5.8 Induction motor losses and efficiency

Figure below summarizes losses in induction motors

Motor efficiency

\[
\eta = \frac{\text{output power}}{\text{input power}} = \frac{P_m}{P_i} \times 100\%
\]

Example 5.3: The power supplied to a three-phase induction motor is 32 KW and the stator losses are 1200 W. If the slip is 5% .Determine (a) The rotor copper losses, (b) The total mechanical power developed by the rotor, (c) The output power of the motor if the friction and windage
losses are 750 W, and (d) The efficiency of the motor, neglecting rotor iron loss.

Solution:

(a) Input power to rotor = stator input power – stator losses

\[ S = \frac{\text{Rotor} \cdot \text{copper} \cdot \text{loss}}{\text{rotor} \cdot \text{input}} \]

\[ 0.05 = \frac{\text{rotor} \cdot \text{copper} \cdot \text{loss}}{30.8} \]

Rotor copper loss = 1.54 KW

(b) Total mechanical power developed by the rotor

= rotor input power – rotor losses

= 30.8 - 1.54 = 29.29 KW

(c) Output power of motor

= power developed by the rotor – friction and windage losses

= 29.26 - 0.75 = 28.51 KW

(d) Efficiency of induction motor

\[ \eta = \left( \frac{\text{output.power}}{\text{input.power}} \right) \times 100 \% \]

\[ = \left( \frac{28.51}{32} \right) \times 100 \% = 89.1 \% \]
5.9 Starting methods for induction motors

(Squirrel –Cage Rotor)

(i) Direct-on-line starting (D.O.L)
With this method, starting current is high and may cause interference with supplies to other consumers.

(ii) Auto transformer starting
With this method, an auto transformer is used to reduce the stator voltage, \( E_1 \), and thus the starting current. However, the starting torque is seriously reduced, so the voltage is reduced only sufficiently to give the required reduction of starting current. When the motor is up to speed the switch is moved to the run position which connects the supply directly to motor.

(iii) Star-delta starting
With this method, for starting, the connections to the stator phase winding are star-connected so that the voltage across each phase winding is \( \frac{1}{\sqrt{3}} \) (i.e 0.577) of the line voltage.

For running, the windings are switched to delta-connection. This method of starting is less expensive than by auto transformer.

(Wound Rotor)

When starting on load is necessary, a wound rotor induction motor must be used. This is because maximum torque at starting can be obtained by adding external resistance to rotor circuit via slip-ring, and as the resistance is gradually reduced, the machine characteristics at each stage will be similar to Q, S, R and P of figure (5.8).

At each resistance step, the motor operation will transfer from one characteristic to the next so that the overall starting characteristic will be as shown by the bold line in figure (5.8).
Fig.(5.8)