Hydrodynamic Lubrication Mechanisms under Transient Severe Loading Conditions

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Abstract

Hydrodynamic bearings can be found in all modern cars. Indeed, the camshafts, which are responsible for opening the intake and exhaust valves in both combustion and hybrid engines, are supported by these systems. Moreover, the engines in electric vehicles, which represent one of the most environmentally-friendly form of motorized transportation in the present era, also have rotating shafts supported by bearings operating under hydrodynamic conditions, although at a significantly higher velocity than those seen in combustion engines. In recent years, it has been demonstrated that more than a quarter of the energy consumed in these systems is used only to compensate friction losses. In order to reduce fuel consumption and therefore greenhouse gas emissions in one case, or electricity consumption to extend autonomy in the other, it is necessary to enhance comprehension of the tribological and dynamic phenomena inherent to these mechanical systems for steady-state and transient loading regimes. A novel full-scale measurement bench was developed enabling the experimental simulation of journal bearings with a radial clearance of 20 μm under real-life working thin-film conditions. The fully instrumented measurement system allowed for the acquisition of in situ in operando data series, including the nominal friction torque in the bearing, pressure gradient, temperature and shaft position under controlled contact kinematics and loading kinetics. The dynamic loads can be applied to the bearing in a contactless manner via a dedicated electromagnet, thus preventing any alteration to the low torque measurement. This type of actuator has the potential to induce any type of excitation over time: for instance, it can apply a rapid loading, reaching 2500 N in less than 3 ms. This talk presents the results obtained on smooth surfaces for a low-viscosity lubricant, at speeds up to 2000 RPM, with varying acceleration values, and radial forces ranging from 600 to 1500 N. The relevance of the data collected was analyzed, the dynamics of the shaft was investigated as a function of the velocity and the thin-film hydrodynamic lubrication mechanisms under steady-state and transient loading conditions were discussed.

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