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Analysis of oil film distribution on roller surface by using two-phase flow analysis

T. Suwa, M. Ochiai*, H. Hashimoto

Department of Mechanical Engineering, Tokai University, 4-1-1 Kitakaname, Hiratsuka, Kanagawa 259-1292, Japan.

*Corresponding e-mail: ochiai-m@tsc.u-tokai.ac.jp

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ABSTRACT – Traction Drive is an excellent driving mechanism. However, traction coefficient is decreased by heat generation at contact point. When the appropriate amount of traction oil is used in the traction drive, the roller as rolling element will be cooled and the decrease of traction coefficient is prevented. In this study, the distribution of oil film on the roller surface analyzed with two-phase flow analysis using VOF (Volume of fluid) method. As a result, it is found that when the roller rotating direction and traction oil amount is changed, the different oil film distribution is formed on the roller surface.

1. INTRODUCTION

Traction Drive is an excellent driving mechanism that transmits the rotating power by using the pressurized oil film. Therefore, compared with gears, it has an advantage of low vibration, low noise and high-speed rotation. However, the oil temperature increases by shearing stress in the contact point. It causes problems such as decrease in maximum traction coefficient [1] and deformation of components such as bearings, rollers and so on. Sano et. al. suggested the temperature estimation model in the contact point and conducted verification experiments [2]. On the other hand, traction oil has cooling effect and leads to avoid rise in temperature. However, the temperature estimation model of Sano et. al. didn't consider the cooling effect of the oil and temperature on the roller surface. Moreover, the oil will circulate and scatter when the roller rotates. Therefore, it is also necessary to consider these effects.

Under these background, in this study, the distribution of oil film on the roller surface analyzed with two-phase flow analysis using VOF method. It can calculate condition in roller surface in detail due to set the surface tension and contact angle. The oil film distribution analyzed when the rotating direction, the peripheral speed and the supply oil amount change.

2. METHODOLOGY

2.1 Calculation models

In this study, the high-power two-roller traction tester that can compare with many experimental results of Itagaki et. al. as analysis model [3]. Figure 1 shows the roller calculation model on the two-phase flow analysis. This calculation model is formed from space that eliminated the roller and oil filler port. Moreover, the condition of symmetry against the contact surface of the roller and the calculation cost is cut down. The maximum size of computational grids is 0.65mm and minimum size of those is 0.03mm near the contact point. Moreover, four layers of mesh are formed on the roller surface at a thickness of 100μm and the total of the computational grids is 4.36 million.

2.2 Calculation condition

In this study, the oil-air two-phase flow around the roller surface is analyzed by ANSYS Fluent 17.2. Table 1 shows the fluid property. The type of traction oil is KTF-1. The rotating direction, the peripheral speed and the supply oil amount was changed. The rotation direction was clockwise and counterclockwise, the peripheral speed was 10, 40, 70m/s and the supply oil amount were 2, 6, 16L/min.

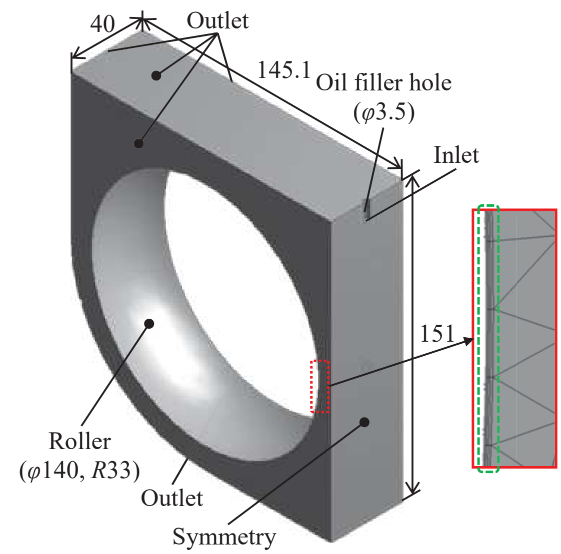

Figure 1 Calculation model of roller.

Table 1 Fluid property.

Density ρ [kg/m^3]	Oil	888
	Air	1.23
Viscosity μ [Pa･s]	Oil	0.027
	Air	1.75×10^{-5}
Surface tension T [N/m]		0.022
Contact angle θ [°]		5.83

3. RESULTS AND DISCUSSION

Figure 2 shows the analysis results of volume fraction distribution of oil on roller surface under the supply flow rate 6L/min and the peripheral speed 10m/s. The result is shown by oil volume fraction and the area of warm color means full oil while cold color means full air. From figure 2(a), in the case of clockwise, the most oil is distributed around the roller vertex and it decreases as going to the edge. From figure 2(b), in the case of counterclockwise, the oil is evenly distributed on roller surface. It's thought that this is because the oil tends to spread laterally because it rotates in the direction opposite to the oil supply direction. This tendency appeared in all results.

