UNIT 03 : WIND ENERGY SYSTEMS

Marks:12

❖ WIND ENERGY:

- Wind energy is a form of solar energy. Wind energy (or wind power) describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power.

- Wind is caused by the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth. Mountains, bodies of water, and plants all influence wind flow patterns.

- Wind turbines convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator. Three key factors affect the amount of energy a turbine can harness from the wind: wind speed, air density, and swept area.

- Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

❖ <u>Classification of Wind Mills</u>:

The wind mills can be classified as follows:

1.Based on orientation of the axis of rotor:

i) Horizontal Axis

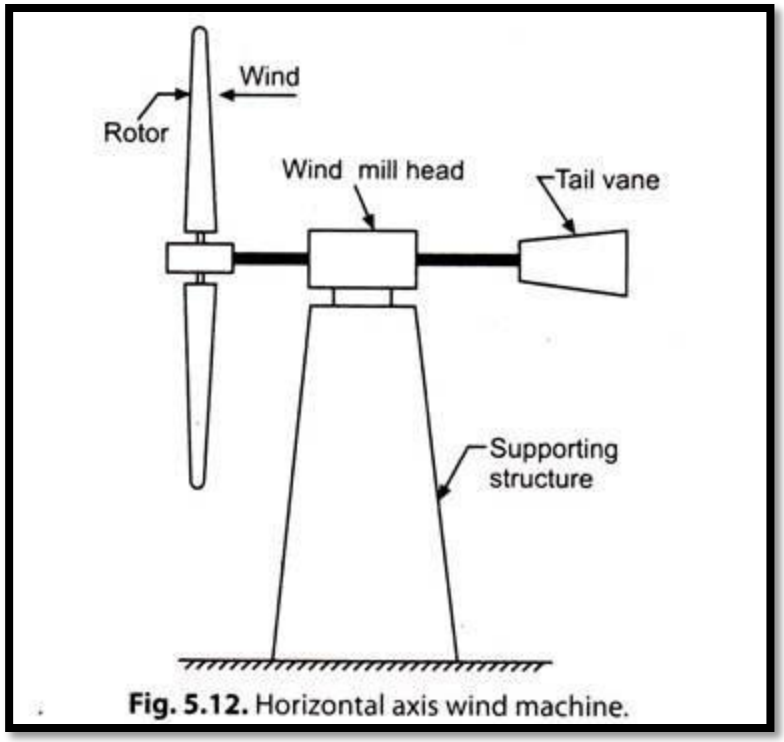


Fig. 5.12. Horizontal axis wind machine.

ii) Vertical Axis

2.Based on type of rotor:

i) Propeller Type (Horizontal Axis)

Fig. 5.7. Propeller type (two blade design).

ii) Multiple Type (Horizontal Axis)

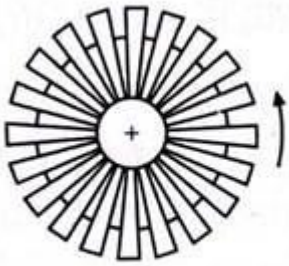


Fig. 5.8. Multiblade type.

iii) Savonius Type (Vertical Axis)

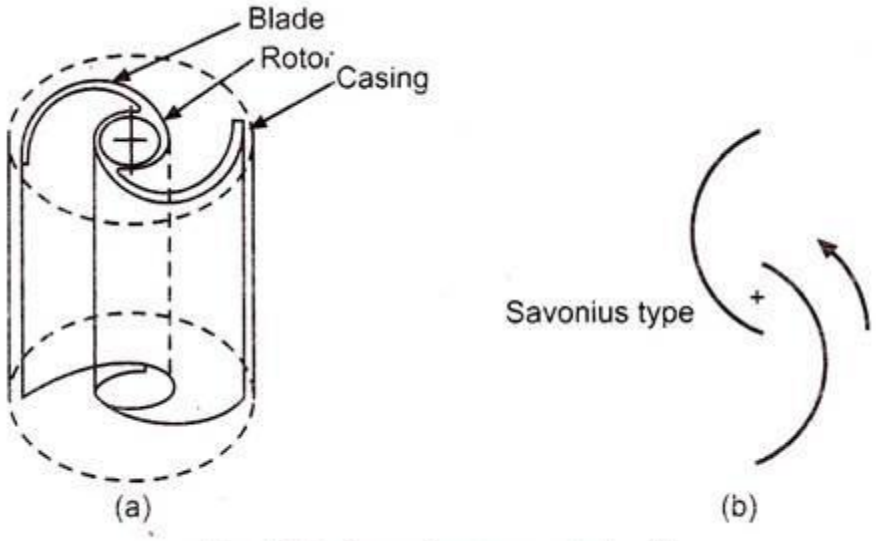
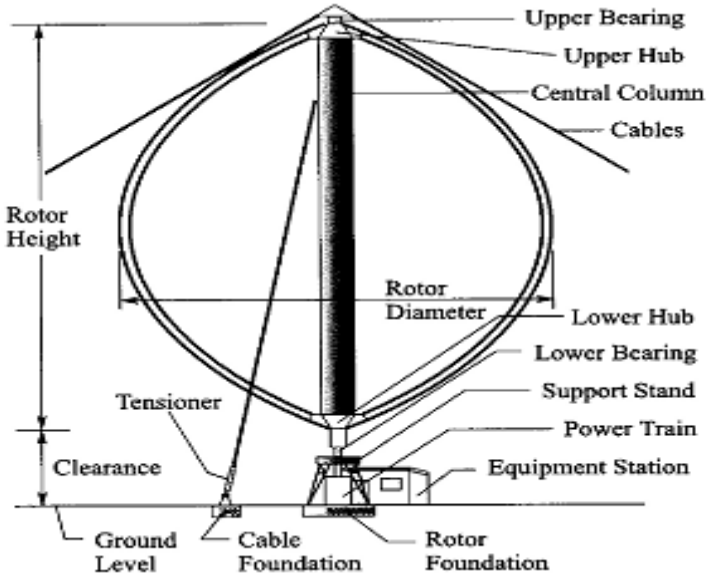


