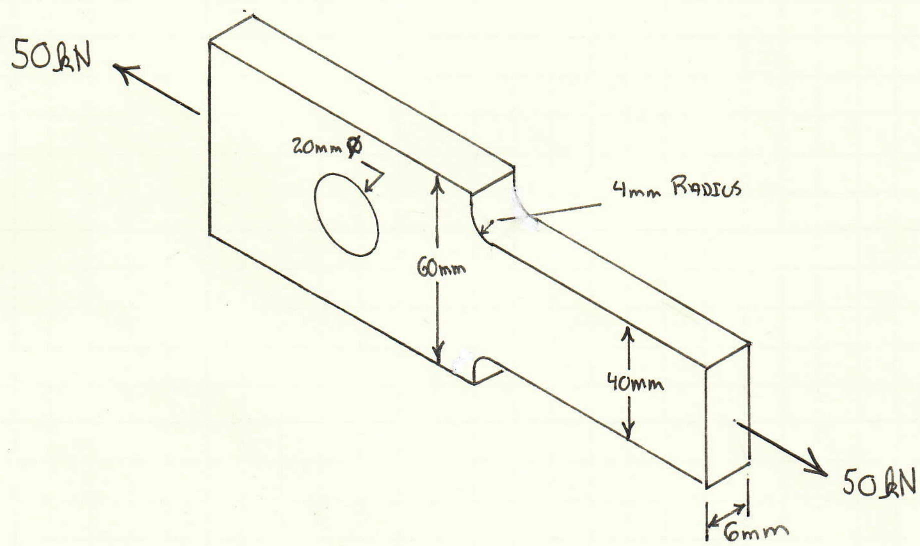
PROBLEM 7.47 | THE BAR SHOWN IS MACHINED FROM STEEL WITH $S_y = 420\,MPa$ AND $S_u = 560\,MPa$. THE AXIAL FORCE OF 50 kN IS COMPLETELY REVERSING. ESTIMATE THE NUMBER OF CYCLES TO FAILURE.

GIVEN:
1. MACHINED STEEL BAR
2. $S_y = 420\,MPa$, $S_u = 560\,MPa$
3. 20mm DIA HOLE IN SECTION OF WIDTH 60mm
4. RADII OF TRANSITION FROM 60mm TO 40mm WIDTH IS 4mm
5. THICKNESS OF BAR 6mm
6. 50 kN LOADING ON BAR IS COMPLETELY REVERSING.

ASSUMPTIONS:
1. LINEAR ELASTIC RESPONSE

FIND:
1. NUMBER OF CYCLES TO FAILURE.

FIGURE:



SOLUTION:

THE AVERAGE STRESS IN THE TWO SECTIONS OF THE BAR ARE

$$\sigma_{60} = \frac{50\,kN}{(0.06m)(0.006m)} = 138.9\,MPa \quad (1)$$

$$\sigma_{40} = \frac{50\,kN}{(0.04m)(0.006m)} = 208.3\,MPa \quad (2)$$

THE AVERAGE STRESS THROUGH THE CENTER OF THE HOLE IN THE 60mm SECTION

$$\sigma_{60,H} = \frac{50\,kN}{(0.06m-0.02m)(0.006m)} = 208.3\,MPa \quad (3)$$

THE AVERAGE STRESS AT THE HOLE AND IN THE 40mm SECTION ARE THE SAME. THE 208.3MPa STRESS LEVEL REPRESENTS THE MAXIMUM AVERAGE STRESS IN THE BAR; THEREFORE THE REMAINDER OF THE PROBLEM FOCUSES ON THIS VALUE OF STRESS.

THE S-N CURVE NEEDS TO BE CALCULATED. THE FIRST POINT ON THE S-N CURVE IS

$$0.9 \cdot S_{UT} = 0.9(560\,MPa) = \underline{504\,MPa \text{ @ } 10^3 \text{ CYCLES}} \quad (4)$$

THE SECOND POINT IS S_e @ 10^6 CYCLES. THE VALUE FOR S_e OF THIS BAR MUST BE CALCULATED. FROM LECTURE 15

$$S_e' = 0.5 \cdot S_{UT} = (0.5)(560\,MPa) = 280\,MPa$$

$$S_e = k_a \cdot k_b \cdot k_c \cdot k_d \cdot k_e \cdot k_f \cdot S_e' = (0.75)(0.85)(0.4902)(280\,MPa) = 87.5\,MPa$$

- $k_a = 0.75$ (machine finish)
- $k_b = 0.85$ (size effect)
- $k_c = 1$ (Reliability)
- $k_d = 1$ (Temperature)
- $k_e = 1/K_{f,H} = 1/2.04 = \underline{0.4902}$ $\quad 1/K_{f,R} = 1/1.88 = 87.5\,MPa$
  - $K_{T,H} = 2.3$ (BUDYNAS 2ND APP. F) $\quad d/w = 20mm/60mm = 1/3 = 0.333$
    $K_{fH} = 1 + q(K_{T,H} - 1) = 1 + 0.8(2.3-1) = 2.04$
    - $q = 0.8$ (LECTURE 15 pg 22)
  - $K_{T,R} = 2.1$ (BUDYNAS 2ND APP F) $D/d = \frac{60}{40} = 1.5 \quad r/d = 4/40 = .1$
    $K_{f,R} = 1 + q(K_{T,R} - 1) = 1 + .8(2.1-1) = 1.88$
    - $q = 0.8$ (Lecture 15 pg 22

THE PARAMETERS FOR THE S-N CURVE CAN NOW BE CALCULATED

$$m = \frac{1}{3} \cdot \log \frac{0.9 \cdot S_{UT}}{S_e} = \frac{1}{3} \log \frac{0.9(560\,MPa)}{87.5\,MPa} = 0.2535$$

$$b = \log \frac{(0.9 \cdot S_{UT})^2}{S_e} = \log \frac{(0.9 \cdot 560\,MPa)^2}{87.5\,MPa} = 3.464 \log MPa$$

GIVEN THE REVERSING STRESS OF 208.3 MPa

$$N = \frac{10^{b/m}}{S_f^{\,1/m}} = \frac{10^{3.464 \log MPa / 0.2535}}{(208.3\,MPa)^{1/0.2535}} = \frac{10^{3.464/0.2535} \; 10^{\log MPa}}{(208.3\,MPa)^{1/0.2535}}$$

$$= \boxed{33.0(10^3) \text{ CYCLES}}$$

SUMMARY:

THE SN DIAGRAM WAS CONSTRUCTED USING THE CORRECTED ENDURANCE LIMIT THAT ACCOUNTS FOR THE SPECIFIC CONDITIONS OF THE COMPONENT BEING CONSIDERED.