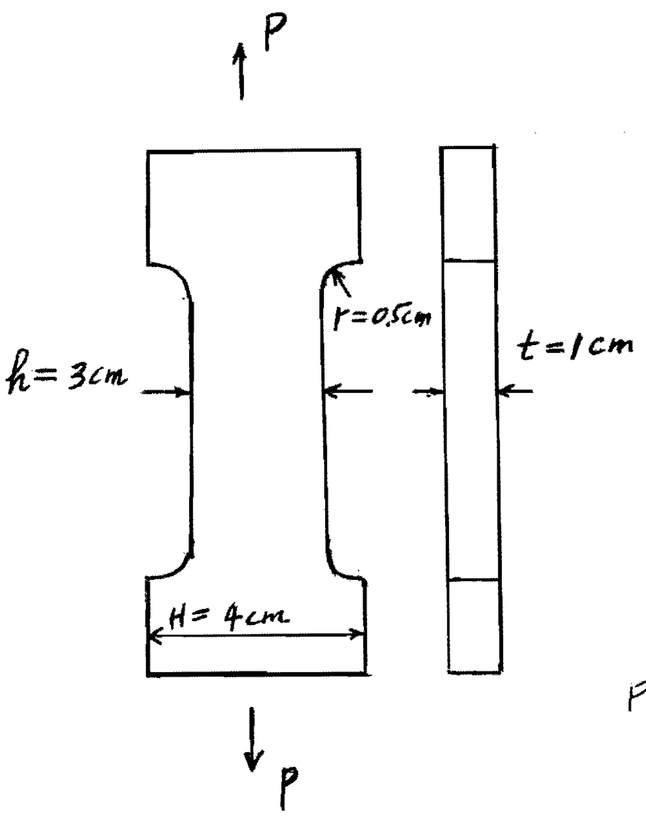
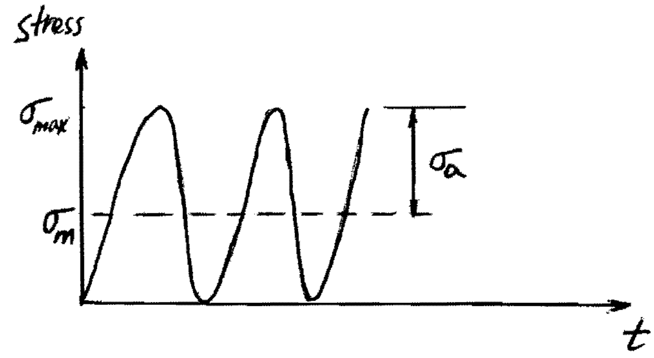
Example

Consider a machined flat bar of annealed AISI 4130 steel as shown. If the load P is cycled between 0 and 20 kN, what is the safety factor against infinite life with 90% reliability?





Applied Stress Cycle

From Appendix C-4a $S_y = 361$ MPa

$S_u = 561$ MPa (81 ksi)

(1 psi = 6.895 kPa)

The nominal stress S_{nom} in the centre section (Figure 4.38)

$$S_{nom} = \frac{P}{A} = \frac{20000\ N}{(3 \times 1)cm^2} = \frac{20{,}000}{(3) \times [10^{-2}]^2}\ N/m^2$$

$$= 66.7\ MPa \Rightarrow \begin{array}{l} S_a = 33.35\ MPa \\ S_m = 33.35\ MPa \end{array}$$

Find σ_m, σ_a by considering the stress concentration at the fillet:

i.e. $\left.\begin{aligned} \frac{H}{h} &= 4/3 = 1.33 \\ \frac{r}{h} &= \frac{0.5}{3.0} = 0.167 \end{aligned}\right\}$ $\therefore$ From Figure 4.38 $K_t \doteq 1.65$

