3

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1996

TRIBOLOGY
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

-- **Please sign your name on the back of this page** --

GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENGINEEERING
Ph.D. QUALIFYING EXAM-TRIBOLOGY
FALL QUARTER 1996

1. In the EHL theory of line contacts, the elastic solid-variable viscosity (E-V) regime is governed by

$$h' = 2.65 g_1^{0.54} g_3^{0.06}$$

where

$$h' = \frac{2h_{\min} w}{\mu_o R(u_1 + u_2)}; \qquad g_1 = \left[\frac{2\alpha^2 w^3}{\mu_o R^2 (u_1 + u_2)}\right]^{1/2}; \qquad g_3 = \left[\frac{2w^2}{\mu_o E R(u_1 + u_2)}\right]^{1/2}$$

(a) Identify each of the parameters appearing in the expressions for h', g_1, and g_3.

(b) Express h_{min} in terms of μ_o, u_1 , u_2 , w, R, E and α

(c) Based on your result in (b), do changes in the load have a large effect on h_{min}? Does your answer make sense on physical grounds? Explain.

2. A shaft of diameter D=60 mm is rotating at 1200 rpm, and is supported by two journal bearings. One bearing is of length L_1=60 mm and clearance C_1=30 μm. The second bearing is of length L_2=30 mm. The two bearings receive oil supply from a common reservoir. For optimal performance it is necessary that each bearing operates at its own maximum minimum-film-thickness, and that the operational temperature in each bearing is the same.

(a) Determine the clearance of the second bearing, C_2, which is necessary to establish the optimal performance stated above.

(b) Determine the size (specs) of the filter necessary for the system.

(c) Find the total oil flow; i.e., the necessary pumping capacity.

Note: You have been provided with a graph and a table. Just for the purpose of solving this exam you may perform linear interpolation/extrapolation for entry values that do not appear in the table. In practice this is not recommended.

Reminder: The temperature increase in a journal bearing is directly proportional to f(R/C) and P, and inversely proportional to $\overline{q_z}$.

3. This is a question about polishing and the use of tribological principles to describe the polishing process. Polishing is typically done by 'rubbing' a sample on a paper coated with abrasive particles, usually much harder than the sample. The particles are glued to a paper and the rubbing is done by a rotating platten flooded with lubricating fluid. Polishing produces a roughness on the sample related to the particle sizes, and a subsurface damage. As the particle sizes are decreased by using different cloths, the sample surfaces get smoother and surface damage decreases in extent. Answer the following questions about this process:

1. Draw to scale a cross and front section of a sample and polishing paper, after some steady state polishing has been achieved, assuming spherical particles with a size of 100 microns in diameter and the average roughness of the sample surface to be 50 microns. Estimate the roughness of the sample after this polishing.

2. Sketch out the method you would use to estimate the depth of the plasticity beneath the sample surface.

L/D	ϵ	$\phi°$	S	$\bar{q}_z$	$f\left(\frac{R}{C}\right)$
0.25	0.2	75	7.90	0.40	146.5
	0.4	61	2.96	0.79	55.3
	0.6	47	1.12	1.18	23.1
	0.8	31	0.27	1.57	7.25
	0.9	22	0.075	1.74	2.80
0.5	0.2	75	2.11	0.38	39.3
	0.4	61	0.81	0.76	15.3
	0.6	48	0.33	1.13	6.9
	0.8	32	0.094	1.47	2.7
	0.9	24	0.032	1.60	1.4
1.0	0.2	74	0.66	0.32	12.4
	0.4	62	0.27	0.64	5.3
	0.6	50	0.12	0.94	2.8
	0.8	35	0.045	1.21	1.4
	0.9	26	0.019	1.28	0.90
1.5	0.2	72	0.38	0.27	7.3
	0.4	62	0.16	0.52	3.3
	0.6	51	0.083	0.76	2.0
	0.8	38	0.035	0.96	1.2
	0.9	27	0.016	1.02	0.80

