DISCUSSION

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The authors reported an interesting phenomenon of thermally induced shear localization in a lubricating film. Although the experiment and analysis were conducted in a plane-Couette-shear process, it is suggested that such a phenomenon may be operating in the thermally dominated regime of EHD traction. This discusser would appreciate authors' comments to the following questions and statements:

(1) According to the authors, the thermal runaway will not take place in a strain-rate controlled process. It appears to this discusser that the EHD problem encountered in practice is more or less such a process.

(2) In the Hertzian region of the EHD conjunction, the temperature can vary considerably in the direction of surface motion. In a plane-Couette-shear process, on the other hand, the temperature variation in this direction is negligibly small. Will the large variation of temperature in this direction significantly change the mechanism of the shear-band formation?

(3) If the thermally induced shear band indeed forms in the EHD conjunction, it should be detected relatively easy through traction measurements using a well-controlled disk machine apparatus. It seems to this discusser that the reported traction data do not sugget the formation of such a shear band.

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Authors' Closure

The authors appreciate Dr. Chang's interest in our work. We will address his comments in the order in which they were presented.

(1) The Couette component of flow in lubricated concentrated contact is in most part determined by the slip velocity and is essentially rate-controlled. The Poiseuille component, however, is driven by the pressure gradient which is in turn controlled by the load. The Poiseuille flow component is therefore, to a first approximation, stress-controlled. One may define a Poiseuille Brinkman Number

$$Bp = \frac{\beta p'^2 h^4}{\mu_0 k}$$

where p' is the pressure gradient in the flow direction. A preliminary numerical analysis shows that localization does occur on two planes (Wilson, 1993). The dimensionless energy equation can be written in a manner similar to Eq. (7) as

$$\frac{1}{F_0}\frac{\partial \bar{T}}{\partial \bar{t}} = \frac{\partial^2 \bar{T}}{\partial \bar{y}^2} + Bp\bar{y}^2 e^{\bar{T}}$$

with initial and boundary conditions of $\bar{T}=0$. The numerical temperature solution for $Bp=100$ is shown in Fig. 5 for time, t, progressing as shown by the arrow. The velocity profile regresses to plug flow with the plug boundaries at the temperature spikes in the figure.

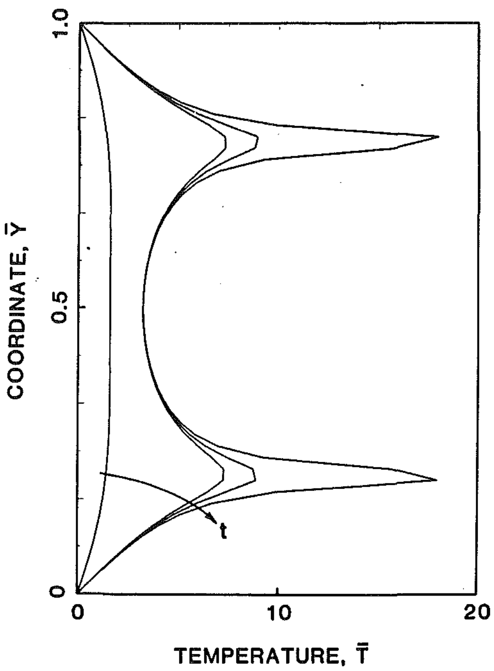

Fig. 5 Development of temperature across the film for $Bp = 100$

(2) The temperature gradient in the flow direction is relatively small and is not believed to influence localization. We performed a simple two dimensional analysis of our experimental plane Couette flow geometry which included the inlet at $\bar{T}=0$ and localization occurred as described in the paper.

(3) The authors do not understand how one might detect thermally induced localization from disc machine traction data. Such experimental results are the integrated average of the local shear stresses in the contact area. These disc machine results cannot even discriminate among the several proposed lubricant constitutive laws (Khonsari and Hua, 1994) for the same reason—details of local shear stresses are hidden in the averaged shear stress.

Additional References

Khonsari, M. M., and Hua, D. Y., 1994, "Thermal EHD Analysis Using a Generalized Non-Newtonian Formulation," JOURNAL OF TRIBOLOGY, Vol. 116, No. 1, p. 37.

Wilson, W. R. D., 1993, Private Communication, Oct.