# Modeling and Control of Advanced Turbocharged Engines

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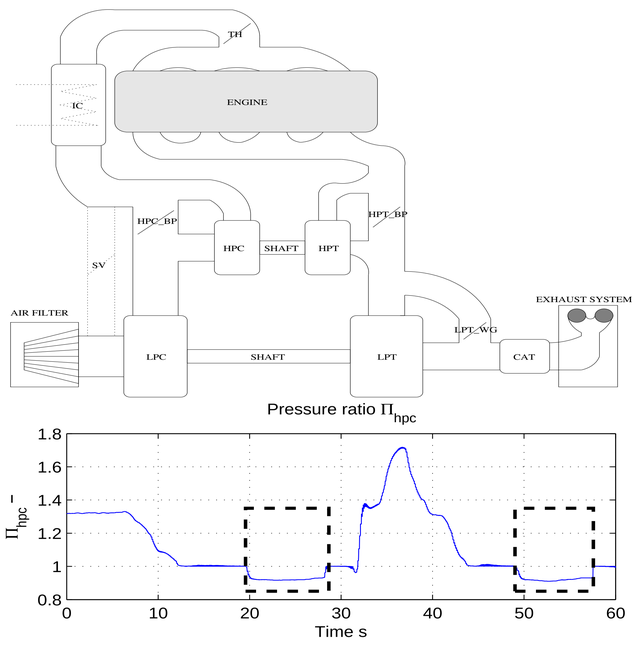
## Project Background and Status

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 two stage turbo system modeling and control and the second stage of the project has been devoted to the installation of a two stage turbo system on the common engine platform.

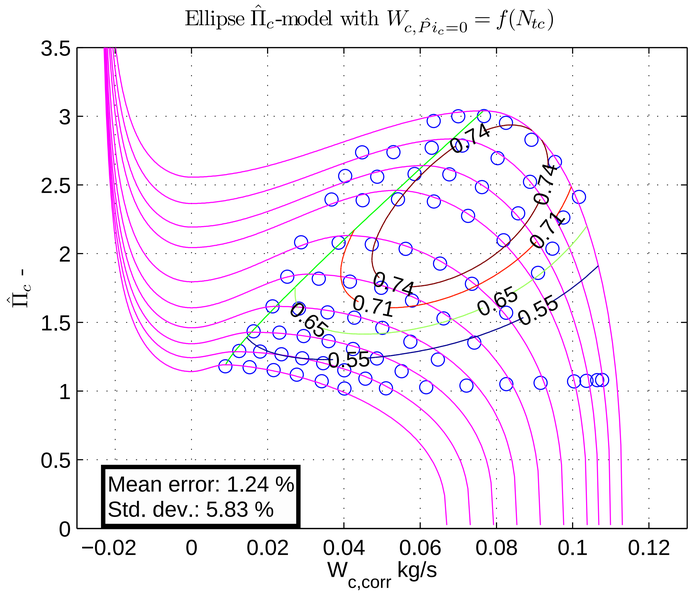
The motive to use a two stage system comes from the fact that dual parallel systems have potential to give good response over the full engine operating region, but has, one the other hand, problems with instability phenomena that can occur between the compressors. Increasing the complexity of the system also puts increasing demand on the controllers. Model based control is one possible way to handle this increasing complexity and is chosen here.

The available Mean Value Engine Model framework is extended with component models capable of reproducing a two stage turbo system behavior. The extended MVEM is suitable for investigation of both instability issues and control principles for dual stage turbocharging configurations.




## Compressor Performance Modeling

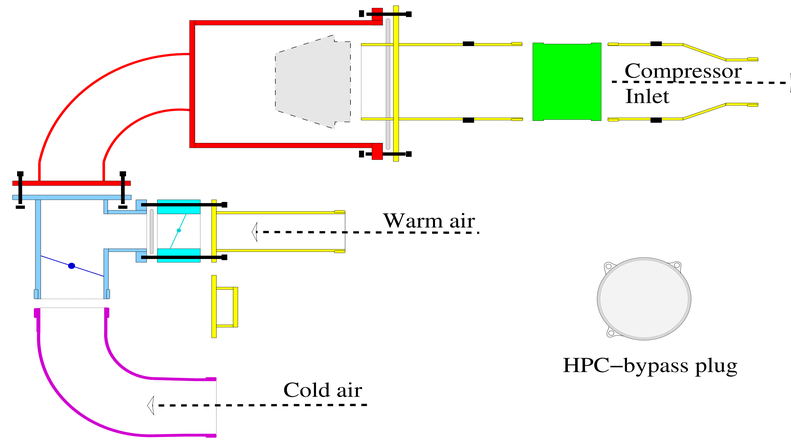
Measurements has exposed an interesting fact; the high pressure compressor in a dual stage system can be forced to operate in a region that is not covered by conventional compressor models. In particular it can operate in a region where the pressure ratio is less than one. This has driven the development of new compressor models that are able to describe the compressor operation in this region.




## Compressor Inlet Variation Test Setup

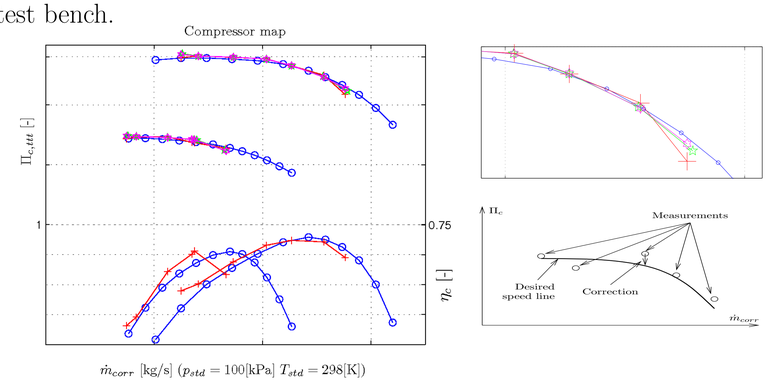
The common engine platform has been extended with equipment giving the possibilities to change both pressure and temperature of the compressor inlet and consists of two extra throttles before the first compressor stage. The throttles governs the mix of a warm and a cold air flow. The extension can be used to i.e. simulate high altitude or desert driving.

The equipment also gives possibility to investigate the commonly used correction factors of the compression system. The importance of investigating changing inlet conditions is motivated by the fact that the second stage of a two stage system has inlet conditions diverging largely from the reference conditions stated in the compressor mapping standards.




## Engine Test Stand Turbo Mapping

The capabilities of the test stand equipment extension described in previous section was demonstrated and prestented in a submitted SAE paper titled “Engine Test Stand Turbo Mapping”. The paper investigates the possibilities and limits when mapping a turbo system installed on an engine in an engine test stand in general. The extra throttle system was used to decrease the pressure upstream of the compressor stage, thus effectively increasing the corrected mass flow given the same “real” mass flow. The result shows that is it possible to map a turbo in an engine test stand but also demonstrates some differences between stationary flow measurements in a gas stand and those from pulsating flows in an engine test bench.




The paper further presents a controller structure to automate the mapping process as well as methods for adjusting data points having slightly different corrected shaft speeds than desired.