A PROJECT REPORT ON

"PM STATOR-LESS CONTRA-ROTATION WIND POWER GENERATOR"

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Engineering in Electrical Engineering

Submitted by

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The foregoing dissertation entitled **"PM STATOR-LESS CONTRA-ROTATION WIND POWER GENERATOR"** is hereby approved as a creditable study of Electrical Engineering presented by

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We, the undersigned, declare that the project entitled **"PM STATOR-LESS CONTRA-ROTATION WIND POWER GENERATOR"** , being submitted in partial fulfillment for the award of Bachelor of Engineering Degree in Eletrical Engineering, affiliated to Mumbai University, is the work carried out by us.

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Chapter 1

Asbtract

The objective of this paper is to propose an efficient, low cost and rugged design of medium sized gearless permanent magnet stator-less contra-rotation wind power generator (PMSLCRWPG). The earlier models of such medium sized generators, capable of generating less than one megawatt electric power, are facing huge mechanical losses due to wear and tear in the tightly coupled mechanical gear system. Due to this heavy arrangement in its mechanical assembly, the earlier design and its prototype could not function with high efficiency. The proposed design focuses on the performance of the model using the concept of stator-less dual rotor arrangement in the generator. The design was tested at various wind speeds and directions and the performance of the proposed permanent magnet machine has been experimented. The results of this sustainable and renewable model and design were compared with those of the existing models to promote green energy systems in the future.

A wind turbine generator comprises a stator disposed between first and second generator rotors. The first generator rotor comprises a first rotor shaft and an inner permanent magnet rotor. The second generator rotor is configured to contra-rotate relative to the first generator rotor, and comprises a second rotor shaft and an outer permanent magnet rotor. Inner and outer annular ferromagnetic cores are anchored respectively to radially inner and outer portions of the stator. First and second inner permanent magnets of opposite polarity are anchored to a radially outer surface of the inner permanent magnet rotor adjacent the inner annular ferromagnetic core across an inner air gap, and first and second outer permanent magnets of opposite polarity are anchored to a radially inner surface of the outer permanent magnet rotor adjacent the outer annular ferromagnetic core across an outer air gap.

Chapter 2

Introduction of Wind Energy

2.1 Importance Of Green Energy

The term green energy is used to describe energy sources which are environment friendly. Green energy sources are non-polluting and help in lowering the carbon emission, thereby decreasing the risks of global warming. With the increase in pollution created by the fossil fuels, people are now looking forward to build an energy efficient environment with the help of green energy resources so as to have safer living.

These energy resources are called ‘green’ as they don’t emit any poisonous gases that cause global warming.

Solar and wind energy are the most commonly used renewable energy resources. They are trapped and converted to low cost electricity with the help of solar panels and wind mills.

Sun is one of the most popular sources for renewable energy. The energy captured from the sun, using solar panels, can be easily converted to electrical energy. The solar panels contain photovoltaic cells that convert solar energy to electrical energy. This will help in reducing the electric bills or even eliminating in completely.

Wind energy is another common renewable energy source. Windmills can be constructed in a windy location and can be used as an alternative power source.

Water can also be used as a source for alternative power. But for this you need to live in a location that’s close to an abundant source of running water.

2.2 Role Of Wind Energy

The principle application of wind power is to generate electricity. Large scale wind farms are connected to electrical grids. Individual turbines can provide electricity to isolated locations and rural areas. In case of wind mills, wind energy is used directly for generating electricity.

Wind energy is plentiful, renewable, widely distributed, cleans, and reduces green house gas emission when it displace fossil fuel-derived electricity. Therefore, it is considered by experts to be more environmentally friendly than many other energy sources.

The earth is unevenly heated by the sun resulting in the poles receiving less energy from the sun that the equator does. Also,the dry land heats up (and cools down) more quickly than the see do.

The differential heating drives a global atmospheric conversion system reaching from the earth’s surface to the stratosphere which acts as a virtual ceiling.

