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Computational Fluid Dynamics Calculations of Turbocharger's Bearing Losses

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ABSTRACT

Fuel consumption in internal combustion engines and their associated CO2 emissions have become one of the major issues facing car manufacturers everyday for various reasons: the Kyoto protocol, the upcoming European regulation concerning CO2 emissions requiring emissions of less than 130g CO2/km before 2012, and customer demand. One of the most efficient solutions to reduce fuel consumption is to downsize the engine and increase its specific power and torque by using turbochargers. The engine and the turbocharger have to be chosen carefully and be finely tuned. It is essential to understand and characterise the turbocharger's behaviour precisely and on its whole operating range, especially at low engine speeds. The characteristics at low speed are not provided by manufacturers of turbochargers because compressor maps cannot be achieve on usual test bench.

Experiments conducted in our laboratory on a special test rig equipped with a high-precision torquemeter, demonstrate that compressor performances in this area cannot be deduced from adiabatic assumption. Nevertheless, our study suggests that as long as torque at the shaft end is measured and mechanical power losses are known, the effective power provided to the air flow can be calculated. Tests and calculations reveal that these mechanical power losses cannot be evaluated by general physical laws. A better knowledge of these losses is required. In this paper, a CFD model of a turbocharger journal bearing system is proposed. The real behaviour of what occurs in the bearing system (such as leakage flow, heat transfer from the inner film to the outer through the brass bearing material) has been computed with the energy equation. The bearing system performance is presented against the rotational speed at various oil inlet temperatures and pressures. The impact of those parameters has been studied in detail and presented in this paper. It is demonstrated that the oil temperature rise decreases the friction torque along the rotational speed by making the viscosity drop. Moreover, an increase of the oil inlet pressure results into a higher friction torque. This paper provides an analysis of this trend showing the link between oil inlet pressure, oil mass flow and thermal exchange inside the bearing. Results also present the variation of oil mass flow along the entire speed range and its distribution between the inner and outer clearances.