Next we must find the notch sensitivity, q:

i.e. Figure 8.24 $\quad q = 0.83$

$$\therefore \quad K_f = 1 + (K_t - 1)\, q = 1.54$$

$$\therefore \quad \sigma_m = K_f \cdot S_m \,, \quad \sigma_a = K_f \cdot S_a$$

$$\therefore \quad \sigma_m = 51.4 \text{ MPa}$$

$$\sigma_a = 51.4 \text{ MPa}$$

$\sigma_{max} = 51.4 + 51.4 = 102.8 \text{ MPa} < S_y$

No local yielding

For "corrected" endurance limit ($\geq 10^6$ cycle fatigue strength)

$$S_n = S_n' \cdot C_L \cdot C_G \cdot C_S \cdot C_R$$

where $S_n' = \frac{1}{2} S_u = \frac{1}{2}(561) = 280.5$ MPa

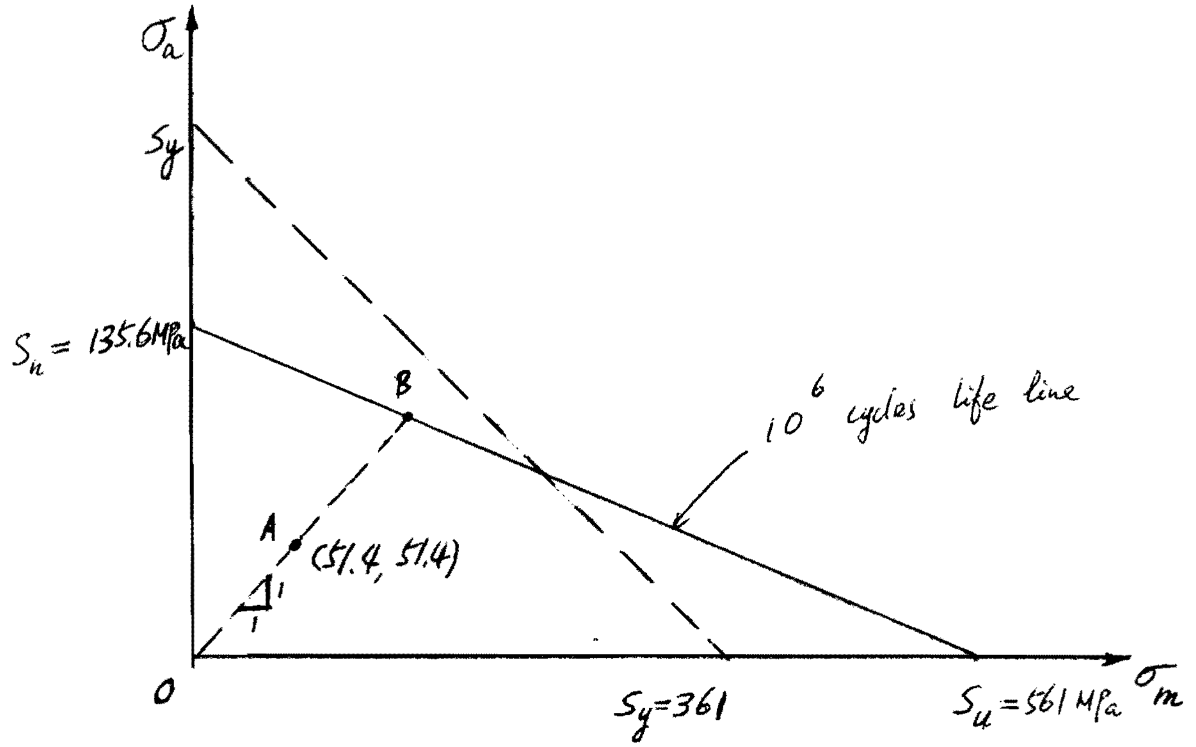
$C_L = 1$ (Table 8.1)

$C_G = 0.7$ (Table 8.1)

$C_S = 0.77$ (Figure 8.13)

$C_R = 0.897$ (Table 8.1, 90% reliability)

$\therefore$ $S_n = 135.6$ MPa



Equation of Goodman's Line:

$$\frac{\sigma_m(B)}{S_u} + \frac{\sigma_a(B)}{S_n} = 1, \quad \sigma_m(B) = \sigma_a(B) = \frac{1}{\frac{1}{S_u} + \frac{1}{S_n}}$$

$$= \frac{135.6 \times 561}{(135.6 + 561)} = 109.2 \text{ MPa}$$

Safety factor:

$$n = \frac{OB}{OA} = \frac{109.2}{51.4} = 2.12 \quad //$$