International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-1, Issue-3, August 2012

# Study of Wind Power Generation Using Slip Ring Induction Generator

**K Y Patil, D S Chavan**

***Abstract*: *Wind energy is now firmly established as a mature technology for electricity generation. There are different types of generators that can be used for wind energy generation, among which Slip ring Induction generator proves to be more advantageous. To analyze application of Slip ring Induction generator for wind power generation, an experimental model is developed and results are studied. As power generation from natural sources is the need today and variable speed wind energy is ample in amount in India, it is necessary to study more beneficial options for wind energy generating techniques. From this need a model is developed by using Slip ring Induction generator which is a type of Asynchronous generator*.**

***Index Terms*: *Wind energy, Slip Ring Induction Generator***

## I. INTRODUCTION

Wind power generation has developed dramatically. Up to end of last year the installed capacity was 15000 MW worldwide. The global perspectives for wind power seem to be quite good. A goal of 80, 0000 MW is set up to end of 2020. As a result of growth of installed capacity the wind power is one of the fastest expanding industries.

There is huge potential in wind power. India today has the fifth largest installed capacity of wind power in the world and potential for on-shore capabilities of 65000MW. The increase in interest in wind energy is due to investment subsidies, government action towards renewable energy playing a big part in nation's energy system. There is a need to generate environment friendly power that not only raises energy efficiency and is sustainable too. The time has come for moving to generation based subsidies and understanding the drawbacks associated with wind power in India. However advances in technologies such as offshore construction of wind turbines, advanced control methodologies, and simulation of wind energy affecting overall grid performance are helping wind energy generation.

Fortunately, many new wind power plants are equipped with state of the art technology, which enables them to provide good service while producing clean power for the grid. The advances in power electronics have allowed many power system applications to become more flexible and to accomplish smoother regulation. [1]

There are different types of generators for generation of wind energy as synchronous, asynchronous; permanent magnet D.C. etc .Here experimental model is developed by using Slip ring induction generator which is one of the effective generators to generate wind energy. By doing analysis of this model advantages of slip ring induction generator is compared to other generators.

**Revised Manuscript Received on 30 August 2012.**
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## II. PRINCIPLE OF ENERGY CONVERSION

A Wind mills or turbines works on the principal of converting kinetic energy of the wind into mechanical energy.

Power available from wind mill = ½ ρ A $V^3$ ---------- (1)

Where, ρ=air density = 1.225 Kg. / $m^3$ at sea level. (Changes by 10-15% due to Temperature and pressure variations)

A – Area swept by windmill rotor

V – Wind speed m/sec.

Air density, which linearly affects the power output at a given speed, is a function of altitude, temperature and barometric pressure. Variation in temperature and pressure can affect air density up to 10 % in either direction. Warm climate reduces air density. The equation 1 shows that, maximum power available from wind mill is directly proportional to area of rotor and cube of wind speed.

## III. TYPES OF GENERATORS FOR WIND POWER

A generator is a device which converts mechanical energy into electrical energy. Wind Generators have traditionally been wind turbines, i.e. a propeller attached to an electric generator attached to appropriate electronics to attach it to the electrical grid.

Types of generators used:-

For Small rating systems - P. M. type D.C. generators

Medium rating systems - P. M. type D.C. generators

Induction generators (Asynchronous):

*A) Squirrel cage Induction Generator*

*B) Slip Ring (wound rotor) Induction Generator*

*C) Doubly fed Induction Generator*

The basis of this categorization is the speed at which the generators are running. Synchronous Generators are running at synchronous speed (1500 rpm for a 4 pole machine at 50Hz frequency). While asynchronous generators run at a speed more than the synchronous speed.[5]

## IV. SLIP RING INDUCTION GENERATOR

The induction generator is nothing more than an induction motor driven using external prime mover above its synchronous speed by an amount not exceeding the full load slip the unit would have as a motor. The induction generator requires one additional item before it can produce power it requires a source of leading VAR's for excitation.


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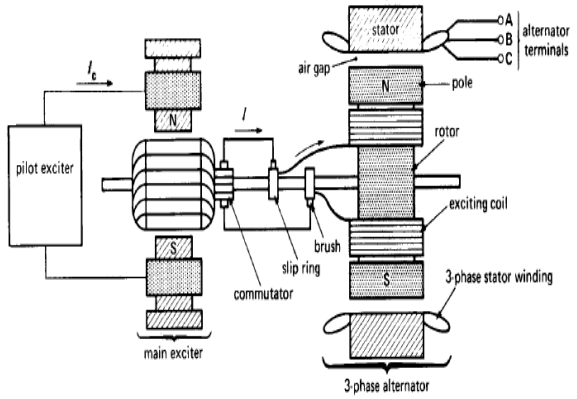


Fig. 1 Schematic diagram of slip ring induction generator

The VAR's may be supplied by using capacitors or from the utility grid. The schematic diagram for slip ring induction generator is shown in Fig.1 The main advantage of three phase induction generators is that they are easily available as compared to synchronous generators.

