Fatigue in Fasteners in tension joint.
- NOT analyzing the clamped parts. - why not?

External Force

$$P_m = \frac{1}{2}(P_{max} + P_{min})$$

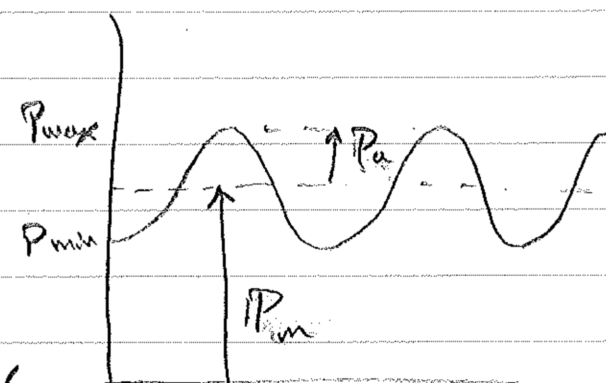
$$P_a = \frac{1}{2}(P_{max} - P_{min})$$

If $P < 0$, then set $P = 0$ — why explain

reminder $F_b = CP + F_i$

$$F_{b\,min} = CP_{min} + F_i$$

$$F_{b\,max} = CP_{max} + F_i$$

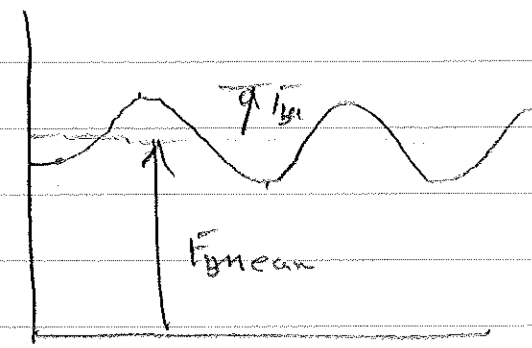


$$F_{ba} = \frac{1}{2}(F_{b\,max} - F_{b\,min})$$

$$= \frac{1}{2}(P_{max} + F_i - (P_{min} + F_i))C$$

$$F_{ba} = \underbrace{\frac{1}{2}(P_{max} - P_{min})}C$$

$$F_{ba} = CP_a$$



$$F_{bm} = \frac{1}{2}(F_{b\,max} + F_{b\,min})$$

$$= \frac{1}{2}(CP_{max} + F_i + CP_{min} + F_i)$$

$$= F_i + \frac{1}{2}\underbrace{(P_{max} + P_{min})}_{= 2P_m}C$$

$$F_{bm} = F_i + CP_m$$

Stresses in bolt (fastener):

mean: $\sigma_{bm} = \frac{F_{bm}}{A_t} = \frac{CP_m}{A_t} + \frac{F_i}{A_t}$

amplitude: $\sigma_{b-a} = \frac{F_{b-a}}{A_t} = \frac{CP_{amp}}{A_t}$

Stress concentration at threads & head fillet are ~2. Therefore, local yielding <u>will</u> occur during installation (if tightened to 50% of proof or higher).

Goodman:

$$\frac{K_f \sigma_{b-a}}{S_e} + \frac{\sigma_{b-m}}{S_{UT}} = 1$$

(If design life is $< 10^6$ cycles, replace S_e with appropriate S_{fail})

<u>NOTE</u> Table 8-17 gives values for modified endurance limit of fasteners (S_e). It <u>includes</u> stress concentration!

S_e in Table 8-17 also assumes 50% reliability and room temperature

Table 8-17 $S_e = S_e' k_a k_b k_c k_d k_e k_f \frac{1}{K_f}$

where $k_d = 1$ (room temp) and
$k_e = 1$ (50% reliability)

Since K_f is included w/ S_e of the threaded fastener, it should NOT be included w/ Goodman.

Goodman (if using S_e from Table 8-17):

$$\frac{\sigma_{b-a}}{S_e} + \frac{\sigma_{b-m}}{S_{UT}} = 1$$

$$= \frac{C P_{amp}}{A_t S_e} + \frac{C P_m + F_i}{A_t S_{UT}} = 1$$

FOS: Factor of safety is generally NOT applied to preload (F_i) – only to the applied load (P)

$$= \frac{n C P_{amp}}{A_t S_e} + \frac{n C P_m + F_i}{A_t S_{UT}} = 1$$

FOS for bolt fatigue:

$$n = \frac{S_{UT} A_t - F_i}{C \left\{ P_{amp} \frac{S_{UT}}{S_e} + P_{mean} \right\}}$$

Shigley considers $P_{min} = 0$
and lets nomenclature $P = P_{max}$

Therefore $P_{amp} = P_{mean} = \frac{1}{2} P$

Using this, FOS for bolt fatigue is:

$$n = \frac{2 S_e (S_{UT} A_t - F_i)}{CP(S_{UT} + S_e)} \quad \text{(eq 8.45)}$$

Again, S_e is from Table 8-17 which incorporates stress concentration, and also assumes room temp & 50% reliability.

Example. What is the appropiate value for S_e in eq 8.45 for a 5/16" grade 5 fastener with 99% reliability?

Table 8-17: $S_e = 18.6$ ksi (w/ 50% reliab.)
reliability factor $k_e = 1$ (for 50%)
$k_e = 0.814$ (for 99% rel.)

$$(S_e)_{99\%} = 0.814 (S_e)_{50\%} = 0.814 (18.6 \text{ ksi})$$

for eq 8.45: $S_e = 15.1$ ksi