Lecture Notes

for

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Subject: Power Station Practices

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Unit- 5 (Wind Energy)

How Wind Power is Generated :

The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. 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.

Winds are caused because of two factors :

(1) The absorption of solar energy on the earth's surface and in the atmosphere.

(2) The rotation of the earth about its axis and its motion around the sun.

Because of these factors, alternate heating and cooling cycles occur, differences in pressure are obtained, and the air is caused to move. The potential of Wind energy as a source of power is large. This can be judged from the fact that energy available in the wind over the earth's surface is estimated to be 1.6x107 K.W Besides the energy available is free and clean.

The problems associated with Utilizing wind energy are that:

(i) The energy is available in dilute form, because of this conversion machines have to be necessarily large.

(ii) The availability of the energy varies considerably over a day and with the seasons. For this reason some Means of storage have to be devised if a continuous supply of power is required.A wind mill converts the kinetic energy of moving air into mechanical energy that can be either used directly to run the machine or to run the generator to Produce electricity.

Wind energy conversion system

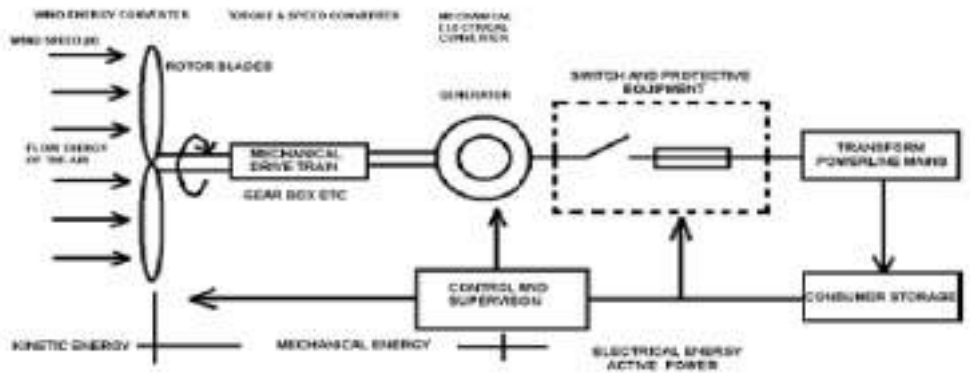


Figure : Functional chain and conversion stages of a wind energy converter

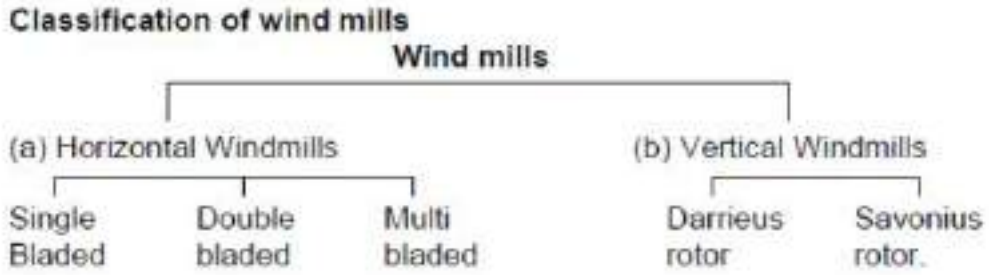
An apparatus for converting the kinetic energy available in the wind to mechanical energy that can be used to power machinery (grain mills, water pumps, etc).

The major components of a typical wind energy conversion system include a wind turbine, a generator, interconnection apparatus, and control systems. At the present time and for the near future, generators for wind turbines will be synchronous generators, permanent magnet synchronous generators, and induction generators, including the squirrel-cage type and wound rotor type. For small to medium power wind turbines, permanent magnet generators and squirrel-cage induction generators are often used because of their reliability and cost advantages. Induction generators, permanent magnet synchronous generators, and wound field synchronous generators are currently used in various high power wind turbines.

1. Batteries (for off-grid and backup systems) provide energy storage for periods of calm or during utility grid outages.
2. A charge controller and/or voltage clamp take raw energy from a wind generator and condition it so it can charge batteries safely and effectively or interface with an inverter and the utility grid.
3. Disconnects and over current protection provide safety from overloaded circuits and allow you to isolate different parts of the system.
4. A dump load is a place to divert excess energy in off-grid systems or when the utility grid is down, it's windy, and your batteries are full.
5. An inverter converts direct current (DC) electricity to conventional household alternating current (AC) electricity, and it may "sell" surplus electricity to the utility grid.
6. Loads in a system are energy-using devices, such as lights, appliances, and other electricity users.
7. Metering gives you data display and logging so you can tell what your system is doing and whether it's performing well.
8. A tower supports a wind generator, getting it up into the smooth, strong wind that's needed to generate meaningful amounts of electricity.
9. Transmission wiring and conduit allow you to transfer energy from where it's made to where it's stored and used.
10. Wind generators (or turbines) collect the energy in the wind and use it to make electricity.

Classification of wind mills

The wind mills are classified as follows :



Horizontal Wind mills :

i. Horizontal Axis single blade Wind mills If extremely long blades are mounted on rigid hub. Large blade root bending moments can occur due to tower shadow, gravity and sudden shifts in wind directions on a 200ft long blade. Fatigue load may be enough to cause blade root failure. To reduce rotor cost, use of single long blade centrifugally balanced by a low cost counter Weight as shown in fig 1.1.
The relatively simple rotor hub consists of a Universal Joint between the rotor shaft and blade allowing for blade. This type of hub design contains fewer parts and costs less.

