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Conversion of Wind Energy to Electrical Energy

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ABSTRACT: Wind has been utilized as a source of power for many years. The generation of electrical energy from wind has experienced a remarkable pace in the past decade because of depleting conventional resources and increasing environmental issues. Wind energy conversion has become a reliable and competitive means for electric power generation, thanks to extensive Research and Development efforts in last 30 years. The life span of modern wind turbines is now 20-25 years, which is comparable to many other conventional power generation technologies. The average availability of commercial wind power plants is now around 98%. This paper reviews WECS system covering Aerodynamics, Mechanical and Electrical aspects.This design conveys simple wind turbine which converts kinetic energy into mechanical energy that can produce electricity. The energy stored in the battery which is produced by windmill on a small vehicle. The vehicle can be setup by the small wind mill that produce energy. the alternator will boost the energy and produce.

INTRODUCTION

The demand for renewable energy has contributed immensely towards the growth of wind energy industry. Nations such as the United States have shifted away from using fossil fuels. However, the success of wind energy industry depends greatly on wind turbines. A wind turbine is a technological device used in converting energy present in the moving wind into mechanical energy.Occasionally, the mechanical energy that rotates the shaft is converted by a wind turbine generator into electrical energy. The generators are usually fixed at the top of the towers in order to maximize the output of wind energy turbines. To enhance their activity, generators are usually joined to the rotors by gears that multiply the speed of the generator. This paper seeks to describe how wind turbines convert wind energy into electrical energy. This paper also provides broad explanation on how various parts of the turbine work together in enhancing conversion of wind energy into electrical energy.

Stages For Generating Electricity

The process of generating electricity from wind energy is a bit complex. It involves two stages. In the first stage, it dictates for the conversion of kinetic energy present in the moving wind into mechanical energy that drives the shaft fixed into the wind generator. The crucial elements that play a significant role during this stage are the wind blades.

Therefore, careful designs of the blades aid in maximizing the efficiency of the turbines in electricity generation. However, diverse factors affect the amount of mechanical energy produced by the blades. For instance, the shape of blade tips and general profile of the blades determines the amount of mechanical energy produced by the blades.

The second stage of electricity generation from wind energy involves the conversion of trapped mechanical energy into electrical energy via aid of wind generators. This stage also aids in outlining various parameters that assist in determining the conversion efficiency of the generators. For instance, it aids in calculating the efficiency of gearbox, generators, and electric appliances.

Energy Requirements

80% of global population lives in developing areas as regards energy consumption 16% of global

Population in the OECD countries would consume more than 40% of energy by the year 2030. No doubt in the period of 2005-2030 the rate of growth of energy consumption in non-OECD countries would be higher than OECD countries & providing access to adequate energy to their people is really a challenge for developing country. In the profile of energy sources, coal in India has dominant position. Coal constitutes about(51%) of India‟s primary energy resources followed by oil (36%), natural gas (9%), nuclear (2%) and hydro (2%). There is shortage in all energy segments. Indiantargetof(9%-10%) economic growth rate is sustainable over next 10 to 15 year.

Wind Conversion

The conversion of wind energy to other forms of energies (i.e. mechanical, electrical, light, and heat) is by the process of assembly of components/devices to convert the wind speed available to electricity for social-economic development and domestic application in a given environment. There are two types of wind known as the geothermal and wind. Electricity is generated from

wind through the use of wind turbines also known as wind energy converters (WEC). The wind turbines convert the kinetic energy of wind into mechanical energy and then to electrical through the generator. The generator may be of fixed or variable speed due to changing wind speed and direction; the yaw mechanism is used to turn the blades of the wind turbines in line with wind direction to increase its output. The main components of a WEC include rotor blade, generator, pitch, wind measurement system, brake, gearbox, rotor hub, yaw mechanism, nacelle, transformer, diode, capacitor, battery, and tower. These components are categorized into mechanical and electronic components during the conversion of wind energy into electricity. Table 1 shows the variation of blade diameter during wind energy conversion. The schematic diagram for the conversion of wind energy components is shown in figure 1.

