New boosting concept for a methane-powered engine

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Boosting for performance, efficiency- and power density increase is well known and established in all classes of serial production engines. Most of the engines produced today are equipped with a turbocharger. There are many different configurations available – multiple turbochargers in parallel or sequential configurations. The target is one – high boost pressure over a wide range of operation. The main drawbacks are surge, which means basically lack of potential on low engine speed, which is really important in typical vehicle operation, and lack of fast transient response. The Swiss invention of pressure wave superchargers (usually known as Comprex™) have the potential to overcome these main restriction. Antrova AG has recently completely redesigned the Comprex to overcome the technical challenges this machine had in the past. In combination with Miller cycle it has the potential for fast response, high output and reduced fuel consumption.

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Introduction

Pressure wave superchargers (Figure 1) use pressure waves of the exhaust gases to compress fresh air in the cells of the rotor. The rotor turns, driven by electric motor, so this process can be synchronized. Due to the principle that exhaust gases are compressing fresh air in direct contact, the rotor speed can also be used to control exhaust gas recirculation. In engines working at λ=1 principle the three-way-catalyst needs to be located before boosting device, which can have a positive impact on its performance, for example during cold start.

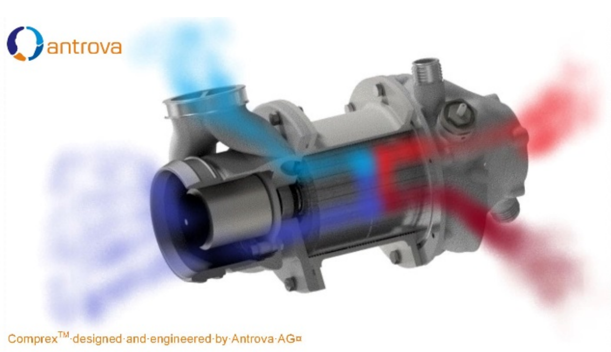

Fig. 1 Comprex™ – pressure wave supercharger

1d simulation

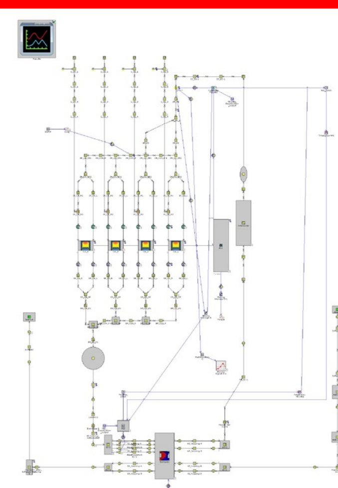

Fig. 2 Model of the engine with Comprex™ in GT-Power

A complete model of the engine and Comprex™ created in GT-Power was used to estimate the potential. A special attention is given to study the benefit from choosing the ideal combination of boost pressure levels and gas exchange valve timing.

The most critical points for emission lay in low load and speed area. On opposite site – high load and speed between 2000 and 2700 rpm – lays area important for fuel consumption. Optimizing such a powertrain means basically an optimization of simultaneously fuel consumption and emissions.

It is expected to improve the engine's output with a Comprex, especially at low speed conditions which leads changes in gear shifting strategy and reduction of fuel consumption.

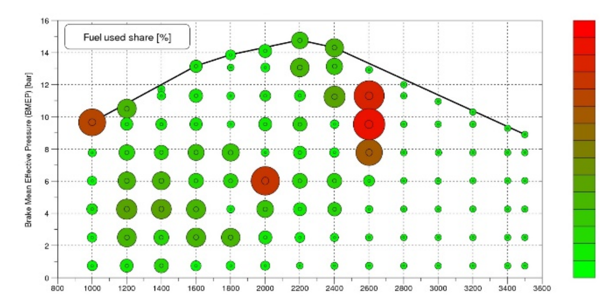

Fig. 4 Fuel used share in WLTC

Approach

To achieve the project goals to find a good solution for natural gas engines used in light commercial vehciles, both simulation and experimental validation are performed. Following tools are used:

- Calibration of combustion model (for 1d model – Figure 2) based on measured data with turbo setup,
- 1d simulation of the whole engine with Comprex™ and different camshafts,
- Validation of simulation results with data from the test bench
- Modifications of current setup/geometry,
- Tests of modified geometry and validation in parallel,
- Implementation of water injection.

WLTC

The targeted commercial vehicle equipped with the engine under consideration was simulated in the Worldwide Harmonized Light Vehicles Test Cycle (WLTC). The results presented of Figure 3 and Figure 4 show that the engine speed does not exceed 2700 rpm. They also show that the low speed range is the most important for emissions and fuel consumption.

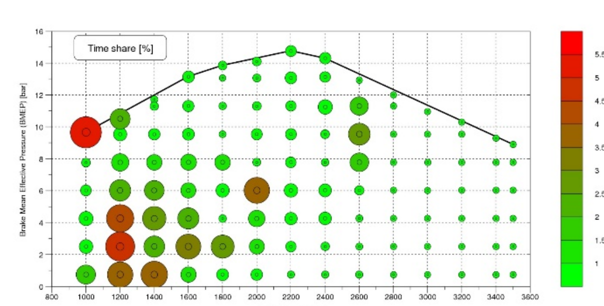

Fig. 3 Time share in WLTC

Outlook

Simulations were performed with different cam profiles. Currently validation of simulation data is ongoing with data previously collected during multiple runs on a test-bench (Figure 5).

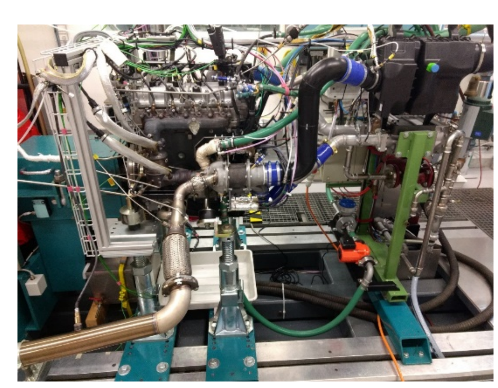

Fig. 5 Comprex-equipped engine on test bench at Empa

Expected impact

Final output will be a CNG powered engine with which has a similar performance as its diesel version, but a lower level of CO_2 emissions. New knowledge on the feasibility of Comprex in combination with a natural gas engine is gained.

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