

en [mm]

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

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 [mm^3/m])

$T_{\text{wear}} = V_{\text{wear}} / (L F_n)$ (wear coefficient [$\text{mm}^3/\text{m N}$])

$T_{\text{wear}} = V_{\text{wear}} H / (L F_n)$ (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] · 8

I)

Hertz Contact Mechanics Formalism

Ball-plane contact

Radius of contact area (circle)

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

Maximum contact pressure

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

Average contact pressure

$$p_m = \frac{F_z}{\pi a^2}$$

Maximum deflection

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

Maximum shear stress

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

Depth of maximum shear strength

$$z = 0.638 \cdot a$$

E = Young's modulus
 ν = Poisson's ratio

$$\frac{1}{E'} = 0.5 \left[\frac{1 - \nu_1^2}{E_1} + \frac{1 - \nu_2^2}{E_2} \right]$$

$$a = \left(1.5 \cdot \overset{F_z}{15} \cdot \frac{\overset{R [m]}{12.7 \cdot 10^{-3}} \cdot \overset{\frac{1}{E'}}{3.36 \cdot 10^{12}} \right)^{1/3} = 7.83 \cdot 10^{-5} [m]$$

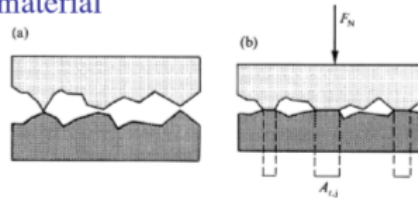
$$\rightarrow A = \pi a^2 = \pi \cdot (7.83 \cdot 10^{-5})^2 = 1.926 \cdot 10^{-8} [m^2]$$

$$p_0 = \frac{3}{2} \frac{15}{1.926 \cdot 10^{-8}} = 1.168 \cdot 10^9 [Pa] = 1168 [MPa]$$

$$\frac{1}{E'} = 0.5 \left(\frac{1 - 0.3^2}{210 \cdot 10^9} + \frac{1 - 0.14^2}{410 \cdot 10^9} \right) = 3.36 \cdot 10^{-12} \left[\frac{1}{Pa} \right]$$

Adhesion at asperities

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



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 :

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

54

$$H \quad \updownarrow \quad P_r = \frac{F_N}{A_r}$$

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

V)

The λ factor: criterion for regime transition

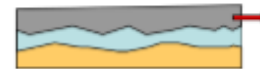
$$\lambda = h_0 / R_q$$

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



81

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

$$R_q \leq 0,029 [\mu m]$$