Crack Growth

Stage I Crack initiation

- geometric stress concentrations under tensile loads => start cracks
- yielding locally even if under yield strength overall part
- creates zone of distortion and slip bounds along the crystalline boundary
- these coalesce into microscopic cracks
- Cracks will develop more quickly in Brittle materials

Stage II Crack propogation

- crack growth primarily due to tensile loads
- repetitive compressive loads won't cause cracks to grow
- if a corrosive env => faster propogation
- frequency and mag. of loading plays major role in crack growth rate

Stage III Fracture

cracks will grow until its size increases past the toughness of material, and at the next cycle ⇒ fracture

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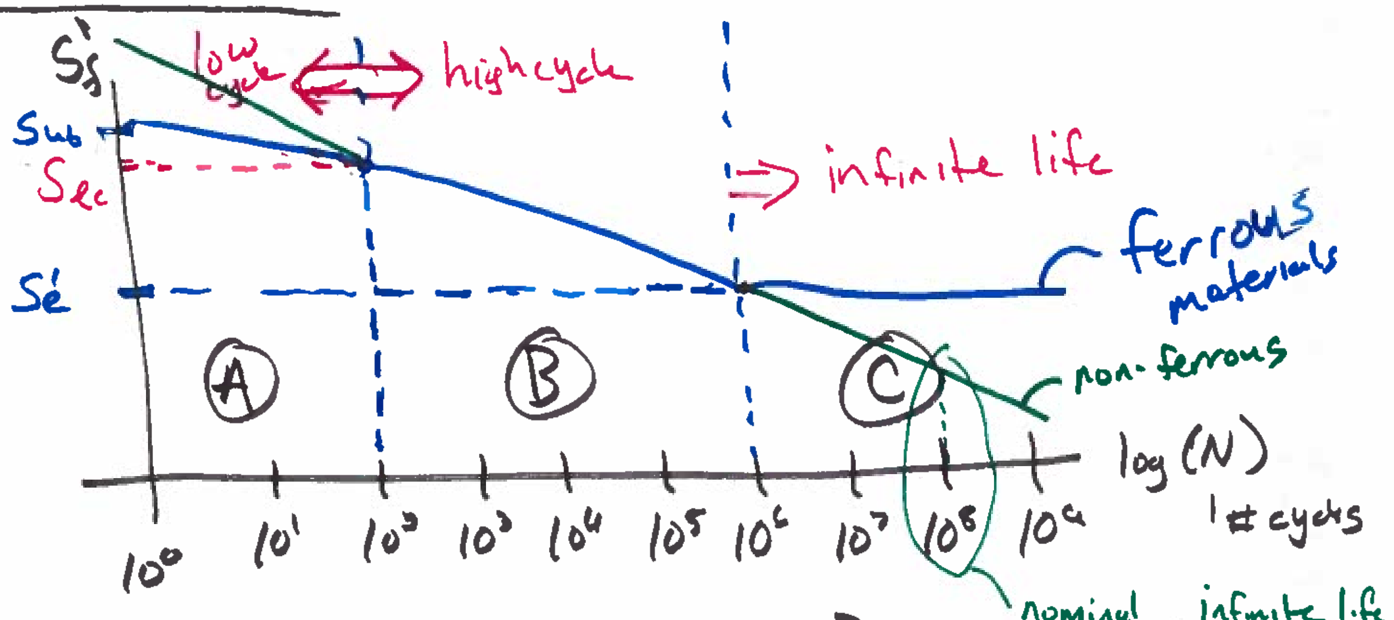
S-N Curve



Ferrous

(A) Low Cycle $10^0 \leq N \leq 10^3$

$$(S_f)_{10^3} = S_{ec} = f\, S_{ut} \qquad f: \text{Fig 6-18}$$

(C) Infinite Life $N \geq 10^6$ or 10^7

$$S_e' = 0.5\, S_{ut} \begin{cases} S_{ut} \leq 200\text{ Kpsi} \\ S_{ut} \leq 1400\text{ MPa} \end{cases}$$

Infinite Life $N \geq 10^6$ or 10^7

$$S_e' = 100\text{ Kpsi} \qquad S_{ut} > 200\text{ Kpsi}$$
$$700\text{ MPa} \qquad S_{ut} > 1400\text{ MPa}$$

