Note that we can express the distance b in terms of the prime circle radius R_p and the eccentricity ε, by the construction shown in Figure 8-45. Swing the arc of radius R_p until it intersects the axis of motion of the follower at point D. This defines the length of line d from effective link 1 to this intersection. This is constant for any chosen prime circle radius R_p. Points A, C, and $I_{2,4}$ form a right triangle whose upper angle is the pressure angle ϕ and whose vertical leg is $(s + d)$, where s is the instantaneous displacement of the follower. From this triangle:

$$c = b - \varepsilon = (s + d)\tan\phi$$

and (8.31a)

$$b = (s + d)\tan\phi + \varepsilon$$

Then from equation 8.30,

$$v = (s + d)\tan\phi + \varepsilon \tag{8.31b}$$

and from triangle CDO_2,

$$d = \sqrt{R_P^2 - \varepsilon^2} \tag{8.31c}$$

Substituting equation 8.31c into equation 8.31b and solving for ϕ gives an expression for pressure angle in terms of displacement s, velocity v, eccentricity ε, and the prime circle radius R_p.

$$\phi = \arctan\frac{v - \varepsilon}{s + \sqrt{R_P^2 - \varepsilon^2}} \tag{8.31d}$$

8

The velocity v in this expression is in units of length/rad, and all other quantities are in compatible length units. We have typically defined s and v by this stage of the cam design process and wish to manipulate R_p and ε to get an acceptable maximum pressure angle ϕ. As R_p is increased, ϕ will be reduced. The only constraints against large values of R_p are the practical ones of package size and cost. Often there will be some upper limit on the size of the cam-follower package dictated by its surroundings. There will always be a cost constraint and bigger = heavier = more expensive.

Choosing a Prime Circle Radius

Both R_p and ε are within a transcendental expression in equation 8.31d, so they cannot be conveniently solved for directly. The simplest approach is to assume a trial value for R_p and an initial eccentricity of zero, and use program DYNACAM; your own program; or an equation solver such as *Matlab*, *TKSolver* or *Mathcad* to quickly calculate the values of ϕ for the entire cam, and then adjust R_p and repeat the calculation until an acceptable arrangement is found. Figure 8-46 (p. 434) shows the calculated pressure angles for a four-dwell cam. Note the similarity in shape to the velocity functions for the same cam in Figure 8-6 (p. 385), as that term is dominant in equation 8.31d.

USING ECCENTRICITY If a suitably small cam cannot be obtained with acceptable pressure angle, then eccentricity can be introduced to change the pressure angle. Using eccentricity to control the pressure angle has its limitations. For a positive ω, a positive value of eccentricity will *decrease the pressure angle on the rise* but will *increase it on the fall*. Negative eccentricity does the reverse.