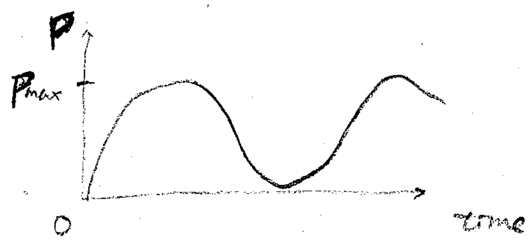
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

- Fatigue loading on pressure vessel

Assume $\overset{\to \text{Force}}{P}$ varies between 0 and $\overset{\to \text{Force}}{P_{max}}$ (e.g. pressure vessel)

$$\begin{cases} P_a = \frac{1}{2} P_{max} \\ P_m = \frac{1}{2} P_{max} \end{cases}$$



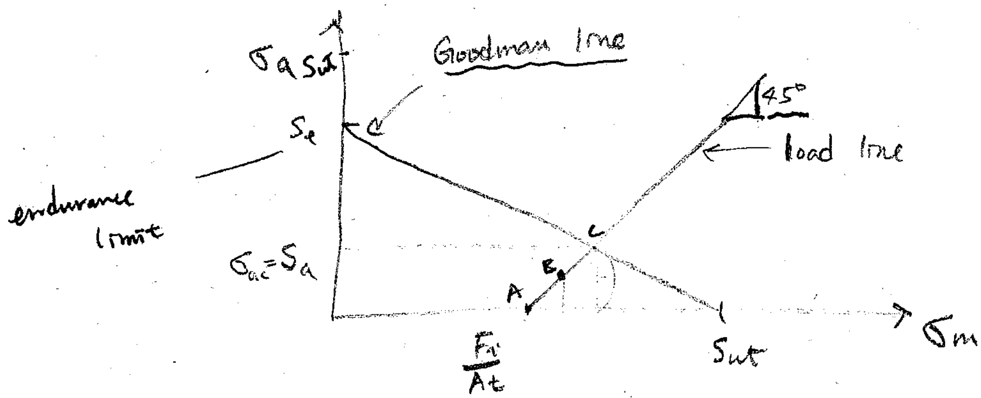
force on bolt

$$F_b = \underset{\substack{\uparrow \\ \text{fixed}}}{F_i} + \underset{\substack{\uparrow \\ \text{time dependent}}}{cP}$$

$$\begin{cases} \sigma_a = \dfrac{C P_{max}}{2 A_t} \\ \sigma_m = \dfrac{F_i}{A_t} + \dfrac{C P_{max}}{2 A_t} \end{cases}$$

these equations define the "load line" as :

$$\sigma_a = \sigma_m - \frac{F_i}{A_t}$$



intersection of the load & Goodman lines → σ_{ac} → alternating strength

$$\sigma_{ac} = S_a = \frac{S_{ut} - F_i/A_t}{1 + S_{ut}/S_e}$$

$$S.F. = \frac{\overline{AC}}{\overline{AB}} \quad \rightarrow S.F. = \frac{S_a}{\sigma_a} = \frac{\dfrac{S_{ut} - F_i/A_t}{1 + S_{ut}/S_e}}{C P_{max}/2A_t}$$

$$\Rightarrow \quad P_{max} \leq \frac{2}{S.F. \cdot C} \; \frac{S_{ut} A_t - F_i}{1 + S_{ut}/S_e}$$

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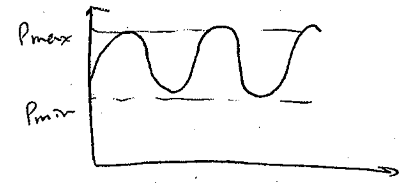
• more on Fatigue. $P_{min} \neq 0$



$$\begin{cases} F_{b,max} = F_i + P_{min}\, C \\ F_{b,min} = F_i + P_{max} \cdot C \end{cases}$$

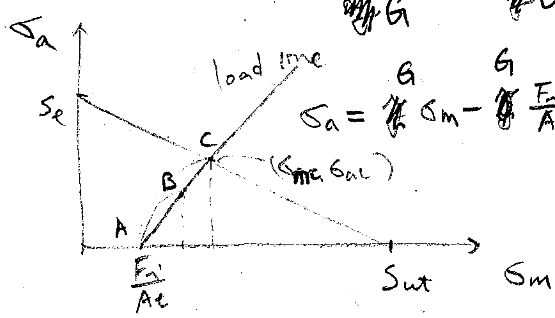
$$\rightarrow \begin{cases} \sigma_a = \dfrac{F_{max} - F_{min}}{2A_t} = \dfrac{C\,(P_{max} - P_{min})}{2A_t} \\ \sigma_m = \dfrac{F_{max} + F_{min}}{2A_t} = \dfrac{F_i}{A_t} + \dfrac{C\,(P_{max} + P_{min})}{2A_t} \end{cases}$$

Let $P_{max} = P_0$
$P_{min} = \alpha P_0 \quad (0 < \alpha < 1)$

$$\Rightarrow \begin{cases} \sigma_a = \overbrace{\dfrac{C P_0}{2A_t}}^{\beta}(1-\alpha) = \beta(1-\alpha) \\ \sigma_m = \dfrac{F_i}{A_t} + \dfrac{C P_0 (1+\alpha)}{2A_t} = \dfrac{F_i}{A_t} + \beta(1+\alpha) \end{cases}$$

$$\frac{\sigma_a - 0}{\sigma_m - \frac{F_i}{A_t}} = \frac{\beta(1-\alpha)}{\beta(1+\alpha)} = \frac{1-\alpha}{1+\alpha}$$

$$\Rightarrow \quad \sigma_a = \underbrace{\frac{1-\alpha}{1+\alpha}}_{\text{slope} \; G} \sigma_m - \underbrace{\frac{1-\alpha}{1+\alpha}}_{G} \frac{F_i}{A_t}$$



$$\sigma_a = G\,\sigma_m - G\,\frac{F_i}{A_t}$$

$$S.F. = \frac{\overline{AC}}{\overline{AB}} = \frac{\sigma_{ac}}{\sigma_a} \neq \frac{\sigma_{mc}}{\sigma_c}$$

Solve intersection point

$$\Rightarrow \begin{cases} \sigma_{mc} = \dfrac{S_e + G \frac{F_i}{A_t}}{G + \frac{S_e}{S_{ut}}} \\ \sigma_{ac} = \dfrac{S_{ut} - \frac{F_i}{A_t}}{\frac{1}{G} + \frac{S_{ut}}{S_e}} \end{cases} \Rightarrow S.F. = \frac{\sigma_{ac}}{\sigma_a}$$

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