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Design and Fabrication of Wind Mill for Power Generation

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ABSTRACT

The year 1973 has awakened the entire world from the energy crisis. Since then the entire focus of all developing countries turned towards non-conventional sources of energy. Of all the non-conventional energy sources wind energy is an inexhaustible, non-polluting, freely available energy. Enormous potential is associated with the kinetic energy of the wind. Previously the KE of the wind was utilized to drive wind turbines mostly for pumping water and grinding corns. The first wind turbine was employed for generation electricity in Denmark in 1890.India has started its power generation through (WEGs) from 1986. Later on number of wind electric generators (WEGs) has been installed every year. The paper deals with the technical details involved in the generation of power through wind technology. It discusses the factors responsible for generation of wind power and the limitations of the generator. While the emphasis is given on the various schemes used for production of electricity using wind power, the paper also gives insight into energy storage methods, safety precautions and site selection criteria. Wind power gave rise to public debate as the acceptance of wind turbines decreased during the expansion phase. These challenges were countered by policies enacted by state actors at the regional and local levels. Decisive factors were the amount, duration and reliability of the feed-in compensation, funding policy and the zoning and building laws. The successful establishment of wind power has been possible in spite the fact that it has been difficult to integrate wind power into the energy supply system due to wind power's intermittent nature, and despite resistance from actors of the fossil-nuclear energy supply system. This has been possible as a result of continually adjusting the policy approaches at various governance levels and reflecting various requirements in the different phases of the innovation process. Wind Power Generation in Germany the timing of policies demands a flexible design that is both relevant to a number of different public policy levels, yet tailored to the process in question.

Keywords: Power Generation, Wind Mill, Wind Speed, Aerodynamics, Local Ecology

I. INTRODUCTION

Wind result from air in motion. Air in motion arises from a pressure gradient. On a global basis one primary forcing function causing surface winds from the poles toward the equator is convective circulation. Solar radiation heats the air near the equator, and this low density heated air is buoyed up. At the surface it is displaced by cooler more dense higher pressure air flowing from the poles. In the upper atmosphere near the equator the air thus tend to flow back toward the poles and away from the equator. The net result is a global convective circulation with surface wins from north to south in the northern hemisphere. It is clear from the above over simplified model that the wind is basically caused by the solar energy irradiating the earth. This is why wind utilization is considered a part of solar technology. It actuality the wind is much more complex. The above model ignores the earth's rotation which causes a carioles force resulting in an easterly wind velocity component in the northern hemisphere. There is the further complication of boundary layer frictional effects between the moving air and the earth's rough surface. Mountains, trees, buildings, and similar obstructions impair stream line air flow. Turbulence results and the wind velocity in a horizontal direction markedly increase with altitude near the surface.

Local winds are caused by two mechanisms. The first is differential hating of land and water. Solar isolation during the day is readily converted to sensible energy of the land surface but is partly absorbed in layers below the water surface and partly consume in evaporating some of that water. The land mass becomes hotter than the water, which causes the air above the land to heat up and become warmer than the air above water. The warmer lighter air above the land rises and the cooler heavier air above the water moves into replace it. This is the mechanism of shore breezes. At night, the direction of the breezes is reversed because the land mass cools to the sky more rapidly than the water, assuming a sky. The second mechanism of local winds is caused by hills and mountain sides. The air above the slopes heats up during the day and cools down at night, more rapidly than the air above the low lands. This causes heated air the day to rise along the slopes and relatively cool heavy air to flow down at night. Wind turbines produce rotational motion; wind energy is readily converted into electrical energy by connecting the turbine to an electric generator. The combination of wind turbine and generator is sometimes referred as an aero generator. A step-up transmission is usually required to match the relatively slow speed of the wind rotor to the higher speed of an electric generator.

In Indian the interest in the windmills was shown in the last fifties and early sixties. A part from importing a few from outside, new designs was also developed, but it was not sustained. It is only in the last few years that development work is going on in many institutions. An important reason for this lack of interest in wind energy must be that wind, in India area relatively low and vary appreciably with the seasons. Data quoted by some scientists that for India wind speed value lies between 5 km/hr to 15-20 km/hr. These low and seasonal winds imply a high cost of exploitation of wind energy. Calculations based on the performance of a typical windmill have indicated that a unit of energy derived from a windmill will be at least several times more expensive than energy derivable for electric distribution lines at the standard rates, provided such electrical energy is at all available at the windmill site.

The above argument is not fully applicable in rural areas for several reasons. First electric power is not and will not be available in many such areas due to the high cost of generation and distribution to small dispersed users. Secondly there is possibility of reducing the cost of the windmills by suitable design. Lastly, on small scales, the total first cost for serving a felt need and low maintenance costs are more important than the unit cost of energy. The last point is illustrated easily: dry cells provide energy at the astronomical cost of about Rs.300 per kWh and yet they are in common use in both rural and urban areas.

Wind energy offers another source for pumping as well as electric power generation. India has potential of over 20,000 MW for power generation and ranks as one of the promising countries for tapping this source. The cost of power generation from wind farms has now become lower than diesel power and comparable to thermal power in several areas of our country especially near the coasts. Wind power projects of aggregate capacity of 8 MW including 7 wind farms projects of capacity 6.85 MW have been established in different parts of the country of which 3 MW capacities has been completed in 1989 by DNES. Wind farms are operating successfully and have already fed over 150 lakes units of electricity to the respective state grids. Over 25 MW of additional power capacity from wind is under implementation. Under demonstration programmer 271 wind pumps have been installed up to February 1989. Sixty small wind battery charges of capacities 300 watts to 4 kW are under installation. Likewise to stand-alone wind electric generators of 10 to 25 kW are under installation.

