PROBLEM 6-9

Statement: **For the Vise Grip plier-wrench is drawn to scale in Figure P6-3, and for which the forces were analyzed in Problem 3-9 and the stresses in Problem 4-9, find the safety factors for each pin fo an assumed clamping force of P = 4000 N in the position shown. The pins are 8-mm dia, S_y = 400 MPa, S_{ut} = 520 MPa, and are all in double shear. Assume a desired finite life of 5E4 cycles**

Units: $N := newton$ $kN := 10^3 \cdot N$ $MPa := 10^6 \cdot Pa$

Given:

Pin stresses as calculated in Problem 4-9:

Pin 1-2	$\tau_{12} := 74.6 \cdot MPa$	Yield strength	$S_y := 400 \cdot MPa$
Pin 1-4	$\tau_{14} := 50.7 \cdot MPa$	Tensile strength	$S_{ut} := 520 \cdot MPa$
Pin 2-3	$\tau_{23} := 50.7 \cdot MPa$	Pin diameter	$d := 8 \cdot mm$
Pin 3-4	$\tau_{34} := 50.7 \cdot MPa$	Desired life	$N_{life} := 5 \cdot 10^4$

Assumptions: 1. Links 3 and 4 are in a toggle position, i.e., the pin that joins links 3 and 4 is in line with the pins that join 1 with 4 and 2 with 3.

Solution: See Figure 6-9 and Mathcad file P0609.

1. The FBDs of the assembly and each individual link are shown in Figure 6-9. The dimensions, as scaled from Figure P5-3 in the text, are shown on the link FBDs.

