UNIVERSITY OF GAZIANTEP
ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EEE 322 EXPERIMENT 6

NO-LOAD, LOCKED-ROTOR TESTS ON AN INDUCTION MOTOR AND DETERMINATION OF THE PARAMETERS

A.Object of the Experiment

The object of this experiment is to carry out no-load and locked-rotor test on a squirrel-cage/wound-rotor induction motor and to use the results of these tests to determine the parameters of the equivalent circuit of the machine.

B. Theory

The induction is one in which alternating current is supplied to the stator directly and to the rotor by induction and transformer action from the stator, Balanced polyphase stator and rotor currents create stator and rotor component mmf waves of constant amplitude rotating in the air gap at synchronous speed and therefore stationary w.r.t each other regardless of the mechanical speed of the rotor. This property of induction motor enables it to be an a.c m/c that can run also at speeds other than the synchronous speed.
Fig.1 shows the approximate equivalent circuit of induction motor per phase.
where:

V_1 :stator voltage
R_1 :stator winding resistance
g_c :reactance corresponding to core losses
X_1 :stator leakage inductance
X_2' :stator leakage impedance(referred to stator side)
R_2' :rotor winding resistance(referred to stator side)
n_s :synchronous speed of the motor

s : slip; $s = \frac{n_s - n}{n_s}$

$R_2' \frac{(1-s)}{s}$:resistance corresponding to output mechanical power

I_0 : magnetazing branch current
I_2' : rotor current (referred to stator)
I_1 : motor input current

DETERMINATION OF THE PARAMETERS

a) No-load test

This test is normally performed at rated voltage and frequency with no mechanical load. Under this condition motor will operate slightly below the synchronous speed due to the internal mechanical losses. (Friction and windage losses).

When we let the motor to run at no-load, the speed becomes very close to the synchronous speed, hence slip s=0. As can be seen from the equivalent circuit, when s approaches to zero, the variable term in the circuit approaches to infinity. Hence under this condition, the right-hand branch of the circuit will be open-circuit (copper-losses are neglected) and the equivalent circuit under no-load condition takes the form in Fig.2.

For this condition.

$$I_1 = I_0 \qquad |Y| = \left|(G_C{}^2 - jB_n)\right| = (G_C{}^2 + B_n{}^2)^{1/2} = \frac{I_0}{V_1}$$

$$P_{in} = G_C V_1{}^2$$

Where the quantities Pin, V_1 and I_1 are phase values.

Hence, we can calculate G_c and B_m

b)Locked-Rotor Test

To find the other parameters, locked rotor test is performed. When we locked the rotor (rotor is kept stationary), n=0. so, s=1 and the variable term in equivalent circuit become zero. Approximately full load current is supplied to the stator. Therefore a reduced voltage should be applied. The input power is measured and gives copper loss. The core losses are negligible. Under this condition, magnetizing branch can be neglected since R2' is much higher than the right hand branch. Equivalent circuit takes the form in Fig.3.

$$I_1 = I_2{}'$$

$$P = (R_1 + R_2{}')(I_1)^2$$

$$|Z| = \left|(R_1 + R_2{}') + j(X_1 + X_2{}')\right| = \left[(R_1 + R_2{}')^2 + (X_1 + X_2{}')^2\right]^{1/2} = \frac{V_1}{I_1}$$

using the equations above and assuming.

$$\left.\begin{array}{l} R_1 = R_2{}' \\ X_1 = X_2{}' \end{array}\right\} \text{ we can find } R_1, R_2', X_1, X_2'$$

$$|Y| = \left|(G_C{}^2 - jB_n)\right| = (G_C{}^2 + B_n{}^2)^{1/2} = \frac{I_0}{V_1}$$

C) Procedure

(1) Connect the circuit as shown in Fig.4, with the rotor winding open-circuited. Apply voltage to the stator winding and for several different values, measure the voltage induced in the rotor winding (this does not apply to induction motor with squirrel-cage rotors). Record at each step the values of stator voltage and rotor voltage.

(2) Disconnect the induction motor from the combined brake assembly '"where possible"' and apply a short-circuit to the rotor winding.(The induction motors with squirrel-cage rotor windings have already short-circuited windings due to their constructional features) apply a stator voltage of around 100 volt (line-to-line) and allow the-machine to run-up to no-load speed and then increase the stator voltage to the rated value. Now decrease the voltage in steps until the machine will no longer run recording at each step the value of stator voltage and current and the reading of each wattmeter. Record also the value of rotor-slip either by viewing a white mark on the rotor shaft with a stroboscope (stroboflash) operating in the 'line" position and counting the number of slips in a given time or using a tachometer whichever is the most appropriate.

(3) Lock the rotor using the combined brake assembly tuning the hydraulic-oil disc brake) and carefully increase the stator voltage in steps up to a value at which the stator current exceeds the rated value by 25%. Record at each step the values of stator or voltage and current and reading of each wattmeter. (Switch power back to zero.

