Modeling and Control of Advanced Turbocharged Engines

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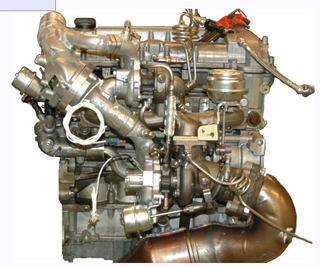
Project background and status

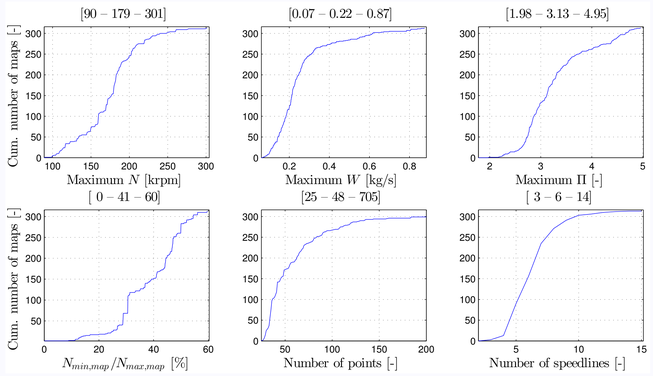


The ever increasing focus on fuel efficient vehicles forces the automotive industry towards more advanced engine concepts. Downsizing and turbocharging has been one possible solution. To still be able to provide the desired vehicle and engine behavior a single turbo is more often insufficient. This project focuses on modeling and control of turbo systems with more than one turbo.

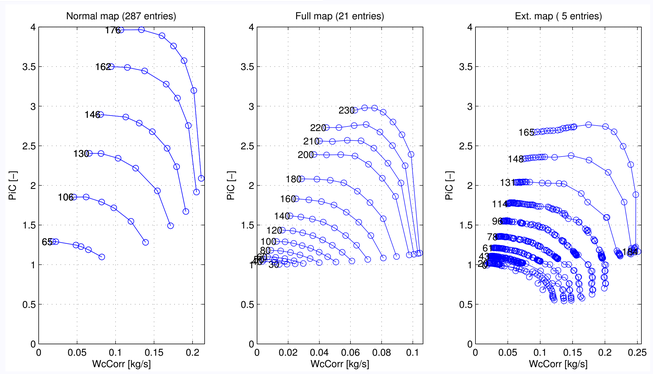
The work, therefore, evolves around development of component models capable of reproducing control relevant phenomenons (surge, choke, low speed and restriction operation etc.), and extensions of the available Mean Value Engine Model framework. The extended MVEM is suitable for investigation of both instability issues and control principles, for advanced turbocharged engines. The availability of experimental facilities within LINK-SIC is greatly appreciated, and used during the model development.

The fifth stage of the project has been devoted to further develop and analyze the compressor model structure. Focus has been on measuring and preparing data from different sources, with the goal of developing a model that is general to the automotive community. The same model structure should thus be usable for both small car sized compressors, and up to heavy truck applications. Compared to the previous efforts, focus has been on the high flow behavior, and restriction operation.

