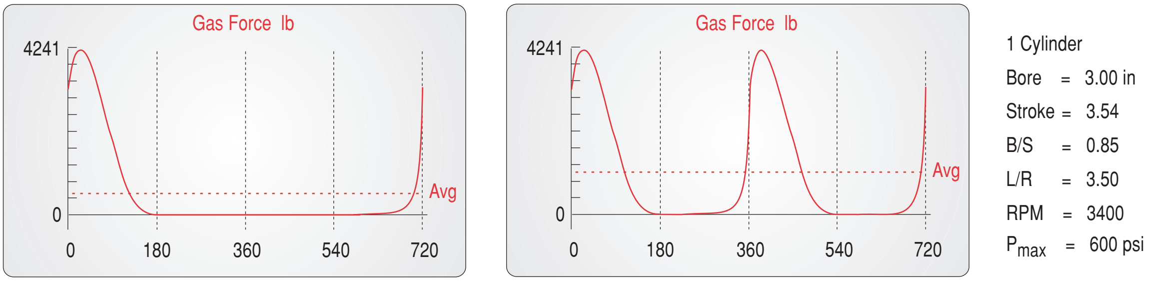

(*a*) Otto four-stroke cycle (*b*) Clerk two-stroke cycle

FIGURE 13-6

Gas force functions in the two-stroke and four-stroke cycle engines

$$q = r\sin\theta = l\sin\phi$$
$$\theta = \omega t \tag{13.1a}$$
$$\sin\phi = \frac{r}{l}\sin\omega t$$

$$s = r\cos\omega t$$
$$u = l\cos\phi \tag{13.1b}$$
$$x = s + u = r\cos\omega t + l\cos\phi$$

$$\cos\phi = \sqrt{1-\sin^2\phi} = \sqrt{1-\left(\frac{r}{l}\sin\omega t\right)^2} \tag{13.1c}$$

$$x = r\cos\omega t + l\sqrt{1-\left(\frac{r}{l}\sin\omega t\right)^2} \tag{13.1d}$$

Equation 13.1d is an exact expression for the piston position x as a function of r, l, and ωt. This can be differentiated versus time to obtain exact expressions for the velocity and acceleration of the piston. For a steady-state analysis we will assume ω to be constant.

$$\dot{x} = -r\omega\left[\sin\omega t + \frac{r}{2l}\frac{\sin 2\omega t}{\sqrt{1-\left(\frac{r}{l}\sin\omega t\right)^2}}\right] \tag{13.1e}$$

$$\ddot{x} = -r\omega^2\left\{\cos\omega t - \frac{r\left[l^2\left(1-2\cos^2\omega t\right)-r^2\sin^4\omega t\right]}{\left[l^2-(r\sin\omega t)^2\right]^{\frac{3}{2}}}\right\} \tag{13.1f}$$