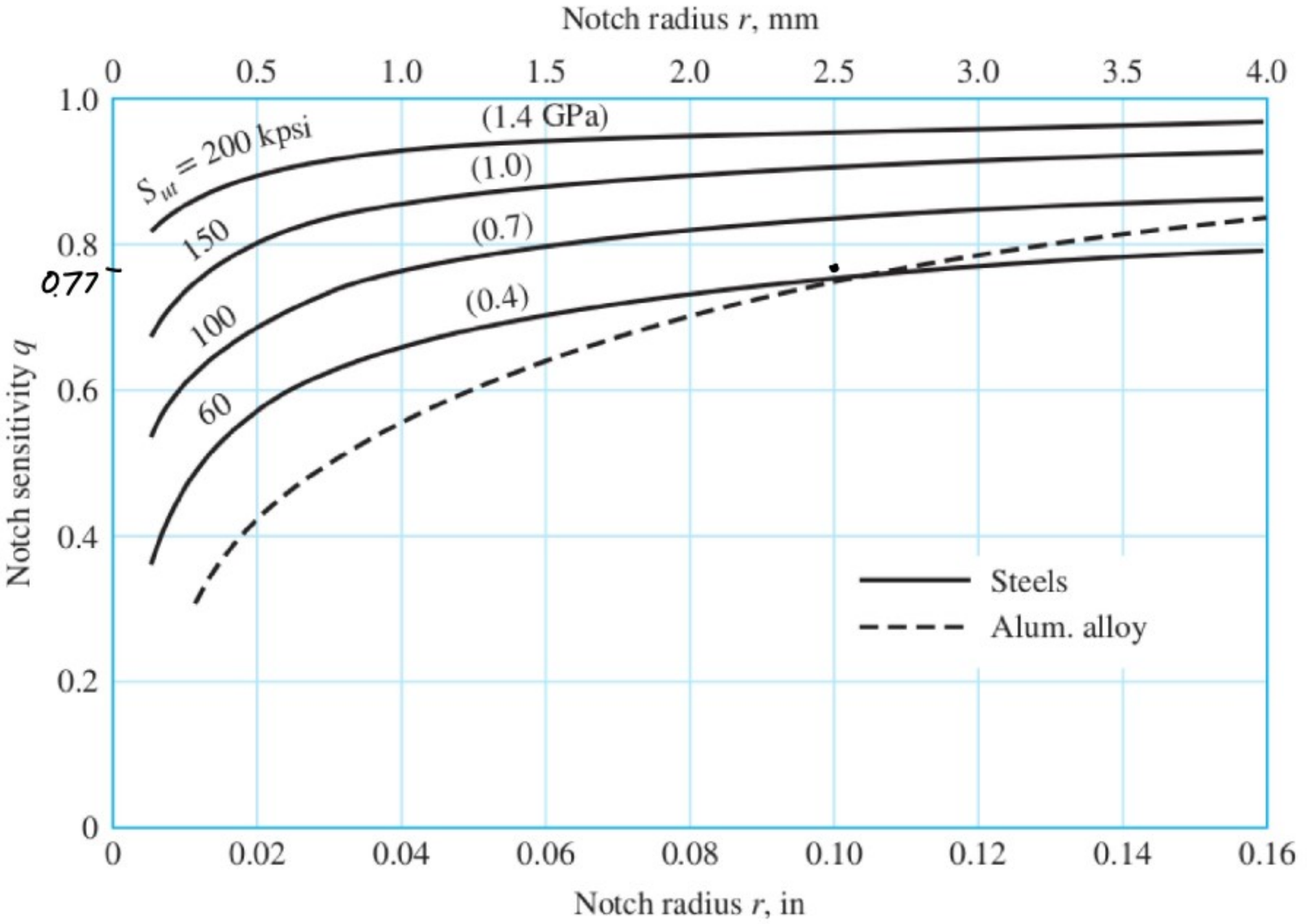
$$A = \sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2}$$