(4) Measure the resistance of the rotor (for wound rotor machines) and stator winding using the voltmeter-ammeter method. Calculate rotor resistance of the squirrel-cage machine using the test values.

D) Results and Conclusions

(1) Plot the no-load and locked-rotor characteristics and the power-loss curves; hence determine the referred parameters. Draw the equivalent circuit of the machine.

(2) Determine the turns ratio between stator and rotor and calculate the actual machine parameters.

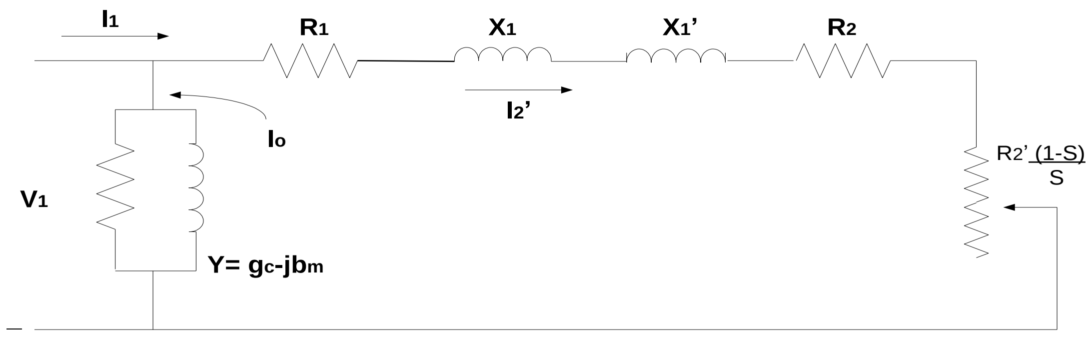

Fig.1 approximate per phase equivalent circuit for an induction motor.

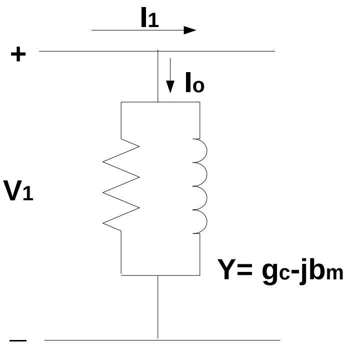

Fig.2 approximate equivalent circuit for no-load test (open circuit test)

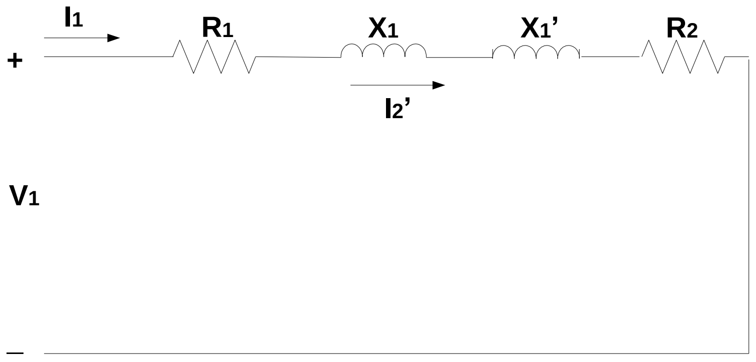

Fig.3 Approximate equivalent circuit for locked-rotor test (short circuit test)

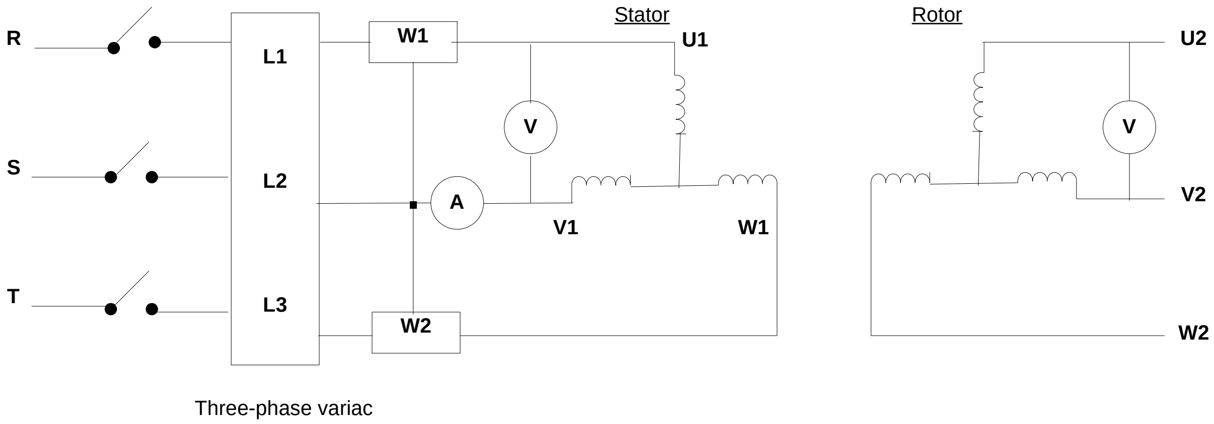

Fig.4

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