UNIT-3
WIND POWER
TOPICS TO BE COVERED...

3.1 Growth of wind power in India
3.2 Types of wind turbines – Vertical axis wind turbines (VAWT) and horizontal axis wind turbines (HAWT)
3.3 Types of HAWTs – drag and lift types
3.4 Working of large wind turbines
3.5 Aerodynamic control of large and small wind turbines
3.6 Types of electrical generators used in small and large wind turbines
3.1 Growth of Wind Power in India

- The potential of wind power in India is inexhaustible. It has been estimated that at current level technology, wind energy generation potential in India is staggering 45000 MW or more while present power generation through wind energy is approximately 17644 MW at the end of 2012.

- Government of India has launched various schemes to attract the power generation through wind energy.

- Capital cost of installation of wind energy power plants have been reduced due to innovation in Technology, modern manufacturing system and easy availability of finance.
3.1 GROWTH OF WIND POWER IN INDIA

- With attractive schemes of Government of India there is rapid growth in wind power generation in our country.
- Samana in Gujarat’s Rajkot district is set to become a major hub of wind power energy in the country as energy.
- ONGC Ltd has commissioned its first wind power project.
- The 51 MW project is located at Motisindholi in Kutch district of Gujarat.
- In this way the future potential of wind power in India is very Good.
3.2 Types of Wind Turbines

- There are two types of wind turbines.
- 1) Vertical axis wind turbines and
- 2) Horizontal axis wind turbines.

We know that there is enough wind globally to satisfy much, or even most, of humanity’s energy requirements — if it could be harvested effectively and on a large enough scale.
VERTICAL AXIS WIND TURBINE

- The axis of wind turbine of this type is vertical.
- Tie ropes and supports are used to keep main shaft of turbine vertical.
- Its generator is kept on ground level.
- Vertical axis wind turbine can be rotated by the winds coming from any direction.

Types of vertical wind turbines
- Savonius wind turbine.
- Darrieus wind turbine.
VAWT
Savonius Wind Turbine - VAWT

- Savonius wind turbine has designed by S.J> Savonius in 1920.
- The rotor of this vertical axis wind turbine mill is S-Shape.
- It is made from hemispherical drums welded to the vertical shaft fitted in the bearing which are fixed on the ground.
- Winds incidental on the vertical blades comes from any direction strikes the surfaces of the blades generating torque to rotate the shaft.
Mechanical energy available on the shaft can be used for running water pump, flour mill and farm machineries.
ADVANTAGES

- It is not necessary to track the wind mill head in the direction of winds.
- It gives better aerodynamic efficiency and high torque.
- There is no weight of machinery such as pump or generator on the structure of the wind mill.
- Structure is simple and low cost.
- Operation and maintenance are simple and convenient.
DISADVANTAGES

- The wind mill rotor is not efficient and it is heavier.
- The rotor has small area to face the winds.
- It cannot withstand thunder storms and high speed winds.
- The drive shaft is very long and requires long supports.
Darrieus Wind Turbine – VAWT

- In 1925 George Darrieus has designed the vertical axis wind turbine with light weight aerofoil blades to give less resistance to air and more rotational speed in low speed winds.
- The rotor is made up of two, three or more numbers of thin metallic strips with their ends fitted into the shaft.
The generator or pump kept on the ground is also rotated to give power.

The driving forces of the winds are applied on thin section of aerofoil blades.

It gives better speed and efficiency.

It does not over-speed in high-speed winds.
ADVANTAGES

- It is high speed turbine with better efficiency.
- Its aerodynamic efficiency is higher.
- It does not require tracking its direction towards the winds.
- No power transmission devices such as gear box or belt drive are required.
- Blades are simple in design and have low cost.
- It can be used in low speed winds.
**DISADVANTAGES**

- It has lower output in comparison with other wind mills.
- It has less starting torque.
- It produces vibrations and noise in the blades during variations in wind speeds.
- The height of rotor is lower than that of horizontal axis wind mill. Hence it generates less power.
- Brakes are required to prevent over speeding.
The horizontal wind turbine is a turbine in which the axis of the rotor's rotation is parallel to the wind stream and the ground.

Most HAWTs today are two- or three-bladed, though some may have fewer or more blades.

