2.1 Wind Turbines:

In the recent years there is considerable increase in renewable energy sources. The estimated wind capacity at the end of 2011 is 238GW. India is ranked the 5th largest producer of wind power with16GW production. Wind energy production is completely pollution free and therefore it is being adopted in all modern power systems, thereby encouraging works on wind power based research.

The toughest part is construction of the required experimental setup to mimic the real time wind turbine environment. This paper involves the configuration of a test system working on a wind turbine's power-speed characteristics. It mainly involves the power-speed and torque-speed characteristics and models the wind turbine characteristics reproducing the same utilizing MAT LAB SIMULINK.

The wind energy is captured by the wind turbine which is converted into electrical energy by the turbine. Due to the massive size of the wind turbine it is not possible to do research work in a real wind farm. In order to carry out the research work we need to develop a simulator to simulate the wind turbine which does not depend on natural wind, thereby reducing the experimental cost.

Basing on the orientation of axis of rotation the wind turbines are classified as the follows:

1. Horizontal axis wind turbines or HAWTS;
2. Vertical axis wind turbines or VAWTS.

Horizontal axis wind turbines:

In this design the rotor shaft and the motor are placed at the top of the tower facing the wind. The gear box steps up the rotations of the wind turbine to drive the electric generator. The HAWTs propeller design is similar to that of aircraft propellers, which basically work on aerodynamic principles. The air passes over the air foil fashioned blades which devlop a lifting force that help in turning the rotor.

Vertical axis wind turbines:

In this design the rotor shaft is vertically arranged. The major advantage of design is that the turbine need not point in the direction of the wind in order to be effective. Which is very much required in highly variable wind sites. In VAWT arrangement, the gearbox and generator can be placed close to the ground, using a ground based gear box, which improves the access for maintenance. Further advantage of a VAWT over the counterpart HAWT is that Yaw mechanism is not needed because wind can be harnessed from any direction. The main disadvantage are low rotational speed and the higher cost for drive train because of lower torque and higher power coefficient.

As a turbine is positioned on a rooftop, the redirected wind from the building doubles the speed of the wind coming to the wind turbine. The efficiency is maximum when the turbine tower mounted in the rooftop is around 50% of the height of the building.

2.2 Relevant definitions:

Described below the explanations of some significant parameters associated with wind turbines. Control of the wind turbine models is facilitated by these parameters.

* + 1. Solidity

he ratio of the blade area projection to the intercepted wind area is defined as solidity. The projected blade area here is denoted by the blade area seen by the wind or projected in the direction of the wind. The area intercepted by the wind is also defined as the swept area.

Study shows direct association of solidity with torque and speed. High-solidity rotors are characterized with greater torque and lower speed appropriate for jobs like pumping water. On the other hand, low-solidity rotors are characterized with greater speed and lesser torque. This is usually appropriate for electrical power generation.

* + 1. Tip Speed Ratio (TSR)

𝜆 or the Tip Speed Ratio (TSR) is the ratio of velocity of the rotor’s blade tip to the air flow.

where, 𝑟𝑟= rotor radius in meters, 𝜔𝑟= angular speed in rad/sec and 𝑉𝑤= wind speed in m/s.

* + 1. Coefficient of Performance.

The power essentially taken from the wind turbine rotor, 𝑃 , is some portion of the offered power, described by the coefficient of performance, 𝐶𝑝 , that is basically a type of power conversion efficiency.

Here 𝐶𝑝 (power coefficient) signifies the efficiency of the blades to obtain the power in wind. It is the portion of power which is fetched from the wind to the turbine blades. The theoretical boundary of 𝐶𝑝 is about 59.3%.

2.2 Wind turbine simulators:

Due to an increase in wind power establishments, studies related to wind energy structures is developed. So development of equipment which can simulate the wind turbine closely is very important. The primary purpose of this type of equipment, that possibly be termed as a wind turbine simulation device, is the capability to determine dynamic and static characteristics of an actual wind turbine.

There exists several varieties of wind turbine simulators evolved using various types of motors and control practices. DC motors, induction motors and quite seldom, synchronous motors are utilized as the mechanical prime mover of the wind turbine simulators. Wind turbine simulating device employing separately exited DC motors generally utilize armature and field voltage control techniques to realize static characteristics of a fixed pitch wind turbine. These simulators basically lack the dynamic operations.

