Induction Motor Examples

1. A three-phase induction motor has four poles and is supplied from a 50 Hz system. Calculate:

(i) The synchronous speed.

The synchronous speed = 60xf/(pairs of poles) = 60 x 50/2= 1500 r/min

(ii) The speed of the rotor when the slip is 6%.

S=0.06=(synchronous speed-rotor speed)/synchronous speed =

(1500 – rotor speed)/1500

So: rotor speed = 1410 r/min

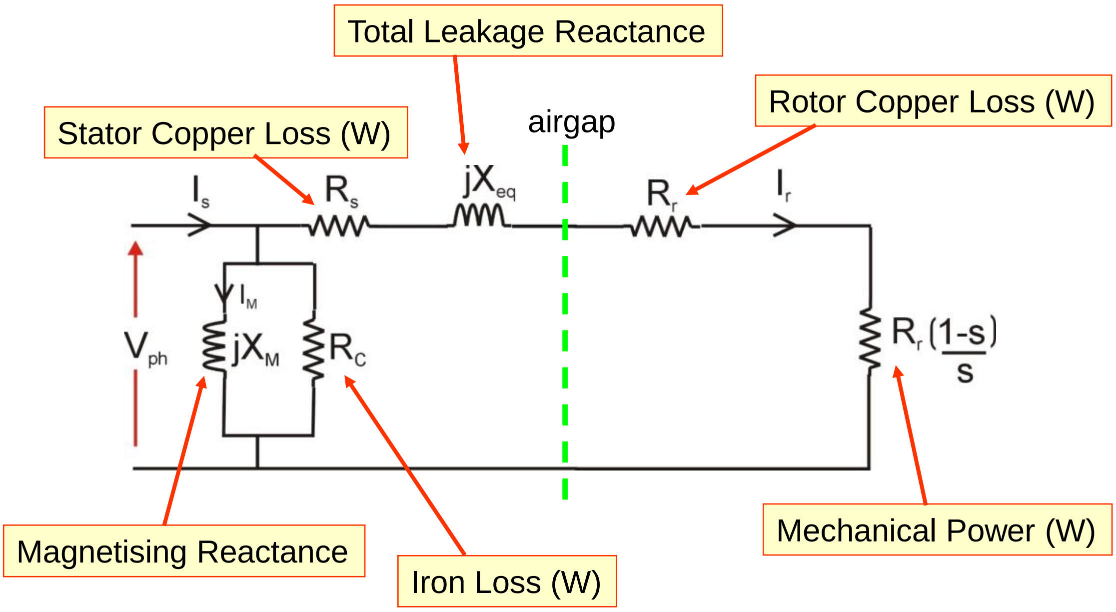
(iii) The rotor frequency when the speed of the rotor is 580 r/min.

Per-unit slip = (1500-580)/1500=0.613

So: Rotor frequency = per-unit slip x f = 0.613 x 50 = 30.67 Hz

2. A Locked Load test was conducted on a 3-phase star connected induction motor. The test resulted in a per phase power of 99 W, with a phase current of 3A at a phase voltage of 220V. The stator resistance, R_s, is 0.6 Ω. Determine:

Note: If the rotor is locked the slip is 1. It's like a short circuit test for a transformer, so we can determine the series circuit components.



(i) The rotor resistance (R_r)

Total resistance = R_s+R_r = $99/3^2$=11 Ohms

R_r=11-0.6=10.4 Ohms

(ii) The equivalent reactance (X_{eq})

