Experiments on Induction Generators :

Expt. 1: ***Determination of the equivalent circuit parameters and the performance characteristics of a grid-connected induction generator***

Procedure:

1. In the open-circuit test, connect the circuit as shown in the figure. The stator supply is given through an autotransformer. In this experiment the measurements are to be done when the machine is rotating exactly at the synchronous speed (which cannot be achieved simply by running at no-load). First start the induction machine as a motor with the help of the autotransformer. Once it reaches approximately the rated speed, open the shorting switch across the ammeter and wattmeter.

In order to bring it to exactly the synchronous speed, give field supply to the coupled dc machine. The d.c. machine is to be connected to the d.c. supply terminals in the separately excited configuration, with two different switches for the field and the armature (see Fig. 1). Voltage builds up at the armature terminals. This voltage and the supply voltage appear at the two ends of the armature switch. By varying the field resistance, bring the armature voltage to the d.c. supply voltage. After checking the polarity and magnitudes of these two voltages, close the armature switch. Then increase the speed by reducing the field current of the d.c. machine.

The slip of the induction machine can be measured in two different ways. If it is a wound-rotor machine, connect a zero-centred d.c. ammeter across two of the rotor terminals, and shunt it with an SPST switch. The other two rotor terminals are shorted. The current passing through the ammeter will be exactly at the slip frequency. As a result the pointer will oscillate at that frequency, which can be easily measured by counting the number of oscillations per minute. If the machine is squirrel cage, the rotor terminals are not available. In that case the slip is to be obtained with a line-frequency stroboscope. Put a chalk-mark on the rotor shaft. When the strobe is on, the chalk-mark will appear to rotate at the slip frequency, which can be also be measured by counting the number of oscillations per minute.

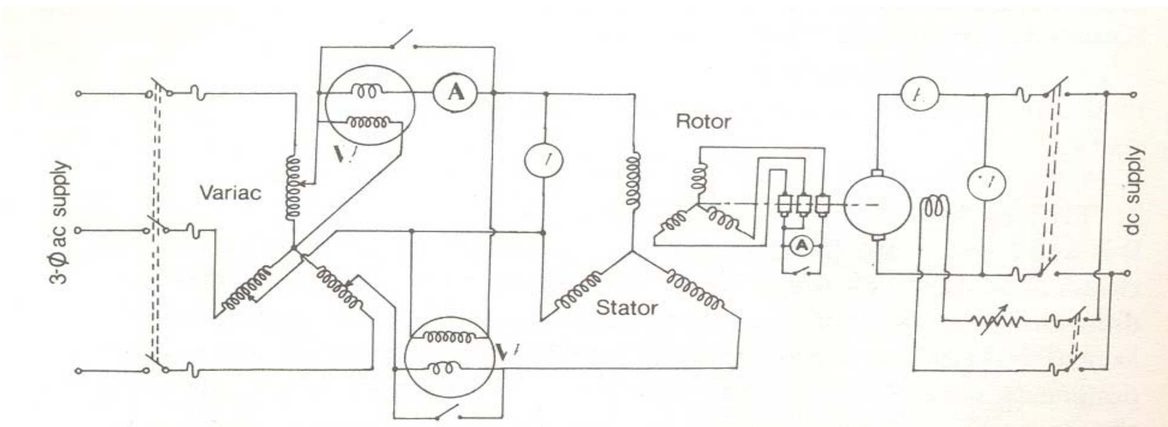

Fig.1: Circuit diagram for the open-circuit test and load test.

To measure the 3-phase active and reactive power, two wattmeters are used, as the load can be assumed to be balanced. One LPF wattmeter, with the line current in the current coil and the same phase voltage in the pressure coil, measures the active power (3-phase power = 3 times wattmeter reading). Another wattmeter, with the line current in the current coil and the voltage between the other two lines in the pressure coil, measures the reactive power (3-phase reactive power = √3 times the wattmeter reading). If three-phase active/reactive power meters are available, these can also be used.

As the speed is increased by reducing the dc machine field current, the oscillation of the rotor ammeter of the induction machine slows down, indicating a decrease in slip. Finally bring it to a standstill by adjusting the field rheostat. The induction machine is now running at synchronous speed; the rotor is truly open-circuited.

Then obtain the open-circuit voltage-current characteristics by varying the stator voltage of the induction machine in steps, while varying the d.c. field resistance to keep the machine always at synchronous speed. Try to obtain approximately equally spaced points on the curve, till the typical bend (knee point) is visible. Plot while you take the readings (current in the x-axis and voltage in the y-axis).

3. Use the same circuit as in the open circuit test. The only difference is that the ammeter, voltmeter, and wattmeter ratings should correspond to the machine ratings. Use normal wattmeters instead of the LPF wattmetsrs. After the synchronous speed is reached, increase the speed further by reducing the field current of the d.c. machine. The induction machine then runs in the generator mode. Increase the speed in steps up to the maximum permissible value, and take the readings. Limit the range of experiment to the stable zone of the torque-slip characteristics. If the oscillation of the rotor ammeters become too fast to count, short the SPST switch and use a stroboscope to measure the slip. Calculate and plot the torque, power output, power factor and efficiency against slip.

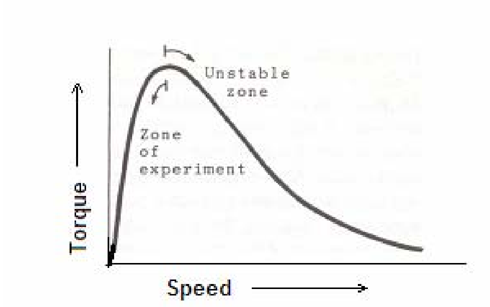

Fig.2: Torque-slip characteristics of an induction generator

3. Then perform the short-circuit or locked-rotor test. Note that you have to choose the ammeter rating equal to the machine rating, and the voltmeter rating about one fourth the machine rating. The wattmeter should be a low power factor meter. After connecting the circuit, increase the input voltage in stages, so that input current varies from half the rated current to the rated current. Keep the rotor static by physically holding it. Tabulate the input voltage, input current and input power.

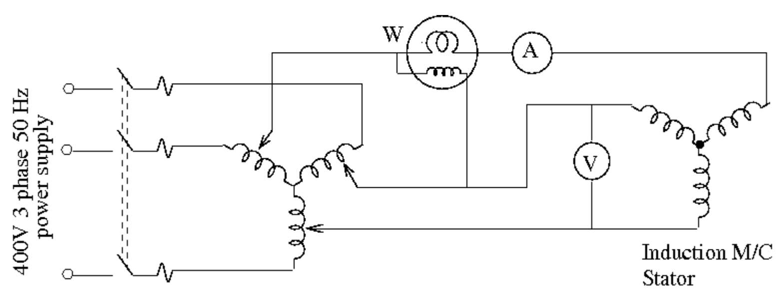

Fig.3: Circuit diagram for the blocked rotor test

Report:

1. Obtain the parameters of the approximate equivalent circuit from the locked rotor test and the open-circuit test at rated voltage.
2. Using the equivalent circuit, calculate the power, power factor, stator current, torque and efficiency at slips -0.02 and -0.05, when the machine is connected to the line. Compare the experimental results of the load test with the values predicted.
3. Obtain the minimum value of capacitance required for the machine to self-excite. Note down the capacitance of the 3-phase capacitor bank available in the lab. Calculate the minimum speed at which the machine will self-excite if this capacitor bank is connected to the stator terminals. Calculate the capacitance requirement for self-excitation to 400 V at rated speed and no-load.
4. Derive qualitative conclusions from the load test graphs and write in the discussion.