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## **A novel exhaust heat recovery system to reduce fuel consumption**

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### **ABSTRACT**

Internal combustion engines release about 1/3 of the energy bound in the fuel as exhaust waste gas energy and another 1/3 energy is wasted through heat transfer into the ambient. On the other hand losses through friction are the third largest root cause for energy loss in internal combustion engines. During city driving frictional losses can be of the same size as the effective work, and during cold start these losses are even bigger. Therefore it is obvious to utilise wasted exhaust energy to warm up the engine oil directly. Frictional losses of any engine can be reduced during part load. Sensitivity analyses have been conducted for different concepts that utilise exhaust energy to reduce engine viscosity and friction. For a new system with an exhaust gas/oil heat exchanger the following benefits have been demonstrated:

- Fuel consumption reductions of over 7% measured as an average over 5 NEDC tests compared to the standard system configuration.
- Significant reductions in exhaust emissions, mainly CO and NO<sub>x</sub> have been achieved
- Significantly higher oil temperatures during cold start indicate large potential to reduce engine wear through reduced water condensation in the crankcase
- Fuel consumption reductions of further 3.3% to 4.6% compared to the 7% measured over the NEDC test can be expected under real world customer usage conditions at lower ambient temperatures.

Oil temperature measurements and analysis resulted in the idea of a novel system with further potential to reduce fuel consumption. This Oil Viscosity Energy Recovery System (OVER 7™) consists of 3 key features that add significant synergies if combined in a certain way: an oil warm up circuit/bypass, including oil pressure control and Exhaust Gas/Oil Heat Exchanger. The system separates the thermal inertias of the oil in the engine galleries and the oil pan, reduces hydraulic pumping losses, increases the heat transfer from the cylinder head to the oil, and utilises the exhaust heat to reduce oil friction.

The project demonstrated that sensitivity analysis is an important tool for the evaluation of different concepts. Especially for new concepts that include transient heat transfer such a qualitative approach in combination with accurate experiments and measurements can be faster and more efficient in leading to the desired improvements compared to time consuming detailed simulations.