Figure 3 shows the average value of volume fraction of entire roller. At the peripheral speed of 10 m/s, the volume fraction increases when the supply flow rate is 6, 16 L/min in the counterclockwise direction, however the other conditions are the clockwise. When the supply flow rate is increased, the difference of volume fraction becomes small. From these results, it was found that the oil adhering to the roller increases as the amount of supplied oil increases in the clockwise direction however it is difficult to increase when it exceeds a certain value.

From the contour of oil volume fraction on roller surface, it was found that the oil is evenly distributed on roller surface when the rotating direction is the counterclockwise compared with the clockwise. However, the average value of volume fraction in case of clockwise rotation is higher than counterclockwise under the condition of that high peripheral speed velocity. From these results, since the contact point that is a heat source is at the vertex of the roller, the cooling effect is considered to be higher in the clockwise.

4. CONCLUSION

In this study, the distribution of oil film on the roller surface analyzed with two-phase flow analysis using VOF method. The effect of the rotating direction, the peripheral speed and the supply oil amount were studied. It was found that the effective cooling method at each peripheral speed is considered to be clockwise rotation except for case of low peripheral speed and high amount of supplied oil.

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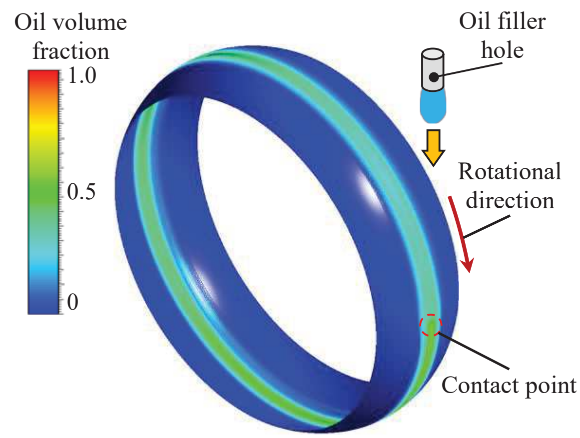
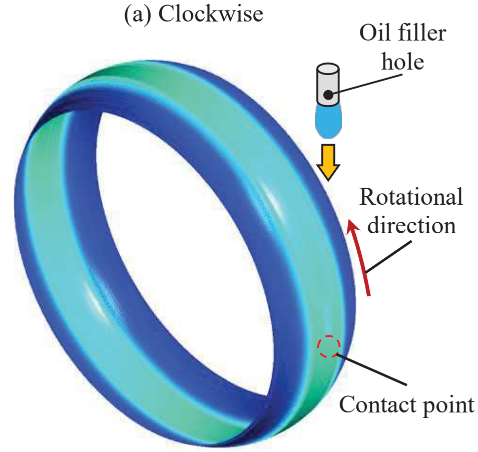


(a) Clockwise



(b) Counterclockwise

Figure 2 Contour of oil volume fraction on roller. (U=10m/s, Q=6L/min)

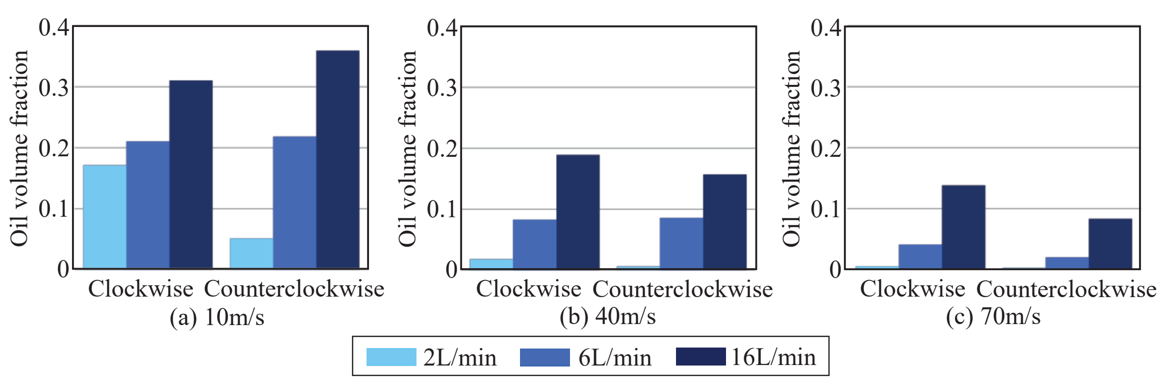


Figure 3Average value of volume fraction of entire roller.