Numerical Simulation of Hydrodynamic Lubrication by SPH method – Oil Film Profile at Inlet –

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Hydrodynamic lubrication analyses are carried out with smoothed particle hydrodynamics method. The method allows to simulate hydrodynamic problems with free surface flow. While, oil film profiles in outlet are almost the same with directions of gravity, the ones in inlet shows different feature such as dripping off along with cylinder surface or accumulation in inlet. The method will provide robust way to analyze a violent flow in lubrication.

Keywords: SPH, starved lubrication, free surface flow, surface tension

1. Introduction

When solving the Reynolds equation of hydrodynamic lubrication, boundary conditions at the inlet and the outlet of lubricated area are important. Especially, the oil film rupture at the outlet has been an intense subject of interest [1]. It is difficult to predict exactly both the position at which the oil film rupture will occur and the pressure in the area. A number of boundary conditions have been proposed for the outlet end of the pressure profile. On the other hand, we have few choices of the boundary condition for the inlet area. Usually, it is assumed that the inlet area is fulfilled with oil. However, some bearings have to be operated in a starved condition. To determine the boundary condition at the inlet, oil film profile at the inlet area should be taken into account.
To avoid the problems of boundary conditions, we applied Smoothed Particle Hydrodynamics (SPH) [2] method to hydrodynamic lubrication with the Navier-Stokes equations.

2. Methods and Model

Classical hydrodynamic lubrication problem which have a cylinder and a moving plate is analyzed with SPH method [3]. SPH method can track the motion of continua by discrete dynamics of a finite number of particles. By tracking the motion of particles, it is easy to treat a large deformation of fluid surface.
The minimum separation between the cylinder and the plate is fixed at 400 µm. the plate moves at constant velocity, 0.131m/s. Model geometry and other conditions are the same with the Fig.3(a) of ref. [1].

3. Result and Discussion

Figure 1 shows oil film profiles with different direction of gravity. While oil film profiles in outlet (right side) are almost the same, the ones in inlet (left side) shows different features. Upward gravity induces dripping off along with cylinder surface, which results in starved lubrication. Oil accumulation occurred in downward gravity and non-gravity condition. Figure 2 shows pressure profile around inlet, measured on bottom plate surface. Because of positive surface curvature at an edge of oil film, the pressure of downward gravity is slightly larger than analytical solution of Reynolds eq. Starved lubrication in upward gravity results in shortage of pressure.

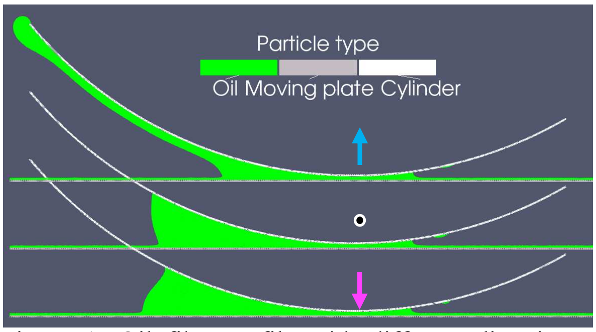

Figure 1: Oil film profile with different direction of gravity. Arrows represent the direction of gravity.

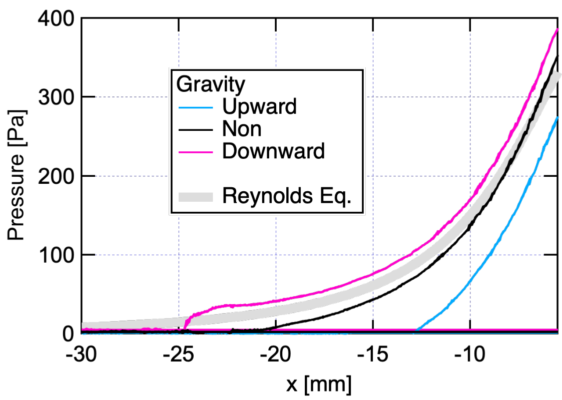

Figure 2: Pressure profile around inlet with different direction of gravity.

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4. References

[1] Bruyere, V., Fillot, N. et al., ASME J. Tribology, 134, 2012, 041503:1-041503:10.
[2] Adami, S., Hu, X.Y. and Adams, N.A., J. of Computational Physics, 231, 2012, 7057-7075.
[3] Tanaka, K., Fujino, T., Fillot, N., Vergne, P. and Iwamoto, K., Abstract Book of Leeds-Lyon symposium on Tribology 2019, 2019, 21.