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.

Phase angle for no-load condition $\Phi_0 = \dfrac{P_0}{\sqrt{3}\, V_0\, I_0}$

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}.

Phase angle for blocked rotor condition $\Phi_{SC} = \dfrac{P_{SC}}{\sqrt{3}\, V_{SC}\, I_{SC}}$

Current drawn if rated voltage is applied at blocked rotor condition $I_{SN} = I_{SC} \dfrac{V_0}{V_{SC}}$

Power input at rated voltage and motor in the blocked rotor condition $P_{SN} = P_{SC}\left(\dfrac{V_0}{V_{SC}}\right)^2$

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)

9. Efficiency of the machine at the operating point P, $\eta = \dfrac{PE}{PD}$

10. Power factor of the machine at operating point P = $\cos\Phi_1$

11. Slip of the machine at the operating point P, $s = \dfrac{EF}{PF}$

12. Starting torque at rated voltage (in syn. watts) = SK

13. To find the operating points corresponding to maximum power and maximum torque, draw tangents to the circle diagram parallel to the output line and torque line respectively. The points at which these tangents touch the circle are respectively the maximum power point (T_{max}) and maximum torque point (P_{max})