A. Utilization of Wind Energy

The utilization of wind energy can be dated back to 5000 B.C. when sail boats were propelled across the river Nile. It was recorded that from 200 B.C. onwards wind was used as an energy source to pump water, grind grain, and drive vehicles and ships in ancient China and Middle East. The first documented windmill was in a book Pneumatics written by Hero of Alexandria around the first century B.C. or the first century A.D. Effectively, these wind mills are used to convert kinetic energy into mechanical energy.

The use of wind energy to generate electricity first appeared in the late 19th century but did not gain ground owing to the then dominance of steam turbines in electricity generation. The interest in wind energy was renewed in the mid-1970s following the oil crises and increased concerns over resource conservation. Initially, wind energy started to gain popularity in electricity generation to charge batteries in remote power systems, residential scale power systems, isolated or island power systems, and utility networks. These wind turbines themselves are generally small (rated less than 100kW) but could be made up to a large wind farm (rated 5MW or so).

II. BASIC PRINCIPLES OF WIND ENERGY CONVERSION

The circulation of air in the atmosphere is caused by the non-uniform heating of the earth's surface by the sun. The air immediately above a warm area expands; it is forced upwards by cool, denser air which flows in from surrounding areas causing a wind. The nature of the terrain, the degree of cloud cover and the angle of the sun in the sky are all factors which influence this process. In general, during the day the air above the land mass tends to heat up more rapidly than the air over water. In coastal regions this manifests itself in a strong onshore wind. At night the process is reversed because the air cools down more rapidly over the land and the breeze therefore blows off shore. The main planetary winds are caused in much the same way: Cool surface air sweeps down from the poles forcing the warm air over the topics to rise. But the direction of these massive air movements is affected by the rotation of the earth and the net pressure areas in the countries-clockwise circulation of air around low pressure areas in the northern hemisphere, and clockwise circulation in the southern hemisphere. The strength and direction of these planetary winds change with the seasons as the solar input varies.

Despite the wind's intermittent nature, wind patterns at any particular site remains remarkably constant year by year. Average wind speeds are greater in hilly and coastal areas than they are well inland. The winds also tend to blow more consistently and with greater strength over the surface of the water where there is a less surface drag. Wind speeds increase with height. They have traditionally been measured at a standard height of ten meters where they are found to be 20-25% greater than close to the surface. At a height of 60 m they may be 30-60% higher because of the reduction in the drag effect of the earth's surface.

A. The Power in the Wind

Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass of moving air, like a sail or propeller, can extract part of the energy and convert is into useful work. Three factors determine the output from a wind energy converter:

- The wind speed;
- The cross-section of wind swept by rotor; and
- The overall conversion efficiency of the rotor, transmission system and generator or pump.

No device, however well designed, can extract all of the wind's energy because the wind would have to be brought to a halt and this would prevent the passage of more air through the rotor. The most that is possible is for the rotor to decelerate the whole horizontal column of intercepted air to about one-third of its free velocity. A 100% efficient aero generator would therefore only be able to convert up to a maximum of around 60% of the available energy in wind into mechanical energy. Well-designed blades will typically extract 70% of the theoretical maximum, but losses incurred in the gearbox, transmission system and generator or pump could decrease overall wind turbine efficiency to 35% or loss. The schematic diagram of turbine wheel is shown in figure 1.The power in the wind can be computed by using the concept of kinetics. The wind will works on the principle of converting kinetic energy of the wind to mechanical energy. We know that power is equal to energy per unit time. The energy available is the kinetic energy of the wind. The kinetic energy of any particle is equal to one half its mass times the square of its velocity, or $1/2m\ V^2$. The amount of air passing in unit time, through an area A, with velocity V, is AV, and its mass m is equal to its volume multiplied by its density ρ of air, or

$$m=\rho AV$$

(m is the mass of air transverse the area A swept by the rotating blades of a wind mill type generator).

Substituting this value of the mass in the expression for the kinetic energy, we obtain, kinetic energy = $1/2\ \rho AV.V^2$ watts.

$$=1/2\ \rho AV^3 \text{ watts}$$

Equation tells us that the maximum wind available the actual amount will be somewhat less because all the available energy is not extractable-is proportional to the cube of the wind speed. It is thus evident that small increase in wind speed can have a marked effect on the power in the wind. Equation also tells us that the power available is proportional to air density 1.225 kg/m^3 at sea level). It may vary 10-15 percent during the year because of pressure and temperature change. It changes negligibly with water content. Equation also tells us that the wind power is proportional to the intercept area. Thus an aero turbine with a large swept area has higher power than a smaller area machine; but there are added implications. Since the area is normally circular of diameter D in horizontal axis aero turbines, then $A = \prod/4\ D^2$, (sq.m), which when put in equation gives.

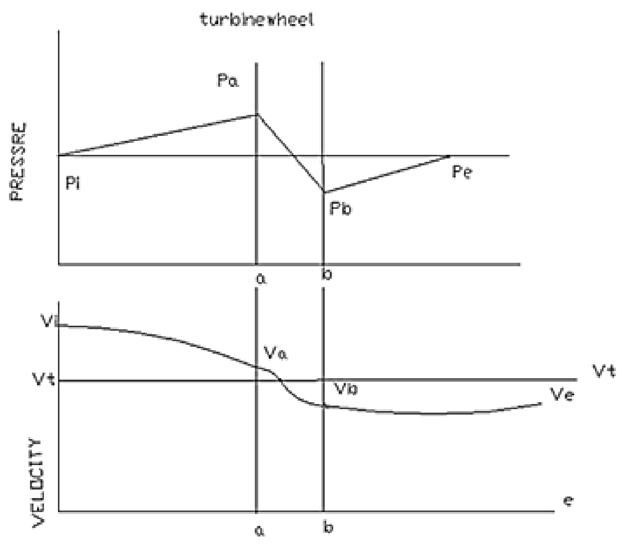

Figure 1: Line diagram of Turbine wheel

Available wind power $P\alpha = \frac{1}{2}\ \rho\ \pi/4\ D^2V^3$ watts

$= 1/8\ \rho\pi\ D^2V^3$

The power extracted by the rotor is equal to the product of the wind speed as it passes through the rotor (i.e. V_r) and the pressure drop Δp. In order to maximize the rotor power it would therefore be desirable to have both wind sped and pressure drop as large as possible. However, as V is increased for a given value of the free wind speed (and air density), increases at first, passes through a maximum, and the decreases. Hence for the specified free-wind speed, there is a maximum value of the rotor power. Where power available is calculated from the air density, rotor diameter, and free wind speed as shown above. The maximum theoretical power coefficient is equal to 16/27 or 0.593. This value cannot be exceeded by a rotor in a free-flow wind-stream.

