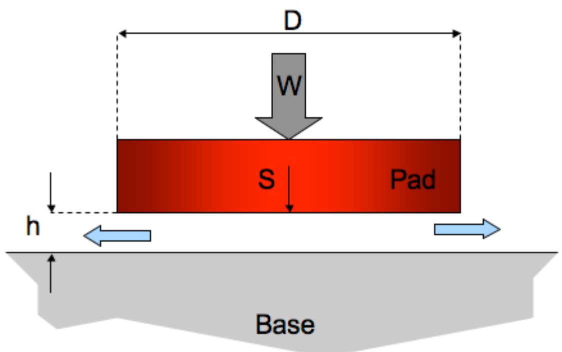
MIT Department of Mechanical Engineering

2.25 Advanced Fluid Mechanics

Problem 6.21

This problem is from "Advanced Fluid Mechanics Problems" by A.H. Shapiro and A.A. Sonin



The sketch shows a circular bearing pad which rests on a flat base through the intermediary of a film of viscous liquid of instantaneous thickness $h(t)$. The load W causes the pad to sink slowly at the speed S, and this squeezes the liquid out from under the pad. Assume that $h \ll D$, that the viscosity is very high, and that the speed S is very small.

- (a) Making approximations (state them precisely) consistent with theses assumptions, show that the settling speed is

$$S = \frac{32}{3\pi}\frac{Wh^3}{\mu D^4}. \tag{6.21a}$$

- (b) An apparatus with two very flat plates of 0.3 m diameter carries a load of 100 kg on a film 0.003 cm thick. If the liquid is a heavy oil with a kinematic viscosity of 10 $\frac{cm^2}{s}$ and a density of 0.93 $\frac{gm}{cm^3}$, estimate the speed S.

- (c) If the load W is constant, and the gap width is h_0 at time zero, show that the width h varies with time accordingly to

$$\frac{h}{h_0} = \left[1 + \frac{64}{3\pi}\frac{Wh_0^2}{\mu D^4}t\right]^{-\frac{1}{2}}. \tag{6.21b}$$

- (d) Calculate, for the initial conditions of part (b), the time (in hours) required for the gap width to be decreased to half its initial value.

- (e) Suppose now that the initial thickness is h_0, and that a constant upward force F pulls the disk away from the base. Show that the disk will be pulled away in a time

$$t_\infty = \frac{3\pi}{64}\frac{\mu D^4}{h_0^2 F}. \tag{6.21c}$$

NB When h_0 is very small, the time t_∞ is very large. This is the basis for the phenomenon of viscous adhesion, e.g., adhesives such as Scotch tape, or the apparent adhesion of accurately-ground metal surfaces.

