Effect of Hertzian Contact Pressure on Shear Stress Distribution of EHL Oil Films

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1. Introduction

In the present investigation, the maximum Hertzian pressure P_H for the thermal elastohydrodynamic lubrication (EHL) analysis was chosen by the lubrication regime diagram for the elliptical parameter K_e=1.4. Each of the pressure is 0.6 GPa, 0.8 GPa or 1.5 GPa. The inlet oil temperature t_0 and the entrainment velocity u_e were fixed at 353 K and 10 m/s. As the lubricating oil properties, the values of an automobile CVT traction oil were used. Under the above analytical conditions, the same non-Newtonian thermal EHL analysis as the previous investigation[1)] was performed at the slide roll ratio Σ of 4 % or less. Based on the calculating results, the relation between the Hertzian contact pressure and the shear stress distribution of EHL oil films was discussed.

2. Procedure of numerical analysis

Fig. 1 shows the lubrication regime diagram for the elliptical parameter K_e=1.4. In the figure, G, U, α and P_{av} show the dimensionless material parameter, the dimensionless speed parameter, the pressure viscosity coefficient and the average Hertzian pressure. When an automobile CVT traction oil corresponding to ISO VG 32 (kinetic viscosity v: 32.2 mm^2/s at 313 K, α: 31.2 GPa^{-1} at 313 K, specific gravity 288/ 277 K: 0.962) is used, all analytical conditions are included in the piezo-viscous elastic (PE) region. However, the behaviour of EHL oil films varies depending on the parameter of αP_{av}. Namely, when the maximum Hertzian pressure P_H is 0.6 GPa or 0.8 GPa, αP_{av} becomes less than 13. Thus, the EHL oil films behave as the viscous fluid. In the case of P_H=1.5 GPa, αP_{av} shows the value between 13 and 25, and so the behaviour of EHL oil films becomes the visco-elastic solid.

A non-Newtonian thermal EHL analysis was carried out in the same contact condition as a pair of steel flat disk with steel roller[1)]. The disk diameter and the roller radius R_x in rolling direction are 102 mm and 10.32 mm. The elliptical parameter K_e is 1.4. Regarding the governing equations and the material properties, those used in the previous study[1)] were applied, and in accordance with the identical calculating procedures with before, the numerical calculations were performed.

3. Results and discussion

In the analytical condition, the dimensionless load parameter W increases with an increase in the Hertzian pressure, and the values become 6.25×10^{-7}, 1.48×10^{-6} and 9.77×10^{-6}. U and G are 3.53×10^{-11} and 4.11×10^3.

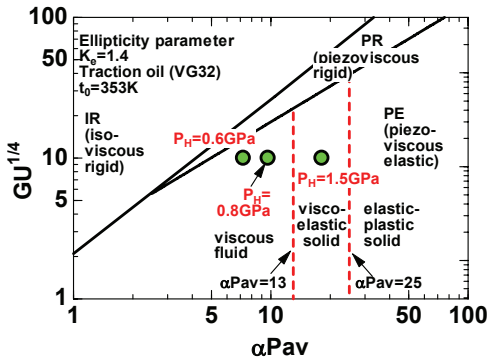

Fig.1 Lubrication regime diagram for K_e=1.4

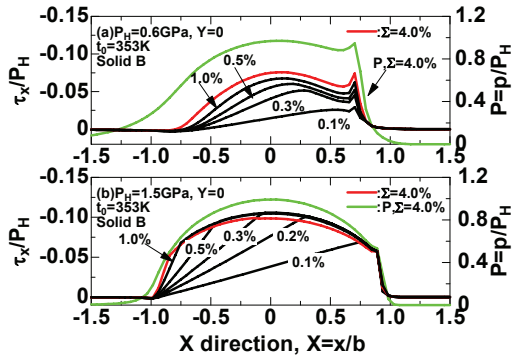

Fig.2 Shear stress τ_x/P_H and pressure P distributions

Fig.2 shows the dimensionless shear stress τ_x/P_H distributions on the central cross section of motion direction. The shear stress τ_x is the rolling direction component on the slow side solid surface. In the figure, the dimensionless pressure $P=p/P_H$ distributions are also indicated. Where, p is the fluid pressure. The shear stress varies with an increase in the slide roll ratio Σ. In the case of P_H =0.6 GPa, the shear stress varies on the small region compared with the fluid pressure. On the other hand, the changes in the shear stress at P_H=1.5 GPa occurs on almost the same area to the fluid pressure. The velocity distribution of oil films had the close relation to the occurrence region of the shear stress varying in accordance to the Hertzian pressure.

4. References

[1] Mawatari, T. and Nakajima, A., "Shear Stress Analysis of EHL Oil Films based on Thermal EHL Theory - In the case of Elliptical Contact Condition-", Tribol. Online, 4 (3), 2009, 70-73.