Numerical Analysis of the Journal Motion in the Hydrodynamic Bearing of the Internal Combustion Engine

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ABSTRACT

The analysis of a dynamically loaded bearing requires repeated solutions of the Reynolds equation at each point of the journal orbit. The Reynolds equation, which governs the hydrodynamic lubrication of journal bearings, is a partial differential equation with an unknown boundary of the loaded zone.

A number of numerical solutions of the Reynolds equation are known for cylindrical bearing. The solution is often presented in form of tables or approximating formulae. However, these formulae can not be applied for a more realistic case when bearing geometry may include oil feed features such as grooves or holes, as well as surface irregularities due to machining operations and wear. It is not practical to perform the tabulations for all possible combinations of bearing parameters in advance.

In the present work a new (spectral) method is described, which allows the Reynolds equation to be solved sufficiently quickly and accurately, so that the preliminary tabulation is not required. The solution of the Reynolds equation is sought as a Fourier series with respect to the circumferential coordinate. This allows the original partial differential equation to be reduced to a system of ordinary differential equations, which, in turn, is further approximated with a linear algebraic system.

In addition, a novel method is introduced to determine the loaded zone corresponding to the Reynolds boundary conditions. The method uses ideas of functional analysis. The Reynolds equation along with the condition that pressure in the oil film be non-negative, allows a functional equation to be written and then solved with a quickly converging iterative method.

The dynamic characteristics of the bearing are used for numerical simulation of journal motion in the bearing with the Runge-Kutta method.

Examples of the pressure distribution and journal motion in the bearings of the internal combustion engine are given for bearings with various geometrical features on the surface.

Keywords: Hydrodynamic Lubrication, Journal Bearing, Internal Combustion Engine, Journal Orbit Stability.