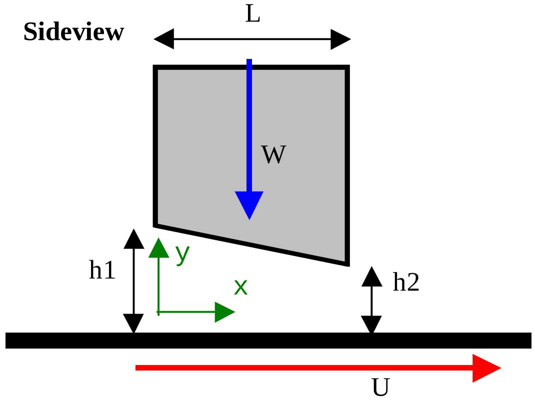
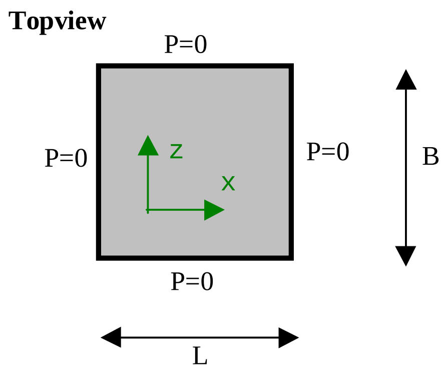
Performance of 1D-Slider Bearing

Modern Lubrication
Luis San Andres (c) 2009

ORIGIN := 0





$h(x) := h_2 \cdot \left[\alpha + (1-\alpha)\cdot \frac{x}{L}\right]$ $\alpha := \frac{h_1}{h_2}$ film thickness profile

(SI units)

U: surface speed - varies

Bearing geometry:

$L := 0.06$ m   length and width of bearing $taper\_angle := 0.001$ rads   (machined)

$B := 0.180$

Fluid properties $\mu_{in} := 0.0597$ Pa-sec $\rho := 878$ kg/m3 $c_p := 1880$ J/kg-degC

$\alpha_v := 0.0414$ 1/degC viscosity temperature coefficient

Operating conditions: $T_{inlet} := 40$ degC - inlet temperature $\kappa_T := 0.80$ thermal convection parameter

$W := 20000$ N   external load

visc-Temperature relationship $\mu(T) := \mu_{in} \cdot e^{-\alpha_v \cdot (T - T_{inlet})}$

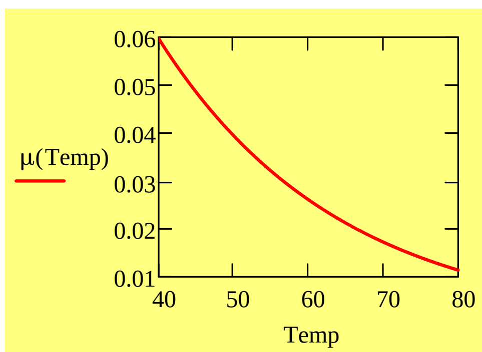
Calculated performance (Vary runner surface speed)

$U_{min} := 2$ $U_{max} := 20$ [m/s]

Number of cases: $N_{cases} := 10$

Convergence params in load & temperature:

$W_{eps} := 0.001$ $T_{eps} := 0.05$



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GUESS values: $h_2 := 20 \cdot 10^{-6}$ $T_{out} := 55$ based on experience

tapered height (h1-h2) $taper := taper\_angle \cdot L$ $taper = 6 \times 10^{-5}$ m

Specific pressure (bars)

$P_{spec} := \frac{W}{L \cdot B \cdot 10^5}$

$P_{spec} = 18.519$

EXPAND regions below to display code

slider bearing parameters

$$\text{Find\_pars}(h_2, U, T_{out}) := \left| \begin{array}{l} T_{eff} \leftarrow 0.5 \cdot (T_{inlet} + T_{out}) \\ \mu_{eff} \leftarrow \mu(T_{eff}) \\ \alpha \leftarrow \dfrac{taper}{h_2} + 1 \\ q \leftarrow \dfrac{\alpha}{1+\alpha} \\ p_{max} \leftarrow \dfrac{1}{4} \cdot \dfrac{(\alpha - 1)}{\alpha \cdot (1+\alpha)} \\ w \leftarrow \dfrac{1}{(1-\alpha)^2} \cdot \left[\ln(\alpha) + 2 \cdot \dfrac{(1-\alpha)}{(1+\alpha)} \right] \\ f \leftarrow -1 \cdot \left(\dfrac{6}{1+\alpha} + 4 \cdot \dfrac{\ln(\alpha)}{1-\alpha} \right) \\ t \leftarrow \dfrac{f}{q} \\ Cpre \leftarrow \mu_{eff} \cdot U \cdot \dfrac{L}{h_2^{\,2}} \\ Force \leftarrow 6 \cdot Cpre \cdot B \cdot L \cdot w \\ Q \leftarrow q \cdot U \cdot h_2 \cdot B \\ ShearF \leftarrow f \cdot Cpre \cdot B \cdot h_2 \\ \Delta T \leftarrow t \cdot \kappa_T \cdot \dfrac{Cpre}{(\rho \cdot c_p)} \\ T_{out} \leftarrow T_{inlet} + \Delta T \\ P_{max} \leftarrow p_{max} \cdot Cpre \cdot 6 \\ (h_2 \;\; T_{eff} \;\; Force \;\; ShearF \;\; Q \cdot 60000 \;\; T_{out} \;\; \mu_{eff} \;\; P_{max}) \end{array} \right.$$

