KTH CCGEx

Divided Exhaust Period

Improved use of blow-down energy

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Abstract

It is becoming increasingly important to reduce the fuel consumption of vehicles both from an environmental point of view and for the sake of end consumer's fuel economy. Engine performance has been improved over the years by means of many different research areas, where one of these are the use of free valve technology. In this project, a gas exchange concept called Divided Exhaust Period (DEP) that utilizes free valve technology will be numerically simulated on a variety of engine types. The aim is to reduce fuel consumption, residual gas content and improve transient response while maintaining current EGR (Exhaust Gas Recirculation) rates.

Background

Introducing a turbocharger on an engine creates an exhaust back pressure for the piston to work against during the exhaust stroke. As a way to reduce these pumping losses a second exhaust manifold is introduced, that leads the exhaust gases past the turbine. The standard two exhaust valves are each assigned to one of the two manifolds, as can be seen in Figure 1. The valves and manifold connected to the turbine are denoted as the blow-down system, while the valves and manifold that are bypassing the turbine are denoted as the scavenging system. The strategy of the Divided Exhaust Period (DEP) concept is to let the initial high enthalpy blow-down pulse run the turbine, but lead the exhaust gases through the scavenging system during the rest of the exhaust stroke. Since the piston then can expel the exhaust gas out of the cylinder against atmospheric pressure instead of the turbine back pressure, a reduction in pumping losses is achieved. This in turn leads to a potential reduction in fuel consumption.

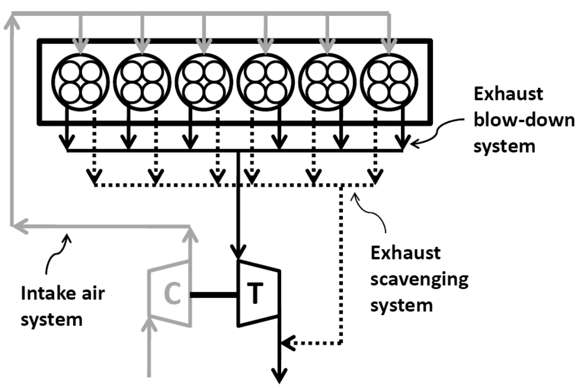

Fig. 1 *Engine sketch of the DEP concept.*

Method

The DEP concept will be initially investigated through extensive numerical simulations with the aid of GT-Power, which is a 1D code for engine simulations. Baseline models for the different engines that are under investigation are calibrated against measurement data acquired at the engine test cell facilities of KTH. These baseline models are then modified to incorporate the DEP concept and simulations covering optimization of valve timing strategies, valve sizes, turbocharger matching etc. is carried out, and results are compared to the baseline models. If the numerical simulations show potential improvements, the project can be extended to incorporate real engine tests with a prototype DEP engine.

Results

Fig. 2-3 shows results of DEP simulation on a Scania Euro3 HD-Diesel engine running at 1400 rpm and 1200 Nm.

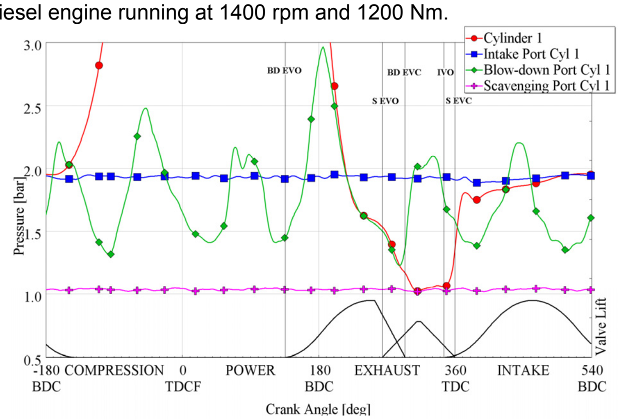

Fig. 2 *Pressure in cylinder, intake port, blow-down port and scavenging port.*

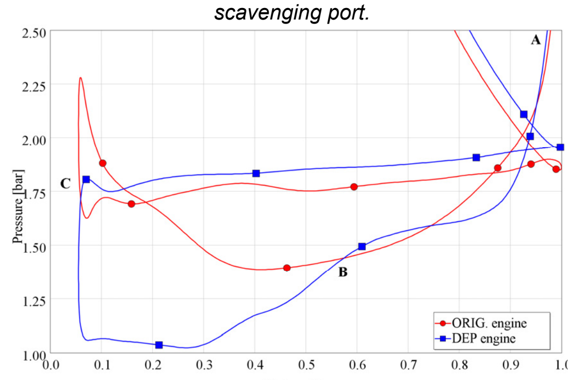

Fig. 3 *Pressure vs. volume for the original and the DEP engine during the gas exchange loop for the same load point as above.*

Conclusions

Results from the numerical study of a Scania Euro3 engine shows a substantial reduction of pumping losses which causes a reduction in fuel consumption by up to 4.9 % depending on torque and engine speed. This is mainly due to the reduced pumping losses, but the DEP concept also offers the possibility to control the mass flow and therefore also the pressure ratio over the turbine. This gives the advantage of being able to keep the turbocharger in a high efficiency operating mode for a wide range of load and engine speeds.