B. Maximum Power

The total power cannot be converted to mechanical power. Consider a horizontal-axis, propeller-type windmill, henceforth to be called a wind turbine, which is the most common type used today. Assume that the wheel of such a turbine has thickness αb. Let p_i and V_i are the wind pressure and velocity at the upstream of the turbine. V_e is less than V_i because the turbine extracts kinetic energy. Considering the incoming air between I and a as a thermodynamic system, and assuming that the air density remains constant (since changes in pressure and temperature are very small compared to ambient), that the potential energy is zero, and no heat or work are added or removed between i and a, the general energy equation reduces to the kinetic and flow energy-terms only:

C. Wind Energy Conversion

Traditional windmills were used extensively in the middle Ages to mill grain and lift water for land drainage and watering cattle. Wind energy converters are still used for these purposes today in some parts of the world, but the main focus of attention now lies with their use to generate electricity. There is also growing interest in generating heat from the wind for space and water heating and for glass-houses but the potential market is much smaller than for electricity generation.

The term “wind mill” is still widely used to describe wind energy conversion systems, however it is hardly adopt. Description any more. Modern wind energy conversion systems are more correctly referred to as ‘WECS’, aero generations’, ‘wind turbine generators’, or simply ‘wind turbines’. The fact that the wind is variable and intermittent source of energy is immaterial of some applications such as pumping water for land drainage – provided, of course, that there is a broad match between the energy supplied over any critical period and the energy required. If the wind blows, the job gets done; if it does not, the job waits. However, for many of the uses to which electricity is put, the interruption of supply may be highly inconvenient. Operators or users of wind turbines must ensure that there is some form of back-up to cover periods when there is insufficient (or too much) wind available. For small producers, back-up can take the form of :

- Battery storage,
- Connection with the local electricity distribution system; or

For utilities responsible for public supply, the integration of medium – sized and large wind turbines into their distribution network could require some additional plant which is capable of responding quickly to meet fluctuating demand.

III. WIND DATA AND ENERGY ESTIMATION

The seasonal as well as instantaneous changes in wind both with regard to magnitude and direction need to be well understood to make the best use of them in windmill designs. Winds are known to fluctuate by a factor of 2 or more within seconds (and thus causing the power to fluctuate by a factor of 8 or more). This calls for a proper recording and analysis of the wind characteristics. There are various ways the data on wind behaviour is collected depending on the use it is intended to be put into. The hourly mean wind velocity as collected by the meteorological observations is the basic data used in a windmill designs. The holy means is the one averaged over a particular hour of the day, over the day, month, year and years. The factors, which affect the nature of the wind close to the surface of the earth, they are:

a) Latitude of the place,
b) Altitude of the place,
c) Topography of the place,
d) Scale of the ours, month or year.

Winds being an unsteady phenomenon, the scale of the periods considered are an important set of date required in the design. The hourly mean velocity (for many years) provides the data for establishing the potential of the place for tapping the wind energy. The scale of the month is useful to indicate whether it is going to be useful during particular periods of the year and what storage if necessary is to be provided for. Since the winds near the surface of the earth are derived from large scale movements of atmospheric winds, the location height above ground level at which the wind is measured and the nature of the surface on earth have an influence on the velocity of wind at any given time. The winds near the surface of the earth are interpreted in terms of boundary layer concept, keeping in mind the factors that influence its development. The wind velocity at a given height can be represented in terms of gradient height and velocity.

In as much as the height of the windmill rotor depends on the design wind velocity and cost of supporting structure. The above factors have a bearing on the design. Similarly, winds being an unsteady phenomenon, the scale of periods considered for this the temporal parameters (scale of our, month and year) is an important set of data required in the design. While the hourly mean velocity (for many years) provides the data for establishing the potential of the place for tapping the wind energy. The scale of the month is useful to indicate whether it is going to be useful during particular periods of the year and what storage if necessary is to be provided for as already mentioned above. The data based on scale of the hour is useful for mechanical aspects of design. In addition to the data on the hourly mean velocity, two other information's required are:

- Spells of low wind speeds, and
- Gusts

The site choice for a single or a spatial array of WECS (wind energy conversion system) is an important matter when wind electric is looked at from the systems points of view of aero turbine generators feeding power into a conventional electric grid. If the WECS sites are wrongly or poorly chosen the net wind electric generated energy per year may be sub optimal with resulting high capital cost for the WECS apparatus, high cost for wind generated electrical energy, and no returns on investment. Even if the WECS is to the small generator not tied to the electric grid, the sitting must be carefully chosen if inordinately long break even times to the avoided. Technical, economic environmental, social, and other factors are examined before a decision is made to erect a generating plant on a specific site. Some of the main considerations are discussed below.

1. High annual average wind speed. A fundamental requirement of the successful use of WECS, obviously, is an adequate supply of wind has stated above. The wind velocity is the critical parameter. The power in the wind Pw, through a given cross sectional area for a uniform wind velocity V is

$$Pw=KV^3$$

Where K is a constant. It is evident; because of the cubic dependence on wind velocity that small increases in V markedly affect the power in the wind, EX. Doubling V, increases Pw by a factor of 8. it is obviously desirable to select a site for WECS with high wind velocity. Thus a high average wind velocity is the principal fundamental parameter of concern in initially appraising a WECS site. For a more detailed estimate value, one would like to have the average of the velocity cubed. Anemometer data is normally based on wind speed measurements from a height of 10m. For the most accurate assessment of wind power potential it is absolutely essential that anemometer data be obtained at the precise site and hub height for any proposed WECS.