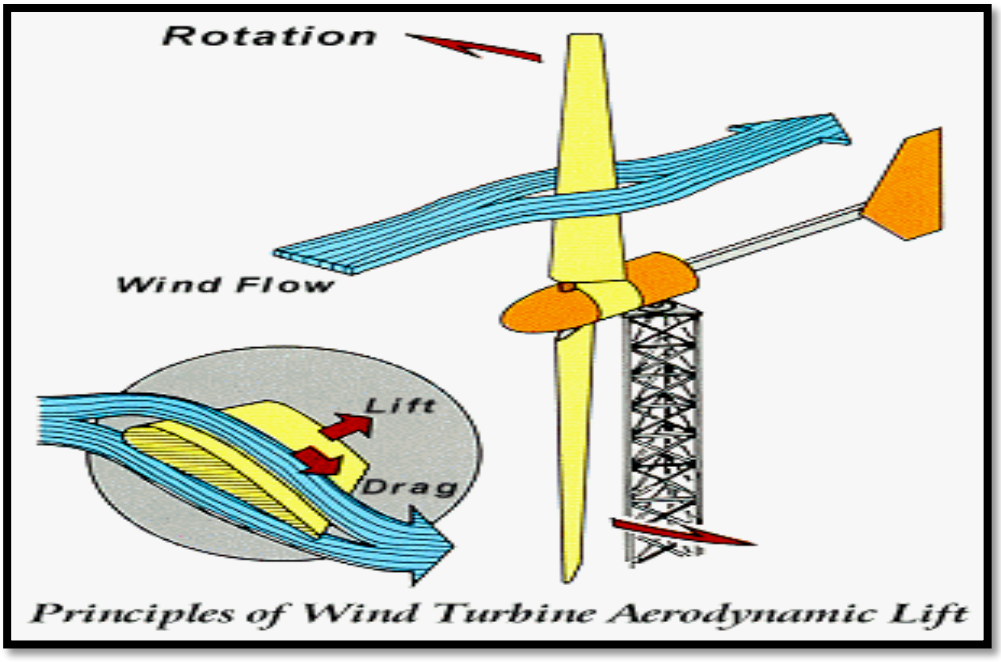
Fig. 5.10. Savonius type wind mill.

iv) Darrieus Type (Vertical Axis)