Advantages of induction generator

1. It is less expensive and more readily available than a synchronous generator.
2. It does not require a DC field excitation voltage.
3. It automatically synchronizes with the power system, so its controls are simpler and less expensive.

## V. DEVELOPMENT OF MODEL FOR WIND POWER GENERATION USING SLIP RING INDUCTION GENERATOR

As wind energy is mechanical type of energy, in development of a model, an artificial source of mechanical energy is required. Also to model actual wind speed conditions, a variable speed input is needed. Thus, D. C. shunt motor is used to provide variable speed mechanical input to generator. A model using D.C shunt motor coupled with slip ring induction generator for wind energy generation is developed and studied at different wind speed conditions. Main components of model are

### *A. Slip Ring Induction generator*

3 Phase ,415 volt, 1410 RPM,50 Hz, B class Insulation, IP 22,0.5 HP, 1.4 A

### *B. D.C. Shunt motor*

220 volt, 3000RPM, 1 HP, 0.3 A, Extn type Shunt

Model using D.C. shunt motor coupled with Slip ring Induction Generator for wind energy generation at different wind speed conditions. Circuit diagram for the model is as shown in Fig. 2. To obtain variable speed conditions potential divider method of speed control of D.C. shunt motor is used. With change in the speed, there is change in voltage generated from slip induction generator. Different readings were taken at different excitation voltages to rotor of slip ring induction generator. As excitation voltage is changed there is change in speed of rotation and change in output voltage generated from generator.

### *C. Observations with different excitation to generator*

On this model by giving different excitation voltages the readings are taken the observations for field excitation from 25 volt to 50 volt is given in Table 1 and 2. The variation is represented graphically as shown in Fig.3

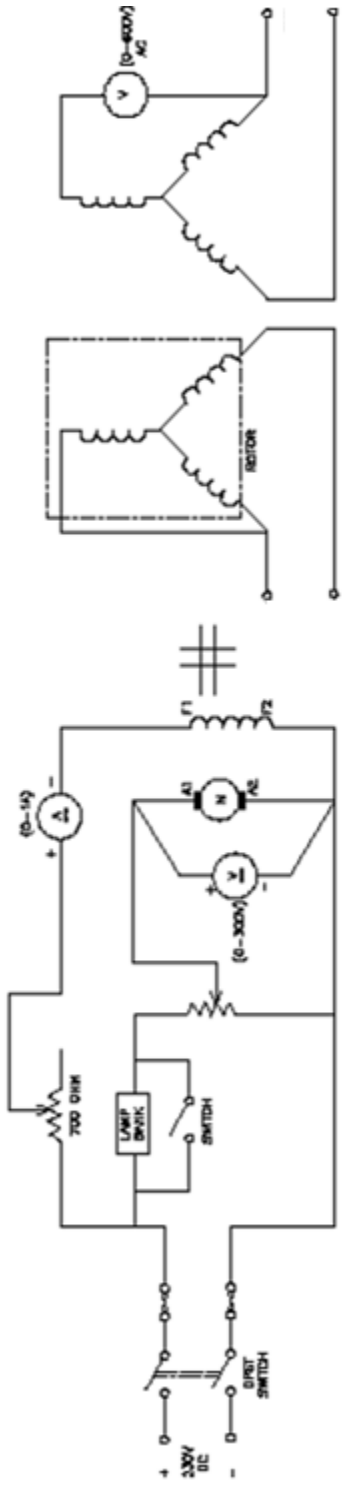

**Fig.2. Circuit Diagram for Slip Ring Induction Generator Coupled with D.C. Shunt Motor**

### *D. Observations with different load types*

As most common load to grid in India is resistive and inductive type, it is important to carry out experiment with both resistive and inductive load. Thus observations of generated voltage and speed are taken for resistive load and inductive load as shown in Table 3 and 4 respectively.



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**Table 1. Output voltage of generator for field excitation 25 volt and 30 volt.**

| Sr. No. | Speed (In rpm) | Slip Ring Induction generator, AC Voltage output at no load across Stator as synchronous generator | |
|---|---|---|---|
| | | field Excitation voltage to slip ring = 25 volt(dc) | field Excitation voltage to slip ring = 30 volt (dc) |
| 1 | 100 | | -- |
| 2 | 200 | | 50 |
| 3 | 250 | | 60 |
| 4 | 300 | | 75 |
| 5 | 350 | | 80 |
| 6 | 400 | 50 | 90 |
| 7 | 500 | 90 | 105 |
| 8 | 600 | 105 | 125 |
| 9 | 700 | 120 | 140 |
| 10 | 800 | 135 | 165 |
| 11 | 900 | 150 | 175 |
| 12 | 1000 | 170 | 205 |
| 13 | 1100 | 185 | 220 |
| 14 | 1200 | 200 | 240 |
| 15 | 1300 | 220 | 260 |
| 16 | 1400 | 240 | 280 |
| 17 | 1500 | 250 | 300 |
| 18 | 1600 | 270 | 315 |
| 19 | 1700 | 285 | -- |
| 20 | 1800 | 305 | |
| 21 | 2000 | 340 | |
| 22 | 2400 | 415 | |