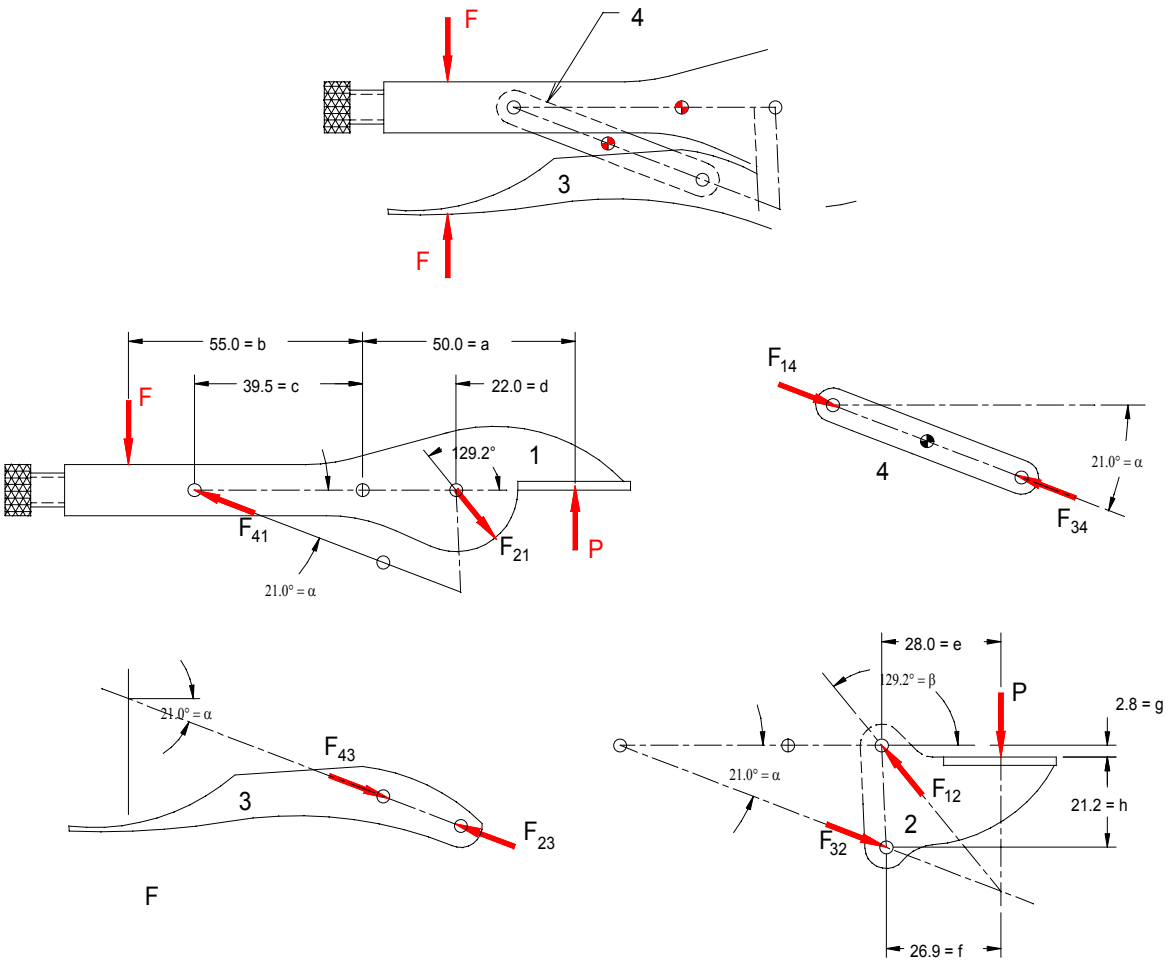

FIGURE 6-9
Free Body Diagrams for Problem 6-9

2. The pins are in pure shear, so the principal stresses are

Pin joining 1 and 2	$\sigma'_{12} := \sqrt{3}\cdot\tau_{12}$	$\sigma'_{12} = 129.211\,MPa$
All other pins	$\sigma'_{14} := \sqrt{3}\cdot\tau_{14}$	$\sigma'_{14} = 87.815\,MPa$

3. This is a case of repeated fatigue loading. The alternating and mean von Mises stress components are:

Pin joining 1 and 2	$\sigma'_{12a} := 0.5\cdot\sigma'_{12}$	$\sigma'_{12m} := \sigma'_{12a}$
All other pins	$\sigma'_{14a} := 0.5\cdot\sigma'_{14}$	$\sigma'_{14m} := \sigma'_{14a}$

4. Calculate the unmodified endurance limit. $S'_e := 0.5\cdot S_{ut}$ $S'_e = 260\,MPa$

5. Calculate the endurance limit modification factors for a non rotating round pin (uniformly stressed).

Load $C_{load} := 1$

Size $A_{95} := \dfrac{\pi\cdot d^2}{4}$ $A_{95} = 50.265\,mm^2$

$d_{equiv} := \sqrt{\dfrac{A_{95}}{0.0766}}$ $d_{equiv} = 25.617\,mm$

$C_{size} := 1.189\cdot\left(\dfrac{d_{equiv}}{mm}\right)^{-0.097}$ $C_{size} = 0.868$

Surface $A := 4.51$ $b := -0.265$ (machined)

$C_{surf} := A\cdot\left(\dfrac{S_{ut}}{MPa}\right)^{b}$ $C_{surf} = 0.86$

Temperature $C_{temp} := 1$

Reliability $C_{reliab} := 1.000$ (R = 50%)

6. Calculate the modified endurance limit.

$S_e := C_{load}\cdot C_{size}\cdot C_{surf}\cdot C_{temp}\cdot C_{reliab}\cdot S'_e$ $S_e = 194.07\,MPa$

7. Using equation (6.9), calculate the fatigue strength at $N = 10^3$ cycles. $S_m := 0.9\cdot S_{ut}$ $S_m = 468\,MPa$

8. The equation for the *S-N* curve in the HCF region is given by equation (6.10a): $S_f = a\cdot N^b$

9. Determine the constants *a* and *b* from equations (6.10c) and (6.10a). From Table 6-5, for $N = 10^6$, $z := -3.000$

$b := \dfrac{1}{z}\cdot\log\left(\dfrac{S_m}{S'_e}\right)$ $b = -0.0851$

$$a := \frac{S_m}{\left(10^3\right)^b} \qquad a = 842.4\,MPa$$

10. Calculate the corrected fatigue strength at $N_{life} = 5 \times 10^4$ cycles. $S_f := a \cdot N_{life}^{\ b}$ $S_f = 335.49\,MPa$

11. Assuming a Case 3 load line, use equation (6.18e) to determine the factor of safety.

Pin joining 1 and 2 $N_f := \dfrac{S_f S_{ut}}{\sigma'_{12a} \cdot S_{ut} + \sigma'_{12m} \cdot S_f}$ $N_f = 3.2$

All other pins $N_f := \dfrac{S_f S_{ut}}{\sigma'_{14a} \cdot S_{ut} + \sigma'_{14m} \cdot S_f}$ $N_f = 4.6$