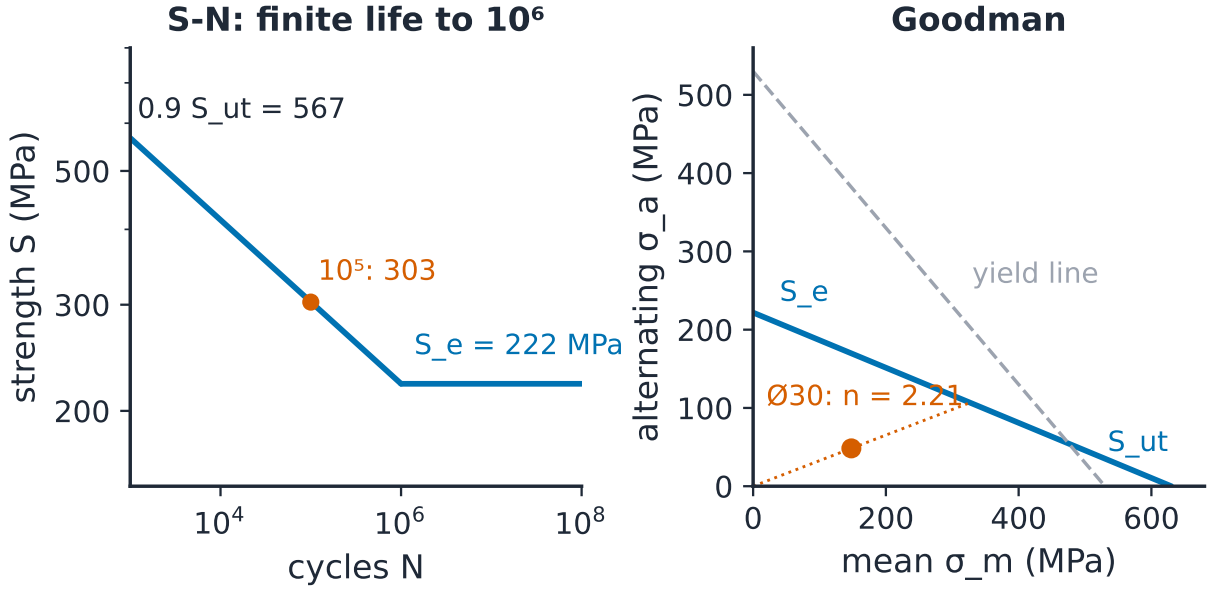
Exercise walk-through

9.3
Static and fatigue criteria

University Mechanical Engineering

S-N curve and Goodman line



C45 machined, $d = 30$: $S_e = 0.817 \times 0.862 \times 315 = \mathbf{222}$ MPa; Goodman at the shoulder gives $n = \mathbf{2.21}$.

Goodman at the shoulder

1. **Notch** $K_t = 2.0$, $q = 0.8 \rightarrow K_f = \mathbf{1.8}$; torsion $K_{fs} = \mathbf{1.51}$.
2. **Stresses** $\sigma_a = K_f \cdot 32 M_a / \pi d^3 = \mathbf{48.4}$ MPa; $\sigma_m = \sqrt{3}\, K_{fs} 16\, T_m / \pi d^3 = \mathbf{148.0}$ MPa.
3. **Goodman** $1/n = 48.4/222 + 148.0/630 \rightarrow n = \mathbf{2.21}$.
4. **Yield** $n_y = 530/\sqrt{48.4^2 + 148.0^2} = \mathbf{3.40}$ - **fatigue** governs.

Decision

Check both; the lower factor sets the design.

Exercises 2.1·2.2

2.1 Find k_a, k_b and S_e for a 40 mm shaft (three decimals, three decimals, nearest MPa). [4]

2.2 Using that S_e, find the fully reversed strength at 10^4 cycles from the S-N line (nearest MPa). [3]

Exercises 2.1·2.2

2.1 Find k_a, k_b and S_e for a 40 mm shaft (three decimals, three decimals, nearest MPa). [4]

2.1

- $S'_e = 0.5 S_{ut} = 315$ MPa.
- $k_a = 4.51 S_{ut}^{-0.265} = 4.51 \times 630^{-0.265} = \mathbf{0.817}$; $k_b = 1.24 d^{-0.107} = 1.24 \times 40^{-0.107} = \mathbf{0.836}$.
- $S_e = k_a k_b S'_e = 0.817 \times 0.836 \times 315 = \mathbf{215}$ MPa.

2.2 Using that S_e, find the fully reversed strength at 10^4 cycles from the S-N line (nearest MPa). [3]

2.2

- The line is straight on log axes: each decade from 10^3 multiplies S by $(S_e/0.9S_{ut})^{1/3} = (215/567)^{1/3} = 0.724$.
- At 10^4: $S = 567 \times 0.724 = \mathbf{410}$ MPa.

Exercise 3.1

3.1 At its shoulder the 40 mm shaft carries $\sigma_a = 60$ MPa (bending, K_f included) and a von Mises mean $\sigma_m = 120$ MPa. Find the Goodman factor of safety and the first-cycle yield factor of safety (two decimals). Which governs, and what would you change first to raise it? [6]

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3.1

- Goodman: $1/n = \sigma_a/S_e + \sigma_m/S_{ut} = 60/215 + 120/630 = 0.469$, so $n = \mathbf{2.13}$.
- Yield: $n_y = S_y/\sqrt{\sigma_a^2 + \sigma_m^2} = 530/\sqrt{60^2 + 120^2} = \mathbf{3.95}$.
- Fatigue governs. Lower K_f first, with a larger shoulder fillet radius, before resorting to a bigger shaft or a stronger steel.