Pedal axle calculations:

Input values:

Axle diameter: $d := 12 \cdot mm$

Shank diameter: $D := 18 \cdot mm$

Originl fillet radius: $r := 2.0 \cdot mm$

Compound fillet radius: $r_2 := 6.0 \cdot mm$

Compound fillet radius: $r_1 := 1.4 \cdot mm$

Diameter at line II: $d_1 := 13.6 \cdot mm$

$ORIGIN \equiv 1$

Calculation:

Using Knovel Graph Digitizer for Chart 3.10:

Original condition: $\frac{r}{d} = 0.167$

$\frac{D}{d} = 1.5$

Thus, the stress concentration factor is: $K_t := 1.548$

At circumferential line I: $\frac{r_2}{d} = 0.5$

$\frac{D}{d} = 1.5$

In this case, the stress concentration factor i about: $K_{tI} := 1.322$

$$\Delta\sigma := \frac{K_t - K_{tI}}{K_t}$$

Stress reduction: $\Delta\sigma = 15 \cdot \%$

At circumferential line II: $\frac{r_1}{d_1} = 0.103$

$$\frac{D}{d_1} = 1.324$$

The stress concentration factor is: $K_{tII} := 1.703$

Although the nominal diameter is larger at this section

Nominal stresses: $\sigma_{nomII} = \frac{32 \cdot M}{\pi \cdot d_1^3}$

$$\sigma_{nomI} = \frac{32 \cdot M}{\pi \cdot d^3}$$

$$K_\sigma = \frac{\sigma_{nomII}}{\sigma_{nomI}}$$

Nominal stress reduction: $K_\sigma := \frac{d^3}{d_1^3}$ $\quad K_\sigma = 0.687$

Maximum stresses: $\sigma_{maxII} = \sigma_{nomII} \cdot K_{tII} = \sigma_{nom} \cdot K_{tII} \cdot K_\sigma$

$$\sigma_{maxI} = \sigma_{nom} \cdot K_{tI}$$

$$\sigma_{maxII} = \sigma_{maxI} \cdot \frac{K_{tII} \cdot K_\sigma}{K_{tI}}$$

$$\sigma_{rel} = \frac{\sigma_{maxII}}{\sigma_{maxI}} = \frac{K_{tII} \cdot K_\sigma}{K_{tI}}$$

$$\sigma_{rel} := \frac{K_{tII} \cdot K_\sigma}{K_{tI}} \quad \sigma_{rel} = 0.885$$

the maximum stress σ_{max2} is smaller than σ_{max1}.
Consequently, stress reduction using double radius fillet is $\Delta\sigma = 15 \cdot \%$

Using the equations to calculate stress concentration factors:

Shoulder height: $t := (D - d) \cdot 0.5$ $\qquad t = 3 \cdot mm$

$$tr := \frac{t}{r} \qquad tr = 1.5$$

$$C := \begin{cases} \begin{pmatrix} 0.947 + 1.206 \cdot \sqrt{tr} - 0.13 \cdot tr \\ 0.022 - 3.405 \cdot \sqrt{tr} + 0.915 \cdot tr \\ 0.869 + 1.777 \cdot \sqrt{tr} - 0.555 \cdot tr \\ -0.810 + 0.422 \cdot \sqrt{tr} - 0.260 \cdot tr \end{pmatrix} & \text{if } tr \le 2 \\ \begin{pmatrix} 1.232 + 0.832 \cdot \sqrt{tr} - 0.008 \cdot tr \\ -3.813 + 0.968 \cdot \sqrt{tr} - 0.260 \cdot tr \\ 7.423 - 4.868 \cdot \sqrt{tr} + 0.869 \cdot tr \\ -3.839 + 3.070 \cdot \sqrt{tr} - 0.600 \cdot tr \end{pmatrix} & \text{otherwise} \end{cases}$$

Stress concentration factor, original condition:

$$K_t := C_1 + C_2 \cdot \left(\frac{2 \cdot t}{D}\right) + C_3 \cdot \left(\frac{2 \cdot t}{D}\right)^2 + C_4 \cdot \left(\frac{2 \cdot t}{D}\right)^3$$

$$K_t = 1.524$$

At circumferential line I:

If filleting radius: $r_2 = 6 \cdot mm$

$$tr := \frac{t}{r_2} \qquad tr = 0.5$$

$$C := \begin{cases} \begin{pmatrix} 0.947 + 1.206\cdot\sqrt{tr} - 0.13\cdot tr \\ 0.022 - 3.405\cdot\sqrt{tr} + 0.915\cdot tr \\ 0.869 + 1.777\cdot\sqrt{tr} - 0.555\cdot tr \\ -0.810 + 0.422\cdot\sqrt{tr} - 0.260\cdot tr \end{pmatrix} & \text{if } tr \le 2 \\ \begin{pmatrix} 1.232 + 0.832\cdot\sqrt{tr} - 0.008\cdot tr \\ -3.813 + 0.968\cdot\sqrt{tr} - 0.260\cdot tr \\ 7.423 - 4.868\cdot\sqrt{tr} + 0.869\cdot tr \\ -3.839 + 3.070\cdot\sqrt{tr} - 0.600\cdot tr \end{pmatrix} & \text{otherwise} \end{cases}$$

$$K_{tI} := C_1 + C_2\cdot\left(\frac{2\cdot t}{D}\right) + C_3\cdot\left(\frac{2\cdot t}{D}\right)^2 + C_4\cdot\left(\frac{2\cdot t}{D}\right)^3$$

$K_{tI} = 1.274$

$$\Delta\sigma := \frac{K_t - K_{tI}}{K_t}$$

Stress reduction: $\Delta\sigma = 16\cdot\%$

At circumferential line II:

Partial shoulder height: $t := (D - d_1) \cdot 0.5$ $\qquad t = 2.2 \cdot mm$

$$tr := \frac{t}{r_1} \qquad tr = 1.571$$

$$C := \left| \begin{array}{ll} \begin{pmatrix} 0.947 + 1.206 \cdot \sqrt{tr} - 0.13 \cdot tr \\ 0.022 - 3.405 \cdot \sqrt{tr} + 0.915 \cdot tr \\ 0.869 + 1.777 \cdot \sqrt{tr} - 0.555 \cdot tr \\ -0.810 + 0.422 \cdot \sqrt{tr} - 0.260 \cdot tr \end{pmatrix} & \text{if } tr \le 2 \\ \begin{pmatrix} 1.232 + 0.832 \cdot \sqrt{tr} - 0.008 \cdot tr \\ -3.813 + 0.968 \cdot \sqrt{tr} - 0.260 \cdot tr \\ 7.423 - 4.868 \cdot \sqrt{tr} + 0.869 \cdot tr \\ -3.839 + 3.070 \cdot \sqrt{tr} - 0.600 \cdot tr \end{pmatrix} & \text{otherwise} \end{array} \right.$$

Stress concentration factor:

$$K_{tII} := C_1 + C_2 \cdot \left(\frac{2 \cdot t}{D}\right) + C_3 \cdot \left(\frac{2 \cdot t}{D}\right)^2 + C_4 \cdot \left(\frac{2 \cdot t}{D}\right)^3$$

$$K_{tII} = 1.691$$

$$\sigma_{rel} := \frac{K_{tII} \cdot K_{\sigma}}{K_{tI}} \qquad \sigma_{rel} = 0.912$$

the maximum stress σ_{max2} is smaller than σ_{max1}.
Consequently, stress reduction using double radius fillet is $\qquad \Delta\sigma = 16 \cdot \%$