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Overview of Wind Turbines in Power Generation System

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ABSTRACT: In last two decades, a lot of development has taken place in technology of Wind Energy sector under Renewable Energy sources. Wind energy is now generally considered as a commercially viable option to increase energy generation and reduce the atmospheric pollution.Wind turbines can be built either as constant-speed machines, which rotate at a constant speed regardless of wind speed, or as variable speed machines in which rotational rate varies in accordance with wind speed. This paper discusses the classification of different wind turbines and its comparison which is used in wind energy system.

KEYWORDS: Wind Turbine, Tubular Tower, Fixed Speed Wind Turbine, Variable Speed Turbine

I.INTRODUCTION

Prior to invention of electricity and combustion engines, wind power was the only viable form of energy source for ocean vessels, large mills and water pumps. However, due to varying nature and unpredictability of wind speed, wind energy is “non-dispatchable” energy source, i.e., the user has to take whatever power is available, whenever available. Wind power along with solar energy, hydro power and tidal energy are possible solutions for an eco-friendly energy production. Among these renewable energy sources, wind power has the fastest growing speed (approximately 20% annually) in the power industry. With the concern of environmental pollution, wind power is being established in many countries by way of government-level policy. With the concern of environmental pollution, wind power is being established in many countries by way of government-level policy**.** Wind turbines can be built either as constant-speed machines, which rotate at a constant speed regardless of wind speed, or as variable speed machines in which rotational rate varies in accordance with wind speed. The first windmill used for the production of electricity was built in Scotland in July1887. A wind farm is a group of wind turbines in the same location used for production of electricity. A large wind farm may consist of several hundred individual wind turbines distributed over an extended area, but the land between the turbines may be used for agricultural or other purposes. In the last decade, two major technological developments have taken place in the field of wind turbine technology. Firstly, the size of an individual wind turbine or the scale of a wind farm has significantly increased to reduce the cost of wind power. The nominal power of an individual wind turbine has grown from several tens of kW to MW class. A typical wind farm consists of several tens to hundreds of such wind turbines. The wind turbine technology is improving rapidly and it soon took the title of champion from all renewable sources of energy. Large wind farms have been planned and installed in various locations around the world. Institutional incentives and government together with wind energy development technologies have enabled the rapid development of wind energy with an annual growth of 30% and a market penetration of electricity by12% 2012. Today, more than 28000 wind generating turbine are successfully operating all over the world (Mohod and Aware, 2012). Wind energy is extracted through wind turbine blades and then transferred by the gearbox and rotor hub to the mechanical energy in the shaft, which drives the generator to convert the mechanical energy to electrical energy as shown in fig. 1. [2]

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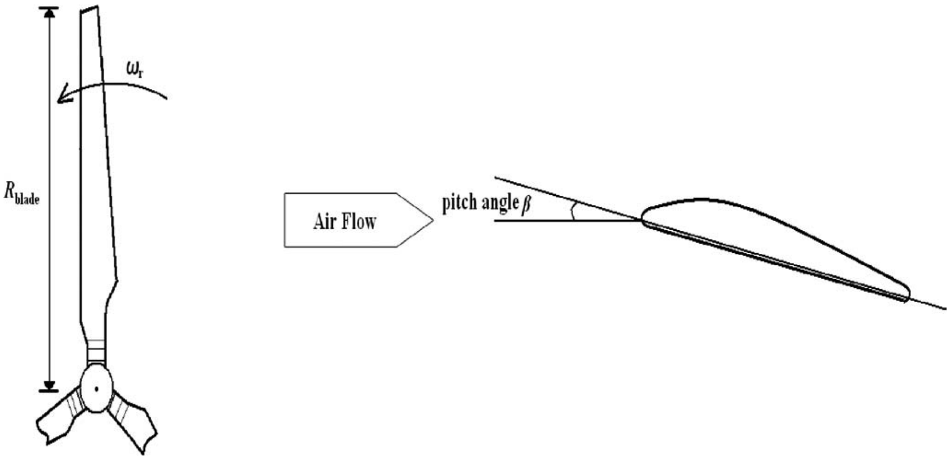

Fig.1 Schematics of turbine blade from different views

II. COMPONENTS INSIDE TUBULAR TOWER

The main components inside tower are

(i) Main Panel
(ii) Power Panel
(iii) Control Panel
(iv)

(i) Main Panel

It is always connected to grid side. It consists of main fuse, which connects transformer with the machine.

