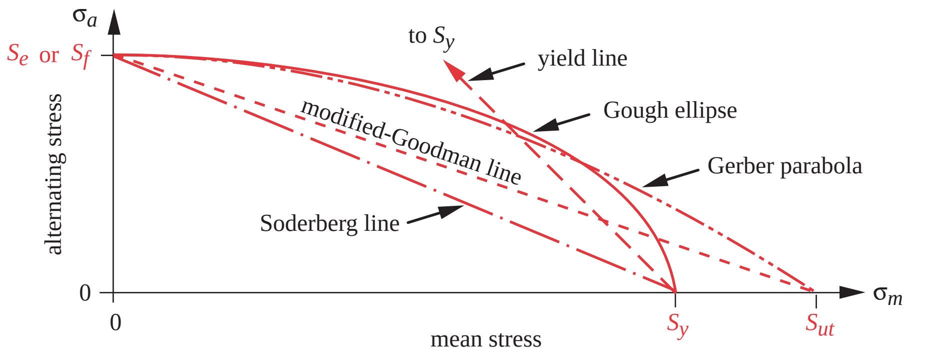

FIGURE 9-4

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

Figure 9-4 shows the Gough elliptical failure line of Figure 9-3 superposed on the Gerber, Soderberg, and modified-Goodman lines. Note that the elliptical line closely matches the Gerber line at the left-hand end but diverges to intersect the yield strength on the mean stress axis. The elliptical line has the advantage of accounting for possible yielding without needing to introduce an additional constraint involving the yield line. However, the Gough elliptical line, while a good fit to the failure data, is less conservative than the combination of Goodman line and yield line used as a failure envelope.

9

Design for Fluctuating Bending and Fluctuating Torsion

When the torque is not constant, its alternating component will create a complex multiaxial stress state in the shaft. Then the approach described in Section 6.12 (p. 398), which computes the von Mises components of the alternating and mean stresses using equations 6.22 (p. 400), can be used. A rotating shaft in combined bending and torsion has a biaxial stress state, which allows the two-dimensional version of equation 6.22*b* to be used.

$$\sigma'_a = \sqrt{\sigma_a^2 + 3\tau_a^2}$$
$$\sigma'_m = \sqrt{\left(\sigma_m + \sigma_{m_{axial}}\right)^2 + 3\tau_m^2} \qquad (9.7a)$$

These von Mises stresses can now be entered into a modified-Goodman diagram (MGD) for a chosen material to find a safety factor, or equations 6.18 (pp. 386–389) can be applied without drawing the MGD.

For design purposes, where the diameter of the shaft is the desired quantity to be found, equations 9.2, 9.3, and 9.6 as presented require iteration to find a value for *d*, given some known loads and assumed material properties. This is not a great difficulty