There are two kinds of Horizontal Axis Wind Turbines: the upwind wind turbine and the downwind wind turbine.

The HAWT works when the wind passes over both surfaces of the airfoil shaped blade but passes more rapidly at the upper side of the blade, thus, creating a lower-pressure area above the airfoil.
**Horizontal Axis Wind Turbines**

- The difference in the pressures of the top and bottom surfaces results in an aerodynamic lift.
- The blades of Horizontal and Vertical Wind Turbines of the wind turbine are constrained to move in a plane with a hub at its center, thus, the lift force causes rotation about the hub.
- In addition to the lifting force, the drag force, which is perpendicular to the lift force, impedes rotor rotation.
COMPONENTS OF HAWT

- Wind Power Rotor
- Gear Box
- Generator
- Control System
- Tower
APPLICATION OF WIND GENERATOR [AEROGENERATOR]

- Wind turbine generator set capacity from 50 to 3000 KW can be used instead of diesel generator sets.
- They are used for remote area electrification projects.
- They are used for running water pump.
- They can supply power to state electricity company.
3.3 Types of HAWT

- Classification according to number of blades in rotor.
- Classification according to the power output.
- Classification according to Lift and Drag type HAWT Plants.
- Classification according to upwind and downwind turbines.
3.4 Working of Large Size Wind Turbine

- Large capacity wind turbines have capacity more than 500 KW.
- They have design, construction and operation quite different from smaller capacity wind turbine.
Figure of Wind Turbine
COMPONENTS OF WIND TURBINES

- Blades
- Rotor
- Pitch
- Brakes
- Low Speed Shaft
- Gear Box
- Generator
- Controller
- Anemometer
- Wind Vane
- Nacelle
- High Speed Shaft
- Yaw Drive
- Yaw Motor
- Tower
 Blades:
- Normally, there are three blades in the rotor of horizontal axis wind turbine.
- Like airplane wings, these blades are aerodynamically designed so that they can generate maximum power with minimum air resistance.

Rotor
- Rotor axis of HWAT is always horizontal.
- The upwind rotor is made of three blades to maintain solidity ratio.
- Large size wind turbine rotor diameter varies from 50m to 150m.
Pitch:
- Pitch is a mechanism of changing the blade angle.
- Large size wind turbines are provided with pitch control mechanism.
- Each blade can rotate in their hub by pitch motors.

Brakes:
- Mechanical brake system is provided in wind turbines.
- Brakes are automatically actuated when high speed winds are blowing.

Low Speed Shaft
- The shaft on which turbine rotor is fitted is called as low speed shaft because it runs slowly.
Gear Box:
- The gearbox is provided between low speed shaft and high speed generator shaft.
- It is a step up gear box which increases the speed of generator shaft.

Controllers:
- The control system is provided for pitch control and you to control wind turbines.

Anemometer:
- The anemometer is a device to measure wind velocity.
- It is a small turbine type runner in which cup-shape wind vanes are provided.
- This runner runs on wind and its speed of rotations depends upon the speed of winds.
- **Wind Vane:**
  - Wind vane is provided on the back side of nacelle.
  - The function of wind vane is to maintain the direction of rotor exactly to face the winds.

- **Nacelle:**
  - Nacelle is a windmill head housing wind mill rotor shaft, gearbox, generator, and controller.
  - Nacelle can rotate through yaw drive mechanism around vertical axis.

- **High Speed Shaft:**
  - The output shaft from gearbox is called high speed shaft which rotate the generator.
- **Yaw Drive:**
  - Yaw drive is a mechanism for rotating wind mill head or nacelle.
  - It is comprised of yaw motor and gears.

- **Yaw Motor:**
  - Yaw motor is provided in yaw drive mechanism to rotate nacelle.
  - When direction is changed, the yaw motor receives signal and it starts running to move wind mill head in front of winds.

