Low- and high-temperature waste heat recovery in internal combustion engines - WP4

1. BACKGROUND

The increasingly stringent requirements for reduced CO_2 emissions have pushed vehicle manufacturers to consider all available and future technologies. Hybridization and electrification of the driveline is such a technique, optimization of the internal combustion engine and energy recovery of exhaust and cooling water heat another. A combination of these two systems can therefore be a holistic solution, but also a prerequisite to return the recovered energy in a suitable form.

2. METHOD

Volvo Car Corporation has built a demonstrator engine with an energy recovery system for a passenger car. The system is based on a Rankine-based recovery system combined with a mild-hybrid drivetrain based on 48 Volt technology and an optimized combustion engine. The purpose of the project is to demonstrate the potential of achieving a fuel consumption less than 210 g/kWh corresponding to 40 % brake efficiency enabling 75 gCO_2/km in a vehicle by means of waste heat recovery.

3. RESULTS

The demonstrator was installed and calibrated in a test rig at Chalmers. The first experimental results were obtained for two modes of operation. In electrical feedback (EFB) the expander is coupled to the 48V generator. In mechanical feedback (MFB) the expander is connected to the engine, making the expander dependent on the engine speed. In MFB, a range of engine speeds and torques was tested and compared to operation without the expander with the resulting bsfc reduction shown in Fig. 1. Up to 5 % bsfc reduction is possible, depending on the engine operating point. With the expander coupled to the generator (EFB mode), the expander speed was varied for three different engine operating points. The resulting expander power output is shown in Fig. 2. The figure shows that the optimum expander speed depends the engine operating point with a maximum expander power of 2.5 kW.

4. CONCLUSIONS AND OUTLOOK

- The integrated design shows that it is possible to mount all WHR components on an existing light-duty engine. The control concept allows the system to run without interference of the driver, allowing for the possibility to fit this system into a passenger car.
- The results show that up to 5 % savings in fuel consumption are possible when directly coupled to the engine. When connected to the generator, up to 5.5 % of the engine power can be recovered.
- The possibility of switching between EFB and MFB, allows for elaborate strategies to maximize performance.

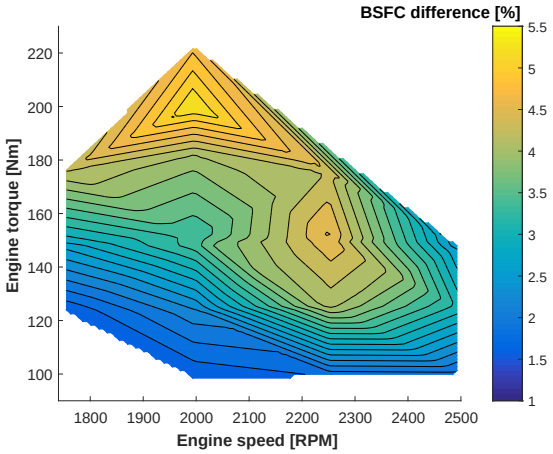

Figure 1: Difference in BSFC with and without the expander coupled to the engine.

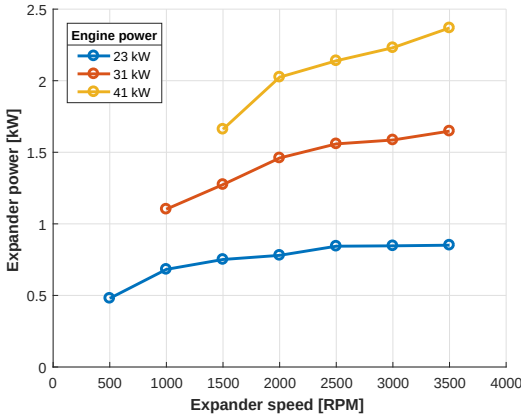

Figure 2: Expander power vs. expander speed for different engine operating points.