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The Effect of Slider Geometry on the Performance of a Powder Lubricated Bearing — Theoretical Considerations©

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An existing one-dimensional analysis for powder lubrication was upgraded to a two-dimensional level, providing an analytical tool for predicting side leakage effects. Prediction of side leakage is crucial since it accounts for heat removal from the solid lubricated contact zone and provides a measure of the wear rate. Using the enhanced analysis, a parametric study was conducted of the effect of key bearing geometric design parameters (such as film thickness and pad aspect ratios) on pressure, powder flow, load and friction. The studies revealed that for a film thickness ratio H_r of approximately 2.4, high load-carrying capability, low coefficient of friction and moderate side leakage result. For the optimum H_r, studies of the effect of Breadth to Length ratio (B/L) revealed that decreasing B/L from two results in a broader pressure peak and hence increased load capability. Decreasing the B/L ratio also lowers both the coefficient of friction and the side flow.

A companion paper, Ref. (9), dealing with the experimental part of the present program provides corroboration for the present approach. The combined analytical and test results offer a tentative explanation for the known phenomenon in "dry" friction studies where a change of orientation and thus B/L ratio of the tested specimen results in different values of the coefficient of friction.

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Solid Lubrication; Power Lubrication; MoS_2 and WS_2 Lubrication

NOMENCLATURE

B	= slider pad bearing breadth or width (in z direction)
L	= extent or length of slider (in x direction)
D	= journal bearing diameter
F	= friction force
G	= shear modulus
Hr	= inlet to exit film thickness ratio, h_o/h_1
L/D	= journal bearing aspect ratio
Q_o	= volumetric flow per unit transverse length at p = 0
S_i	= accommodation site
W	= bearing normal load
h	= filmthickness
h_1	= exit (minimum) film thickness
h_o	= entrance film thickness
p	= pressure, applied unit load W/BL
u	= velocity
u_o, u_1	= surface velocities as shown in Fig. 3
u_{so} , u_{s1}	= intermediate powder film surface velocities at y = 0, h
x,y	= position coordinates (Fig. 5)
α,γ	= constants of rheological equation
$\dot{\epsilon}$	= strain rate
K_ρ	= density-pressure coefficient
$K\tau_y$	= shear yield stress-pressure coefficient
$K\tau_l$	= limiting shear stress-pressure coefficient
μ_o	= reference viscosity
ξ	= Extend of pad, x/l
ρ_o	= reference or tapped density
$\rho(p)$	= powder density as a function of pressure
$\rho(0)$	= powder density at p = 0
τ	= shear stress
τ_y	= yield stress
τ_l	= limiting shear stress
$\tau_{o,h}$	= shear stress at y = 0, h
τ_{oo}	= normal stress
$\tau_y(p)$	= pressure-dependent yield shear stress
$\tau_y(0)$	= reference yield shear stress pressure coefficient
$\phi(\tau)$	= shear stress-shear rate function
$\overline{H}$	= dimensionless film thickness, $h(x)/h_0$
$\overline{U}$	= dimensionless velocity, U/u_o