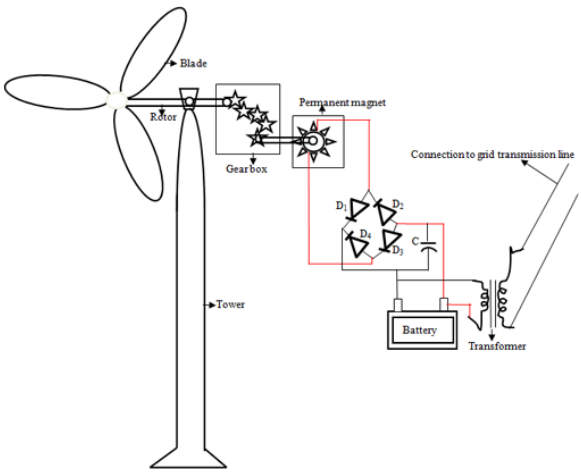


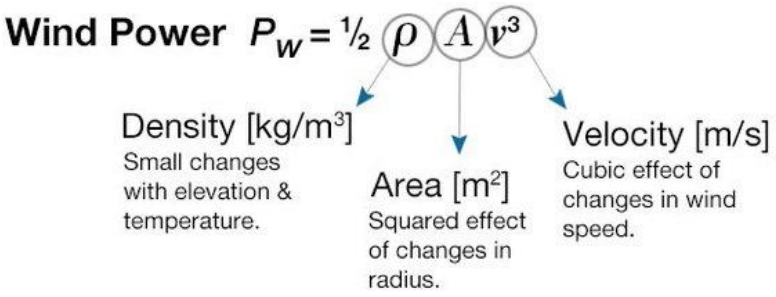
Figure1.Windenergyconversioncomponents

Factors Affecting Wind Energy Conversion

During the conversion of wind energy to electricity, the following factors such as wind speed, air density and swept area of the turbine alongside with the mechanical and electronic components must be considered for effective and efficient electrical generation.

.Wind speed

The amount of energy in the wind varies directly to the cube of the wind speed. When the wind speed is low, the amount of the output power will be low but as the wind speed is high, there will be a corresponding increase in the power generated. Equation 1 shows the relation of power with wind speed.



……(1)

Air density

The density of air determines the energy generation from the wind. The more dense the air, the higher the energy receivedbytheturbine.Thisfactorvarieswithelevationandtemperature of the surrounding air. The air is dense at low temperature and at sea level. Warm air is less dense than cold air. A wind turbine produces high power at lower elevation and in cooler average temperature.

Swept area

The swept area is a factor of the blade design. For the blade to rotate at any little movement of air, the radius must be considered for free rotation. Equation 2 shows the dependence of the swept area to the square of the radius.

$A = Pi * r^2$.....(2)

Where

A = area of the blade

P = blade pitch

i = inclination angle between blade

r = radius

MechanicalComponent

The mechanical parts in the motor system for the generation of electric current in wind conversion comprises of the rotor blade, generator, gear box, permanent magnet, and tower.

These parts are always in motion for the actualization of the renewable energy generation.

A. Rotorblade

The rotor blade rotates or turns by the kinetic energy from the wind. The direction of the movement of the blade is determined by the direction of the wind. The blade is fixed to the shaft which is connected to the generator and gear. As the blade rotates, the shaft moves in turn in the same direction. The blade material is made of alloy which has high resistance to drought. The angular distance between the blades must be 60^{o} to each other for a particular circle.

B. Generator

The generator is a dynamo or machine that converts mechanical energy into electrical energy. Whenever a conductor is wind on anar mature which is connecting the shaft to the mechanical power source. The coil of a generator is made of copper wire and as the conductor moves through the magnetic field, the field will interface with the electrons present in the conductor to induce a flow of electric current in the system. The induced electro motive force(EMF)is equal to the rate of change of flux link ages. The generation of the EMF depends on the relative speed and relative time between the conductor and the magnetic field.

C. A.Cgenerator

Electricity is been consumed mostly in an a.c voltage/current form at home and industry. The a.c operation uses the electromagnetic induction to produce the electricity from the wind turbine. There are two types of generator; the induction and synchronous generator.

The induction generator does not require regulation and frequency control since the coils turn in a magnetic field which actuate current and voltage. But the synchronous generator is used in large size power generation. It may be the rotating field and rotating armature type. In the rotating armature type, armature is at rotor and field is at stator.

The rotor armature current is taken through slip rings and brush. These limit the current produced due to high wind losses and low power output. The rotating field generator is widely employed for high power output generation since it does not require slip ring and brush components incorporation in the generator.

D. Tower

The tower is a rigid material made of mostly iron or steel that suspends the blade and rotor to a height where the wind energy is in abundant. The tower determines the effectiveness of the conversion of wind energy to electrical energy. The higher the height of the tower, the

more effective and efficient electric current output generation from the wind energy.