Strategy for sifting is generally recognized to consists of

- Survey of historical wind data.
- Contour maps of terrain and wind are consulted.
- Potential sites are visited.
- Best sites are instrumental for approximately one year.
- Choose optimal site.

2. Availability of anemometry data. It is another important sitting factor. The principal object is to measure the wind speed, which basically determines the WECS output power, but there are many practical difficulties with the instrumentation and measurement methods. The anemometer height above ground, accuracy, linearity, location on the support tower, shadowing and inaccurate readings there from, icing inertia of rotor whether it measures the horizontal velocity component or vertical, and temperature effects are a few of the many difficulties encountered
3. Availability of wind $V_{(t)}$ curve at the proposed site. This important curve determines the maximum energy in the wind and hence is the principal initially controlling factor in predicting the electrical output and hence revenue returns of the WECS machines.
4. Wind structure at the proposed site. The ideal case for the WECS would be a site such that the $V_{(t)}$ curve was flat, i.e. a smooth steady wind that blows all the time; but a typical site is always less than ideal. Wind especially near the ground is turbulent and gusty, and changes rapidly in direction and in velocity. This departure from homogeneous flow is collectively referred to as "the structure of the wind".
5. Altitude of the proposed site. It affects the air density and thus the power in the wind and hence the useful WECS electric power output. Also, as is well known, the winds tend to have higher velocities at higher altitudes. One must be careful to distinguish altitude from height above ground. They are not the same except for a sea level WECS site.
6. Terrain and its aerodynamic. One should know about terrain of the site to be chosen. If the WECS is to be placed near the top but not on the top of a not too blunt hill facing the prevailing wind, then it may be possible to obtain a 'speed up' of the wind velocity over what it would otherwise be. Also the wind here may not flow horizontal making it necessary to tip the axis of the rotor so that the aero turbine is always perpendicular to the actual wind flow.
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8. Local Ecology. If the surface is bare rock it may mean lower hub heights hence lower structure cost. If trees or grass or vegetation are present, all of which tent to restructure the wind, then higher hub heights will be needed resulting in large system costs than the bare ground case.
9. Distance to Roads or Railways. This is another factor the system engineer must consider for heavy machinery, structures, materials, blades and other apparatus will have to be moved into any chosen WECS site.
10. Nearness of site to local center/users. This obvious criterion minimizes transmission line length and hence losses and costs. After applying all the

previous sitting criteria, hope fully as one narrows the proposed WECS sites to one or two they would be relatively near to the users of the generated electric energy.

11. Nature of ground. Ground condition should be such that the foundations for a WECS, destroying the foundations for a WECS are secured. Ground surface should be stable. Erosion problem should not be there, as it could possibly later wash out the foundations of a WECS, destroying the whole system.
12. Favourable land cost. Land cost should be favorable as this along with other sitting costs, enters into the total WECS system cost.
13. Other conditions such as icing problem, salt spray or blowing dust should not present at the site, as they may affect aero turbine blades, or environmental is generally adverse to machinery and electrical apparatus.

If the area contains buildings, trees, wind machines, or other obstacles, the variation of the wind speed with altitude above ground level is usually greater for these obstructed areas than for the case of open water and flat plains. The characteristics of a good wind power site may be summarized as follows:

- A site should have a high annual wind speed.
- There should be no tall obstructions for a radius of 3 km.
- An open plain or an open shore line may be good location.
- The top of a smooth, well rounded hill with gentle slopes lying on a flat plain or located on an island in a lake or sea is a good site.
- A mountain gap that produces to wind funnelling is good.

The main components of a WECS are shown in Figure 2 in block diagram form. Summary of the system operation is as follows :

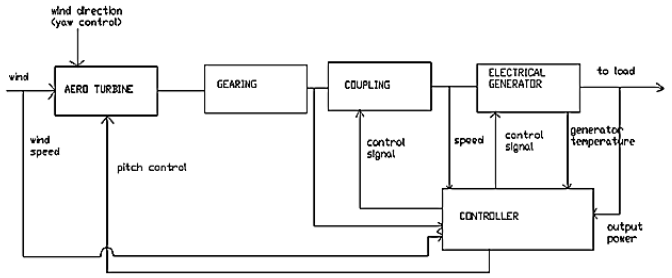

Figure 2. The main components of a WECS

Aero turbines convert energy in moving air to rotary mechanical energy. In general, they require pitch control and yaw control (only in the case of horizontal or wind axis machines) for proper operation. A mechanical interface consisting of a step up gear and a suitable coupling transmits the rotary mechanical energy to an electrical generator. The output of this generator is connected to the load or power grid as the application warrants. For localities with the prevailing wind in one direction, the design of the turbine can be greatly simplified. The rotor can be in a fixed orientation with the swept area perpendicular to the predominant wind direction. Such a machine is said to be yaw fixed. Most wind turbine, however, are yaw active that is to say, as the wind direction changes, a motor rotates the turbine slowly about the vertical (or yaw) axis so as to face the blades in to the wind. The purpose of the controller is to sense wind speed, wind direction, shafts speeds and torques at one or more points, output power and generator temperature as necessary and appropriate control signals for matching the electrical output to the wind energy input and project the system from extreme conditions brought upon by strong winds electrical faults, and the like.

The physical embodiment for such an aero-generator is shown in a generalized form. The sub-components of the windmill are:

- Wind turbine or rotor
- Wind mill head
- Transmission and control, and
- Supporting structure

Such a machine typically is a large impressive structure.

