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Zhe Ji, Milos Stanic, Erwin Adi Hartono, Valery Chernoray

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Numerical simulations of oil flow inside a gearbox by Smoothed Particle Hydrodynamics (SPH) method

Zhe Ji[a], Milos Stanic[a], Erwin Adi Hartono[b], Valery Chernoray[b]

[a] *FluiDyna GmbH, Edisonstrasse 3, D-85716 Unterschleissheim, Germany*
[b] *Department of Applied Mechanics, Chalmers University of Technology, Gothenburg, Sweden*

Abstract

In this paper, numerical simulations of oil flow inside a gearbox are presented and compared to experimental particle image velocimetry (PIV) results. Instead of a traditional grid-based finite volume method, a mesh-free Smoothed Particle Hydrodynamics (SPH) method is employed. A multi-phase SPH formulation is utilized to resolve the complex multiphase fluid flow. A total of nine simulations are carried out for three oil levels and three Reynolds numbers, to investigate the flow field behavior and to compare with the experimental results. The aeration effect is first considered to qualitatively analyze the quantity and size of bubbles generated due to the rotation of the gears. Furthermore, the velocity field and velocity profile beneath the oil surface are comprehensively analyzed. Our simulation results exhibit physically consistent behavior of the oil flow and good agreement is achieved compared to the experimental results. Flow structures, splashing and recirculation areas are very well captured by the simulation. However, some discrepancies of the velocity field between the numerical and experimental results are also observed, and discussed.

Keywords:
Smoothed Particle Hydrodynamics, Gearbox, Oil Distribution, CFD

1. Introduction

In transmission systems, oil churning losses can represent a significant portion of the overall energy losses. Excessive oil churning loss increases the energy dissipation and consequently, hinders the improvement of the efficiency in transmitting power [1].

As one of the most common lubricating solutions in automotive applications [2], **oil-bath lubrication** systems suffer, in particular, from over-dissipation due to the churning losses. In **an oil-bath lubrication** system, gears are partially immersed in the lubricant, in such a way that the rotation of the gears ensures the formation of a lubrication film on critical gear surfaces in the contact area of gear teeth. The adherent lubrication film on

Email addresses: zhe.ji@fluidyna.de (Zhe Ji), milos.stanic@fluidyna.de (Milos Stanic), erwin-adi.hartono@chalmers.se (Erwin Adi Hartono), valery.chernoray@chalmers.se (Valery Chernoray)