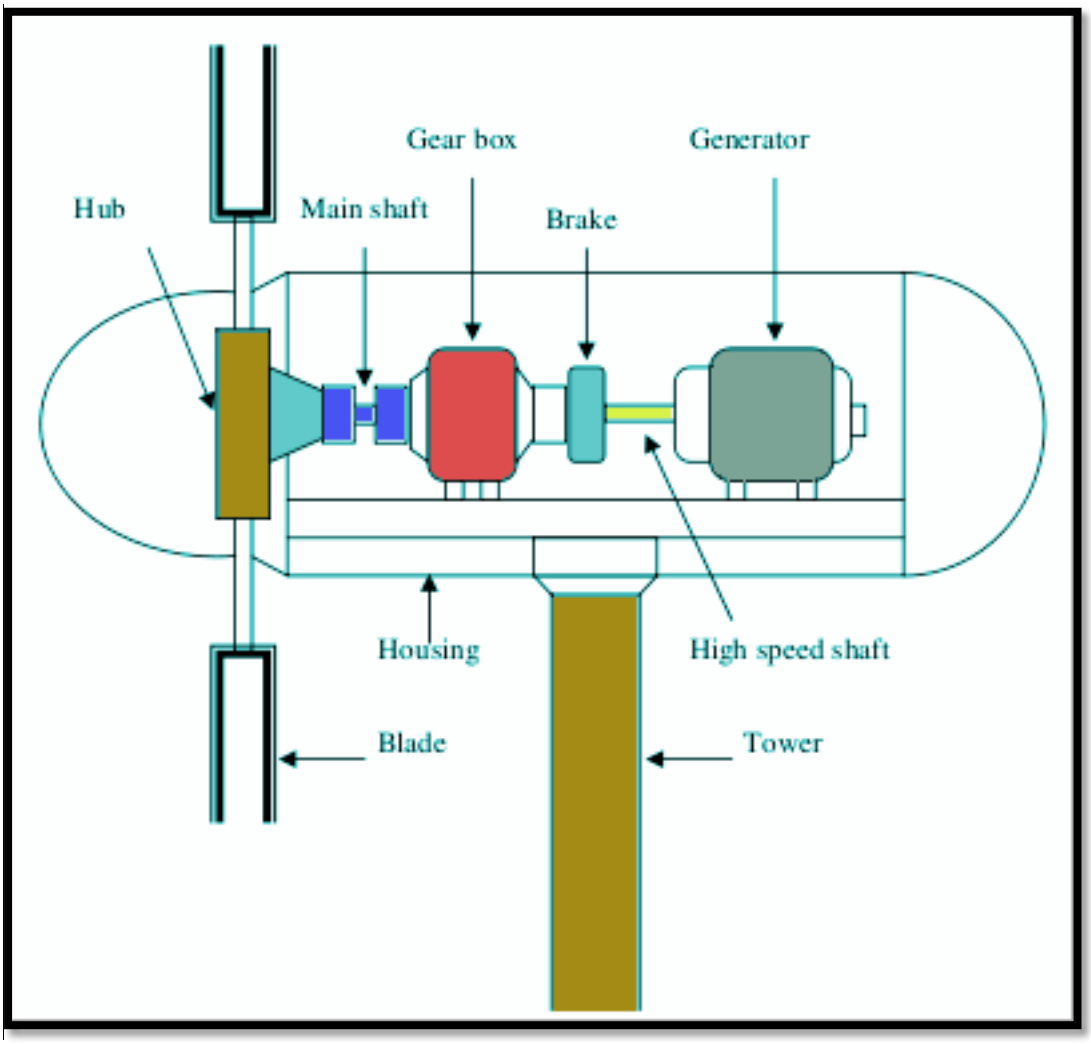


01.HORIZONTAL AXIS WIND MILLS :

- A horizontal-axis wind turbine (HAWT) is a wind turbine in which the axis of the rotor's rotation is parallel to the wind stream and the ground.
- All grid-connected commercial wind turbines today are built with a propeller-type rotor on a horizontal axis (i.e. a horizontal main shaft).
- Most horizontal axis turbines built today are two- or three-bladed, although some have fewer or more blades.
- The purpose of the rotor is to convert the linear motion of the wind into rotational energy that can be used to drive a generator.
- The same basic principle is used in a modern water turbine, where the flow of water is parallel to the rotational axis of the turbine blades.
- The wind passes over both surfaces of the airfoil shaped blade but passes more rapidly over the longer (upper) side of the airfoil, thus creating a lower-pressure area above the airfoil.
- The pressure differential between top and bottom surfaces results in aerodynamic lift. In an aircraft wing, this force causes the airfoil to rise, lifting the aircraft off the ground.
- Since the blades of a wind turbine are constrained to move in a plane with the hub as its center, the lift force causes rotation about the hub.



Principles of Wind Turbine Aerodynamic Lift



* **Blades**

Wind turbine blades are used to extract the kinetic energy of wind and convert to mechanical energy. These blades are made up of fiber glass-reinforced polyester or wood-epoxy. Wind turbines have one or two or three or multiple blades based up on the construction. Most of the HAWT have three blades. These are connected to rotor hub.

* **Hub**

A rotor hub is provided for coupling a wind turbine rotor blade and a shaft. The hub assembly consists of hub, bolts, blade bearings, pitch system and internals . Rotor hubs are made with welded sheet steel, cast iron, forged steel.

The types of rotor hubs are

1.Hinge-less hub

2.Teetering hub

* **Drive shaft**

Drive shafts are a hollow or solid steel hardened shaft under very high stresses and considerable torque. Drive shafts are used to transfer rotational mechanical energy from blade hub to the generator to produce electricity. A wind turbine normally consists two shafts .

* ***Main shaft***:

It is connected between blade hub and input to the gear box. It rotates at low speeds. So It is also called as 'low speed shaft'.