A. Rotors

The Rotors are mainly classified into two types:

(i) Horizontal axis rotor and
(ii) Vertical axis rotor.

One advantage of vertical – axis machines is that they operate in all wind directions and thus need no yaw adjustment. The rotor is only one of the important components. For an effective utilization, all the components need to be properly designed and matched with the rest of the components. The windmill head supports the rotor, housing the rotor bearings. It also houses any control mechanism incorporated like changing the pitch of the blades for safety devices and tail vane to orient the rotor to face the wind. The latter is facilitated by mounting it on the top of the supporting structure on suitable bearings.

B. Transmission

Varying the pitch of the rotor blades, conveniently controls the rate of rotation of large wind turbine generators operating at rated capacity or below,, but it is low, about 40 to 50 revolutions per minute (rpm). Because optimum generator output requires much greater rates of rotation, such as 1800 rpm, it is necessary to increase greatly the low rotor of turning. Among the transmission options are mechanical systems involving fixed ratio gears, belts, and chains, singly or in combination or hydraulic systems involving fluid pumps and motors. For bottom mounted equipment which requires a right-angle drive, transmission costs might be reduced substantially by using large diameter bearings with ring gears mounted on the hub to serve as a transmission to increase rotor speed to generator speed. Such a combination offers a high degree of design flexibility as well as large potential savings. The transmission system of WEC id shown in figure 3.

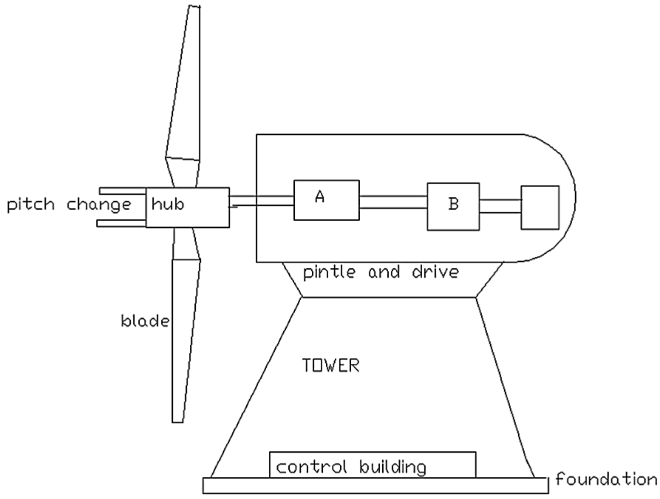

Figure 3: The transmission system of WEC

C. Generator

Either constant or variable speed generators are a possibility, but variable speed units are expensive and/or unproved. Among the constant speed generator candidates for use are synchronous induction and permanent magnet types. The generator of choice is the synchronous unit for large aero generator systems because it is very versatile and has an expensive data base. Other electrical components and systems are, however, under development.

D. Controls

The modern large wind turbine generator requires a versatile and reliable control system to perform the following functions:

- The orientation of the rotor into the wind (azimuth of yaw);
- Start up and cut-in of the equipment;
- Power control of the rotor by varying the pitch of the blades;
- Generator output monitoring – status, data computation, and storage;
- Shutdown and cut out owing to malfunction or very high winds;
- Protection for the generator, the utility accepting the power and the prime mover;
- Auxiliary and / or emergency power; and
- Maintenance mode.

E. Towers

Four types of supporting towers deserve consideration, these are:

- The reinforced concrete tower,
- The pole tower,
- The built up steel- tube tower, and
- The truss tower.

Among these, the truss tower is favoured because it is proved and widely adaptable, cost is low, parts are readily available, it is readily transported, and it is potentially stiff. Shell-tube towers also have attractive features and may prove to be competitive with truss towers. The type of the supporting structure and its height is related to cost and the transmission system incorporated. It is designed to withstand the wind load during gusts (even if the occur frequently and for very short periods). Horizontal axis wind turbines are mounted on towers so as to be above the level of turbulence and other ground – related effects. The minimum tower height for a small WECS is about 10m, and the maximum practical height is estimated to be roughly 60m.The turbine may be located either unwind or downwind of the tower.

IV. CLASSIFICATION OF WEC SYSTEMS

The WEC are generally classified into two broad classifications:

a) **Horizontal Axis Machines.** The axis of rotation is horizontal and the aero turbine plane is vertical facing the wind.
b) **Vertical Axis Machines.** The axis of rotation is vertical. The sails or blades may also be vertical, as on the ancient Persian windmills, or nearly, so, as on the modern Derives rotor machine.

Then, they are classified according to size as determine by their useful electrical power output.

i. Small Scale (up to 2 kW). These might be used on farms, remote applications, and other places requiring relatively low power.
ii. Medium Size Machines (2-100kW). These wind turbines may be used to supply less than 100 kW rated capacity, to several residence or local use.
iii. Large Scale or Large Size Machines (100 kW and up). Large wind turbines are those of 100 kW rated capacity or greater. They are used to generate power for distribution in central power girds. As per the type of output power, wind aero generators are classified as:

- DC output
- DC generator
- Alternator rectifier
- AC output
- Variable frequency, variable or constant voltage AC.
- Constant frequency, variable or constant voltage AC.

As per the rotational speed of the aero turbines, these are classified as:

- Constant Speed with variable pitch blades. This made implies use of a synchronous generator with its constant frequency output.
- Nearly Constant Speed with fixed pitch blades. This mode implies an induction generator.

Variable Speed with fixed pitch blades. This mode could imply, for constant frequency output:

a) Field modulated system
b) AC-DC-AC link
c) Double output induction generator
d) AC commutation generator
e) Other variable speed constant frequency generating systems.

Wind turbines are also classified as per how the utilization of output is made:

a) Battery storage
b) Direct connection to an electromagnetic energy converter
c) Other forms (thermal potential etc.) of storage.
d) Interconnection with conventional electric utility grids.

