Separation of Losses of an Induction Motor

Objective:

To separate the various losses occurring in an induction motor.

Theory:

Apart from the calculable I^2R loss, the losses occurring in an induction motor include the following:

P_b = brush friction loss
P_e = eddy current loss in iron
P_f = mechanical losses in windage and bearing friction
P_h = hysterisis loss
P_p =pulsation loss

The suffices 1 and 2 refer to stator & rotor quantities respectively. At standstill the rotor core loss is pe2 $+p_{h2}$, when the rotor is open-circuited. At a slip s, this loss becomes $s^2p_{e2} + sp_{h2}$.
The pulsation loss is a high-frequency tooth loss in stator & rotor, produced by variations of gap reluctance as the tooth tips pass each other.
The friction loss can be separated by the no-load test.

Procedure:

The following procedure separates all losses for the slip-ring motor:

No-load Test

1. Measure the power supplied to the stator at normal voltage & at rest. The stator input corrected for I^2R loss is the iron losses $P1 = p_{e1} + p_{h1} + p_{e2} + p_{h2}$
2. Measure the power supplied to the stator at normal voltage and frequency with the rotor short-circuited and running on no-load. The corrected stator input is $P2 = p_{e1} + p_{h1} + p_p + p_f + p_b$.

The rotor eddy current loss is small since it is proportional to s. p_{h2} is also supplied by the stator, but practically the whole of it is returned as a driving torque, partly providing for $(p_f + p_b)$

3. With machine running as in (2), the rotor circuit is suddenly opened and the stator input measured. The stator input falls to $P4 = p_{e1} + p_{h1} + p_{h2}$.

Transformation Ratio test

4. Apply a voltage to the rotor such that the stator voltage is (V1+v1)/2 on open circuit, and the mutual flux is normal where V1 is the normal stator applied voltage and v1 is the measured stator voltage when the normal voltage V2 is applied to the rotor.

Measure the rotor input when running on no-load with the stator short-circuited. This corresponds to the condition of (2), except that the functions of the rotor & stator are reversed. The corrected rotor power input is P5 = $p_{e2} + p_{h2} + p_p + p_f + p_b$.

5. With the machine running as in (4), the stator is suddenly open-circuited and the rotor power input falls to P6 = $p_{e2} + p_{h2} + p_{h1}$. This test corresponds to Test3

The mechanical losses P7 (= $p_f + p_b$) are evaluated by the no-load test

Locked Rotor Test

7. Measure the power supplied to the stator at reduced voltage and full-load stator current, with the rotor short-circuited & locked. This test gives the I^2R loss of the machine.

Observations:

Induction Motor Specifications: 110 V, 36A, 3-phase, 50Hz, Y-connected, 1440 RPM

1. Transformation Ratio test

Rotor voltage =
Stator voltage =
Therefore, Turns Ratio =

2. No-load test

Wattmeter constant
C.T Ratio =

No:	V(L-L) (Volts)	W1 (Watts)	W2 (Watts)	W1+W2 (Watts)	Power (Watts)	$V(L-L)^2$ $(Volts)^2$

3. Locked Rotor test

Wattmeter constant
C.T Ratio =

No:	V(L-L) (Volts)	I (amps)	W1 (Watts)	W2 (Watts)	W1+W2 (Watts)	Corrected power (Watts)

Stator resistance per phase =

Calculations:

From no-load test

P7= $p_f + p_b$ Watts
p_{e1} =P1-P6 Watts
p_{e2} =--- Watts
p_{h1} =P +(P2-P5-P1)/2 Watts

p_{h2} =P4+(P6-P1-P2)/2 Watts
p_p = ((P5+P2-P1) /2) - P7 Watts
Assuming $p_b = p_f$ = P7 Watts

From locked rotor test

$I_{f.1}$ = -- amps
V1= Reduced Voltage, Volts
I_{SC1}=--amps
P_{SC1}=--Watts

Corresponding Values for normal voltage V will be:

