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CFD Investigation of hydrodynamic lubrication on textured surface
- Effects of interaction between dimples -

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1. Abstract

Surface texturing has been recognized to be very efficient in modifying tribological performances of sliding surfaces. The effects of surface texturing change with lubricating conditions. In the hydrodynamic lubrication, it is known that the generation of hydrodynamic pressure increases the load carrying capacity of the sliding surface.

In many numerical studies, two- or three-dimensional analyses for the single dimple were investigated in the hydrodynamic lubrication. On the other hand, there is small number of studies about three-dimensional analysis of multi dimples. In the single dimple analyses, it is insufficient to investigate tribological properties of the textured surface because the pressure distribution and flow configuration are affected by the adjacent dimples.

In this paper, influence of the pitch and pattern arrangement of the dimples are investigated using three-dimensional simulations.

In the simulations, commercial CFD software ANSYS CFX Ver.14.5 was used. It is assumed that flow field is three-dimensional, incompressible and laminar. Temperature distribution and a cavitation generation were not taken into account. Working fluid is assumed to be oil (VG-16), and physical properties of the working fluid are listed in Table1. Figure 1 and 2 show cross-sectional profile and pattern arrangement of the dimple, respectively. The pitch and geometry parameters are listed in Table 1. Dimples are placed nine. The periodic boundary conditions are imposed on both sides of the computation unit along the z-direction. The upper wall is smooth and has a relative velocity, which is 1 m/s. Upper and lower wall are parallel. The inlet and outlet boundary conditions along the x-direction are static pressure 100kPa.

Table 1 Dimension properties of simulation and physical properties of working fluid

Dimple depth	d	[μm]	10
Dimple diameter	ϕ	[μm]	50
Film thickness	h	[μm]	5.0
Pitch		[μm]	70, 100
Density	ρ	[kg/m^3]	880
Kinematic viscosity	υ	[m^2/s]	16×10^{-6}

Figure 3 shows the pressure distribution in case of pattern B. In both pitches, minimum and maximum pressure is observed at the first dimple lines and the last dimple lines. The range of the highest and lowest value of pressure is bigger in case of 70 mm pitch. At the each dimple, the peak of the pressure is confirmed, and the magnitude of the peak in case of 100 mm pitch is larger than that in 70 mm pitch. Load capacity of the sliding surface in 70 mm pitch calculated from integration of the pressure is 0.100 N/mm^2. Hence, the effect of the peak observed in each dimple is not dominant. From the figures, small pitch raises maximum pressure and decreases minimum pressure both patterns.

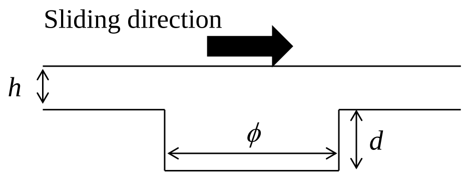
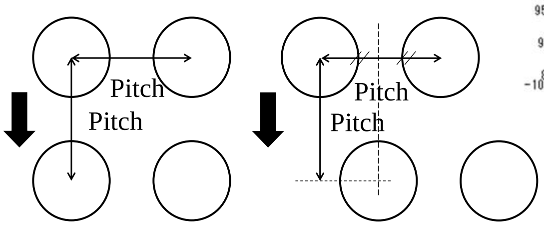
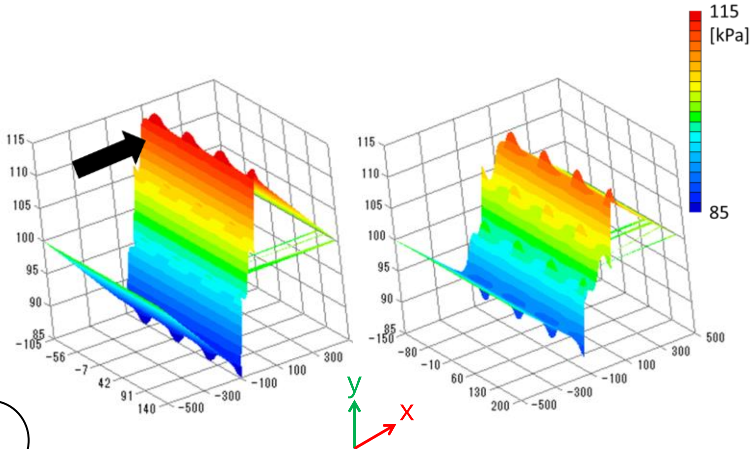


Figure 1 Geometry of texture



(a) Pattern A (b) Pattern B

Figure 2 Pattern arrangement of dimples



(a) Pitch = 70 μm (b) Pitch = 100 μm

Figure 3 Pressure distributions in case of pattern B