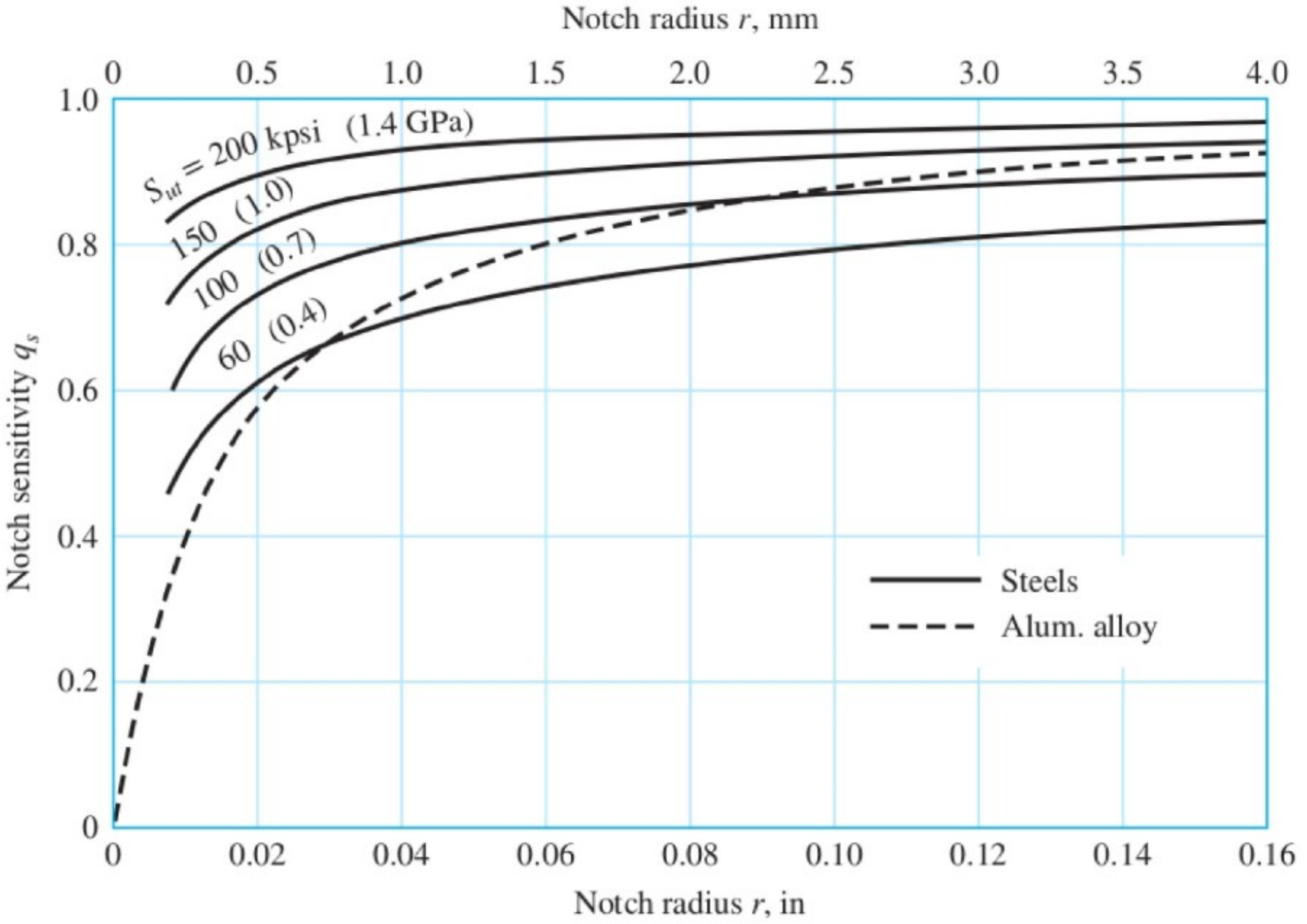
6-26

Bending


Notch radius r, mm
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1.0
0.8
0.6
0.4
0.2
0
0.77
Notch sensitivity q
S_ut = 200 kpsi
(1.4 GPa)
(1.0)
(0.7)
(0.4)
150
100
60
Steels
Alum. alloy
0
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
Notch radius r, in

