SLIPPING ZONES IN MICROSYSTEMS FOR IMPROVED LOAD SUPPORT

D. Savio [a*], M. Moseler [a,b]
*daniele.savio@iwm.fraunhofer.de
[a] Fraunhofer IWM, Fraunhofer IWM, MicroTribology Center µTC
Wöhlerstr. 11, D-79108 Freiburg, Germany
[b] Albert-Ludwigs-University of Freiburg,
Herrmann-Herder-Str. 3, D-79104 Freiburg, Germany

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ABSTRACT
Wall slip at surface-fluid interfaces is often quoted as a way to achieve better performance in micro- and nanoscale systems. Potential benefits involve improved fluid transport and reduced friction in nanochannels [1-3]. In addition, introducing slipping zones of the surfaces in tribological contacts can increase significantly the load carrying capacity [4,5]. This can reduce wear, which is a critical issue in MEMS. Here, slip can be created by modifying the roughness and chemistry of the surfaces [2,3], for instance through oleophobic coatings.

We consider nano- and microsystems, where a single slipping zone is placed between positions x_1 and x_2 in different contact geometries of length L and ratio h_1/h_2 between inlet and outlet film thicknesses (Figure 1a).

Of interest is the optimal positioning of the slipping zone to maximize load support. The standard Reynolds formulation with the addition of a slip length b on the upper surface is employed. This is similar to the methodology in [4], and is valid for nanometer-thin films [5]. An analytical solution based on a flow analysis is proposed to calculate the pressure distribution P and line load $W1$ form P_0 and $W1_0$ of the no-slip case. Parametric studies on the convergence ratio h_1/h_2 and slip length b are then performed. It is found that:

- For low surface slopes, the optimum slipping region starts from the trailing edge and extends approximately towards the middle of the convergent geometry (Figure 1b).
- For high surface slopes, the optimum patch must be moved towards the end of the contact. Placing the slipping zone at the inlet has a negative effect on the load carrying capacity.
- Increasing the slip length results in a slightly broader optimum slipping patch.
- The extent of the optimum slipping zone can be explained from the maximization of inlet flow and minimization of outlet flow. This leads to a simple model for quick estimation of the limits of the slipping region (Figure 1b).
- For large slip length (b/h_2>1), the maximum load carrying capacity is achieved with flat surfaces (Figure 1c). For small b/h_2 the surface should be slightly slanted, since the convergent geometry also plays a role on pressure generation in the contact.

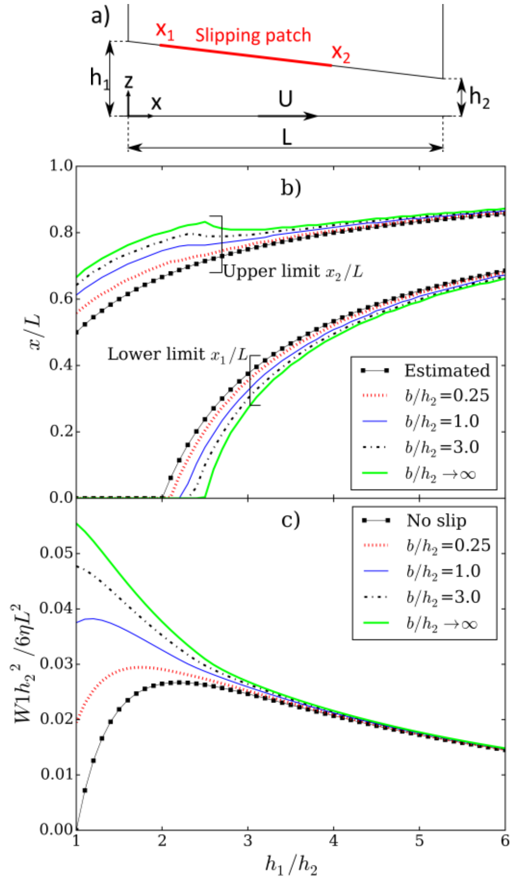

Fig.1 a) Slider of length L and convergence ratio h_1/h_2 with slip patch. b) Lower and upper bounds x_1, x_2 for the optimum zone with constant slip length b. c) Dimensionless line load.

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