slider bearing parameters

$imax := 24$ Max number of steps for convergence

Iterative loop

$$\text{Find\_filmT}(h_2, U, T_{out}, imax) := \begin{array}{|l} i \leftarrow 0 \\ s \leftarrow \text{Find\_pars}(h_2, U, T_{out}) \\ \text{Force} \leftarrow s_{0,2} \\ T_{out} \leftarrow s_{0,5} \\ F_{ratio} \leftarrow \dfrac{\text{Force}}{W} \\ h_{2old} \leftarrow h_2 \\ \text{Force}_{old} \leftarrow \text{Force} \\ h_2 \leftarrow \left| \begin{array}{l} (h_2 \cdot 1.05) \text{ if } F_{ratio} > 1.01 \\ (h_2 \cdot 0.95) \text{ if } F_{ratio} < 1.01 \end{array} \right. \\ T_{outold} \leftarrow s_{0,5} + 10 \\ \text{while } (i < imax) \wedge \left(\left| F_{ratio} - 1 \right| > W_{eps} \right) \wedge \left(\left| T_{out} - T_{outold} \right| > T_{eps} \right) \\ \quad \left| \begin{array}{l} i \leftarrow i + 1 \\ T_{outold} \leftarrow T_{out} \\ s \leftarrow \text{Find\_pars}(h_2, U, T_{out}) \\ \text{Force} \leftarrow s_{0,2} \\ \Delta h \leftarrow h_2 - h_{2old} \\ K \leftarrow \dfrac{-(\text{Force} - \text{Force}_{old})}{(\Delta h)} \\ h_{2old} \leftarrow h_2 \\ \text{Force}_{old} \leftarrow \text{Force} \\ F_{ratio} \leftarrow \dfrac{\text{Force}}{W} \\ h_2 \leftarrow h_{2old} + \dfrac{(\text{Force} - W)}{K} \\ T_{out} \leftarrow s_{0,5} \end{array} \right. \\ \text{dum} \leftarrow 1 \\ (h_2 \;\; T_{out} \;\; \text{Force} \;\; K \;\; i \;\; F_{ratio}) \end{array}$$

Newton-Raphson procedure to determine equilibrium film thickness at exit plane.

NOT a very accurate stiffness since changes in h2 may

$$j := 0 .. N_{cases}$$

$$U_j := U_{min} + (U_{max} - U_{min}) \cdot \frac{j}{N_{cases}}$$

vector of surface speeds

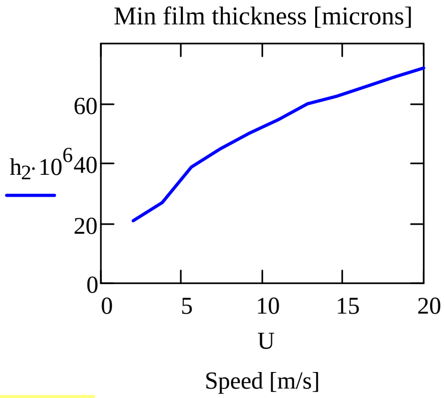
$$\text{Results} := \begin{array}{|l} h_2 \leftarrow h_2 \\ \text{for } j \in 0..N_{cases} \\ \quad \begin{array}{|l} \text{Results} \leftarrow \text{Find\_filmT}\left(h_2, U_j, T_{out}, \text{imax}\right) \\ h_2 \leftarrow \text{Results}_{0,0} \\ T_{out} \leftarrow \text{Results}_{0,1} \\ R_j \leftarrow \text{Results} \end{array} \\ \text{return } R \end{array}$$

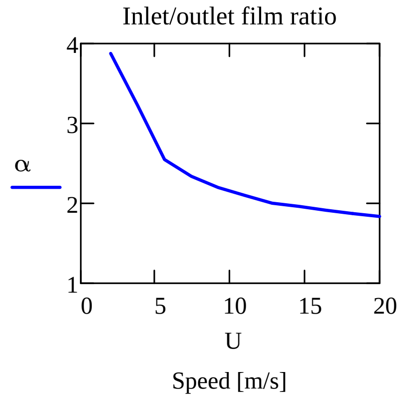
IMPORTANT:
Use prior values of calculated h2 and Tout for next surface speed

Iterative loop

Order results

GRAPHS of bearing Performance versus runner speed. $W = 2 \times 10^{4}$ [N] - External Load