Most of the energy stored in these wind speed of over 160 km/hr (10 mph) occurs. Eventually, the wind earth’s surface and the atmosphere. The total amount of economically extractable power use from the wind is considerably more than present human power use from all sources. An estimated 72 TW of wind power on the earth potentially can be commerciallyviable, compared to about 15 TW average global consumption from all sources in 2005 not all the energy of the wind flowing past a given point can be recovered.

Power generation from winds usually comes from winds very close to the surface of the earth. Winds at higher altitudes are stronger and more consistent, and may have a global capacity of 380 TW.

Chapter 3

Principle of Energy Conversion

3.1 Principle

Wind mills or turbines works on the principle of converting kinetic energy of the wind in to mechanical energy.

Power available from wind mill}= ½ □A V^3

Where, □□– air density = 1.225 Kg. / m^3 at sea level.(changes by 10-15% due to temperature and pressure variations)

A – area swept by windmill rotor = □D^2 sq-m. (D – diameter)
V – wind speed m/sec.

Air density, which linearly affects the power output at a given speed, is a function of altitude, temperature and barometric pressure. Variation in temperature and pressure can
affect air density up to 10 % in either direction. Warm climate reduces air density.

This equation tells us that maximum power available depends on rotor diameter. Thecombined effects of wind speed and rotor diameter can be observed by the

Practically, wind turbines are able to convert only a fraction of available wind power into useful power. As the free wind stream passes through the rotor, it transfers some of its energy to the rotor and its speed decreases to a minimum in the rotor wake. After some distance from the rotor wind stream regains its speed from the surrounding air. We can also observe drop in pressure as the wind stream passes through the rotor. Finally air speed and pressure increases to ambient atmospheric condition.

3.2 Power availability in the world

The total quantum of wind energy is enormous. However, a very small percentage is available for practical use. Efficiency of wind energy conversion plants is only about 30 percent.

The power in wind is proportional to the wind speed cubed; general formula for power in wind is:

$$P = \frac{1}{2}\rho A V^3$$

where ρ is the density of air; v is the wind speed; Av is the volume of air passing through A (which is considered perpendicular to the direction of the wind); Av is therefore the mass m passing through "A".

Because of this cubic relationship availability is extremely sensitive to wind speed; doubling the wind speed increases the power availability by a factor of eight.

To assess prospective wind power sites a probability distribution function is often fit to the observed wind speed data. Different locations will have different wind speed distributions. The Weibull model closely mirrors the actual distribution of hourly/ten-minute wind speeds at many locations. The Weibull factor is often close to 2 and therefore a Rayleigh distribution can be used as a less accurate, but simpler mode

.

3.3 Block diagram

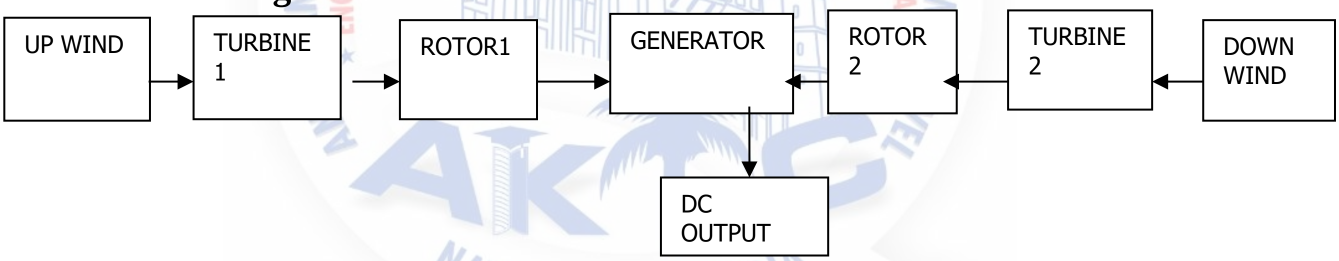


Fig no.3.3.1 Block diagram of PMSLCRWPG

Chapter 4

Site Selection and Generating System

4.1 Factors to be considered for selection of site : -

High annual wind speed -

A fundamental required for a successful use of wind energy , obviously , is an adequate supply of wind as stared above. The wind velocity is the critical parameter. The power in wind is P_W through a given cross section area for a uniform wind velocity V is $P_W=KV^3$.