Zeq=220/3=73.3 Ohms

$$Z_{eq}^2 = X_{eq}^2 + (R_s + R_r)^2$$

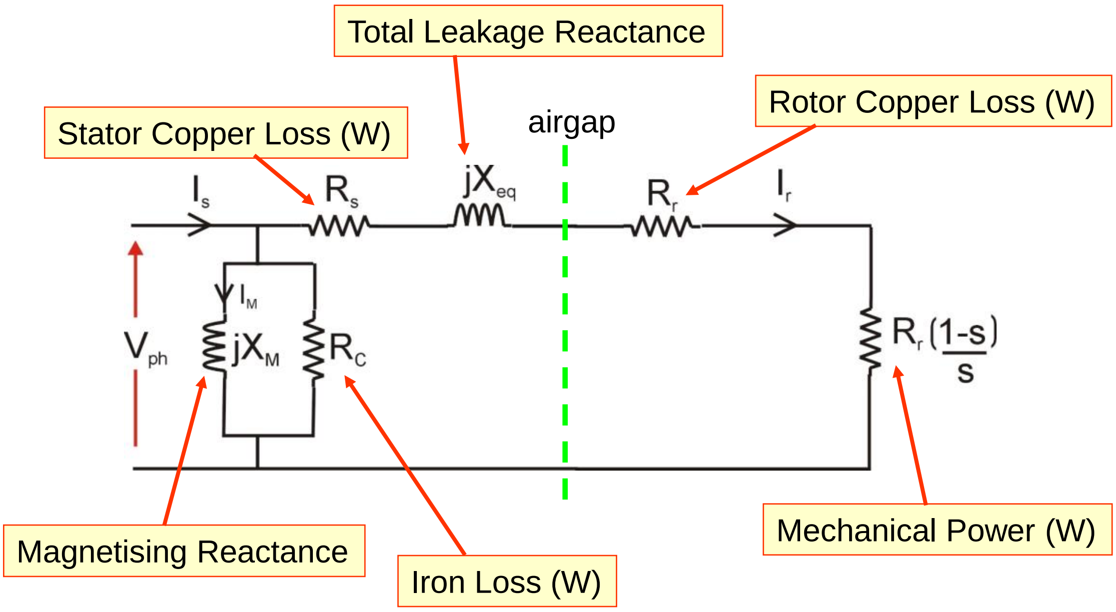
$$so: X_{eq}^2 = 5377 - 121 = 5256\Omega$$

$$X_{eq} = 72.5\Omega$$

(iii) The locked-load power factor

Pf=11/73.3=0.15

3. The 415 V, three-phase, 50 Hz, star-connected induction motor shown in Fig. 38.10 has the following per-phase equivalent circuit parameters: Rs = 1 Ω, Xeq = 5 Ω, Xm = 60 Ω, Rc = 240 Ω, Rr = 1 Ω. Using the per-phase equivalent circuit of the machine, calculate the current drawn from the supply. If the friction and windage loss in the machine is 200 W calculate the efficiency of the motor for a slip of 5%.



The stator is star-connected so the phase voltage is:

$$\frac{415}{\sqrt{3}} = 240V$$

The slip = 5 per cent. The mechanical power resistance value is

$$\text{Mechanical Power (resistance)} = R_r \frac{1-s}{s} = 1\frac{1-0.05}{0.05} = 19\Omega$$

$$I_r = \frac{240}{21+j5} = 11.11\angle -13.4^o\,A$$

We need to find the total current in the magnetizing part, Imag. (That is the current flowing into the parallel network consisting of Rc and Xm).

$$I_{mag} = \frac{240}{240} + \frac{240}{j60} = (1-j4)A$$

So: $I_s = I_r + I_{mag} = 13.51\angle 29^o\,A$

Since the three-phase motor is star-connected, this is also the line current in the supply. The power factor is $\cos 29^{o} = 0.875$.

So, the input power is:

$$Pin = \sqrt{3} \times 415 \times 13.51 \times 0.875 = 8.493kW$$

The Power loss in the equivalent circuit:

Total Copper loss = $3 \times 11.11^2 \times 2 = 740.6W$

Core loss = $3 \times \frac{240^2}{240} = 720W$

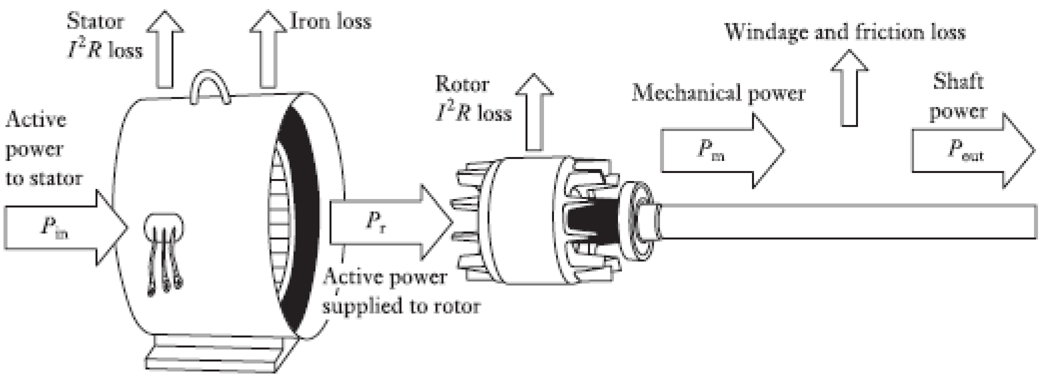
Mechanical power = Input power – power losses =7032.4 W

We could also get this through the mechanical power resistor in the equivalent circuit. If you do this, you will get the mechanical power to be 7035 W. The difference is due to rounding errors in the calculations (but there is <0.05% error).

Note: There is a further 200 W of loss due to friction and winding, so the total output power is 6832.4 W.

The efficiency:

$$\eta = \frac{6832.4}{8493} \times 100 = 80.5\%$$



Ref: Hughes Electrical Technology Figure 38.9