Study of Induction Generator Performance

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ABSTRACT
The renewable energy is considered to help saving energy and energy conservation. The energy from natural sources such as wind and sunlight are being developed for electrical energy supply. For the electrical energy which is produced from wind turbine, some systems use induction generator to produce electrical power. In order to use the induction generator for maximum efficiency, the condition and some parameters must be verified for setting maximum efficiency in wind generator system. The system for finding the working condition of induction generator, three phase induction motor and repulsion motor prime mover are used in this paper. The induction motor is connected in star pattern. The direction of induction motor and prime mover are set in the same direction. The speed of the prime mover is synchronously adjusted at 1500 rpm. The speed of prime mover is adjusted until the speed more than synchronous speed and then the three phase power supply which is supplied to induction stopped. The electrical quantities, current, voltage and power are recorded with varying load profile. The voltage output of induction generator without capacitor at no load is 8.5 V of line voltage and 5.2 v of phase voltage. The voltage output of induction generator with capacitor at on load is 59 V of phase voltage. For the rated voltage at 220 V, the speed of prime mover is increased with increasing out put voltage. The capacitor's bank is connected to make self excite for induction generator. The electric charges are kept in capacitor's bank and are discharged to stator winding. This cycle of charge and discharge system is supported for supplying the output voltage.

1. Introduction

Due to the traditional sources of energy are limited and the problems associated with their use, renewable energy systems are attracting the great interest. So wind energy, solar energy and small hydro-electric energy are the most common alternative energy sources. Unlike the electricity from fossil-fuel-powered sources, Wind energy becomes the least cost renewable energy sources. So wind power is considered more stable than other sources. As modern vertical wind turbines are normally variable-speed units, conventional generators such as induction or synchronous require an electronic power converter for connecting with the grid. But large wind turbines require very complex and more costing power converter. In the wound rotor induction generator (WRIG), the power electronic converters are shifted to the rotor circuit, which means less rating and cost for the converters. WRIG supply power to the grid via both stator and rotor circuits according to operation mode (super synchronous or sub-synchronous mode)
[4]. Static Kramer Drive (SKD) is the kind of generators that use a rectifier and the operation control can be achieved by changes on the firing angle of the inverter. But it's also applicable as super synchronous generator cascade. Many researchers studied the modeling and control of Static Kramer Induction Generator (SKIG). The static Kramer system with a converter extended by controllable freewheeling circuit is studied, two different control schemes for the freewheeling circuit presented to minimize the reactive power and harmonic distortion. A comprehensive review of past and present converter topologies applicable to induction generators is discussed. Analysis and Modeling of the Steady State Behavior of the (SKIG) is discussed. The advantages of (SKIG) that make it a strong contender in wind energy applications its simple design, cheaper cost, lighter weight and can be used for utilizing more than its rating output without overheating.

II. Induction Generator Principle

The induction generator is similar to any other generator, as it is a device that converts mechanical energy into electrical energy. An induction generator consists of a rotating element or rotor and a stationary element or stator. The rotor consists of an aluminum or copper 'squirrel cage' within the rotor laminations. The stator consists of insulated copper windings within the stator laminations. Neither an exciter nor voltage regulator is used or required. An induction machine (motor or generator) connected to the line power source (excitation) is capable of operating in either mode. If the shaft is allowed to rotate at a speed below synchronous, the machine will attempt to operate as a motor. The rotating magnetic field vector caused by the three phase stator windings will deliver real and reactive power to the rotor as it sweeps around the squirrel cage. If the shaft is forced to rotate at a speed higher than synchronous, a change takes place within the machine. The stator magnetic field vector will continue to deliver reactive power, but now accepts real power induced from the rotor (generator mode). Now the squirrel cage is sweeping the field vector, causing a flux reversal. At synchronous speed, the line supplies reactive power and

machine losses, but no torque or power is generated. There is a practical upper limit to the speed at which an induction generator can be operated above synchronous and still generate real power efficiently. This speed is typically 2 to 5 percent above synchronous, but below breakaway torque. Above the breakaway torque speed, the real power generated decays quickly to a low value. The basic circuit was shown in Fig.1.

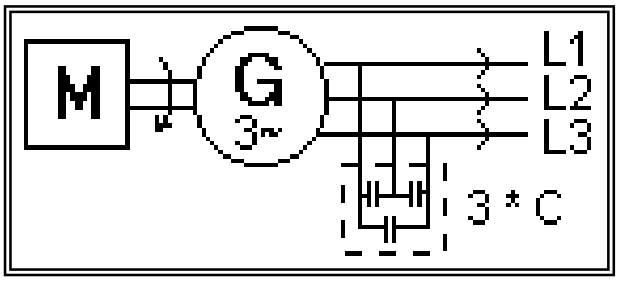

Fig.1. Induction Generator System.

III. Experimental Setup

Induction motor was moved to generate voltage with 3 phase 4 pole, 1 hp, 220 V/380 V using self-excited system. The experimental equipment was shown in Fig. 2.

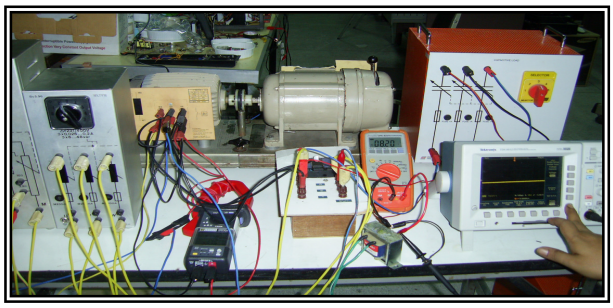

Fig.2. Experimental Equipments.