B High Cycle to Infinite Life $10^3 \leq N \leq 10^{6 \text{ or } 7}$

$$S_f = aN^b \qquad \text{or} \qquad N = \left(\frac{\sigma_{rev}}{a}\right)^{1/b}$$

$$a = \frac{(f S_{ut})^2}{S_e} \qquad b = -\frac{1}{3}\log\left(\frac{f S_{ut}}{S_e}\right)$$

Non-ferrous

Use High Cycle B for $N > 10^6$

$N = 5 \times 10^8 \Rightarrow$ considered infinite life

Marin Modifying Parameters

S_e': unmodified endurance limit for a particular material with specimen in fully reversed rotating / bending

S_e: endurance limit ~~of~~ at critical location in your machine element under specific conditions

$$S_e = \underbrace{K_a K_b K_c K_d K_e K_f}_{\text{generally } <1} S_e'$$

Surface Finish Factor K_a

$$K_a = a\, S_{ut}^{\,b} \quad \text{Table 6-2}$$

Size Factor K_b

$$k_b = \begin{cases} 0.87\, d_e^{-0.107} & 0.11\text{ in} \le d_e \le 2\text{ in} \\ 0.91\, d_e^{-0.157} & 2\text{ in} \le d_e \le 10\text{ in} \end{cases}$$

Table 6-3

Effective diameter, d_e, Table 6-3

Load Factor K_c

$$K_c = \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases}$$

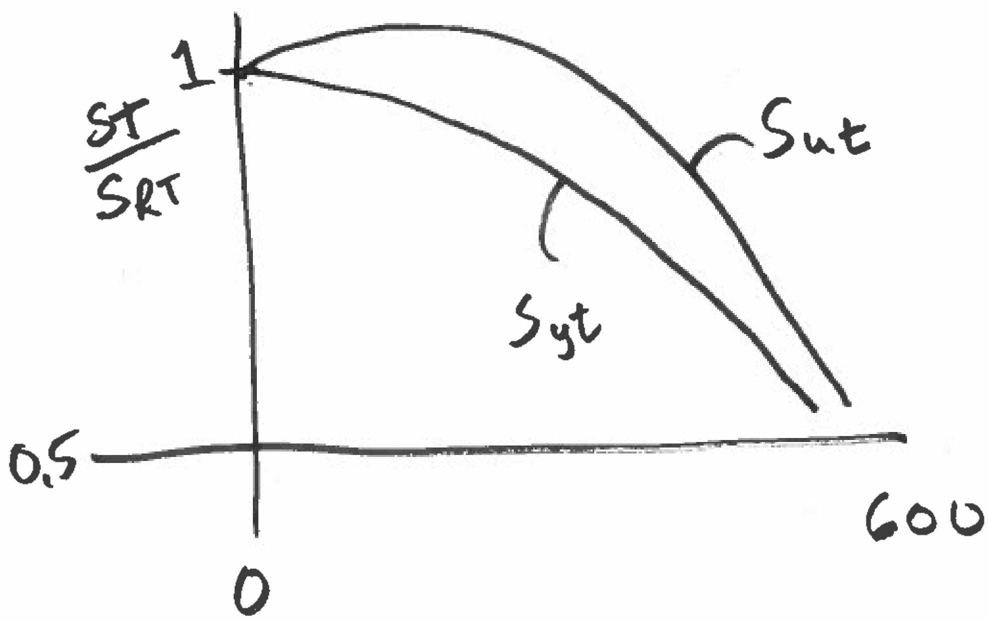
accounts for shear failure being less than tensile

MSS $\Rightarrow$ $S_{ys} = 0.577\,S_{yt}$

Temperature Factor, K_d

$$K_d = \frac{S_T}{S_{RT}} = \frac{\text{Tensile strength at operating temp}}{\text{Tensile strength at room temp}}$$

Table 6-4 & also eq 6-26



yield and ultimate strengths in general decrease with temperature

Reliability Factor

$$k_e = 1 - .08\, z_a$$

Table 6-5 and A-10

Misc. Effects Factor

k_f

- Residual stress from manufacturing techniques
- Corrosion
- Plating reduces the endurance limit
- Metal Spray " " " "
- stress concentration factors: for fatigue are important for both ductile & brittle mats.