The effect of microbubble on friction characteristics of fluid film lubrication

Masayuki Ochiai [1)*], Shyun Takahashi[1)], Yuki kawamoto[1)], Teppei Otani[2)] and Shinpei Kotani[2)]

[1)] Department of Mechanical Engineering, Tokai University, Japan.
[2)] Graduate School of Engineering, Tokai University, Japan
*Corresponding author: ochiaim@keyaki.cc.u-tokai.ac.jp

In this study, in order to experimentally verify whether or not the microbubbles are effective in reducing the friction of the journal bearing, the friction torque of the journal bearing was measured using the lubricating oil containing the microbubbles and the lubricating oil not containing the microbubbles. Then, a comparison was made. Furthermore, by visualizing the flow of lubricating oil, we attempted to consider the effect of microbubbles in the bearing clearance on the friction torque of the journal bearing.

Keywords: Fluid film lubrication, Microbubble, Friction, Journal bearing, Flow visualization, CFD analysis

1. Introduction

Countermeasures are urgently needed due to the recent demand for high-speed rotation due to the miniaturization of rotating machines, and the authors focused on microbubbles as a new method for reducing friction loss in journal bearings. Microbubbles are minute bubbles with a diameter of several hundred µm or less, and it has been reported that drag is reduced by a liquid mixed with microbubbles in circular tubes and ships. Microbubbles are more environmentally friendly and economical than friction modifiers, and since the microbubbles in the lubricating oil disappear over time, the low viscosity of the lubricating oil irreversibly changes the physical properties of the lubricating oil. It is thought that it is highly versatile, unlike the case of chemicals. On the other hand, there are many unclear points about the friction reduction effect of microbubbles and its mechanism. Especially, the friction resistance reduction effect of microbubbles in a minute flow path with a low Reynolds number and shear flow, such as a bearing clearance of a journal bearing. As far as the authors know, no studies have verified this.
Therefore, in this study, the friction torque of the journal bearing is measured using the lubricating oil containing the microbubbles and the lubricating oil not containing the microbubbles. Furthermore, by visualizing the flow of lubricating oil and CFD analysis, the mechanism of microbubble lubrication is discussed.

2. Methods

The friction force of the oil film was measured with tension gage under conditions of with and without microbubbles in the lubricating oil, and the friction torque was calculated. In this study, as a basic study, a bearing with an average bearing clearance of 125 µm was used, and the rotor was removed when a static load was applied by the rotor (hereinafter referred to as eccentricity), and the journal was fixed concentrically with the bearing. The friction torques of the cases (hereinafter, concentric) were compared. During the experiment, the micro-bubble generator was kept in operation, and the oil tank was replenished with lubricating oil as needed. The oil temperature was 35 ± 1 ° C, the amount of refueling was 0.13 L / min, the journal speed was 1000 rpm to 2500 rpm, and measurements were taken every 500 rpm, and the measurements were taken 5 times under each condition.

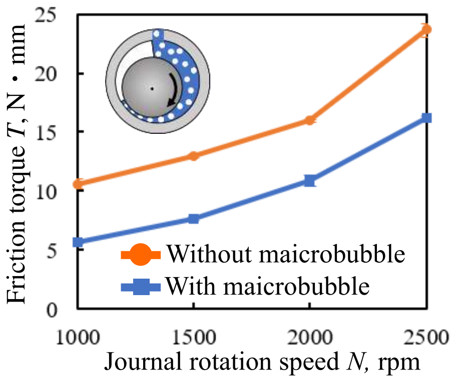

Fig.1 Measurement result of friction torque

3. Result and Discussion

Figure 1 shows the measurement results of the friction torque. From the figure, it is confirmed that the friction torque is reduced by microbubbles at all rotation speeds, and that the friction torque is reduced by 30% at 2500 rpm. Regarding the factors that caused this difference in the tendency of friction reduction, the authors focused on the size of the bubble occupying the flow path. As a result, it was found that the friction reduction effect appears as the bearing clearance and the size of the microbubbles approach each other in the journal bearing. When the friction reduction effect is exhibited, it is observed that the bubble flows while deforming the center of the flow path into an elliptical shape as shown in Fig. 2, suggesting that it may affect the flow in the gap. Next, the behavior of the bubbles confirmed in this study was reproduced by numerical analysis, and the mechanism of friction reduction by microbubbles was clarified.

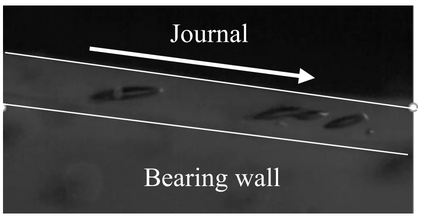

Fig.2 Microbubbles in bearing clearance