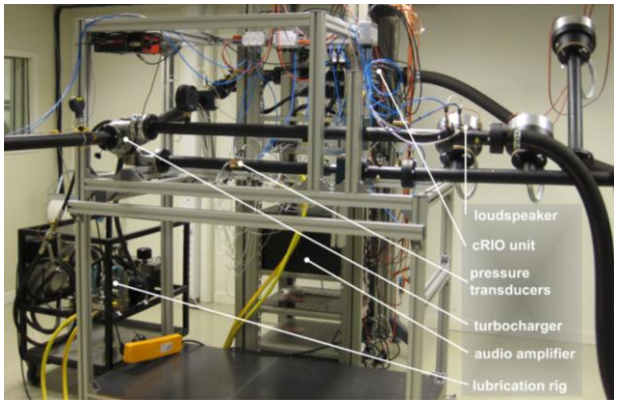
Abstract

Research and development for higher efficiency has led to engine downsizing where the use of exhaust gas driven turbochargers has currently raised the importance of turbocharger acoustics. The progressively tougher legislations on engine noise emissions have reached the stage where the turbocharger is critically focused on. Although the first exhaust-driven turbocharger was introduced almost a century ago the acoustical performance of these devices is still a field where relatively little published information exists. During this project a test facility has been developed to perform the acoustic characterization of turbochargers. The results for the sound transmission and -generation in the turbochargers are presented and the influence of the operating conditions of the unit has been analyzed.

Background

The application of turbochargers to internal combustion engines has increased considerably and nowadays almost all the diesel engines produced, together with the vast majority of modern high performance spark-ignition engines, are turbocharged. According to this trend, the acoustics of the turbo-chargers is increasingly becoming an issue. Despite the first exhaust-driven turbocharger was developed almost a century ago and the strong present motivation to implement them, there is still rather few research published on the acoustical performance of these devices.



KTH CCGEx turbocharger test facility.

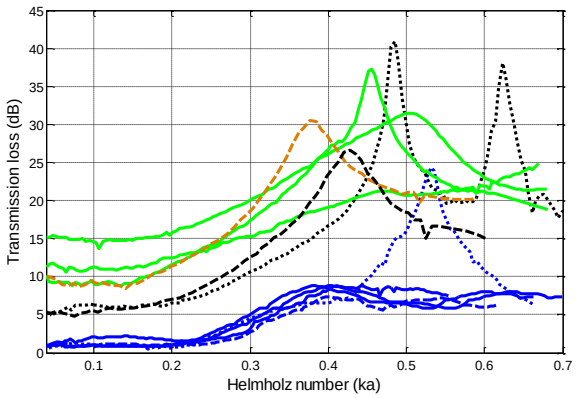
The turbocharger always consists of a compressor which is normally driven by an exhaust turbine. Both the turbine and the compressor have an influence on how the low frequency engine pulsations propagate in the gas exchange system. This is referred to as the passive acoustic property of the turbocharger. In this study three different turbochargers were analyzed. Measurements were performed in different operating point according to the compressor and turbine maps.

Method

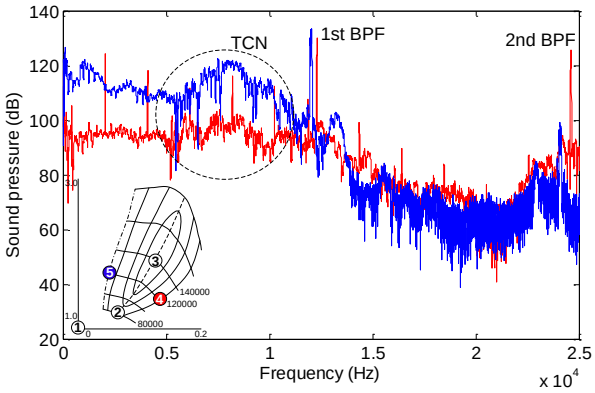
The turbocharger characterization facility has been established at the research competence centre for investigations on IC-engine gas management at KTH CCGEx in Stockholm. The ambition was to develop accurate experimental procedures for the determination of the scattering data for automotive turbochargers at realistic operating conditions selectable from the compressor and turbine charts. To determine sound transmission the automotive turbocharger was treated as an acoustic two-port.

Additionally to the measurements for the passive data, the facility can also be implemented to measure the sound generation by the turbo unit (the active properties).

Results



The transmission loss for three different turbo-compressors in upstream direction.



Comparison of sound pressure spectral densities between OP4 (red line) and OP5 (blue line) in outlet side of turbo-compressor.

Conclusions

The level of the TL results in the low frequencies (up to He 0.2) is determined by the losses in the system and increases with the mass flow. In the middle frequencies an upward slope is clearly recognisable. The angle of the slope is determined by the inner volume of the unit and it tends to increase when the volume increases. In the high frequency range characteristic peaks typically appear. The peaks originate from the resonances in the system - for example due to the cavity inside the waste gate actuator or due to the multiple sound paths through the rotor blades.

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