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## COMMENTS

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### Comment on “Stress-density ratio slip-corrected Reynolds equation for ultra-thin film gas bearing lubrication” [Phys. Fluids 14, 1450 (2002)]

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The stress-density model proposed in the paper<sup>1</sup> was presented and verified by numerical simulations in an earlier paper.<sup>2</sup> Specifically, Morris, Hannon, and Garcia<sup>2</sup> performed both molecular dynamics and direct simulation Monte Carlo (DSMC) simulations of Couette and Poiseuille flow and measured slip length (referred to as the coefficient of slipping,  $G$ , in Ref. 1) at high Knudsen number. Morris *et al.* found that if  $\text{Kn} < 0.1$  then  $G \approx \lambda_h$ , where  $\lambda_h$  is the mean free path evaluated from the collision cross section. The slip length was observed to be significantly smaller than  $\lambda_h$  at higher Knudsen number; this result was verified recently by Wijesinghe and Hadjiconstantinou.<sup>3</sup> Most importantly, Morris *et al.* proposed approximating the slip length as  $G = \alpha \lambda_v$  where  $\lambda_v$  is the mean free path evaluated from the viscosity.<sup>4</sup> When the effective viscosity is obtained from the

wall shear stress they found that  $\alpha \approx 1$  for a wide range of Knudsen number. Ng *et al.* performed DSMC simulations of slider bearing flow, which is a composite of Couette and Poiseuille flow.<sup>5</sup> Since their simulations are performed at  $\text{Kn} \approx 1$ , they also observe that  $G < \lambda_h$ . Comparing Eqs. (1)–(4), (7) and (10) in Ref. 2 with Eqs. (4), (6), and (7) in Ref. 1 shows that the stress-density model is equivalent to  $G = \lambda_v$ .

<sup>1</sup> E. Ng, N. Liu, and X. Mao, “Stress-density ratio slip-corrected Reynolds equation for ultra-thin film gas bearing lubrication,” *Phys. Fluids* **14**, 1450 (2002).

<sup>2</sup> D. Morris, L. Hannon, and A. Garcia, “Slip length in a dilute gas,” *Phys. Rev. A* **46**, 5279 (1992).

<sup>3</sup> H. Wijesinghe and N. Hadjiconstantinou, “Velocity slip and temperature jump in dilute hard sphere gases at finite Knudsen numbers,” *Proceedings of the First MIT Conference on Computational Fluid and Solid Mechanics*, 2001, Vol. 2, p. 1019.

<sup>4</sup> C. Cercignani, *The Boltzmann Equation and its Applications* (Springer-Verlag, New York, 1988).

<sup>5</sup> S. Fukui and R. Kaneko, “Analysis of ultra-thin gas film lubrication based on linearized Boltzmann equation,” *ASME J. Tribol.* **110**, 253 (1988).

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