(ii) Power panel

This gets input from PLC and maintains the target power factor within the tolerance by switching capacitors. Inside the Power Panel three capacitor banks, each of rating 25 KVAR is used for reactive power compensation as shown in fig.2.

Fig. 2 Power Panel inside tubular tower

It carries, switches, protects power circuit and gives soft starting for an asynchronous Generator. It consists of two contactors. First contactor is ON position, when the induction machine initially running as an induction motor, which takes power from the grid. Above synchronous speed the machine acts as a generator. At that time second contactor is turned ON, which delivers power to the grid.

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(iii) Control Panel

This is the master controller of a wind turbine. It is divided into 2 parts, one sits up in the nacelle and the other one is part of the bottom panel.

Fig. 3 Control Panel inside tubular tower.

This is essentially a PLC- microprocessor based panel. It receives signal from various sensors for wind speed, direction, position of yaw, temperature, humidity, grid conditions etc., and controls the turbine for start, stop, brake, pitching in/out, yawing etc., in addition to communicating to central monitoring system. Yawing is the process of rotating the entire top load to face the direction of the wind.

III. TYPES OF WIND TURBINE

The first kind of wind turbines used was asynchronous squirrel-cage induction generator (SCIG), which are directly connected to the grid as shown in fig 4. The rotational speed of the wind turbine cannot be automatically regulated and will only vary with the wind speed. This type of wind turbine needs a switch to prevent motoring operation during low wind speeds, and also suffers a major drawback of reactive power consumption since there is no reactive power control. This reactive power problem can be avoided by using locally installing capacitor banks (Kadhim and Chavan, 2013).There will be electrical power fluctuations due to the fact that there are no speed or torque control loops. These electrical power fluctuations can lead to an impact at the point of connection in the case of a weak grid.[7] Based on the grid frequency and number of poles, the wind generator will rotate and based on the gearbox ratio the turbine will rotate. First generation wind power plants have some advantages like simple design, lower cost and easy maintenance.[5]

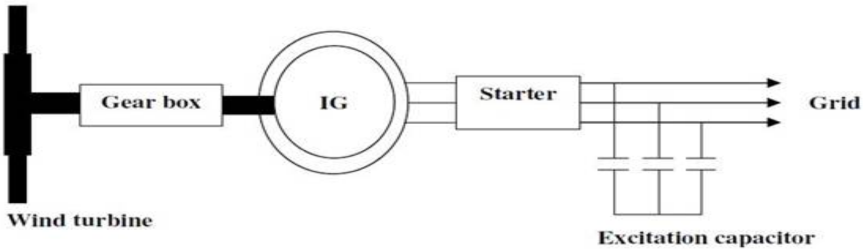

Fig.4 Fixed speed wind turbine with induction generator

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The second generation wind turbines uses a wound rotor induction generator (WRIG) directly connected to the grid. The rotor phase windings of the generator are connected in series with controlled resistances. In this way, the total rotor resistances can be regulated, and thus the slip and the output power can be controlled. The limitations of the series resistance size and the variable speed range is usually small, typically 0-10% above synchronous speed. But the main problem of this type of wind turbine is that large amount of power loss occurs in the rotor resistance (Bhadra*et al.*, 2005) and (Earnest and Wizelius, 2011).
The third generation known as variable speed wind turbine with partial scale power converter (DFIG). The stator phase windings of the DFIG are directly connected to the grid, while the rotor phase windings are connected to a back-to-back converter via slip rings as shown in fig 5.

