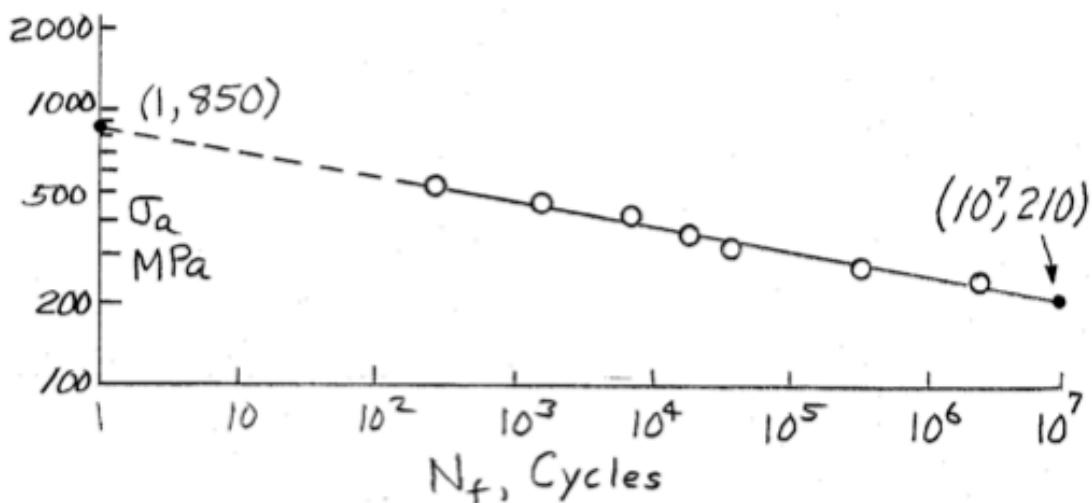


$$\underline{9.4} \quad \sigma_a = A N_f^B \quad \text{HR \& Norm AISI 1045}$$

(a) Plot data on log-log coordinates and draw a straight line through the data.



$A = 850$ is σ_a intercept at $N_f = 1$,
Calculate B from a second pt. on line.

$$\frac{\sigma_a}{A} = N_f^B, \quad B = \frac{\log(\sigma_a/A)}{\log N_f}$$

$$B = \frac{\log(210/850)}{\log(10^7)} = -0.0867$$

$$\sigma_a = 850(N_f)^{-0.0867} \quad \text{MPa} \quad \blacktriangleleft$$

(b) Do a least-squares fit; N_f dependent

$$N_f = \left(\frac{\sigma_a}{A}\right)^{1/B}$$

(9.4, p.2)

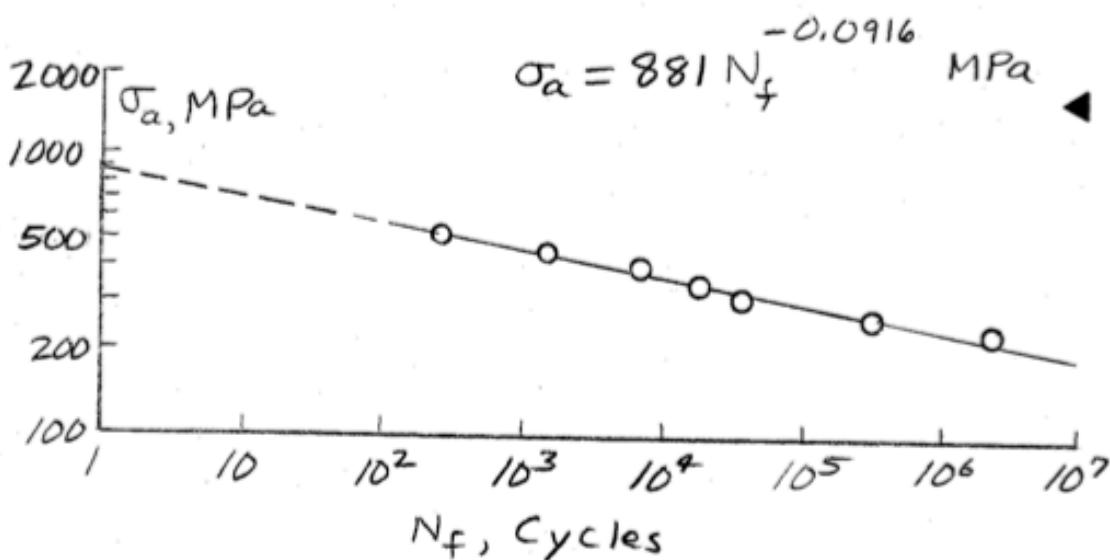
$$\log N_f = \frac{1}{B} \log \sigma_a + \log \frac{1}{A^{1/B}}$$
$$y = m x + c$$

