3D thermal steady-state CFD analysis of power friction losses in turbocharger's journal bearing and comparison with finite difference method and experimentation

M. Deligant – -P. Podevin : Cnam
F. Vidal - W. Tyminski : PSA
S. Guilain - H. Lahjaily : Renault SAS

Conservatoire national des arts et métiers	**PSA PEUGEOT CITRÖEN**	**Renault SAS**
Laboratoire de génie des procédés pour l'environnement l'énergie et la santé *LGP2ES – EA21 - Case 333* *292, rue Saint-Martin* *75141 Paris Cedex 03* *E-mail: pierre.podevin@cnam.fr*	*Direction de la Recherche et de l'Innovation Automobile* *Route de Gisy* *78943 Vélizy Villacoublay Cedex*	*Direction de l'Ingénierie Mécanique* *Centre Technique de Lardy* *1, Allée Cornuel 91510 Lardy*

Abstract :

Regulations of CO2 emission lead car manufacturer to reduce fuel consumption. A first step to reach the objectives is the downsinzing, namely increasing the engine specific power and torque together with reducing the engine capacity and using turbochargers. In order to keep engine power on a wide functioning area, high performances of turbocharger are required. These performances need to be known on the whole range of the engine use. Unfortunately, this is not the case for turbocharger's operation at low speeds (less than 100000 rpm), which is often encountered in automotive applications particularly in the urban conditions where the fuel consumption optimization is important.

In the CNAM laboratory, we have performed some experiments on a turbocharger test bench equipped with a torquemeter in the low speed area.

These experimental results allow a coarse evaluation of friction losses based on the difference between the power delivered to the airflow and the one measured by the torquemeter. It seems that a good accuracy of these losses can be obtained directly by calculation.

Solutions of the generalised Reynolds equation with axial groove device are computed in tables for classical journal bearing used in large machines. These tables compile dimensionless solutions of Reynolds equation for relative eccentricity between 0.1 and 0.95 and different L/D ratios. Unfortunately, turbocharger journal bearing are weakly loaded and oil viscosity is important so eccentricity is less than 0.05.

A finite difference method solving the isothermal Reynolds equation was implemented in order to extend tables for turbocharger applications. This method was validated by recomputing values in tables and it was applied with parameters of the considered turbocharger's journal bearing. As classical method, the program authorizes computed solutions for specified L/D ratios and eccentricity. Since load force results of integration of pressure field, and turbocharger operates with constant load, relative eccentricity value is to be determined. For that purpose, a simple dichotomy procedure on eccentricity was developed.

Then this method has been enhanced considering the real inlet layout device with four holes, and applied on considered turbocharger's journal bearing for different parameters (inlet oil temperature, inlet oil pressure, rotational speed). Calculated friction power losses seem to be over evaluated by this method due to the high rotational speed and the isothermal hypothesis.

Therefore a 3D CFD model using Navier-Stokes, mass and energy equations was developed. Eccentricity was set dynamically using dynamic mesh method. Calculations were split in two steps. The first step computes pressure and velocity maps with constant temperature. Then activation of energy equation and viscous heating allow to compute temperature map over all the oil volume. Friction effects result in increasing oil temperature and decreasing oil viscosity. Thus estimated friction power losses are smaller than with isothermal method and comparison with experiments shows more realistic results..

Keywords: turbocharger, friction losses, journal bearings, CFD, THD, hydrodynamic, lubrication