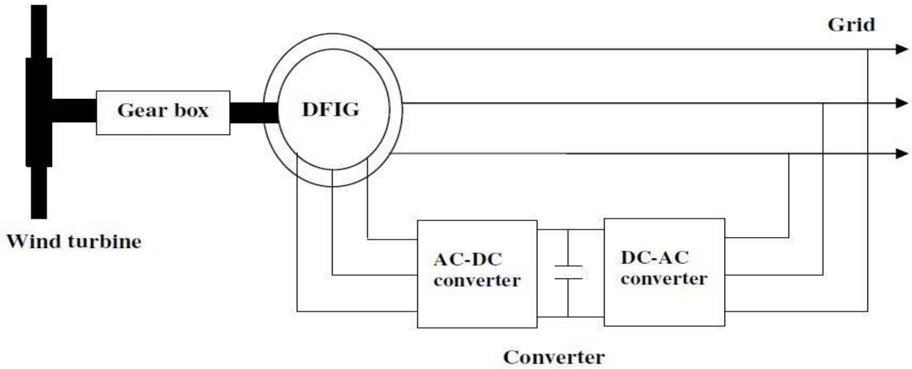

Fig. 5 Variable Speed wind turbine with DFIG

The power converters could control the rotor frequency and thus the rotor speed. Here, the speed range for the DFIG is around 30% of the synchronous speed. The power rating of the power converters is typically rated 30% around the rated power since the rotor of the DFIG would only deal with slip power. The smaller rating of the power converters makes this concept attractive from an economical point of view. This type of wind turbine can also achieve the desired reactive power compensation.
The fourth generation wind turbine consists of wind turbine equipped with a converter connected to the stator of the generator as shown in fig 6. The generator could either be a cage bar induction generator or a synchronous generator. The gearbox is designed so that maximum rotor speed corresponds to rated speed of the generator. Synchronous generators or permanent magnet synchronous generators (PMSG) can be designed with multiple poles which imply that there is no need for a gearbox. Therefore, there are no mechanical stress issues when experiencing wind gusts. Since this full power converter/generator system is commonly used for other applications, one advantage with this system is its well developed and robust control.

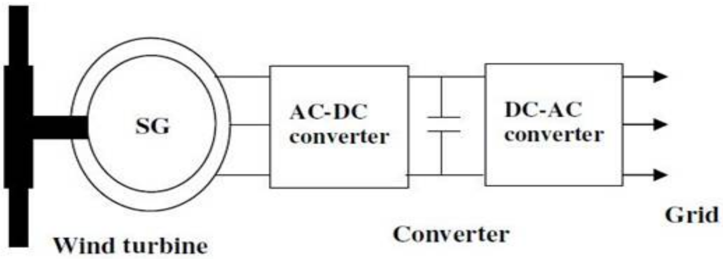

Fig. 6 Variable speed wind turbine with PMSG

But the power converters of a PMSG-based wind turbine-generator system have a full-scale power rating, which means that the power converters will cause high losses, generate high harmonic components, and have high cost. The PMSG is usually a multi-polar generator, which is relatively large and heavy, and causes inconvenience for the installation. The PMSG naturally needs permanent magnets, which will increase the cost for this wind turbine concept considering the current market. The permanent magnets run the risk of demagnetization at high temperature. [6]

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IV. COMPARISON OF WIND TURBINES

The performance and controllability of DFIG are excellent in comparison with FSIG systems; they capture more wind energy, they exhibit a higher reliability gear system, and high quality power supplied to the grid. It saves investment on full rated power converters, and soft starter or reactive power compensation devices (fixed speed systems). Modern wind farms, with a nominal turbine power up to several MWs, are a typical case of DFIG application. Besides this, other applications for the DFIG systems are, for example, flywheel energy storage system, stand-alone diesel systems, pumped storage power plants, or rotating converters feeding a railway grid from a constant frequency utility grid. In practical applications, the DFIG is gradually maturing as a technology for variable speed wind energy utilization. Although topologies of new systems with improved performance are emerging both in academia and industry, DFIG is the most competitive option in terms of balance between the technical performance and economic costs as shown in fig.7.

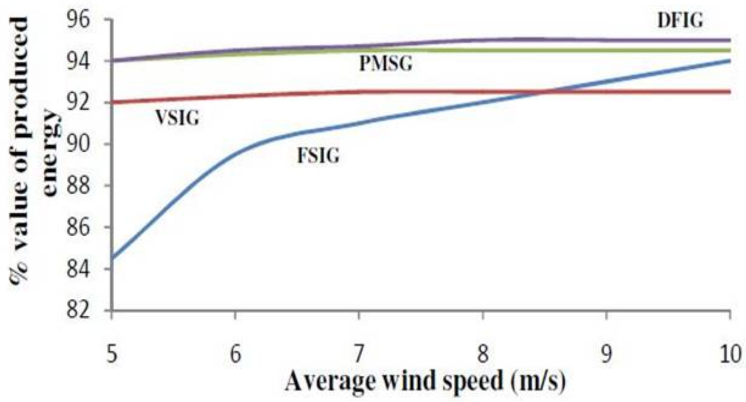

Fig. 7 Energy Efficiency of generators

VI.CONCLUSION

Wind energy grid integration has already reached great proportions and will increase in future although there is insufficient wind forecasting small period and wind speed fluctuations. The main components of wind energy conversion process are turbine and generator. The characteristic of turbine is such that it has the best conversion efficiency at certain rotational speed corresponding to certain wind speed and the efficiency drops either way.

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