EGR-Systems for Diesel Engines

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Abstract

EGR is an important sub system within gas management. Future combustion concepts may need large amounts of EGR to reduce NO_X. This project deals with various aspects of EGR both from a system perspective, i.e. how the EGR system thermo- and gas dynamically interacts with other parts of the engine as well as the performance of a number of specific components, as e.g. connection points, pipe geometries and heat exchangers. Issues to take into account are pressure losses, heat transfer, mixing of EGR with fresh air, as well as particle and soot deposition. A special issue is to be able to deliver high amounts of EGR in any driving situation. In this part of the project different ways to achieve EGR as well as boost pressure are analysed and benchmarked. The fuel economy can be worsened if the system is not optimised for best fuel economy.

Background

To comply with future emission legislation, engine manufacturers will have to reduce the emissions of the engines dramatically. One way to achieve this is the use of after treatment devices; the other is to reduce the formation of emissions during combustion. EGR is a proven method for reducing NO_X formation by decreasing the local temperature during combustion. The extensive use of EGR leads to a reduced engine efficiency. The scope of this project is to find systems with a good EGR-performance, thus delivering the desired amount of EGR, while maintaining the efficiency of the engine at a high level.

Method

Two test engines, a passenger car diesel and a heavy duty diesel, have been run on steady state load points containing full load as well as emission cycle relevant points. Corresponding GT-Power models have been calibrated to match the measured data. The passenger car engine was even run in transient and the model calibrated to the engine behaviour.

For the analysis of EGR-distribution from cylinder to cylinder, a fast four-channel CO_2 analyser is used as well as standard CO_2 analysers.

The calibrated GT-Power models are then used to analyse the performance of different EGR systems. Figure 1 shows some of the systems that have been analyzed in this project.
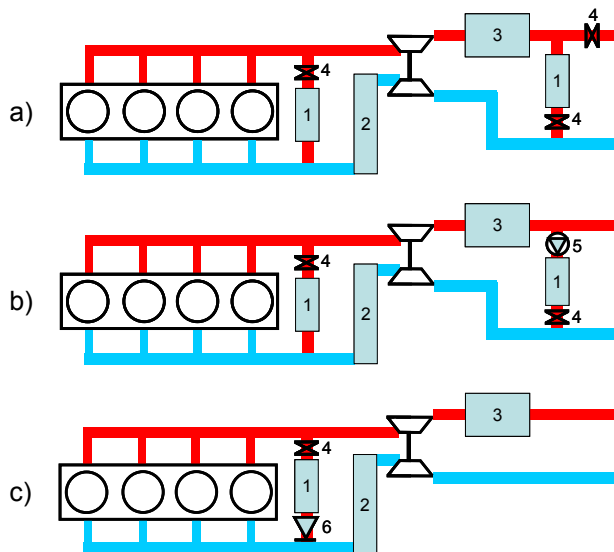

Fig. 1: a) Hybrid EGR-system, b) Driven Pump in long-route (LR), c) Reed valve in short-route (SR), with: 1. EGR-cooler, 2. Intercooler, 3. DPF, 4. Throttle / Valve, 5. Pump, 6. Reed valve

Results

Figure 2 shows a comparison of the brake efficiency achieved on a passenger car diesel engine for the different systems shown in Figure 1.
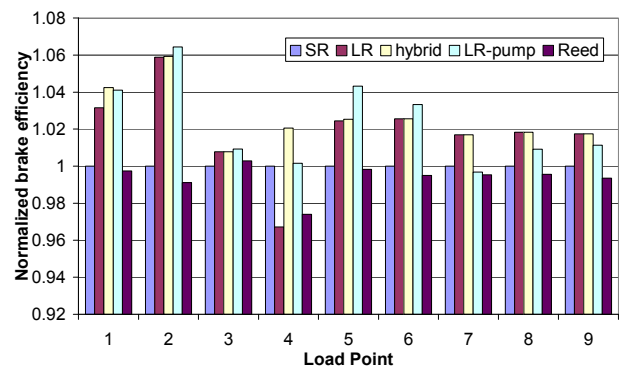

Fig. 2: Normalized brake efficiency for different EGR-systems

Figure 3 shows the load step response of the engine when run with different distributions of the EGR between the long-route and the short-route path in the hybrid system.
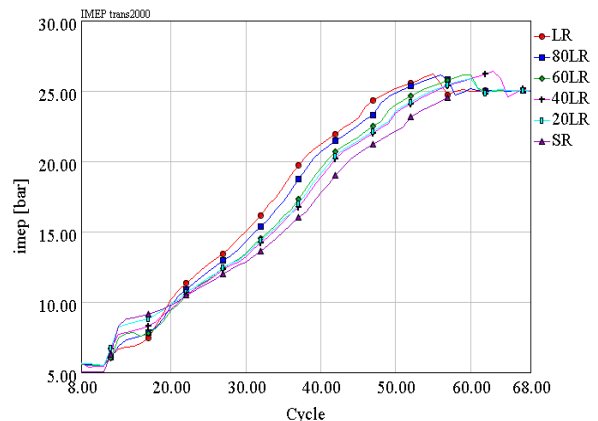

Fig. 3: IMEP for a full load transient at 2000 rpm

Conclusions

This part of the project showed that a hybrid EGR system has advantages regarding transient response and fuel consumption compared to a standard short-route system. Further systems are analyzed in the project and a study about EGR-distribution is conducted.