The resulting constants are

$$m = -10.916, \quad B = 1/m = -0.09161$$

$$c = 32.15 = \log \frac{1}{A^{1/B}}$$

$$10^{-c/B} = A = 881 \text{ MPa}$$



$$(c) \sigma'_f = A/2^b = 881/2^{-0.09161} = 939 \text{ MPa}$$

$$b = B = -0.0916$$

$$\sigma_a = 939 (2N_f)^{-0.0916} \text{ MPa}$$

9.36 Alloy 2024-T4 Al is subjected in service to $\widehat{\sigma}_a = 160$, $\widehat{\sigma}_m = 70 \text{ MPa}$, with $\widehat{N} = 5000$ cycles desired. $x_s, x_N = ?$

$$\sigma_f' = 900 \text{ MPa}, b = -0.102 \quad (\text{Table 9.1})$$

$$\widehat{\sigma}_{ar} = \sqrt{\widehat{\sigma}_{max} \widehat{\sigma}_a} = \sqrt{(160 + 70)160} = 191.8 \text{ MPa}$$

$$\widehat{\sigma}_{ar} = \sigma_f' (2N_{f2})^b, N_{f2} = \frac{1}{2} \left(\frac{\widehat{\sigma}_{ar}}{\sigma_f'} \right)^{1/b}$$

$$N_{f2} = \frac{1}{2} \left(\frac{191.8}{900} \right)^{1(-0.102)} = 1.908 \times 10^6 \text{ cycles}$$

$$x_N = N_{f2} / \widehat{N} = 1.908 \times 10^6 / 5000 = 381.6 \quad \blacktriangleleft$$

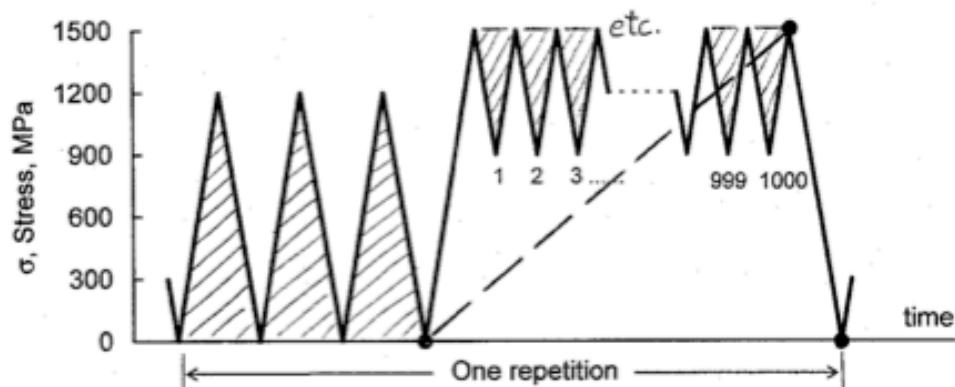
$$x_s = x_N^{-b} = 381.6^{0.102} = 1.834 \quad \blacktriangleleft$$

9.44

For given repeating stress history and material, estimate the number of repetitions to fatigue failure. First perform cycle counting on the stress history. Then for each level of cycling, calculate the life N_f using the SWT equation. Finally, apply the P-M rule.

$$\sigma_a = \frac{\sigma_{\max} - \sigma_{\min}}{2}, \quad \sqrt{\sigma_{\max} \sigma_a} = \sigma'_f (2N_f)^b$$

$$N_f = \frac{1}{2} \left(\frac{\sqrt{\sigma_{\max} \sigma_a}}{\sigma'_f} \right)^{1/b}, \quad B_f \left[\sum \frac{N_j}{N_{fj}} \right]_{\text{one rep}} = 1$$



AISI 4142 steel, 450 HB

$$\sigma'_f = 1937$$

$$b = -0.0762$$

Stresses in MPa

SWT

j	N_j	σ_{\min}	σ_{\max}	σ_a	N_{fj}	N_j/N_{fj}
1	3	0	1200	600	2.53E+04	1.19E-04
2	1000	900	1500	300	5.53E+05	1.81E-03
3	1	0	1500	750	1.35E+03	7.39E-04
$\Sigma =$						2.67E-03

$$B_f = 1/\Sigma = \quad 375$$

(9.44, p. 2)

An alternate solution is to proceed similarly except for calculating the life N_f using the Morrow equation.

$$\sigma_a = \frac{\sigma_{\max} - \sigma_{\min}}{2}, \quad \sigma_m = \frac{\sigma_{\max} + \sigma_{\min}}{2}$$

$$\sigma_a = (\sigma'_f - \sigma_m)(2N_f)^b, \quad N_f = \frac{1}{2} \left(\frac{\sigma_a}{\sigma'_f - \sigma_m} \right)^{1/b}$$

$$B_f \left[\sum_{\text{one rep}} \frac{N_j}{N_f} \right] = 1$$

AISI 4142 steel, 450 HB

Stresses in MPa

$$\sigma'_f = 1937 \quad b = -0.0762$$

Morrow

j	N_j	σ_{\min}	σ_{\max}	σ_a	σ_m	N_j	N_j/N_f
1	3	0	1200	600	600	1.84E+04	1.63E-04
2	1000	900	1500	300	1200	6.63E+04	1.51E-02
3	1	0	1500	750	750	2.07E+02	4.83E-03

$$\Sigma = 2.01E-02$$

$$B_f = 1/\Sigma = 50$$