Where K is constant. It is equivalent because of the cubic dependence on wind velocity that small increase in V markedly the power in the wind. Thus , a high average wind velocity is the principle fundamentals parameter of concern in initially appraising a WECS site.

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 well known, the winds tend to have a higher velocities at higher altitudes.

Nature of ground –

Ground condition should be such that the foundation 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.

Distance to road 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.

The characteristics of good wind power site may be as follows :

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

4.2 Generating System

Wind - electric conversion system consists of the following components :-

1) Wind Turbine(WT) - Converts wind energy into rotational(mechanical) energy

2) Gear system and coupling (G/C)- It steps up the speed and transmits it to the generator rotor

3) Generator(G)- Converts rotational energy into electrical energy.

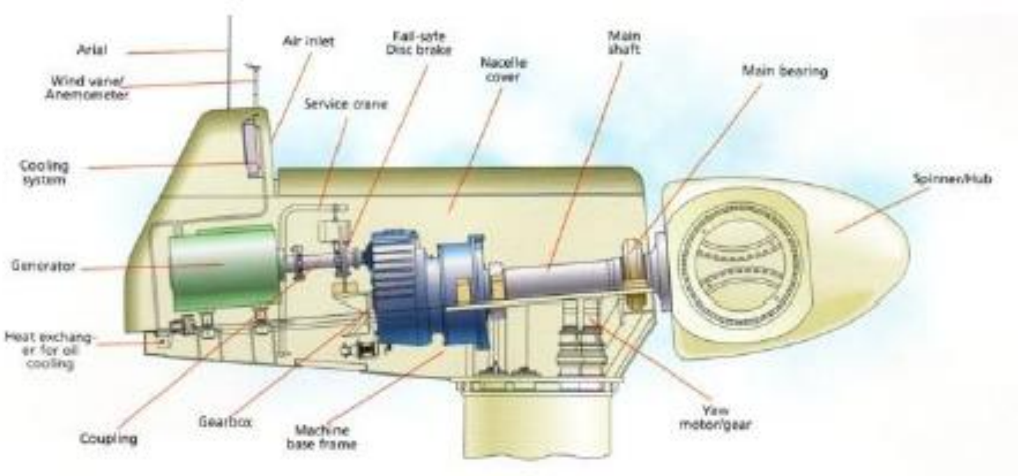
Types of generators used:-

- For Small rating systems - P.M.typed.c. generators
- Medium rating systems - P.M.typed.c. generators
- Induction generators
- Synchronous Generators
- Large rating systems - Induction generators (3-phase)
- Synchronous Generators (3 phase)

4) Controller(C)-Senses wind direction, wind speed generator output and temperature and initiates appropriate control signals to take control action.

5) Yaw motor gear- The area of the wind stream swept by the wind turbine is maximum when blades face into the wind.

Alignment of the blade angle with respect to the wind direction to get maximum wind energy can be achieved with the help of yaw control that rotates wind turbine about the vertical axis. In smaller wind turbines, yaw action is controlled by tail vane whereas, in larger
turbines, it is operated by servomechanism



4.2.1: Construction of wind turbine

Chapter 5

Introduction of the Project

Gearless permanent magnet stator less dual contra rotation wind power generator. The earlier models of such medium sized generators, capable of generating less than one megawatt electric power, are facing huge mechanical losses due to wear and tear in the tightly coupled mechanical gear system. Due to its heavy arrangement in its mechanical assembly, the earlier design and its prototype could not function with high efficiency. The proposed design focuses on the performance of the model using the concept of stator-less dual rotor arrangement in the generator. The design was tested at various wind speeds and directions and the performance of the proposed permanent magnet machine has been experimented. The results of this sustainable and renewable model and design were compared with those of the existing models to promote green energy systems in the future.