The system engineer seeking to integrate WECS will, naturally be most interested in the latter case but should be aware that WECS will, naturally be most interested in the latter case but should be aware that WECS offer other options as well.

A. Advantage and Disadvantage of WECS

- It is a renewable source of energy
- Like all forms of solar energy, wind power systems are non-polluting, so it has no adverse influence on the environment.
- Wind energy systems avoid fuel provision and transport.
- On a small-scale up to a few kilowatt system is less costly. On a large-scale costs can be competitive with conventional electricity and lower costs could be achieved by mass production.

B. Disadvantage of wind energy are:

- Wind energy available in dilute and fluctuating in nature.
- Unlike water energy wind energy needs storage capacity because of its irregularity.
- Wind energy systems are noisy in operation; a large unit can be heard may kilometres away.
- Wind power systems have a relatively high overall weight, because they involve the construction of a high tower and include also a gearbox, a hub and pitch changer, a generator coupling shaft etc. for large systems a weight of 110 kg/kW (rated) has been estimated.
- Large areas are needed, typically, propellers 1 to 3 m in diameter, deliver power in the 30 to 300 W ranges.
- Present systems are neither maintenance free not-practically reliable. However, the fact that highly reliable propeller engines are built for aircraft suggest that the present troubles could be overcome by industrial development work.

C. Horizontal – Axial Machines

The common wind turbine with a horizontal (or almost horizontal) axis, is simple in principle, but the design of a complete system, especially a large one that will produce electric power economically, is complex. Not only must be individual components, such as the rotor, transmission, generator, and tower, be as efficient as possible, but these components must function effectively in combination as shown in figure 4. Some of the horizontal axis type wind machines are below.

- Horizontal axis using two aerodynamic blades. In this type of design, rotor derives generator through a step up gear box. The blade rotor is usually designed to be oriented downwind of the tower. The components are mounted on a bed plate which is attached on a pentle at the top of the tower.
- The rotors blades are continuously flexed by unsteady aerodynamic, gravitational and inertia loads, when the machine is in operation. If the blades are made of metal, flexing reduces their fatigue life with rotor the tower is also subjected to above loads, which may cause serious damage.
- To reduce rotor cost, use of low cost counter weight is recommended which balance long blade centrifugally.

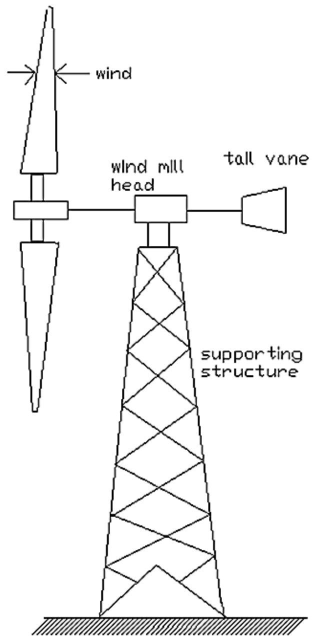

Figure 4 : Horizontal – Axial Machines

D. Horizontal axis Multibladed Type

This type of design for multiblades, made from sheet metal or aluminium as shown in figure 5. The rotors have high strength to weight ratios and have been known to service hours of freewheeling operation in 60 km/hr winds. They have good power coefficient, high starting torque and added advantage of simplicity and low cost.

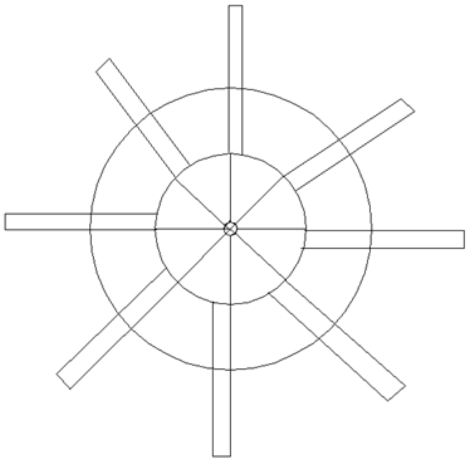

Figure 5: Horizontal axis multibladed type

E. Horizontal axis wind mill-Dutch type.

The blade surfaces are made from an array of wooden slats which 'feather' at high wind speeds as shown in figure

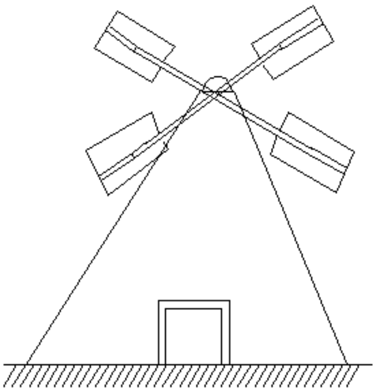

Figure 6 : Horizontal axis wind mill-Dutch type

F. Sail Type

It is of recent origin. The blade surfaces are made from cloth, nylon or plastics arranged as meet and pole or sail wings. There is also variation in the number of sails used.

V. POWER GENERATION

A. Generating Systems

Aero turbines convert wind energy into rotary mechanical energy. A mechanical interface, consisting of a step-up gear and a suitable coupling transmits the energy to an electrical generator. The output of this generator is connected to the load or system grid. The controller senses the wind direction, wind speed, power output of the generator and other necessary performance quantities of the system and initiates appropriate control signals to take suitable corrective actions. The system should be protected from excessive temperature raise of the generator, electrical faults and extra wind conditions as shown in figures 7(top view) and 8.The choice of an electrical generator and control method to be employed (if any) can be decided by consideration of the following three factors:

- The basis of operation i.e. either constant tip speed or constant tip speed ratio.
- The wind-power rating of the turbine and
- The type of load demand e.g. battery connection.

Wind power ratings can be divided into three convenient grouping, small to 1kW, medium to 50 kW and large 200 kW to megawatt frame size.