* ***Generator shaft***:

It connects the gear box output to the generator input. It rotates at very high speed equals to the rating of the generator. It is also called 'high speed shaft'.

* ***Gear Box:***

Gear box used in wind energy systems to change low speed high toque power coming from a rotor blade to high speed low torque power which is used for generator. It is connected in between main shaft and generator shaft to increase rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm. Gearboxes used for wind turbine are made from superior quality aluminum alloys, stainless steel, cast iron etc.

The various gear boxes used in wind turbines are

1.Planetary Gearbox

2.Helical Gearbox

3.Worm Gearbox

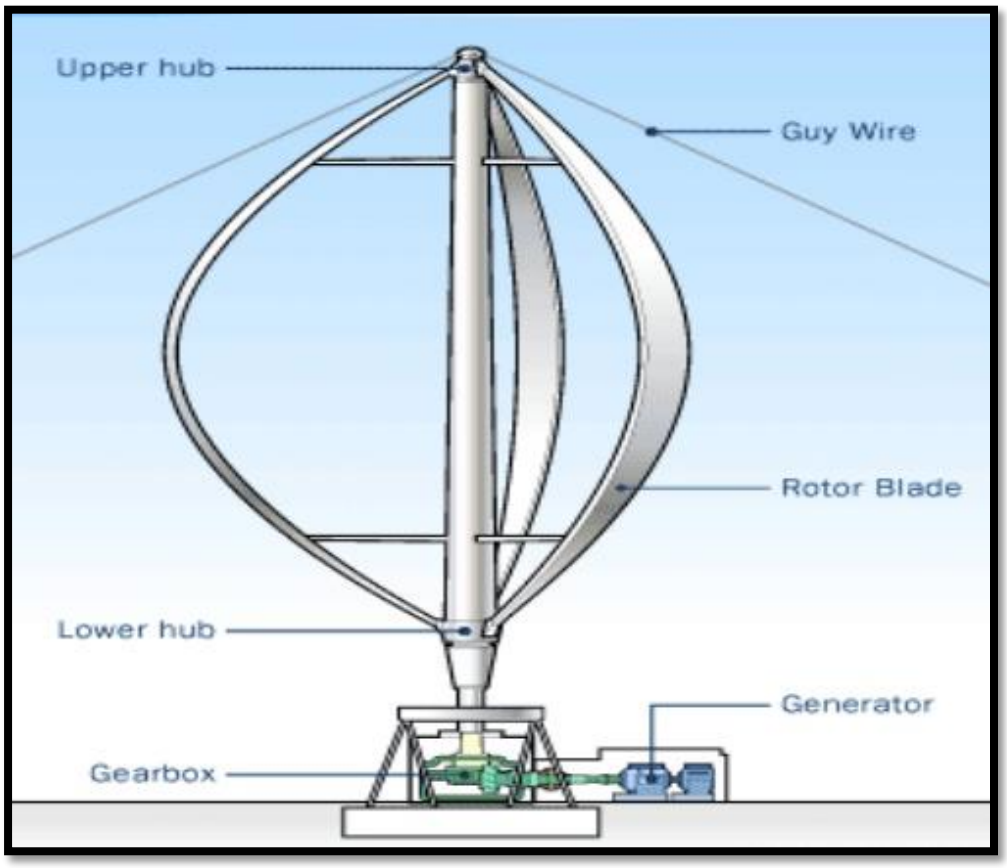
* ***Generator***

The output rotational mechanical energy of the gear box is connected to the generator through generator shaft. It works on the principle of 'Faraday's law of electromagnetic induction''. It converts mechanical energy into electrical energy.

❖ Vertical Axis Wind Turbine:

- The Vertical Axis Wind Turbine is a wind power generation design that puts the main rotor shaft transverse to the wind.
- The main components of the system are located at the base of the tower on which the vertical blades sit. This differs from the more common Horizontal Axis Wind Turbine (HAWT), where the blades attached at the horizontal rotor shaft.

- The gearbox and other pointing equipment are at the top of the pole hundreds of feet off the ground.
- A vertical axis wind turbine has its axis perpendicular to the wind streamlines and vertical to the ground. A more general term that includes this option is "transverse axis wind turbine" or "cross-flow wind turbine."



❖ Difference Between Vertical Axis & Horizontal Axis Wind Mill.

S. No.	Aspects	Horizontal axis wind machines	Vertical axis wind machines
1.	*Power captured (for the same tower height)*	More	Less
2.	*Effect of fatigue (arising from numerous resonance in structure)*	No such problem arises	Suffer from fatigue effect
3.	*Appearance of the unwanted power periodicity*	Nil	Yes
4.	*Noise problem*	Less	More
5.	*Complexity of yaw mechanism*	Exists	No such problem arises
6.	*Complexity of design*	More	Less