$I_{SC}=V\ I_{SC1}\ /V1$ amps
$P_{SC}=P_{SC1}\ (V/V1)^2$ Watts
Stator I^2R loss = $3(I_{SC})^2$ R Watts
Rotor I^2R loss = $P_{SC} - 3(I_{SC})^2$ R Watts

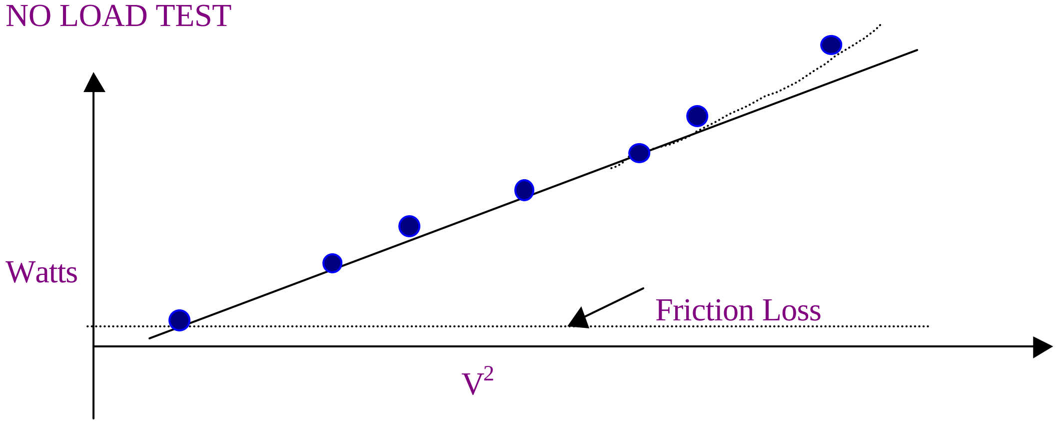
Results:

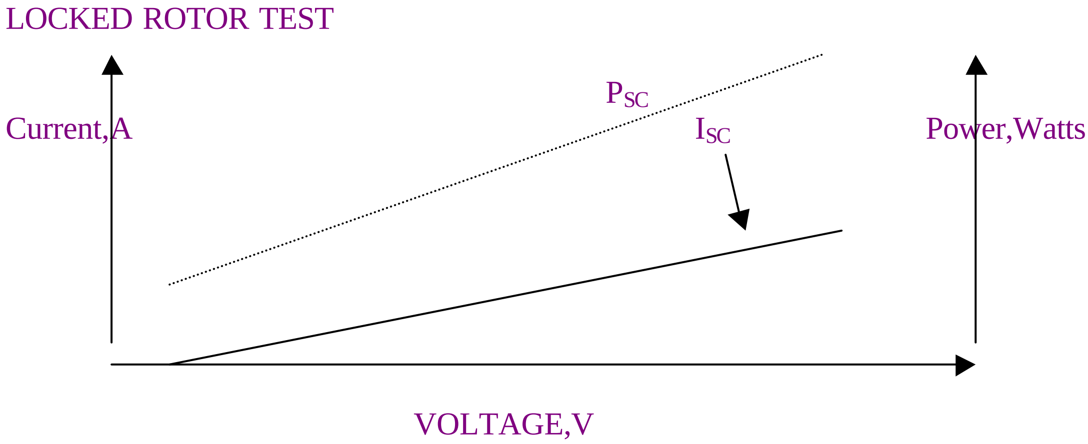
1. Eddy loss in stator =-- Watts
2. Eddy loss in rotor =-- Watts
3. Hysterisis loss in stator =-- Watts
4. Hysterisis loss in stator =-- Watts
5. Pulsation loss =-- Watts
6. Friction + Windage loss =-- Watts

Discussion:

1. The brush friction loss cannot be measured if there is no internal short-circuiting device. In that case, assume $p_b = 0$.
2. The rotor eddy current loss is very small, because it is proportional to $(slip)^2$ and the slip itself is very small.
3. To get accurate results, the voltage should be maintained constant

NO LOAD TEST




LOCKED ROTOR TEST
Current,A
P_SC
I_SC
Power,Watts
VOLTAGE,V