CFD modeling of cavitation flow in journal bearing lubrication

This item was submitted to Loughborough University's Institutional Repository by the/an author.

Citation: SHAHMOHAMADI, H. ...et al., 2015. CFD modeling of cavitation flow in journal bearing lubrication. IN: Crockett, R. (ed.) The European Conference on Tribology 2015 (Ecotrib 2015), Lugano, Switzerland, 3-5th June.

Additional Information:

- This is a conference paper.

Metadata Record: https://dspace.lboro.ac.uk/2134/20361

Version: Accepted for publication

Publisher: Swiss Tribology

Rights: This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. Full details of this licence are available at: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the published version.
CFD Modeling of Cavitation Flow in Journal Bearing Lubrication

Hamed Shahmohamadi*, Ramin Rahmani, Homer Rahnejat and Colin P. Garner

Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, Loughborough, Leicestershire LE11 3TU, UK
*Corresponding author: h.shahmohamadi@lboro.ac.uk

1. Introduction

According to Richardson [1], mechanical friction takes away 4-15% of total energy from a fired engine of which 40-55% is due to the losses in the pistons, rings and connection rod bearings. The rod bearings are responsible for around 0.3 to 2.7% of total energy loss in an engine. Therefore, in order to reduce power loss and improve engine performance, it is important for tribologists to have a deep understanding of lubrication phenomena at the connection rod bearings.

2. Governing Equations and Simulation Method

A schematic of the big end bearing used in the IC engines is shown in Figure 1.

The contact is divided into two distinct regions: (i) full film, (ii) film rupture and cavitation (Figure 2). To describe the physics of fluid flow in the cavitated region, in which two state phases of lubricant co-exist at the same time, a suitable two-phase flow model needs to be employed alongside with the Navier-Stokes equations.

The fluid flow is governed by the 3D compressible Navier–Stokes equations:

\[ \frac{\partial \rho \vec{V}}{\partial t} + \nabla \cdot \rho \vec{V} \vec{V} = -\nabla p + \nabla \cdot (\tau) + \vec{F} \]  

(2)

where \( \frac{D}{Dt} \) is the covariant derivative operator, \( \rho \) is the lubricant density, \( p \) is the pressure, \( \tau \) is the viscous stress tensor and \( \vec{F} \) is the body force field vector. In addition, \( \vec{V} = U_i + V_j + W_k \) is the velocity vector in which \( U \) is the component of velocity in the direction of axial lubricant flow entrainment, \( V \) is that in the side-leakage direction and \( W \) is the squeeze film velocity, \( \partial h / \partial t \). The viscous stress tensor is:

\[ \tau_{ij} = \eta \left( \frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i} - \delta_{ij} \frac{2}{3} \nabla \cdot \vec{V} \right) \]  

(3)

where \( \eta \) is the effective lubricant dynamic viscosity, \( \delta_{ij} \) is the Kronecker delta and it is defined as:

\[ \delta_{ij} = \begin{cases} 0 & \text{if } i \neq j \\ 1 & \text{if } i = j \end{cases} \]  

(4)

To better understand the flow behaviour through the connection rod bearing, a detailed CFD based simulation of the two-phase flow for the 3D geometry is performed, using the commercial CFD software ANSYS Fluent.

3. Results

The pressure profile through the circumferential centre line is illustrated in figure 3. The positions of high pressure and cavitation zones as well as lubricant film rupture and film reformation points can be seen in figure 3.

References