9.4 Shafts and bearings

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

KEY WORDS rolling bearings • basic dynamic load rating • L10 life

Objective

Size a shaft seat from the fatigue design equation, and choose a rolling bearing for a required life from its dynamic load rating.

1 Key knowledge and worked examples

The shaft equation and the life equation

- Shaft diameter for factor of safety n (Goodman, steady torque):

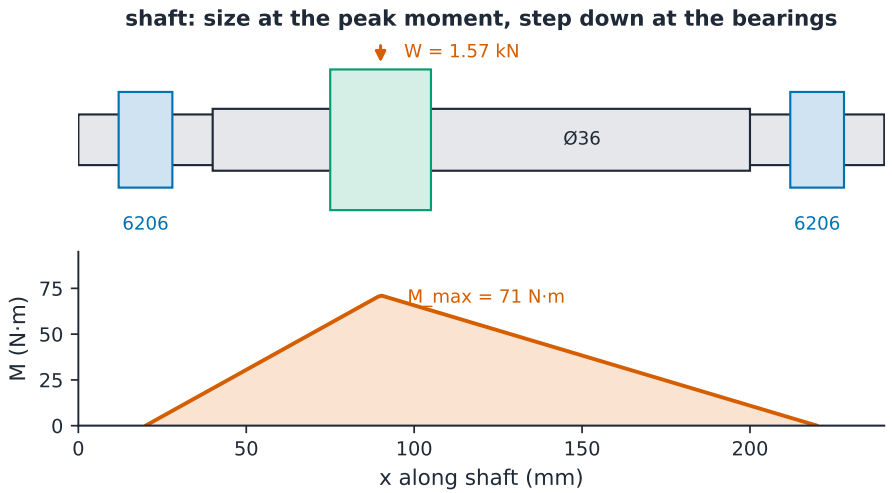
$$d = \left[\frac{16n}{\pi}\left(\frac{2K_f M_a}{S_e} + \frac{\sqrt{3}\,K_{fs}T_m}{S_{ut}}\right)\right]^{1/3}$$

- **Rolling bearings** : **L10 life** $L_{10} = (C/P)^3$ million revolutions for ball bearings, with C the **basic dynamic load rating** .
- Required rating: $C_{req} = P\,(L/10^6)^{1/3}$.

Worked example. The 6206 for 20 000 h

180 rpm for 20 000 h: $L = 180 \times 60 \times 20\,000 = 2.16 \times 10^8$ rev; duty load $P = 2.94$ kN.

- $C_{req} = P(L/10^6)^{1/3} = 2.94 \times 216^{1/3} = \mathbf{17.6}$ kN.
- The 6206 has $C = 19.5$ kN: $L_{10} = (C/P)^3 \times 10^6/(60N) = (19.5/2.94)^3 \times 10^6/(60 \times 180) = \mathbf{27\,000}$ h.



2 Practice

$S_e = 220$ MPa, $S_{ut} = 630$ MPa. Catalogue: 6207 (35 mm bore) $C = 25.5$ kN; 6208 (40 mm bore) $C = 30.7$ kN.

2.1 A shoulder carries $M_a = 90$ N · m ($K_f = 1.8$) and a steady $T_m = 250$ N · m ($K_{fs} = 1.5$). Find the diameter for $n = 2$ (one decimal, mm) and choose a standard size from 30, 35 and 40 mm. [4]

2.2 A 6207 carries $P = 3.2$ kN at 300 rpm. Find its L_{10} life (nearest hundred hours). [3]

3 Exam-style questions

3.1 The drive of 2.2 must last 30 000 h. Find the revolutions needed and C_{req} (two decimals, kN). Does the 6207 meet it? Find the life of the 6208, and state the knock-on change its larger bore forces on the shaft. [6]

Solutions

2.1

- $d = [\frac{16n}{\pi}(2K_f M_a/S_e + \sqrt{3}K_{fs}T_m/S_{ut})]^{1/3} = [\frac{32}{\pi}(2 \times 1.8 \times 90\,000/220 + \sqrt{3} \times 1.5 \times 250\,000/630)]^{1/3}$ (N · mm and MPa).
- $= [10.19 \times (1472.7 + 1031.0)]^{1/3} = \mathbf{29.4}$ mm.
- Choose the next standard size up: **30** mm.

2.2

- $L_{10} = (C/P)^3 \times 10^6/(60N) = (25.5/3.2)^3 \times 10^6/(60 \times 300) = \mathbf{28\,100}$ h.

3.1

- $L = 300 \times 60 \times 30\,000 = \mathbf{5.40 \times 10^8}$ rev.
- $C_{req} = P(L/10^6)^{1/3} = 3.2 \times 540^{1/3} = \mathbf{26.06}$ kN.
- The 6207's 25.5 kN falls short.
- 6208: $L_{10} = (30.7/3.2)^3 \times 10^6/18\,000 = \mathbf{49\,100}$ h.
- Its 40 mm bore needs 40 mm seats and a larger shoulder, so the shaft drawing (and its parameters) changes.