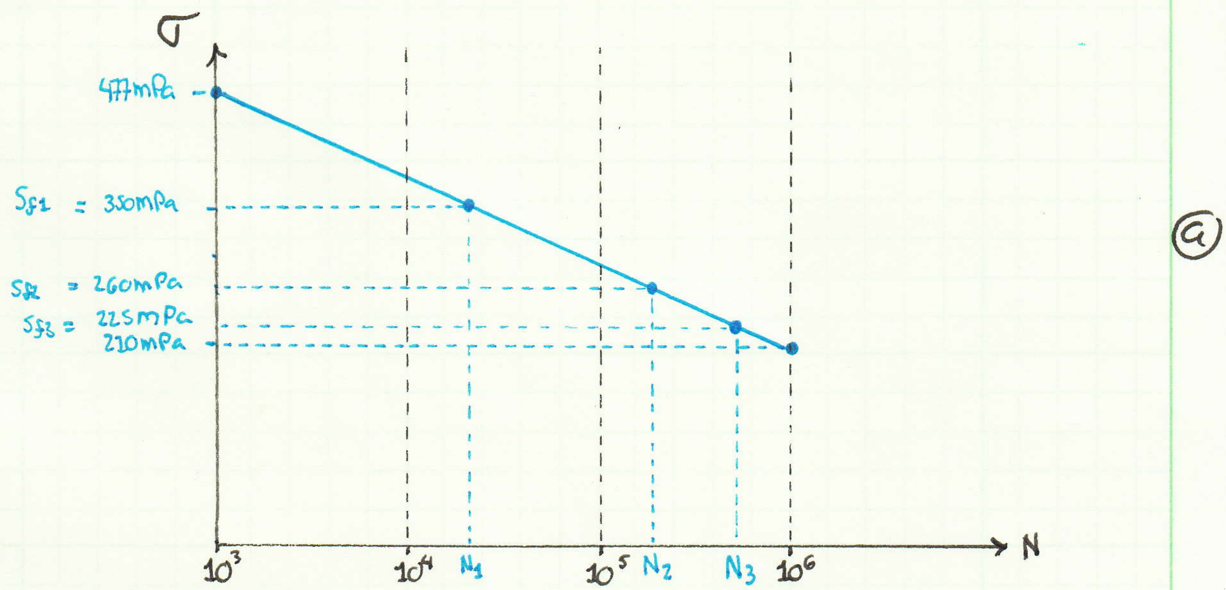
PROBLEM STATEMENT A machined part will be cycled at ±350 MPa for 5×10^3 cycles. Then the loading will be changed to ±260 MPa for 5×10^4 cycles. Finally, the load will be changed to ±225 MPa. How many cycles of operation can be expected at this stress level? For the part, $S_{ut} = 530$ MPa, $f = 0.9$, and has a fully corrected endurance strength of $S_e = 210$ MPa. (a) Use Minor's method.

GIVEN:
1. A machined part
2. Duty cycle i) ±350 MPa for 5×10^3 cycles → ii) ±260 MPa for 5×10^4 cycles → iii) ±225 MPa
3. Material properties: $S_{ut} = 530$ MPa, $f = 0.9$, and $S_e = 210$ MPa

ASSUMPTIONS:
1. All cycling conducted in the linear-elastic region of the material.
2. Specimen heating can be ignored.

FIND:
1. Using Minor's rule, what is the remaining fatigue life at ±225 MPa?

FIGURE:



SOLUTION:

Starting with the construction of th S-N diagram, (a).

$$(S_f)_{10^3} = f\cdot S_{ut} = 0.9\cdot 530\text{ MPa} = 477\text{ MPa} \quad (1)$$

THE FATIGUE LIVES AT THE THREE SPECIFIED FATIGUE STRENGTHS NEED TO BE CALCULATED, BUT FIRST THE PARAMETERS ASSOCIATED WITH THE EQUATION FOR THE S-N CURVE NEED TO BE CALCULATED. THE EQUATION FOR THE S-N CURVE TAKES THE FORM

$$\log S_f = -m \cdot \log N + b \qquad (2)$$

WHERE

$$m = \frac{1}{3} \cdot \log \frac{f \cdot S_{ut}}{S_e} = \frac{1}{3} \log \left[\frac{0.9 \cdot 530\,\mathrm{MPa}}{210\,\mathrm{MPa}} \right] = 0.11877 \qquad (3)$$

$$b = \log \frac{(f \cdot S_{ut})^2}{S_e} = \log \left[\frac{(0.9 \cdot 530\,\mathrm{MPa})^2}{210\,\mathrm{MPa}} \right] = 3.035 \qquad (4)$$

THE THREE FATIGUE LIVES CAN NOW BE COMPUTED

$$S_{f,1} = 350\,\mathrm{MPa} \rightarrow N_1 = \frac{10^{b/m}}{S_f^{\,1/m}} = \frac{10^{3.035/0.11877}}{(350\,\mathrm{MPa})^{1/0.11877}} = 13.60 \times 10^3 \text{ cycles} \qquad (5)$$

$$S_{f,2} = 260\,\mathrm{MPa} \rightarrow N_2 = \frac{10^{b/m}}{S_f^{\,1/m}} = \frac{10^{3.035/0.11877}}{(260\,\mathrm{MPa})^{1/0.11877}} = 166.1 \times 10^3 \text{ cycles} \qquad (6)$$

$$S_{f,3} = 225\,\mathrm{MPa} \rightarrow N_3 = \frac{10^{b/m}}{S_f^{\,1/m}} = \frac{10^{3.035/0.11877}}{(225\,\mathrm{MPa})^{1/0.11877}} = 561.1 \times 10^3 \text{ cycles} \qquad (7)$$

FROM MINER'S RULE

$$1 = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3} = \frac{5 \times 10^3}{13.6 \times 10^3} + \frac{5 \times 10^4}{166.1 \times 10^3} + \frac{n_3}{561.1 \times 10^3}$$

$$\Rightarrow n_3 = \left[1 - \frac{5 \times 10^3}{13.6 \times 10^3} - \frac{5 \times 10^4}{166.1 \times 10^3} \right] \cdot 561.1 \times 10^3 = \boxed{185.9 \times 10^3 \text{ cycles}}$$

<u>SUMMARY:</u>

IN THIS PROBLEM CORRECTED VALUES FOR S_f AND S_e ARE USED TO CONSTRUCT THE ~~SN~~ S-N CURVE. A SIMPLIFIED FORM OF MINER'S RULE IS USED TO COMPUTE THE REMAINING LIFE.