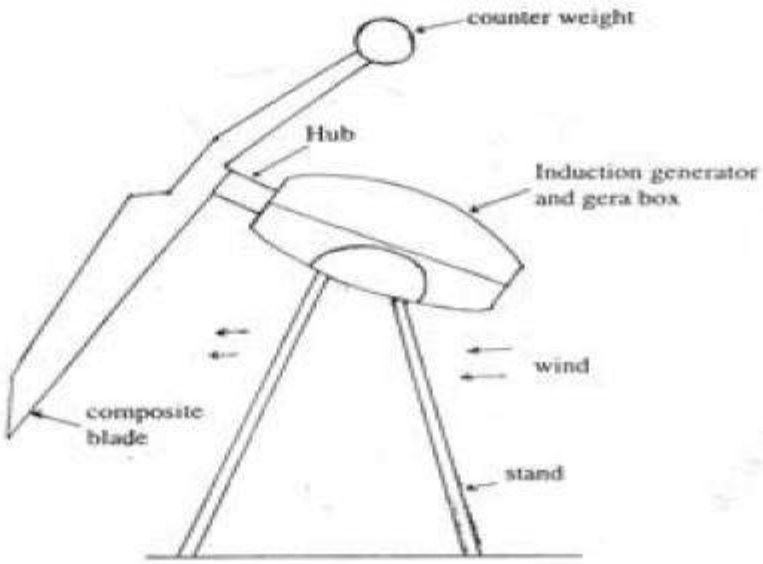


Figure 1.1 : single blade wind mill

(ii) Horizontal axis – two bladed wind mills :

In this arrangement rotor drives generator through a step-up gear box. The components are mounted on a bed plate which is mounted on a pentile at the Top of the tower. The two blade rotor is usually designed to be oriented down wind of the tower. The arrangement of all the Components used in horizontal axis wind mill is shown in fig 1.2. When the machine is operating its rotor blades are continuously flexed by unsteady aerodynamic, gravitational and inertial loads. If the blades are metal, flexing reduces their fatigue life. The tower is also subjected to unsteady load and dynamic interactions between the components of the machine-tower system can cause serious damage.

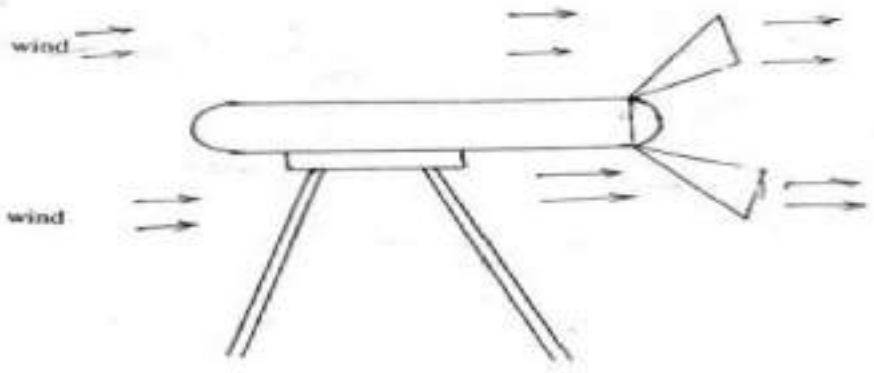


Figure 1.2 : Double blade wind mill

Veritical axis Wind machine:

Vertical axis wind turbines(VAWT),have the main rotor shaft arranged vertically. The main advantage of this arrangement is that the wind turbine does not need to be pointed into the wind. This is an advantage on sites where the wind direction is highly variable or has turbulent winds. With a vertical axis, the generator and other primary components can be placed near the ground, so the tower does not need to support it, also makes maintenance easier. The main drawbacks of a VAWT generally create drag when rotating into the wind.

It is difficult to mount vertical-axis turbines on towers, meaning they are often installed nearer to the base on which they rest, such as the ground or a building rooftop. The wind speed is slower at a lower altitude, so less wind energy is available for a given size turbine. Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration, including noise and bearing wear which may increase the maintenance or shorten its service life. However, when a turbine is mounted on a rooftop, the building generally redirects wind over the roof and this can double the wind speed at the turbine. If the height of the rooftop mounted turbine tower is approximately 50% of the building height, this is near the optimum for maximum wind energy and minimum wind turbulence.

Advantages and disadvantages of vertical and horizontal wind machines

The vertical and horizontal type wind machines have following advantages and disadvantages.

Vertical Axis Wind Turbine :

Advantages:

1. Does not have to be pointed towards the wind to be effective. This creates a flexible location for placement of the turbine in an area with varying wind direction.
2. Capable of operating during minimal wind speed. Long curved propellers are designed to be pushed by a small amount of wind.
3. Does not have to installed at a very high place via a tower. City ordinance regulations do not take effect and lowers cost due to materials needed for construction. Aesthetically more pleasing.
4. Easily visible to wildlife. While spinning or at rest, a vertical axis turbine appears as a solid object.
5. The generator does not have to be installed on the top of a tower. Important for maintenance considerations.

Disadvantages:

The lower the place, the slower the wind. This reduces the turbines efficiency which makes it less cost effective.

Horizontal Axis Wind Turbine:

Advantages :

1. The towers are relatively tal which allows the blades to face much higher velocity winds in high altitude. In some places, the power output of the wind turbine could increase up to 30% every ten meters in altitude because the wind speed is increased by 20%.
2. High efficiency, the blades always move perpendicular to the wind, receiving power through the whole rotation unlike vertical axis wind turbines.

Disadvantages :

1. High construction and installation costs. Large Machinery is needed.