and $s(\theta)$ is the arm rotation angle at each cam position θ. The follower centerline coordinates for each cam angle θ are then:

$$\begin{aligned} x_f(\theta) &= b' \cos\left[\gamma - \operatorname{sgn}(\omega_{cam})\theta - \operatorname{sgn}(\omega_{arm})\psi(\theta)\right] \\ y_f(\theta) &= b' \sin\left[\gamma - \operatorname{sgn}(\omega_{cam})\theta - \operatorname{sgn}(\omega_{arm})\psi(\theta)\right] \end{aligned} \tag{13.9}$$

Note that there are four cases, one for each permutation of the directions of rotation of cam and follower arm. These are accounted for by applying the algebraic signs of their respective rotations (according to the right-hand rule) in equations 13.7 and 13.9. The negative signs on the *sgn* functions reflect the inversion of the follower around the cam in the opposite direction to cam rotation. So, if the cam is in fact stationary, equations 13.9 need to use a virtual cam rotation that is opposite to the actual follower rotation.

CAM SURFACE COORDINATES Figure 13-4 shows an oscillating roller follower in an arbitrary (inverted) position on a rise. The initial position of the follower at $\theta = 0$ is shown dotted. The cam angle is θ and the pressure angle at this position is $\phi(\theta)$. The roller centerline is at coordinates x_f, y_f as defined in equations 13.9. The point of contact x_s, y_s between cam and a roller of radius R_f lies along the common normal defined by angle $\phi(\theta)$. The angle of the follower arm at any cam angle θ is

$$\lambda(\theta) = \theta + \gamma - \delta(\theta) \tag{13.10a}$$

where $\delta(\theta)$ is defined in equation 13.8c, and γ in equation 13.5b.

The angle of the common normal in the XY coordinate system for any position is

$$\sigma(\theta) = \lambda(\theta) + \frac{\pi}{2} + \phi(\theta) \tag{13.10b}$$

where $\phi(\theta)$ is the signed pressure angle of the follower.

The coordinates of the cam surface for an oscillating roller follower can be found from:

$$\begin{aligned} x_s(\theta) &= x_f(\theta) \pm \operatorname{sgn}(\omega_{arm}) R_f \cos[\sigma(\theta)] \\ y_s(\theta) &= y_f(\theta) \pm \operatorname{sgn}(\omega_{arm}) R_f \sin[\sigma(\theta)] \end{aligned} \tag{13.10c}$$

The plus sign gives the inner envelope and the minus sign gives the outer envelope.

CAM CUTTER COORDINATES The coordinates of a cam cutter or grinding wheel of radius R_c for an oscillating roller follower can be found from:

$$\begin{aligned} x_c(\theta) &= x_f(\theta) \pm \operatorname{sgn}(\omega_{arm})(R_f - R_c)\cos[\sigma(\theta)] \\ y_c(\theta) &= y_f(\theta) \pm \operatorname{sgn}(\omega_{arm})(R_f - R_c)\sin[\sigma(\theta)] \end{aligned} \tag{13.10d}$$

The plus sign gives the inner envelope and the minus sign gives the outer envelope. Be sure to check the cutter or grinding wheel radius against the minimum (positive and negative) radii of curvature of the cam to avoid undercutting. (See Chapter 7.)

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