G- 27

Torsion


Notch radius r, mm
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1.0
0.8
0.6
0.4
0.2
0
Notch sensitivity q_s
S_{ut} = 200 kpsi (1.4 GPa)
150 (1.0)
100 (0.7)
60 (0.4)
Steels
Alum. alloy
0
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
Notch radius r, in

$$K_f < K_t$$

$$\sigma_a = K_f \sigma_{a0} \qquad \tau = K_{fs} \tau_0$$

$$\sigma_m = K_f \sigma_{m0}$$

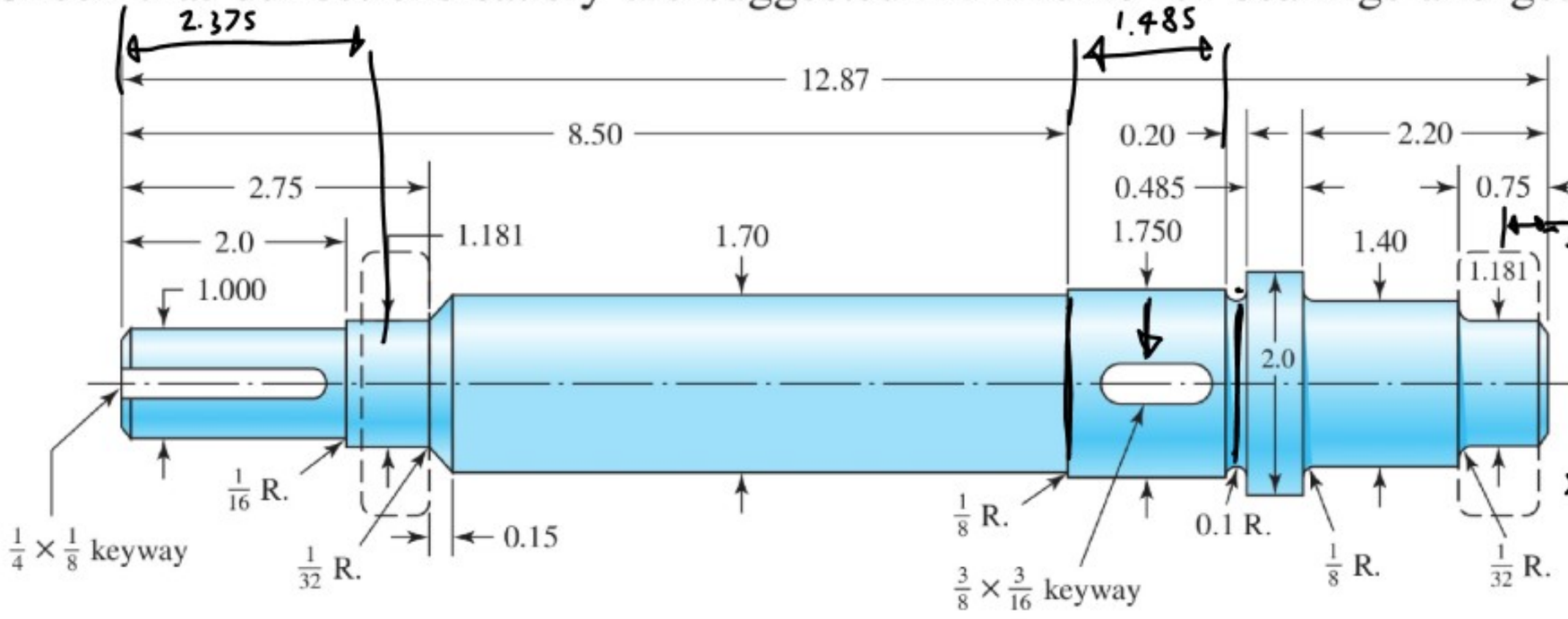
$$K_f = 1 + q(K_t - 1) \qquad K_{fs} = 1 + q_s(K_{ts} - 1)$$

