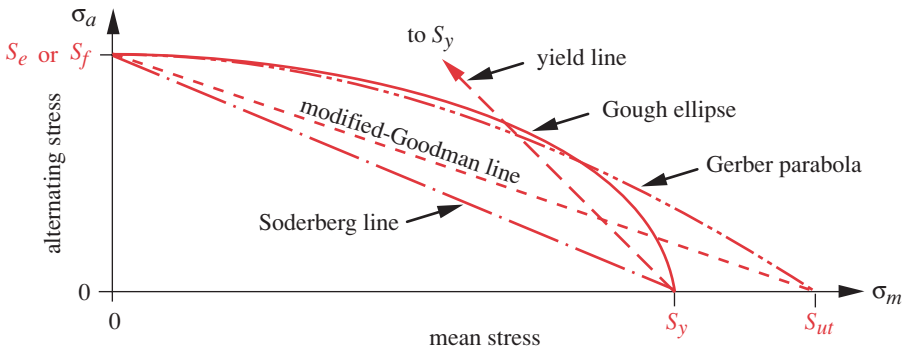

FIGURE 10-4

Elliptical Failure Line Using Yield Strength Shown with Other Failure Lines for Fluctuating Stresses

If we now also assume that the axial load on the shaft is zero and substitute equations 10.2*c*, 10.3*c*, and 10.7*a* into equation 10.7*b* we get

$$d = \left\{ \frac{32N_f}{\pi} \left[\frac{\sqrt{\left(K_f M_a\right)^2 + \frac{3}{4}\left(K_{fs} T_a\right)^2}}{S_f} + \frac{\sqrt{\left(K_{fm} M_m\right)^2 + \frac{3}{4}\left(K_{fsm} T_m\right)^2}}{S_{ut}} \right] \right\}^{\frac{1}{3}} \quad (10.8)$$

which can be used as a design equation to find a shaft diameter for any combination of bending and torsional loading with the assumptions noted above of zero axial load and a constant ratio between alternating and mean values of load over time.

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EXAMPLE 10-1

Shaft Design for Steady Torsion and Fully Reversed Bending

Problem **Design a shaft to support the attachments shown in Figure 10-5 with a minimum design safety factor of 2.5.**

Given **A preliminary design of the shaft configuration is shown in Figure 10-5. It must transmit 2 hp at 1 725 rpm. The torque and the force on the gear are both constant with time.**

Assumptions **There are no applied axial loads. Steel will be used for infinite life. Assume a stress-concentration factor of 3.5 for the step radii in bending, 2 for step radii in torsion, and 4 at the keyways.* Since the torque is steady and the bending moment fully reversed, the ASME method of equation 10.6 can be used, and it will be compared to the general method using equation 10.8.**

Solution **See Figures 10-5 through 10-8.**

1 First determine the transmitted torque from the given power and angular velocity using equation 10.1 (p. 553).

* See R. E. Peterson, *Stress Concentration Factors*, John Wiley, 1974, Figures 72, 79, and 183, which show these numbers as approximate maxima for these contours and loadings. Since we are creating a preliminary design at this stage and have not yet defined the shaft geometry in detail, it is not fruitful to try to define these factors any more accurately. This can be done later and the design refined accordingly.