- **Tower:**
  - The tower of wind mill for large size power generation is very sturdy and is capable to withstand large forces of thunderstorms.
3.5 **AERODYNAMIC DESIGN OF WIND TURBINE BLADE**

- Wind turbine blades are always aerodynamically designed to produce maximum power from wind energy.
- They are designed on the same principles by which aircraft wings are designed.
AERODYNAMIC DESIGN OF WIND TURBINE BLADE

- The aerodynamic design of wind turbine blade need very small cross section of the blade so that they offer minimum resistance to the winds and develop maximum power.
- The wind turbine blades of large size wind turbine units are designed to operate on lift forces instead of drag forces.
- The lift forces giving better speed which is necessary for power generation purpose.

- The control system of small size wind turbine is simple.
- They are provided with mechanical braking system.
- The pitch control and yaw controls are not provided.
- But generator operates on cut-in and cut-out speed control.
CONTROL SYSTEM OF LARGE SIZE WIND TURBINE

- The large size wind turbine have very complex control system.
- Its major control system are as under:
  - Pitch Control System
  - Yaw Control System
  - Aerodynamic Braking System
  - Central Controller with microprocessor.
CONTROL SYSTEM OF LARGE SIZE WIND TURBINE

Pitch Control System
- There are three independently controlled pitching motors are provided to rotate each blade around its chord axis.
- These motors receive signals through microprocessor according to the velocity of winds.
- They change the pitch angle of blade so as to give most optimum output speed of rotor.
CONTROL SYSTEM OF LARGE SIZE WIND TURBINE

**Yaw Control System**
- The assembly of wind turbine rotor and shaft, gearbox, generator and control mechanism is housed in a unit called nacelle.
- This nacelle is mounted on the top of tower with yaw control system so that it can be rotated around vertical axis on sliding bearing.
- Yaw motor receives signal from controller when wind directions is changed.
CONTROL SYSTEM OF LARGE SIZE WIND TURBINE

Central Controller with microprocessor

- The output signals from different sensors such as wind vanes, anemometer, wind turbine R.P.M etc are fed into central controller.
- These signals are processed by microprocessor and distributed through relays and actuators to various controlling points such as pitch motors, yaw motors etc.
3.6 Types of Generators Used in Wind Turbine

- Electric generators are the most important components of wind turbine power plants.
- There are various types of electric generators designed for specific purposes.
- Output electrical power – A.C. power to be directly used for mechanical conversion.
- Output electrical power – A.C. power to be connected to grid power lines.
Types of Generators used in Wind Turbine

- Types of system used in electric generators are:
  - Variable speed constant frequency system [VSCF]
  - Constant speed constant frequency system [CSCF]
VARIABLE SPEED CONSTANT FREQUENCY SYSTEM [VSCF]

- In this type of system, the generator develops power of variable frequency from its variable speed of rotation.
- This power of variable frequency type is converted into constant frequency by rectifiers and inverters.
- This power cannot be used for grid connection.
CONSTANT SPEED CONSTANT FREQUENCY SYSTEM [CSCF]

- In this system, the induction generators are used.
- They generate an electrical power of constant frequency directly.
- When these generators produce power of synchronous frequency, it matches with grid power and hence it can be fed into grid.
AUTONOMOUS POWER GRID MACHINES

- Autonomous power grid machines are actually wind turbine generator sets developing more than 5MW power and feeding it into the power grid.
- They are the number of propeller type wind turbines collectively called as wind farm.
- They are collectively set up at place where there is a good potential to harness wind power all the year round.
APPLICATION OF WIND MILL & WIND POWER

- For water pumping and smaller irrigation schemes.
- For captive electrical power generations.
- For running flour mills.
- Used as stand by energy source.
- To run farm machineries and equipments.
- Used for battery charging.
- Used in fishing and salt industries.
- Used in rural forestry projects.
CRITERIA FOR SITE SELECTIONS FOR SETTING UP WIND TURBINES.

- It should be set up at a place where annual average wind velocity should be around 15 kms or more.
- Winds should be steady, reliable and blowing almost year round at the selected place.
- There should not be big trees, buildings and hills near the wind mills to block the flow of winds.
- Wind mill can be set up on the gentle slopes of mountains.
CRITERIA FOR SITE SELECTIONS FOR SETTING UP WIND TURBINES.

- The wind mill site should be facing sea shore or it should be on the islands where there are large flat lands available without any obstructions.
- The climate should not be such that there are very high speed winds or thunder storms at the place selected for setting up wind mills.
Thank you