MET 4501 Fall 2024: In-Class Quiz 3 Name: SOLUTION

INSTRUCTIONS:

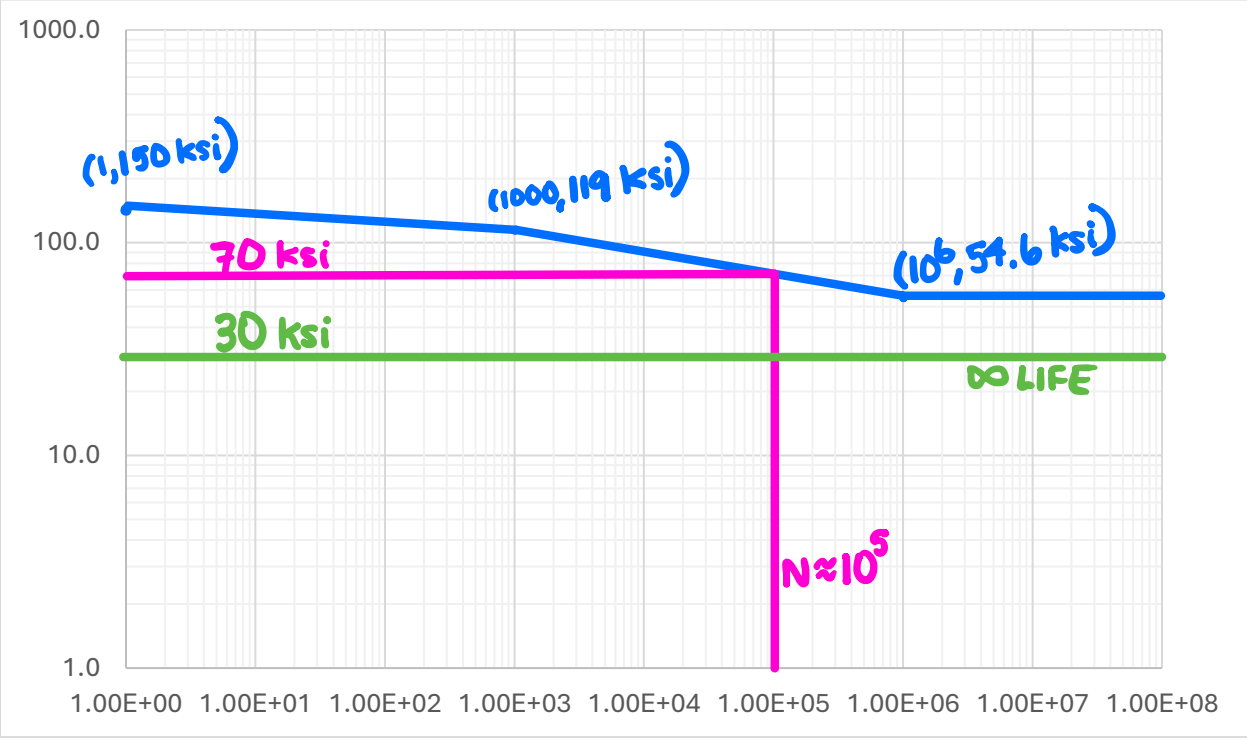
This quiz is open-book and open-note, and you may work with your classmates. Please answer all questions and show all of your work.

GIVEN:

A 1.5-in-diameter rod has a tensile strength of 150 ksi and is loaded in rotating bending. The surface finish is ground.

FIND:

1) The fully corrected endurance limit for the rod, S_e.
2) Sketch and label the S-N diagram using the axes provided below.
3) The life of the rod if it is loaded in completely reversed bending with a maximum stress of 70 ksi. If infinite life is predicted, what is the factor of safety?
4) The life of the rod if it is loaded in completely reversed bending with a maximum stress of 30 ksi. If infinite life is predicted, what is the factor of safety?



BONUS:

a) How would the rod's life change if the surface was machined instead of ground? Briefly justify your choice.

- ● The rod's life would decrease
- O The rod's life would remain the same.
- O The rod's life would increase.

ROUGHER SURFACE WOULD DECREASE LIFE (MORE POSSIBLE CRACK INITIATION SITES)

b) How would the rod's life change if the diameter was decreased to 1 inch? Briefly justify your choice.

- O The rod's life would decrease
- O The rod's life would remain the same.
- ● The rod's life would increase.

SMALLER VOLUME WOULD INCREASE LIFE DUE TO LESS VOIDS/DEFECTS (LESS POSSIBLE CRACK INITIATION SITES)

1) $S_{ut} = 150$ ksi

$S_e' = 0.5 S_{ut} = 75$ ksi

$S_e = k_a k_b k_c k_d k_e S_e'$

$k_a = a(S_{ut})^b$

TABLE 6-2, GROUND FINISH: $a = 1.21$, $b = -0.067$

$k_a = 1.21(150)^{-0.067} = 0.865$

FOR ROTATING BENDING:

$k_b = 0.879 d^{-0.107}$

$= 0.879(1.5)^{-0.107} = 0.842$

$k_c = 1$ (BENDING)

$k_d = 1$ (ASSUME ROOM TEMP)

$k_e = 1$ (ASSUME 50% RELIABILITY)

$$S_e = (0.865)(0.842)(1)(1)(1)(75\ \text{ksi})$$

$$\boxed{S_e = 54.6\ \text{ksi}}$$

2) $f = 1.06 - 2.8(10^{-3})S_{ut} + 6.9(10^{-6})S_{ut}^2$

$= 0.795$

$fS_{ut} = 119$ ksi ← PLOT ON S-N CURVE AT N=1000 CYCLES

3) $$a = \frac{(fS_{ut})^2}{S_e} = \frac{(119)^2}{54.6} = 260.6$$

$$b = -\frac{1}{3}\log\left(\frac{fS_{ut}}{S_e}\right) = -\frac{1}{3}\log\left(\frac{119}{54.6}\right)$$

$$b = -0.113$$

$$N = \left(\frac{\sigma_{ar}}{a}\right)^{1/b} = \left(\frac{70}{260.6}\right)^{1/-0.113} = \boxed{111{,}000 \text{ CYCLES TO FAIL}}$$

4) INFINITE LIFE PREDICTED

$(\sigma_{ar} < S_e)$

$$n = \frac{S_e}{\sigma_{ar}} = \frac{54.6}{30} = \boxed{1.82}$$