$$V_{mf} = V(1 - j/a)/2 \quad \text{.... (17–41)}$$

$$V_{mb} = V(1 + j/a)/2 \quad \text{.... (17–42)}$$

The impedance Z_{1a} is the leakage impedance of the auxiliary winding plus the impedance of the capacitor.

Example 17-1

A 230-V, 50-Hz, 4-pole capacitor start motor has the following constants:

$r_{1m} = 2.8$ ohms $\quad x_{1m} = 2.77$ ohms

$r'_2 = 3.67 \quad x'_2 = 2.77$

$r_{1a} = 16.2 \quad x_{1a} = 18.8$

$Z_c = 6 - j53.2 \quad x_0 = 91.6$

$a = N'_a/N'_m = 1.54$

a. For standstill conditions, compute the current in each winding, the line current and power factor, the voltage across the capacitor, and the internal torque.

b. Repeat a for a slip of 0.25.

c. Repeat a for a slip af 0.04.

Solution

a. At starting $s = 1$

$Z_f = Z_b = Z = 3.45 + j2.82$ ohms

$Z_m = Z_{1m} + Z = 2.8 + j2.77 + 3.45 + j2.82$ ohms $= 8.38 \angle 41.8^\circ$

$I_m = V/Z_m = 230 \angle 0^\circ / 8.38 \angle 41.8^\circ = 27.4 \angle -41.8^\circ = 20.5 - j18.29$ A

$a^2Z = (1.54)^2 (3.45 + j2.82) = 8.18 + j6.69$

$Z_a = Z_{1a} + a^2Z = r_{1a} + jx_{1a} + Z_c + a^2Z$

$= 16.2 + j18.8 + 6.0 - j53.2 + 8.18 + j6.69$

$= 30.38 - j27.71 = 41.1 \angle -42.4$ ohms

$I_a = V/Z_a = 230 \angle 0^\circ / 41.1 \angle -42.4^\circ = 5.60 \angle 42.4^\circ$

$= 4.13 + j3.77$ A

Line current $I = I_m + I_a = 24.6 - j14.5 = 28.6 \angle -30.5^\circ$ A

Power factor $= \cos(-30.5^\circ) = 0.861$ (lag)

$Z_c = 6 - j53.2 = 53.5 \angle -83.56$ ohms

Capacitor voltage at starting $V_c = I_a Z_c = 5.60 \angle 42.4^\circ \times 53.5 \angle -83.6^\circ$

$= 300 \angle -41.2$ V

$w_s = 2\pi n_s = 2\pi (2f/P) = 4\pi f/P = 4\pi \times 50/4 = 157$ mech.rads/sec.

$\alpha = 42.4^\circ + 41.8^\circ = 84.2$

$$T_g = \frac{2}{w_s} I_m a I_a R \sin \alpha$$

$$= \frac{2}{157} \times 27.4 \times 1.54 \times 5.60 \times 3.45 \sin 84.2^\circ = 10.33 \text{ n-m}$$