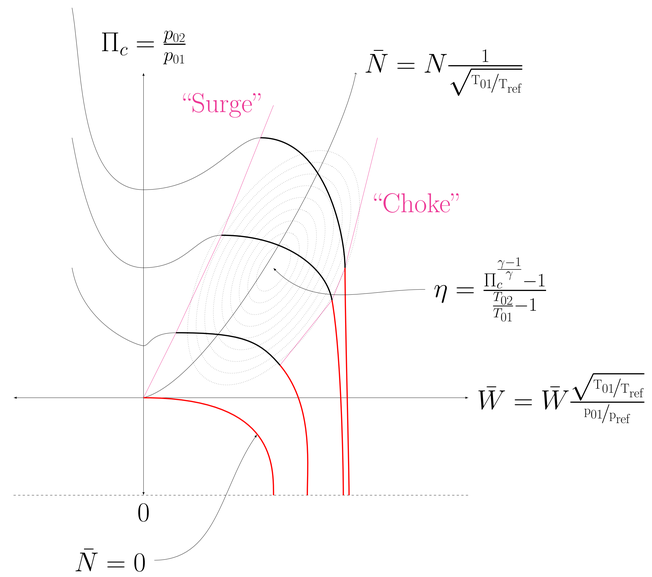
Map database



Compressor map types



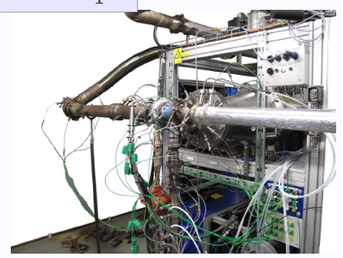
Generalized compressor map



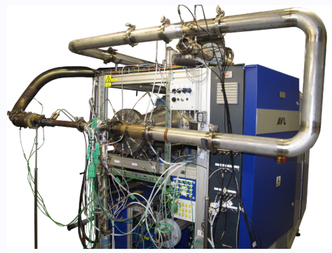
Comprehensive compressor maps

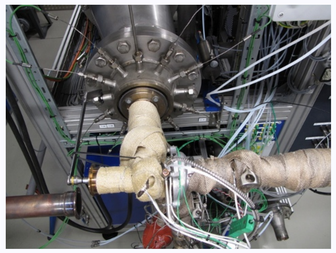
During the fall of 2011, a measurement series was conducted in a gas stand. Three different automotive sized turbochargers, considered representable for car applications, were selected for the study. The following measurements were conducted

- Pressure ratio below unity $\Pi_c < 1$
- Cold maps $T_{oil} = T_2$
- Hot maps $T_3 = \{300, 450, 600, 750\}^o$C
- Choke flow $\Pi_c \approx 1$



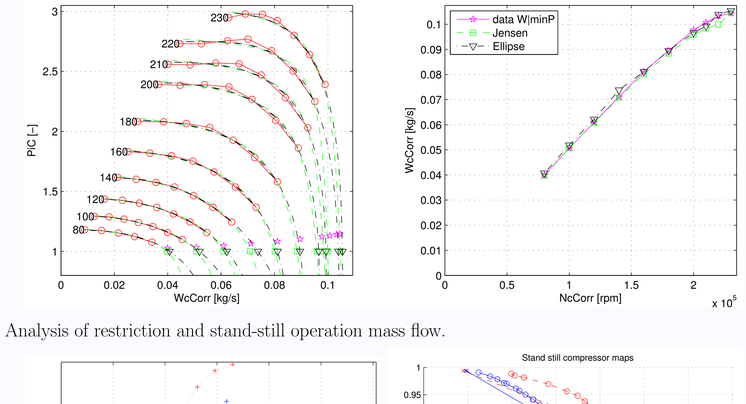
Apart from the normal gas stand sensor setup, a number of extra temperatures were measured, e.g.: eleven turbo surface (both compressor, center housing and turbine housing), four extra compressor inlet air temperature, a special surge indication compressor inlet air etc.



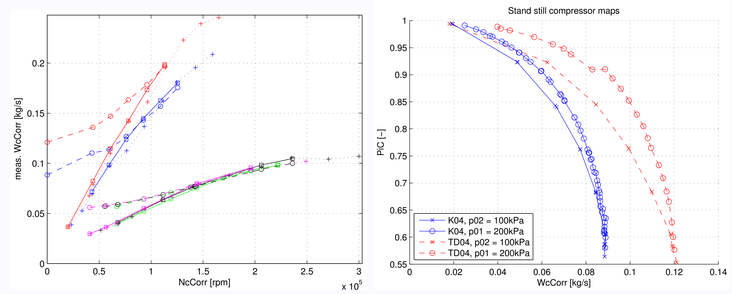


Restriction and stand-still operation

Validation of the Ellipse model as an extrapolation tool.



Analysis of restriction and stand-still operation mass flow.



Publications

Accepted publications

- Lars Eriksson, Tobias Lindell, Oskar Leufven, and Andreas Thomasson, **Scalable Component-Based Modeling for Optimizing Engines with Supercharging, E-Boost and Turbocompound Concepts**, SAE I.J. of Engines, 2012 Vol. 5, Num. 2
- Oskar Leufven and Lars Eriksson, **Investigation of Compressor Correction Quantities for Automotive Applications**, International Journal of Engine Research, 2012
- Lars Eriksson and Tobias Lindell and Oskar Leufven and Andreas Thomasson, **Scalable Component-Based Modeling for Optimizing Engines with Supercharging, E-Boost and Turbocompound Concepts**, 2012-01-0713, SAE World Congress

Masters theses

- Carin Carlsson, **Modeling and Experimental Validation of a Rankine Cycle Based Exhaust WHR System for Heavy Duty Appliations**, LiTH-ISY-EX–12/4595--SE,
- Victor Ingeström and John Hansson, **A Method for Estimating Soot Load in a DPF Using an RF-based Sensor**, LiTH-ISY-EX–12/4584--SE

Submitted publications[a]

- Oskar Leufven, and Lars Eriksson, **A surge and choke capable compressor flow model - Validation and extrapolation capability**
- Andreas Thomasson, Oskar Leufven, Ivan Criscuolo, and Lars Eriksson, **Modeling and validation of a boost pressure actuation system for a series sequentially turbocharged SI engine**

[a]Invitation, collecting the best papers presented at IFAC WC2011 and AAC2010, to write full paper for a CEP Special Issue on Automotive Control