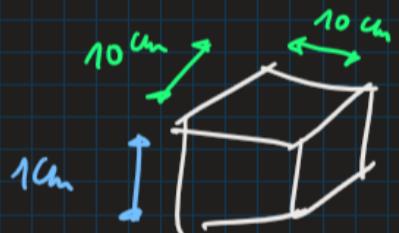


I)



en [mm³]

$$V_{\text{wear}} : 100 \cdot 100 \cdot 10 = 10^5 \text{ [mm}^3\text{]}$$

Quantification of wear

Experience shows that the wear volume V_{wear} is often :

$V_{\text{wear}} \propto$ (sliding distance L)

$V_{\text{wear}} \propto$ (normal load F_n)

$V_{\text{wear}} \propto$ (1/hardness H)

Different ways to define the wear rate T_{wear} exist :

$T_{\text{wear}} = V_{\text{wear}} / L$ (volume loss per unit of sliding distance [mm³/m])

$T_{\text{wear}} = V_{\text{wear}} / (L F_n)$ (wear coefficient [mm³/m N])

$T_{\text{wear}} = V_{\text{wear}} H / (L F_n)$ (dimensionless wear coefficient)

NOTE : These expressions do not necessarily take into account chemical (oxidation, corrosion, ...), metallurgical (hardening, ...) or physical (T, particles, ...) transformations that may occur during a tribological test.

$$T_{\text{wear}} = \frac{V_{\text{wear}}}{L \cdot F_N} = \frac{10^5}{120 \cdot 8 \cdot 3000} = 3,47 \cdot 10^{-2} \left[\frac{\text{mm}^3}{\text{m} \cdot \text{N}} \right]$$

⚠ ↗
120[m] ⋅ ⋯

II)

EPFL

Hertz Contact Mechanics Formalism

Ball-plane contact

Radius of contact area (circle)

$$a = \left(\frac{1.5 F_r R}{E'} \right)^{\frac{1}{3}}$$

Maximum contact pressure

$$p_0 = \frac{3F_r}{2\pi a^2}$$

Average contact pressure

$$p_a = \frac{F_r}{\pi a^2}$$

Maximum deflection

$$w = 1.31 \left(\frac{F_r^2}{E'^2 R} \right)^{\frac{1}{3}}$$

Maximum shear stress

$$\tau_{max} = \frac{p_0}{3}$$

Depth of maximum shear strength

$$z = 0.638 \cdot a$$

E = Young's modulus

$$\frac{1}{E'} = 0.5 \left[\frac{1-v_1^2}{E_1} + \frac{1-v_2^2}{E_2} \right]$$

v = Poisson's ratio

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$$a = \left(1.5 \cdot 15 \cdot \frac{12.7}{2} \cdot 10^{-3} \cdot 3.36 \cdot 10^{-12} \right)^{\frac{1}{3}} = 7.83 \cdot 10^{-5} [m]$$

$$\rightarrow A = \pi a^2 = \pi \cdot (7.83 \cdot 10^{-5})^2 = 1.926 \cdot 10^{-8} [m^2]$$

$$p_0 = \frac{3}{2} \cdot \frac{15}{1.926 \cdot 10^{-8}} = 1,168 \cdot 10^9 [Pa] = 1168 [MPa]$$

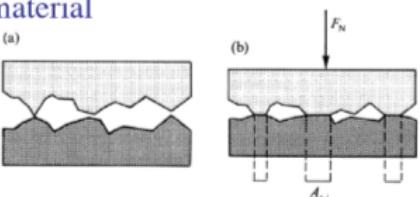
$$\frac{1}{E'} = 0.5 \left(\frac{1-0.3^2}{2 \cdot 10 \cdot 10^9} + \frac{1-0.14^2}{4 \cdot 10 \cdot 10^9} \right) = 3.36 \cdot 10^{-12} \left(\frac{1}{Pa} \right)$$

III

Adhesion at asperities

Contact between a soft and rough material and a hard and rigid material :

$$\text{True contact pressure : } P_r = \frac{F_n}{A_r}$$



Under the pressure, asperities deform until the equilibrium pressure, given by the hardness H (indentation), is reached.

$$P_{r,\max} = H = \frac{F_n}{A_{r,\max}} \quad A_{r,\max} = \frac{F_n}{H}$$

The friction force F_{adh} is the force necessary to shear the junctions at τ_c = critical shear stress of the material :

$$F_{\text{adh}} = A_{r,\max} \tau_c \Rightarrow \mu_{\text{adh}} = \frac{\tau_c}{H}$$

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H



$$\rho_r = \frac{F_N}{A_r}$$

$$\Leftrightarrow A_r = \frac{F_N}{H} = \frac{9}{0,9 \cdot 10^9} = 10^{-8} [\text{m}^2] = 10^{-2} [\text{mm}^2]$$

IV)

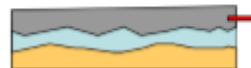
The λ factor: criterion for regime transition

$$\lambda = h_0 / R_q$$

h_0 = thickness of the hydrodynamic film $h_0 \propto (\eta \cdot v / F_N)$

R_q = parameter characterizing the height of asperity

$\lambda > 3$ Hydrodynamic regime



$1 < \lambda < 3$ Mixed regime



$\lambda < 1$ Boundary regime



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$$1 \geq 3 \Leftrightarrow \frac{h_0}{R_q} \leq \frac{87}{3} \Rightarrow 29 [\mu\text{m}] = 2,9 \cdot 10^1 = 2,9 \cdot 10^{-2} \mu\text{m} = 0,029$$

$$R_q \leq 0,029 [\mu\text{m}]$$