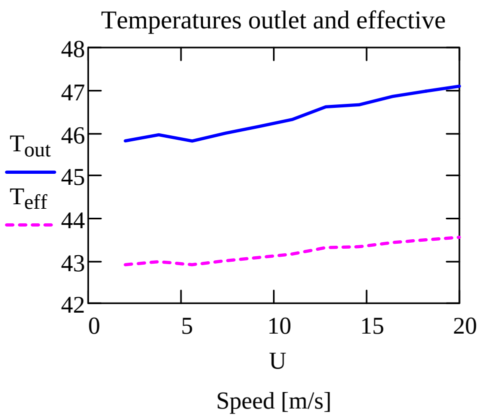


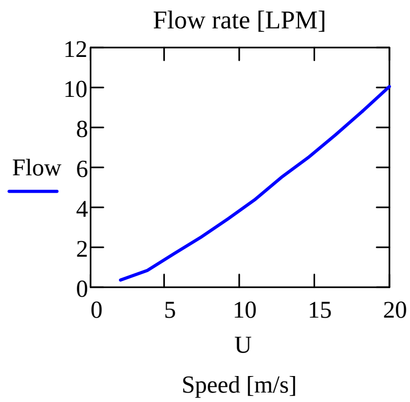


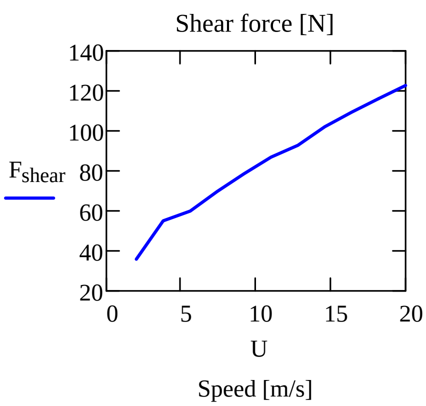
$\max(h_2) = 7.184 \times 10^{-5}$

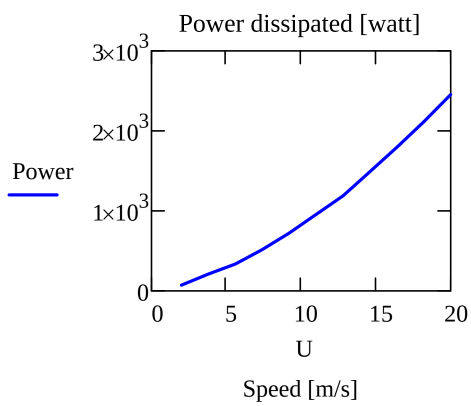
$\min(h_2) = 2.086 \times 10^{-5}$

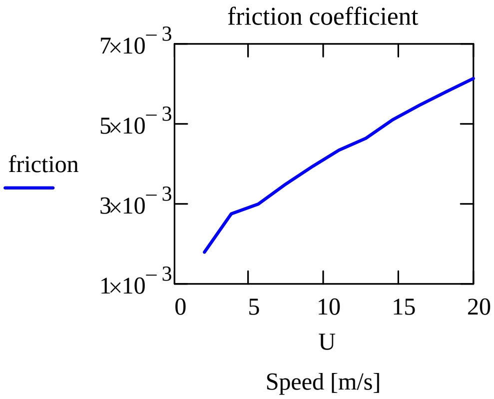
$T_{inlet} = 40$ [C]

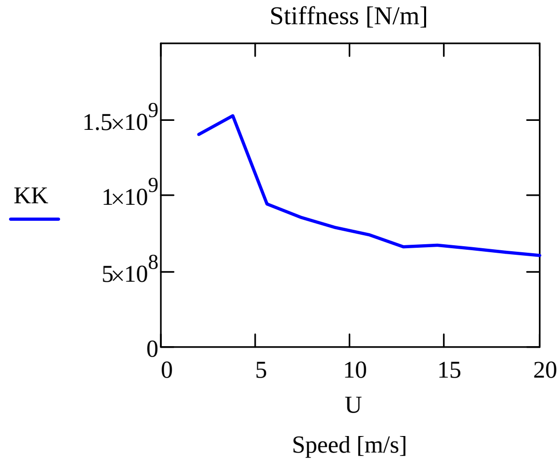






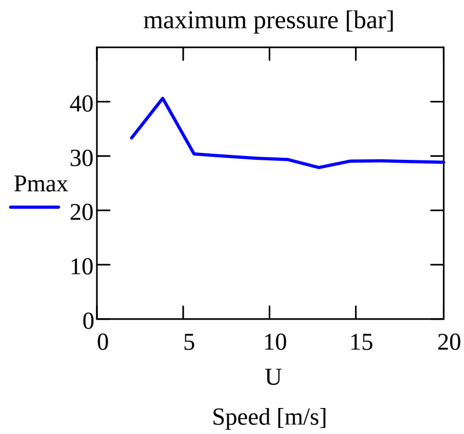






$P_{spec} = 18.519$ [bar]

specific pressure = load/area



imax = 24