The shaft shown in the figure is driven by a gear at the right keyway, drives a fan at the left keyway, and is supported by two deep-groove ball bearings. The shaft is made from AISI 1020 cold-drawn steel. At steady-state speed, the gear transmits a radial load of 230 lbf and a tangential load of 633 lbf at a pitch diameter of 8 in.

(*a*) Determine fatigue factors of safety at any potentially critical locations using the DE-Gerber failure criterion.

(*b*) Check that deflections satisfy the suggested minimums for bearings and gears.

$S_{ut} = 63$ kpsi



$a = 8.5 + \frac{1.485}{2} - 2.375$

$= 6.8675$ in

$l = 12.87 - 0.375 - 2.375$

$= 10.12$

$X = 8.5 - 2.375 + 1.485$

$= 7.61$

$$A = \sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2}$$

$$B = \sqrt{4(K_f M_m)^2 + 3(K_{fs} T_m)^2} = 0$$

$$A = \sqrt{4(1.924 \cdot 392)^2} = 1508$$

$$K_f = 1 + q(K_t - 1) = 1 + 0.77(2.2 - 1)$$
$$= 1.924$$

$$M_a = \frac{F_a}{9}(9 - x)$$

$$= \frac{230\ (6.37)}{10.12}(10.12 - 7.61) = 392\ lb\ in$$

$D = 2$ in

$d = 1.75 - 2(0.1) = 1.55$ in

$r = 0.1$ in

$D/d = 2/1.55 = 1.29$

$r/d = 0.1/1.55 = 0.065$

$K_t = 2.2$

$$\frac{1}{n} = \frac{8A}{\pi d^3 S_e}\left(1+\sqrt{1+\left(\frac{2D\,S_e}{A\,S_{ut}}\right)^2}\right) = \frac{8A}{\pi d^3 S_e}\left(1+\sqrt{1}\right) = \frac{16A}{\pi d^3 S_e} = \frac{16(1508)}{\pi(1.55)^3\ 22.5\times10^3} = 0.091$$

$$\frac{1}{91.6} = n = 10.9$$

$S_e' = 0.5\ S_{ut} = 0.5(68) = 34$ kpsi

$S_e = S_e' k_a k_b k_c k_d k_e = 34 \cdot 0.79 \cdot 0.879(1.55)^{-0.107} \cdot 1 \cdot 1 = 22.5$ kpsi

$$y_{AB} = \frac{Fbx}{6EIl}(x^2 + b^2 - l^2)$$

$$= \frac{230(3.25)x}{6(30\times10^6)\,0.9(10.12)}(x^2 + 3.25^2 - 10.12^2)$$

$$= 1\times10^{-6} \times (x^3 + 10.56 - 102)$$

$$= 1\times10^{-6}x^3 - 9.4\times10^{-5}x$$

$$\frac{dy_{AB}}{dx} = 3.1\times10^{-6}x^2 - 9.4\times10^{-5}$$

$$= 3\times10^{-6}x^2 - 9.4\times10^{-5}$$

$$\left.\frac{dy_{AB}}{dx}\right|_{x=0} = -9.4\times10^{-5}$$

$$y_{BC} = \frac{Fa(l-x)}{6EIl}(x^2 + a^2 - 2lx)$$

$a + b = l$

$6.8675 + b = 10.12$

$b = 10.12 - 6.8675$

$= 3.2525$

$$I = \frac{\pi d^4}{64} = \frac{\pi(1.7)^4}{64}$$

$$= 0.4$$