Figure 7: The schematic view WEC

Figure 8: The schematic view WEC

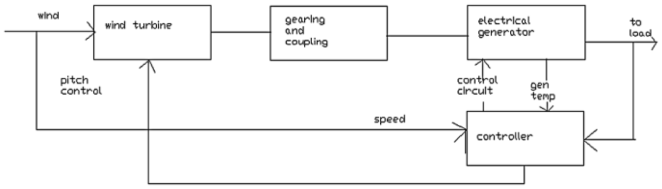

Figure 9: The electrical components of WEC

B. Schemes for electric generation

Several schemes for electric generation have been developed. These schemes can be broadly classified under three categories:

- Constant – speed constant frequently systems (CSCF)
- Variable speed constant frequency systems (VSCF)
- Variable speed variable frequency systems (VSVF)

C. Constant speed constant frequency system (CSCF).

Constant speed drive has been used for large generators connected directly to the grid where constant frequency operation is essential.

- Synchronous Generator.

For such machines the requirement of constant speed is very rigid and only minor fluctuations about 1% for short durations (fraction of second) could be allowed. Synchronization of wind driven generator with power grid also will pose problems with gusty winds.

- Induction Generator.

If the stator of an induction machine is connected to the power grid and if the rotor is driven above synchronous speed Ns (Ns=120f/p), the machine becomes a generator and delivers constant line frequency power to the grid.(f=line frequency – and p=number of poles for which the stator winding is made).Per unit slip is 0 and 0.05. The output power of wind drive n induction generator is uniquely determined by the operating speed. The pull out torque ™ condition should not be exceeded. When this happens the speed continues to increase and the system may 'run away'.

D Variable speed constant frequency scheme. (VSCF scheme).

Variable-speed drive is typical for most small wind generators used in autonomous applications, generally producing variable frequency and variable voltage output. The variable speed operation of wind-electric system yield higher outputs for both low and high wind speeds. This results in higher annual energy yields per rated installed kW capacity. Both horizontal axis and vertical axis turbines will exhibit this gain under variable speed operation. The popular schemes to obtain constant frequency output are as follows:

- AC-DC-AC link.

With the advent of high powered thyristor and high voltage D.C. transmission systems, A.C. output of the 3-phase alternator is rectified using a bridge rectifier and then converted back to A.C. using line commutated inverters.

- Double Output Induction Generator.

In this system a slip-ring induction motor is used. Rotor power output at slip frequency is converted to line frequency power by rectification and inversion output power is obtained both from stator and rotor and hence this device is called double output induction generator. Rotor output power has the electrical equivalence of additional impedance in the rotor circuit.

- A.C. Communication generator

This system is also known as Scherbius system employs two polyphone windings in the stator and a commutator winding on the rotor. Basic problems in employing this device for wind energy conversion are the cost and care required by the commutator and the brush gear.

E. Site selection

Following factors are to be considered for selection of good site for wind power generation:

a) High annual wind speed.
b) No tall obstructions for a radius of 3 Km.
c) Open plain or open shore
d) Top of a smooth, well rounded hill with gentle slopes
e) Mountain gap which produces wind funneling.

F. Generating system

Wind - electric conversion system consists of the following components

- Wind Turbine (WT) - Converts wind energy into rotational (mechanical) energy
- Gear system and coupling (G/C) - It steps up the speed and transmits it to the generator rotor
- Generator (G) - Converts rotational energy into electrical energy.

VI. APPLICATIONS OF WIND ENERGY

Wind power can also be used compress air for use in various applications, including the operation of gas turbines for generating electricity during the peak-demand periods of a public utility system. For this type of application, conventional gas turbines can be modified to separate the compressor, generator, and power stages by clutches. In one mode of operation, the motor generator operating as a motor and powered by a wind machine drives the air compressor as shown in figure 10. The compressed air is fed into a storage tank or into a large cavern, aquifer, or depleted natural gas well. Under this mode, the power turbine is inoperative, and no fuel is consumed. In a second mode of operation, when the demand for power exceeds the supply of the base-load utility system, the compressor is disengaged, and the power turbine is connected to the generator. The burner that drives the power turbine is fed fuel and compressed air from storage to generate power for the utility system. Wind powered pumps can be used to desalinate water, using reverse osmosis units. Wind powered pumps can also be used to save fuel and electricity by compressing the working fluids used in heat pumps for space heating applications.

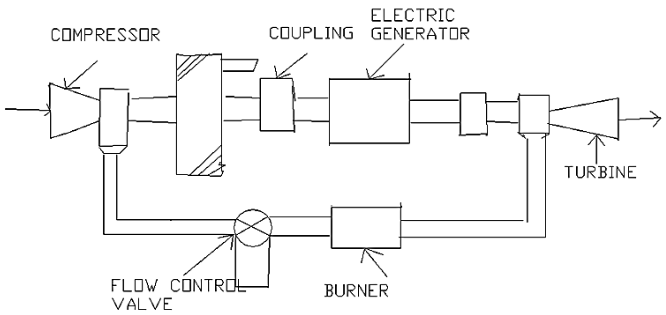

Figure 10 : The mode of operation

A. Direct heat applications

Mechanical motion derived from wind power can be used to drive heat pumps or to produce heat from the friction of solid materials, or by the churning of water or other fluids, or in other cases, by the use of centrifugal or other types of pumps in combination with restrictive orifices that produces heat from friction and turbulence when the working fluid flows through them. This heat may then be stored in materials having a high heat capacity, such as water, stones, eutectic salts, etc.

B. Electric Generation Applications

Wind power can be used in centralized utility applications to drive synchronous A.C. electrical generators. In such applications. The energy is fed directly into power networks through voltage step-up transformers. WECS units can be integrated with existing hydro electrical networks and used in a "water-saver" mode of operation. When the wind is blowing, electrical an amount equal to the being can reduce generation at the hydroelectric plants in the network produced by the WECS units. Thus, the wind turbines supply part of the network load that is ordinarily produced by the hydroelectric generators. Under these conditions some of the water that would have been used by the hydroelectric plant to supply the load is saved in the reservoir and made available for later use when the wind is not blowing.

