

Literature and use of calculator are allowed. Answers can be given by using English or Finnish language.

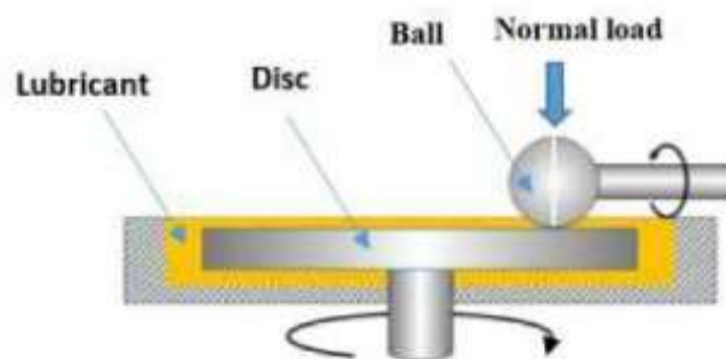
1. What crucial factors are needed for formation of hydrodynamic (full-film) lubrication condition in case of sliding bearings? Explain the main features of each lubrication mechanism (3 pcs), point out the corresponding specific film thicknesses and sketch the Stribeck-curve.
2. Two steel cylinders with diameters of $D_1 = 100$ mm and $D_2 = 80$ mm (both having length of 25 mm) are pressed together with normal force of $1.5 \cdot 10^4$ N. The rotating speeds (circumferential speed in same direction) of the cylinders are $n_1 = 8$ r/s and $n_2 = 4$ r/s. Calculate the maximum pressure and temperature rise in contact. Steel elastic modulus $E = 2,06 \cdot 10^{11}$ Pa, Poisson ratio 0,3, $\rho =$ density 7850 kg/m³, heat conduction $\lambda = 55$ W/(m°C) and specific heat $c = 0,465$ kJ/(kg°C). Coefficient of friction is 0,08.
3. A ball and disc are in rolling/sliding contact lubricated with a mineral oil. The contact specifications and lubricants parameters are given in the tables, and the contact is shown in the figure:

Contact specification

Parameter	Unit	Value
Oil entrainment speed (u)	mm/s	500
Young modulus of disc and ball	GPa	207
Poisson's ratio of disc and ball	-	0.3
Rq Ball (rms)	nm	?
Rq Disc (rms)	nm	?
Ball diameter	mm	19.05
Normal load	N	50

Lubricant parameters

Parameter	Unit	Value
Dynamic viscosity at 40 °C	Pa.s	0.113
Kinematic viscosity at 40 °C	mm ² /s	127.6
Viscosity Index	-	105
Pressure viscosity coefficient	m ² /N	2.0E-8



Ball-on-disc rolling/sliding contact

What is the maximum rms roughness of the contacting surfaces (disc and ball have same roughness), that the contact is still in mixed lubrication regime? Operating temperature is 40 °C.

4. Summarize the essential features of adhesive and abrasive wear mechanisms and how wear can be reduced in these cases. Highlight the differences of these mechanisms. (answer length about 300 words).
5. There are six claims. You can answer yes, no or blank. Correct answer gives 1 point, wrong answer -0,5 points and blank 0 points (total minimum points 0)
 - a) MoS₂ is generally used as solid lubricant (as thin layer)
 - b) The difference between kinetic and static friction is one of the main factors causing stick slip.
 - c) When two bodies are sliding against each other in dry condition, the main guideline is that friction force is independent of nominal contact area
 - d) Rolling with tangential traction causes partial micro slip in cylinder against cylinder contact
 - e) EP-additives contributes the formation of boundary lubrication film (tribolayer), when the temperature is enough high.
 - f) Hard manganese steel fits very well to the harsh impact loading conditions.