Tampere University
MOL-82056 Dimensioning of Machine Elements
Remote Exam 09.12.2020
Responsible: Arto Lehtovaara

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

1. The refined fatigue (rating) life of rolling bearings is as follows: $L_{naa} = a_1 a_{ISO} L_{10}$, where $L_{10} = (C/P)^p$. a_{ISO} is dependent on three main parameters. What are these and how they are affecting on bearing life?

2. The gear set in figure below transfers a mechanical power of 44 kW. Using the given parameters in table, calculate the nominal tangential load, radial and axial loads in mesh as well as bearing 1 support forces. Bearing 1 takes all axial load in input shaft. Bearings takes no bending moments.

Given parameters

Input rotational speed	1500 (RPM)
Pinion reference diameter	57 (mm)
Wheel reference diameter	195 (mm)
Helix angle	20 (deg)
Pressure angle	20 (deg)

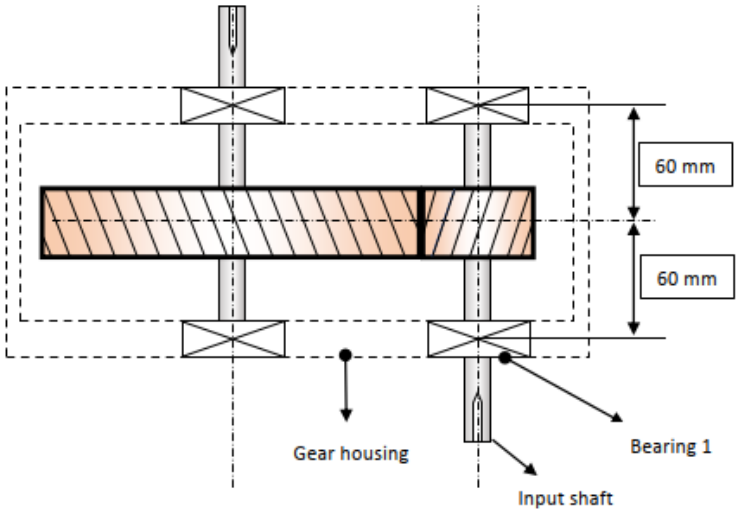

Figure: Gear set layout

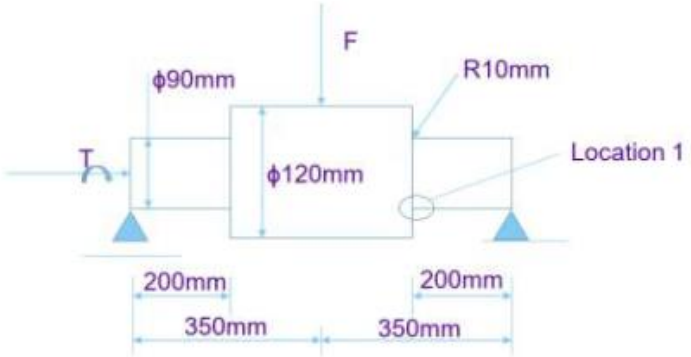

Figure 1. Shaft dimensions and loading

Size factor:

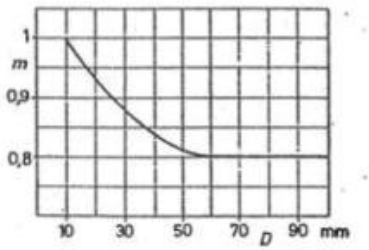

Figure 2: Size factor m, D = shaft diameter

Surface condition factor:

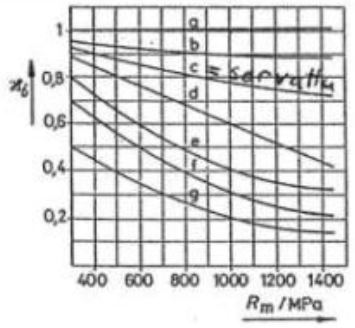

Figure 3. Surface condition factor, c = turning.

3. Explain the main failure mechanism of gears (minimum 4 pcs). What kinds of loading and/or operating conditions causes these failures?

4. The critical location of shaft is having the fluctuation of bending stress during one working cycle as shown in figure 1. The time for one working cycle is 50 s starting from point 1 and ending to point 5. Material of the shaft is steel with following SN-curve (figure 2). Estimate the lifetime of the shaft based on stresses in critical location by utilizing Rainflow (water tank analogy) analysis and Miner rule. In figure 1, Rm = 520 MPa.

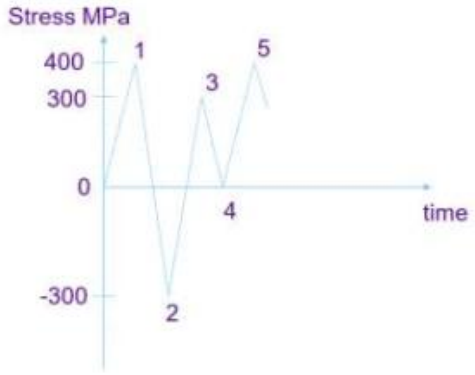

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Figure 1; Fluctuation of bending stress

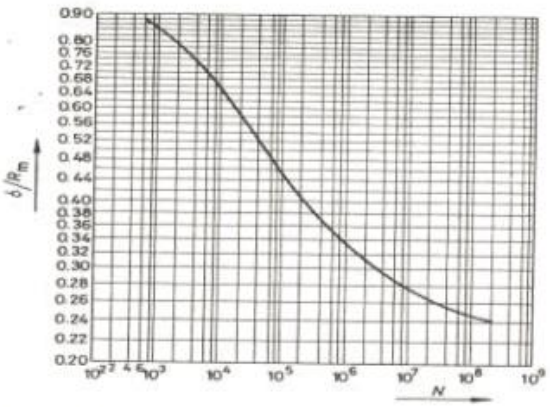

Figure 2. S-N curve

5. The constant normal load F = 60 kN is located on middle of the rotating shaft as shown in the figure 1. In addition, the shaft is loaded with constant torque T = 2000 Nm. The shaft is made of high strength steel with the following properties: Ultimate tensile strength Rm = 1000 MPa, yield strength Re = 850 MPa and fatigue strength σ_{iw} = 420 MPa. Material notch sensitivity is 0.9 and the shaft has been manufactured by turning c (figures 2 and 3). Calculate the shaft safety factor against fatigue in bending at the location 1 by utilizing Goodman diagram. Stresses due to shear force can be neglected.