E. **Permanent magnet**

A Permanent magnet is a device that generates a magnetic field as the rotor rotates within the region of space. As the wind sets the rotor in motion, the generated mechanical energy is converted to electrical energy. In this device, the rotor winding has been replaced with a permanent magnet. It does not require a separate DC supply to excite the circuit or a slip ring and contact brushes.

ElectronicComponent

These are the components that convert the electrical energy to DC form for storage or AC form for use by the consumer or for transmission.

A. Diode

The diode is a unidirectional device which allows current to flow in one direction when biased. It is a p-n junction semiconductor material. The diode is used to convert the AC to DC before it can be stored in the battery. At times, it is connected across the coil to avert kick-back voltage.

B. Capacitor

The capacitor is used in the circuit as a filter. This removes the alternating voltage ripples from the DC. This makes the DC ripple more pure for storage. The higher the value of the capacitor, the better the charges produce.

C. Transformer

A transformer is a device that is used to step up or down voltage/current for transmission or distribution of electricity for home and industrial purposes. The step-up transformer is used for wind energy conversion. It converts the low voltage energy stored in the battery of about 12 V to 500-800 V before it is integrated into the National grid for transmission to various sub-stations.

D. Battery

The battery is a device which stores direct current (DC). The energy generated from wind can be

stored in the battery during the peak wind period, and at low wind period, the stored energy can be converted to alternating current (AC) for transmission. This will prevent shortage of electricity supply or total power outage.

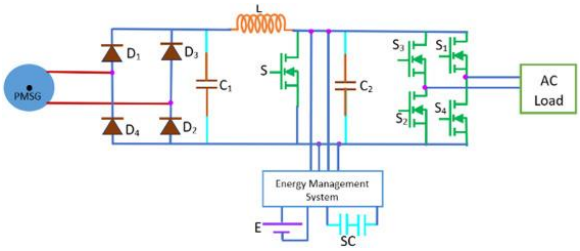


Fig2-functional diagram

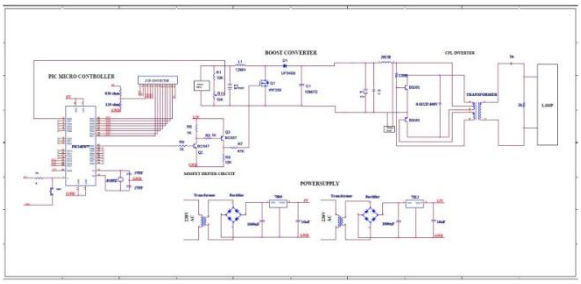


Fig3- hardware circuit diagram

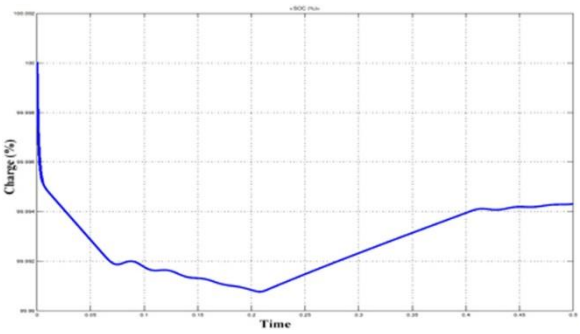


Fig4-State of charge in battery-existing system.

Conclusion

In conclusion, the demand for renewable source of energy has played a significant role towards advancing the usage of wind energy as the source of electricity. It is not only a significant source of energy, but also a pollutant-free source of energy. Its effect is greatly felt by great advancement in technology that has led to the production of effective turbines. Wind turbines are

made up of diverse elements that work as a unit. Some of the devices that make it include the blades, rotor, shaft, and the generator.

The surface area of the wind turbine blades plays a significant role towards the generation of electricity. The rotation of the blades leads to the spinning of the rotor which results in the rotation of the generator. On the other hand, the rotation of the devices within the generator results in the production of electricity.

Various researches carried out on wind energy have identified that great prospects exist for wind energy utilization for renewable electricity generation. Wind power is a clean energy source that we can rely on throughout the day and night for a long period of time.

It has shown from the mechanical and electronic component arrangements in figure 1 optimal electricity generation for domestic and industrial consumption.

A wind turbine creates reliable, cost-effective, and pollution-free energy. Also, wind is a source of energy which is non-polluting and renewable energy; the turbines create power without using fossil fuels. Hence, during the conversion of wind energy to electricity, there is no production of greenhouse gases, radioactive, or toxic waste. This makes the renewable energy conversion system environmental friendly and safe.

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