C. Battery charger

The hydrogen and oxygen can be stored in liquid form in tanks, or in gaseous form in tanks, caverns, aquifers, depleted natural gas wells, etc. The stored hydrogen can be used either as a fuel or direct space heating or industrial process heat, or it can be reconverted to electricity through the use of fuel cells, gas turbine generators that burn hydrogen, or by other means as shown in figure 11.

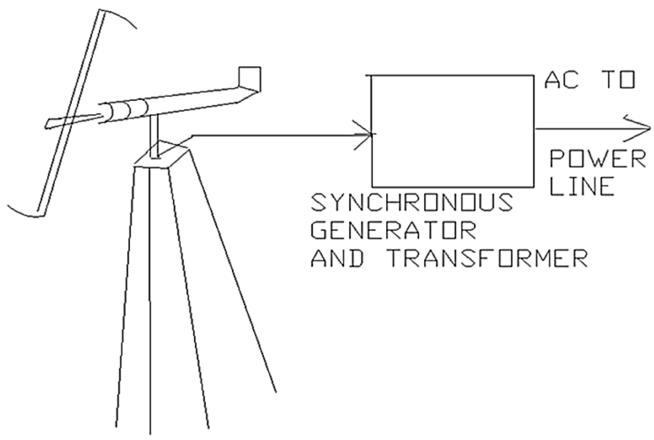

Figure 11: The battery charging unit of WEC

VII. SAFETY SYSTEMS

The Safety systems of the wind turbines comprise the following features **:**

a) The computer**.** The wind turbine is controlled by a computer which monitors the most important gauging instruments and compares the results. If errors are found the wind turbine is stopped.

b) Emergency stop**.** If a situation arises which calls for the wind turbine to be stopped immediately, the emergency stop is used. The wind turbine will stop in few seconds by feathering the blades directly into the wind. It cannot be stated again before what caused the emergency stop has been rectified.

c) Revolution Counters**.** To prevent the rotor from racing, two revolution counters have been mounted on the shaft. These operate quiet independently and activate the emergency stop if the revolutions of the turbine exceed 24 rpm which is maximum.

d) Wind Velocity. This is measured and controlled by the computer in two ways. First gusts of wind are registered and if they are too strong the turbine is stopped. Then average wind speeds are measured over periods of 10 minutes, and the wind turbine is also stopped if there are too high.

e) The Parachutes**.** Each blade tip has a parachute, which is activated if the rpm exceeds 28. An iron plumb bob, otherwise held in place by a magnet, is released from the blade trip, the centrifugal force exceeding the force of the magnet pulling out the parachute. This decrease the speed of the wind turbine con

f) Siderable enough to stop it from racing. The parachute is an extra safety device should other fail. Till now they never had been used.

g) Lightning Rods**.** The tree blades and the mill or wind turbine cap are protected from lighting by these rods going from the tip of each blade to the ground.

A. Environmental Aspects

Wind turbines are not without environmental impact and their operation is not entirely risk-free. Following are the main effects due to a wind turbine.

a) Electromagnetic interference**.** Interference with TV and other electromagnetic communication systems is a possibility with wind turbines as it is with other tall structures. TV interference is most likely in areas where there is a weak signal because of the distance from the transmitter, where existing reception is none too good due to the surrounding hills and where the wind turbine is exposed in good position to receive and scatter the signals. Dispensing with aerials and sending TV signals by cable in areas that would otherwise be affected can overcome interference.

b) Noise. The noise produced by wind farms falls into two categories. The first type is a mechanical noise from the gearbox, generating equipment and linkages and the second type of aerodynamic in nature produced by the movement of the turbine blades. One component of the latter is the broad band noise which ranges up to several kilo hertz and the other is a low frequency noise of 15-20 Hz. Revolving blades generate noise which can be heard in the immediate vicinity of the installation, but noise does not travel too far.

c) Visual Effects**.** Megawatts power generating wind turbines are massive structures which would be quite visible over a wide area in some locations. Variety characteristics such as co lour pattern, shape, rotational speed and reflectance of blade materials can be adjusted to modify the visual effects of wind turbines including the land scape in which they are installed.

B. Advantages of wind energy conversion system

- The major advantage of this design is that the rotor blades can accept the wind from any compass.
- Another added advantage is that the machine can be mounted on the ground eliminating tower structures and lifting of huge weight of machine assembly, i.e. it can be operated close to the ground level.
- Since this machine has vertical axis symmetry, it eliminates yaw control requirement for its rotor to capture wind energy
- Airfoil rotor fabrication costs are expected to be reduced over conventional rotor blade costs.
- The absence of pitch control requirements for synchronous operation may yield additional cost savings.
- The tip speed ratio and power coefficient are considerably better than those of the S-rotor but are still below the values for a modern horizontal-axis, two-bladed propeller rotor.

C. Disadvantages of wind energy conversion system

- Rotor power output efficiency of a Darrieus wind energy conversion system is also somewhat lower than that of a conventional horizontal rotor.

- Because a Darrieus rotor is generally situated near ground proximity, it may also experience lower velocity wind compared to a tower mounted conventional wind energy conversion system of comparable projected rotor disc area. This may yield less energy output.

III. CONCLUSION

This work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between institution and industries.

- We are proud that we have completed the work with the limited time successfully. The **Domestic Wind Mill Power Generation** is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality. We have done to our ability and skill making maximum use of available facilities.
- In conclusion remarks of our project work, let us add a few more lines about our impression project work.
- Thus we have developed a "***wind mill power generation***" which helps to know how to achieve non-conventional power generation. The application of pneumatics produces smooth operation.
- By using more techniques, they can be modified and developed according to the applications.

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