The load testing performances are resistor, capacitor, and inductor. The motor speed is 1500 rpm.

IV. Result and Discussion.

A. Analysis of load changing.

Resistive load was used to test characteristic. Various parameters are speed, voltage, and current are recorded with no-load and on-load test. The results are shown in Table 1.

Table 1. Testing Parameter at

Line Voltage	Phase Voltage	Current	Speed (rpm)	Power	Power Factor
385 V	224 V	2.01 A	1,485	255 W	0.35

B. Analysis of load changing with Capacitor Bank

Line Voltage	Phase Voltage	Current	Speed (rpm)
9.1 V	5.8 V	0.089 A	1,480

In case of the capacitor was connected in delta connection.

C. Induction Generator with capacitor bank.

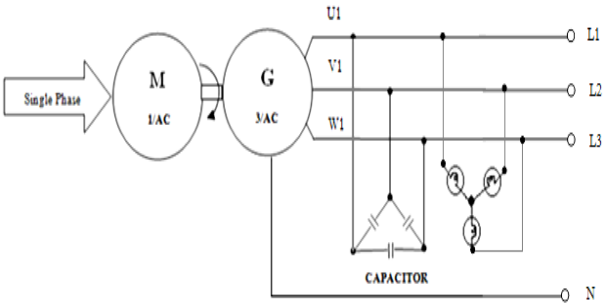

Fig.3. Induction Generator with Capacitor bank

Table 2. Parameter Results

No	Lamp	Impendence	Voltage	Current	Power (VA)	Speed (rpm.)
1	-	-	58.5 V	0 A	0 VA	1090
2	1 หลอด	15.75 Ω	57 V	0.545 A	34.2 VA	1035
3	2 หลอด	30.34 Ω	58 V	1.2 A	73.0 VA	989
4	3 หลอด	45.02 Ω	55 V	1.49 A	90.15 VA	963
5	4 หลอด	60.39 Ω	56 V	2.0 A	110.0 VA	939

Table 4. Parameter Output

Load		Voltage	Current	Voltage (E_L)	(rpm.)	f (Hz)
Lamp	impedance					
-	-	58.5 V	0 A	101.3 V	1090	36.3
1	15.75 Ω	57 V	0.545 A	98.6 V	1035	34.5
2	30.34 Ω	58 V	1.2 A	100.3 V	989	33
3	45.02 Ω	55 V	1.49 A	95.3 V	963	32.1
4	60.39 Ω	56 V	2.0 A	97 V	939	31.3

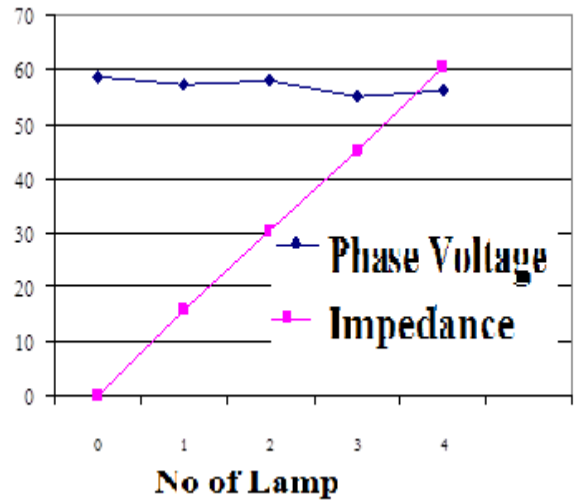

Fig.4. Relation between Load and Characteristic

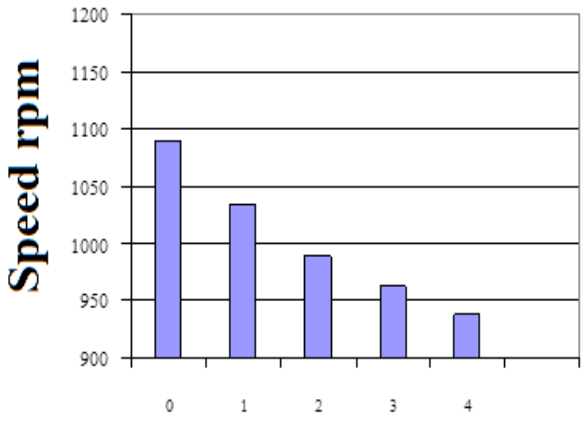

Fig.5. Load vs Speed

V. Conclusions

The induction motor is connected in star pattern. The direction of induction motor and prime mover are set in the same direction. The speed of the prime mover is synchronously adjusted at 1500 rpm. The speed of prime mover is adjusted until the speed more than synchronous speed and then the three phase power supply which is supplied to induction stopped. The electrical quantities, current, voltage and power are recorded with varying load profile. The voltage output of induction generator without capacitor at no load is 8.5 V of line voltage and 5.2 v of phase voltage. The voltage output of induction generator with capacitor at on load is 59 V of phase voltage. For the rated voltage at 220 V, the speed of prime mover is increased with increasing out put voltage. The capacitor's bank is connected to make self excite for induction generator. The electric charges are kept in capacitor's bank and are discharged to stator winding. This cycle of charge and discharge system is supported for supplying the output voltage.

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