**Table 2. Output voltage of generator for field excitation 40 and 50 volt.**

| Sr. No. | Speed (In rpm) | Slip Ring Induction generator, AC Voltage output at no load across Stator as synchronous generator | |
|---|---|---|---|
| | | field Excitation voltage to slip ring = 40 volt(dc) | field Excitation voltage to slip ring = 50 volt(dc) |
| 1 | 100 | | 70 |
| 2 | 200 | 60 | 85 |
| 3 | 250 | | 95 |
| 4 | 300 | 75 | 110 |
| 5 | 350 | | 120 |
| 6 | 400 | 110 | 135 |
| 7 | 500 | 125 | 150 |
| 8 | 600 | 150 | 165 |
| 9 | 700 | 165 | 185 |
| 10 | 800 | | 200 |
| 11 | 900 | | 215 |
| 12 | 1000 | | 240 |
| 13 | 1100 | | 275 |
| 14 | 1200 | | 290 |
| 15 | 1300 | 355 | 310 |
| 16 | 1400 | | 345 |
| 17 | 1500 | 370 | 415 |
| 18 | 1600 | 390 | |
| 19 | 1700 | 420 | |
| 20 | 1800 | | |
| 21 | 2000 | | |
| 22 | 2400 | | |

## VI. ADVANTAGES OF SLIP RING INDUCTION GENERATOR FOR WIND POWER GENERATION

The main advantage of three phase induction generators is that they are easily available as compared to synchronous generators. Other important advantages are,

- It is less expensive and more readily available than synchronous generator.
- It automatically synchronizes with the power system, so its controls are simpler and less expensive.

Advantages of model developed are,

It is possible to operate at low speed as well as high speed range, construction (stator and rotor) is simple, Less maintenance required and speed matching to actual wind speed can be generated using D. C. Shunt motor.

During selection of rating for generator to use in wind power plant, it is necessary to study previous data regarding variation in wind speed of installation area. If there are less events when wind speed fluctuates above rated value, then it is not required to go for next higher rating as slip ring induction generator is also able to rotate with speed above rated value.

Table 3. When resistive load is applied

| Sr. No. | D.C. Excitation (In volts) | Generated Voltage (In Volts) | Current (In Amp) | Speed (In RPM) |
|---|---|---|---|---|
| 1 | 70 | 220 | 0.1 | 1900 |
| 2 | 45 | 50 | 0.25 | 1100 |
| 3 | 40 | 20 | 0.5 | 1300 |

**Table 4. When inductive load is applied**

| Sr. No. | D.C. Excitation (In Volts) | Generated Voltage (In volts) | Current (In Amp) | Speed (In RPM) |
|---|---|---|---|---|
| 1 | 40 | 400 | 0.5 | 1700 |

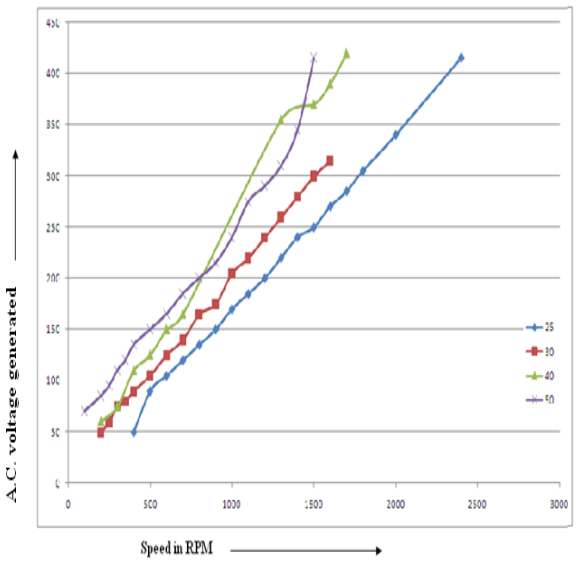


**Fig. 3 Graph of A.C. voltage generated**



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## VII. CONCLUSION

The model developed in this work proves to be useful to study wind power generation using slip ring induction generator, factors affecting amount of power generated and effect of load on output parameters.

As D.C. shunt motor is used as prime mover, it is possible to obtain easy speed variation so as to create natural wind speed conditions as slow speed, medium speed and high wind speeds. By considering all these parameters its impact on wind power generation is observed.

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