Few simulators employ permanent magnet synchronous motors as the mechanical prime mover with a voltage source converter. Like the prime movers, several categories of generators are employed at various wind turbine simulators. Induction generators are most widely used with the irregular use of DC and synchronous generators.

Wind, which is the normal motion of air in the atmosphere, is produced by pressure variations on the surface of the earth owing to the irregular warming via solar irradiation. From fluid mechanics, the air current can be examined as mass flow with kinetic energy [1] given by:

here “A” is the area of the incident air stream, U and v the velocity and density of the flow respectively. Generally, “A”, the stream area of interest is denoted as the area swept by the rotor of a wind energy conversion system (WECS). These systems transform the linear momentum of the air stream into a rotation of the WECS rotor, with a maximum possible efficiency of 59.26%, referred to as Betz limit. Additionally, it can be witnessed from (1) that the obtainable power in the wind surges at the cube of the air velocity, and from a substitution of “A” for the area of disk.

Thus, a two-fold escalation in the radius of a WECS’ blade geometry consequences in a four-fold surge in captured energy.

* 1. Wind energy conversion system:

Several WECS have come , but the most successful one is the horizontal axis wind turbine (HAWT).The design of interest is the low power in expensive HAWT design which is widely used in rural and urban areas . The increased concern over greenhouse gas emissions has made these systems very popular, these consist of the following four main components:

2.4.1 Rotor Assembly:

Blades of the turbine along with the hub upon which the blades are mounted comprises the rotor assembly. The response of a wind turbine is critically affected by blade geometry, and in numerous designs, this factor is also the most costly part of the turbine unit.

2.4.2 Drive train:

Linking the rotor to the generator is the drive train. In larger wind turbine systems, the drive train comprises of gearing to escalate the velocity of rotation from the rotor into the generator. Small turbines lack this attribute; the drive train for those systems is merely a linking shaft.

2.4.3. Generator:

The generator transforms the mechanical rotation of the drive train into electricity. Small turbine generators are normally of the 3-phase, permanent magnet type; yet various generator classes are also employed.

2.4.4. Controller:

For shielding the system, apart from transforming the output of the generator to domestic voltages, the necessity of power electronic interface arises. As already mentioned, the working of a turbine is seriously affected by its geometry. Characterization of the performance is usually done with a Cp - curve; a plot of power coefficient to the tip speed ratio of the blades. The power coefficient Cp signifies the efficiency of the blades in taking out the power stored in the wind, whereas the tip speed ratio (TSR) is defined as the ratio of the blade speed to the air stream.

2.5. CONTROLLING TECHNIQUES OF WIND TURBINES

The power captured from the wind turbine should be maximized. Most important is, the safety of the wind turbine should not be compromised. Thus, proper regulation of power plays a very important role in the operation of wind turbine. In order to prevent any damage to the wind turbine in case of very high wind speed, it is important to limit the amount of power absorbed which can be done by regulating the aerodynamic forces acting upon the rotor. The commonly employed techniques to achieve the above objective are as follows:

2.5.1. Pitch control

Pitch control helps the blades to be twisted into or out the wind. It results into deviation of the force exerted by the wind on the shaft of the rotor. This control has many advantages over other controls:

• power control is perfect,

• Aided startup, and

• Alternative stop.

Power output can be limited to the rated power of the generator using pitch control at higher wind speeds. The system complexity is one of the disadvantages in the pitch mechanism and one more disadvantage is greater power fluctuations at high wind speeds.

2.5.2. Stall control

a. Passive Stall control

The informal controlling method for a wind turbine is stall control and stalling will take place when the wind speeds crosses a certain limit . Thus, the lift force exerted on the rotor stops starting the turbine to stall and restrict them in a allowable speed limit. Therefore, the turbine is safe and secured at a very higher wind speeds. Power control is very smooth using this process. The disadvantage is that , at low wind speeds turbines operate at a lesser efficiency than the measured value . Moreover the reasons behind the disparities in steady state power extraction are due to the variation of grid frequencies and air density.

b. Active Stall Control

The active stall control was a replacement over passive stall control. Instead of using natural stalling, pitching was used by this system for controlling the stall of the blade actively. Therefore , maximum efficiency is achieved by pitching the blades in the same manner as that of pitch controlled wind turbine at low wind speeds and at higher wind speeds, to allow them into a deeper stall, the blades are oriented to some extent into the direction opposed to that of a pitch controlled turbine.