

4.4 Magnetic leakage calculations & Operating characteristics

Magnetic leakage calculations

Leakage factor or Leakage coefficient LC.

All the flux produced by the pole will not pass through the desired path i.e., air gap. Some of the flux produced by the pole will be leaking away from the air gap. The flux that passes through the air gap and cut by the armature conductors is the useful flux

$$\phi_P = \phi + \phi_l$$

As the leakage flux is generally around (15 to 25)% of ϕ ,

$$\phi_P = \phi + (0.15 \text{ to } 0.25)\phi$$

$$\phi_P = \phi * LC$$

and that flux that leaks away from the desired path is the leakage flux where LC is the Leakage factor or Leakage coefficient and lies between (1.15 to 1.25). Magnitude of flux in different parts of the magnetic circuit.

Leakage reactance of polyphase machines:

$$\text{Leakage reactance} = 2\pi f \times \text{inductance} = 2\pi f \times \text{Flux linkage} / \text{current}$$

Note:

1. Useful flux: It is the flux that links with both primary and secondary windings and is responsible in transferring the energy Electro-magnetically from primary to secondary side. The path of the useful flux is in the magnetic core.
2. Leakage flux: It is the flux that links only with the primary or secondary winding and is responsible in imparting inductance to the windings. The path of the leakage flux depends on the geometrical configuration of the coils and the neighboring iron masses.

Magnetizing current:

Effect of magnetizing current and its effect on the power factor can be understood from the phasor diagram of the induction motor shown in Fig.

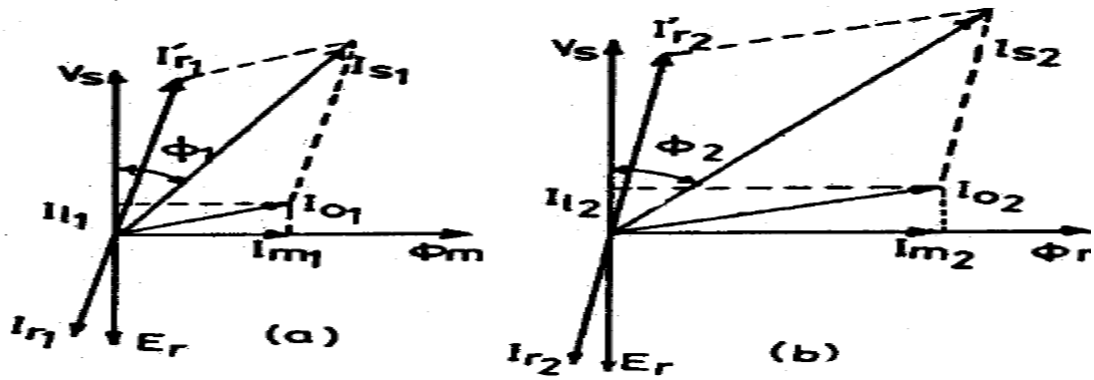


Figure 4.5.1 Phasor diagram of induction motor

[Source: "A Course in Electrical Machine Design" by A.K.Sawhney, page-10.48]

Magnetizing current and power factor being very important parameters in deciding the performance of induction motors, the induction motors are designed for optimum value of air gap or minimum air gap possible. Hence in designing the length of the air gap following empirical formula is employed.

4.6 Circle Diagram for Three Phase Induction Motors

Tests Required

No-load Test

Run the induction motor on no-load at rated supply voltage. Observe the supply line voltage V_0 , No-load line current I_0 and no-load power P_0 .

$$\text{Phase angle for no-load condition } \Phi_0 = \cos^{-1} \left(\frac{P_0}{\sqrt{3} V_0 I_0} \right)$$

Blocked Rotor Test

Block the rotor firmly and apply a reduced voltage to obtain rated current at the motor terminals. Observe the supply line voltage V_{SC} , No-load line current I_{SC} and no-load power P_{SC} .

$$\text{Phase angle for blocked rotor condition } \Phi_{SC} = \cos^{-1} \left(\frac{P_{SC}}{\sqrt{3} V_{SC} I_{SC}} \right)$$

Current drawn if rated voltage is applied at blocked rotor condition $I_{SN} = I_{SC}$

Resistance Test

By voltmeter-ammeter method determine per phase equivalent stator resistance, R_1 .

If the machine is wound rotor type, find the equivalent rotor resistance R_2' also after measuring rotor resistance and required transformations are applied.

Construction of Circle Diagram

1. Draw horizontal axis OX and vertical axis OY. Here the vertical axis represents the voltage reference.
2. With suitable scale, draw phasor OA with length corresponding to I_0 at an angle Φ_0 from the vertical axis. Draw a horizontal line AB.
3. Draw OS equal to I_{SN} at an angle Φ_{SC} and join AS.
4. Draw the perpendicular bisector to AS to meet the horizontal line AB at C.
5. With C as centre, draw a semi circle passing through A and S. This forms the circle diagram which is the locus of the input current.
6. From point S, draw a vertical line SL to meet the line AB.
7. Fix the point K as below.
 - For wound rotor machines where equivalent rotor resistance R_2' can be found out: Divide SL at point K so that SK: KL = equivalent rotor resistance : stator resistance.
 - For squirrel cage rotor machines:
 Find Stator copper loss using I_{SN} and stator winding resistance R_1 .
 Rotor copper loss = total copper loss – stator copper loss.
 Divide SL at point K so that SK : KL = rotor copper loss : stator copper loss

Note: If data for separating stator copper loss and rotor copper loss is not available then assume that stator copper loss is equal to rotor copper loss. So divide SL at point K so that SK = KL

8. For a given operating point P, draw a vertical line PEFGD as shown.

Then, PD = input power, PE = output power, EF = rotor copper loss, FG = stator copper loss, GD = constant loss (iron loss + mechanical loss)

