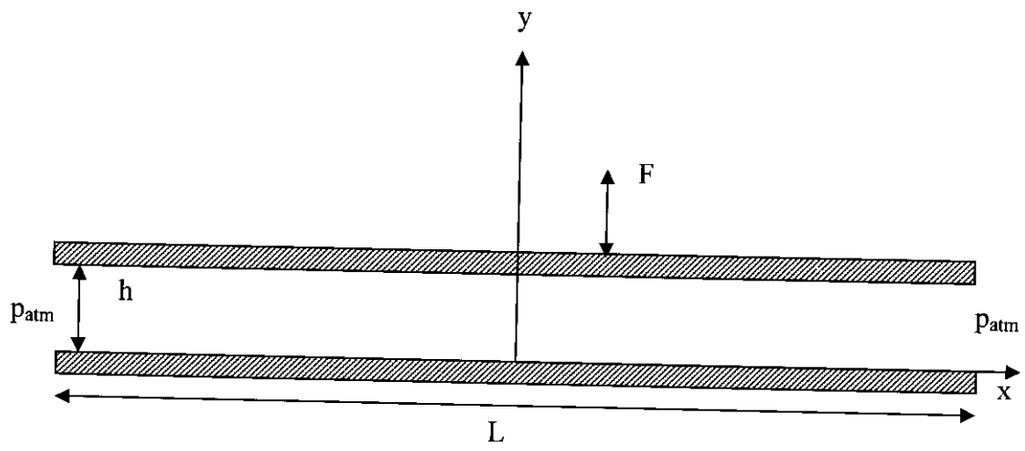
Written Ph.D. Exam Questions

Tribology

October 3, 2005

1.



We would like to study squeeze film effects in a liquid (constant viscosity μ and density ρ) using the apparatus shown above. The liquid is contained between two plates of length L in the x-direction and very long in the z-direction (out of the paper). A time-dependent force is applied to the upper plate so that the film thickness h oscillates with time:

$$h = h_0 + h_1 \cos \omega t$$

i. Find the pressure distribution in the film, p(x,t), assuming cavitation doesn't take place.

ii. Find the required force (per unit length in the z-direction), F.

iii. If ω is increased (holding all other parameters constant), eventually cavitation will occur. At what x-location will it first appear?

iv. Find a dimensionless parameter that includes ω, which characterizes the onset of cavitation.

2.

A mechanical device is made to shuttle back and forth over a distance of ten meters at the rate of one cycle per minute. Each time it approaches the end of the track it must stop and reverse direction. It runs on four mild steel wheels 22 cm in diameter which also serve as disks for disk brakes. The brake pads clamp to both sides of each wheel to stop the device. The inner and outer radii of the pads are five and ten cm respectively. The pads cover one eighth of the circumference of the wheel. The braking force on each pad is 100 Newtons and the device is designed to stop in three revolutions of the wheel.

It has been suggested that the brake pad material be a composite which the supplier claims has a dimensional wear coefficient against mild steel of $4x10^{-5}\ mm^3\ N^{-1}\ m^{-1}$. This material has the necessary frictional characteristics for stopping the device. Do you recommend this material? If so, how thick do you recommend the pads be made if the unit is to run continuously for two years without servicing the brakes. If you do not recommend this material, why not and what would you recommend?

3. It is well known that there are different types of wear and that each depends on external variables (temperature, environment, etc.) and the properties of the materials in sliding contact. (roughness, hardness, yield strength, fracture toughness, work hardening rate, etc.)

For example adhesive wear refers to the sticking/adhesion of the surfaces and the eventual shearing of one of the materials. Yield strength and shearing stresses play a big role in this wear process.

(a.) Finish the above description of adhesive wear by drawing a schematic of this process and describing the role of yield strength. Is wear reduced if yield strength is high?

(b.) Describe one other wear process again using diagrams and equations.