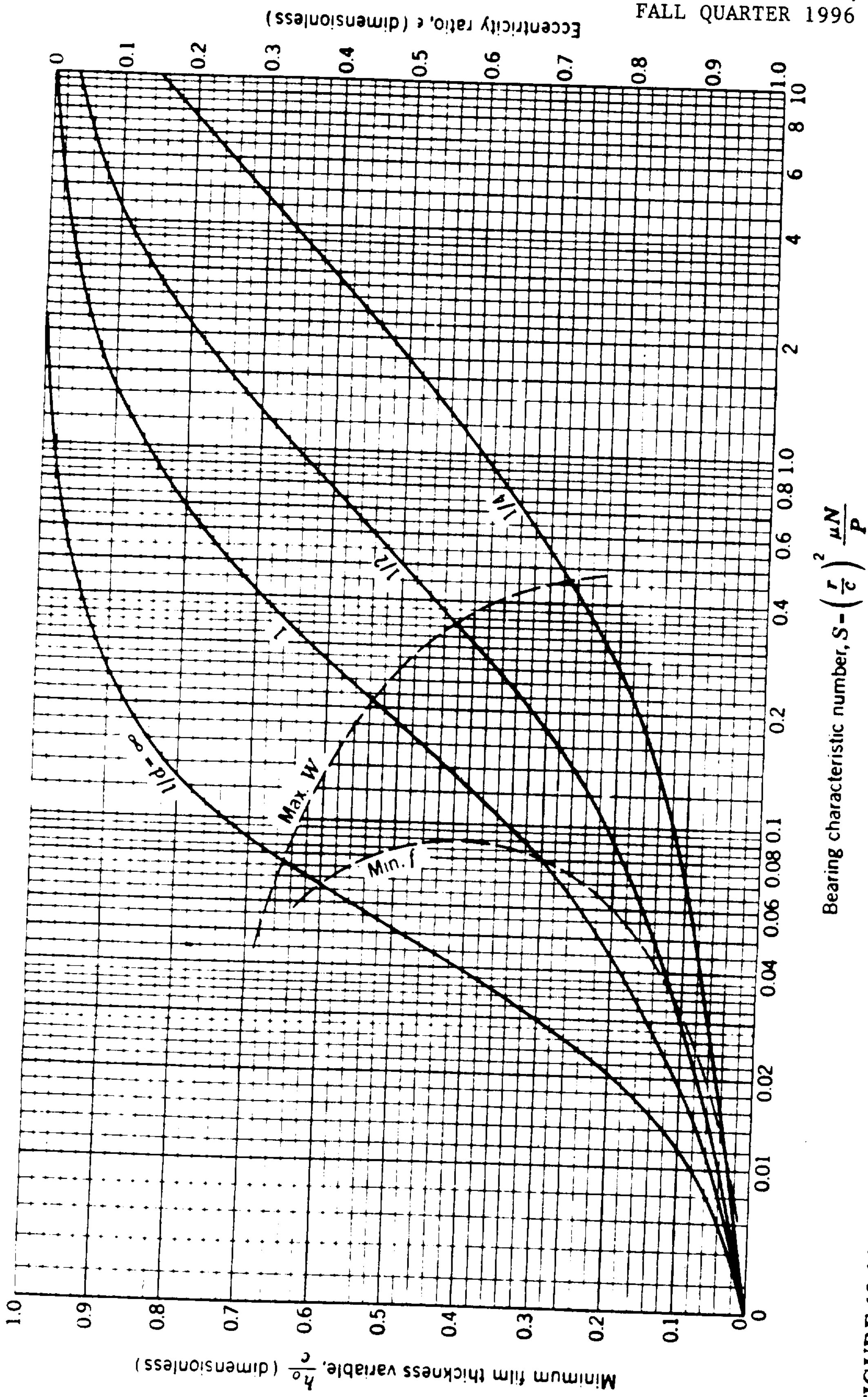

FIGURE 12-14 Chart for minimum-film-thickness variable and eccentricity ratio. The left boundary of the shaded zone defines the optimum h_0 for minimum friction; the right boundary is the optimum h_0 for maximum load. (*Raimondi and Boyd.*)