The conventional energy sources are limited and have high pollution levels. Hence, more attention and interest have been paid to the utilization of renewable energy sources such as wind energy, fuel cell, solar energy , etc. Wind energy is the fastest growing and most promising renewable source among the economically viable ones. In the last two decades, the penetration of wind turbines in the power system has been closely related to the advancement of wind turbine technology and how to control it.With increasing penetration of wind-derived power in interconnected power systems, it has become necessary to model the complete wind energy systems in order to study their impact and also to study the wind power plant control. In spite of this development, advanced technologies are still needed to make the wind energy competitive with other energy supply techniques.

In a dual rotor wind turbine generator system, the machine consists of two rotors and a single stator. The general equations of motion for the constrained multi-body system were used to obtain the dynamic model for this new wind turbine generator system. The design of the novel dual-stator hybrid excited synchronous wind power generator includes its structured features and its operating principles. No-load magnetic fields with different field currents are computed by a 3-D finite-element method.

A contra-rotating permanent magnet generator direct drive wind turbines that using a parametric finite element model, the magnetic design and pole-slot combination are optimized to meet the application requirements of high specific torque, low starting torque, and high efficiency. Small-scale prototypes have been built to experimentally verify the performance of the small wind energy conversion system (SWECS). Wind tunnel tests of the power output, power coefficient, and turbine speed were carried out to ascertain the aerodynamic power conversion and the operation capability at lower wind speeds.The problem of wind disturbance and aerodynamic parameter estimation of a Gun-Launched Micro Air Vehicle (GLMAV) which is a new Micro Air Vehicle (MAV) concept, intended for outdoor flights, and using two-bladed coaxial contra-rotating rotors.

It is to propose a low cost model and design of gear-less permanent magnet stator-less dual rotor wind power generator (PMSLCRWPG). It is possible to design it as stand-alone model for low power applications like domestic use in remote areas, such as highly isolated locations like hilly areas, where it is not possible to transmit the electricity through overhead lines or underground cables.The maximum energy conversion efficiency of conventional wind turbines having a single rotor is about 59%. But the maximum efficiency obtained by contra rotors having the same area is increased to 64%

This type of wind power generation has low production cost. Therefore, this model is viable for implementing in large scale electricity generation for meeting high power requirements. This model has capable to generate economical and efficient power than a single rotor type wind electric generation system. Also, it can produce power approximately twice that of a single rotor power generation.

Chapter 6

Construction of Project

6.1 Constructional Details

6.1.1 Generator (Dynamo)

It converts mechanical energy into electrical energy. The **dynamo** was the first electrical generator capable of delivering power for industry, and is still the most important generator in use in the 21st century. The dynamo uses electromagnetic principles to convert mechanical rotation into an alternating electric current. It is the most common way to generate electrical energy for bicycle lighting.

6.1.2 PMMC :

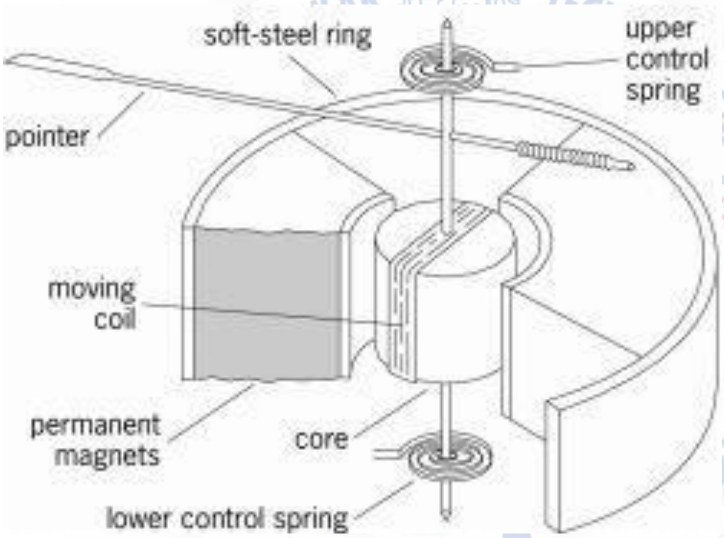


Fig.6.1.1 PMMC

PMMC instrument generally used in small scale wind turbines

6.1.3 Armature

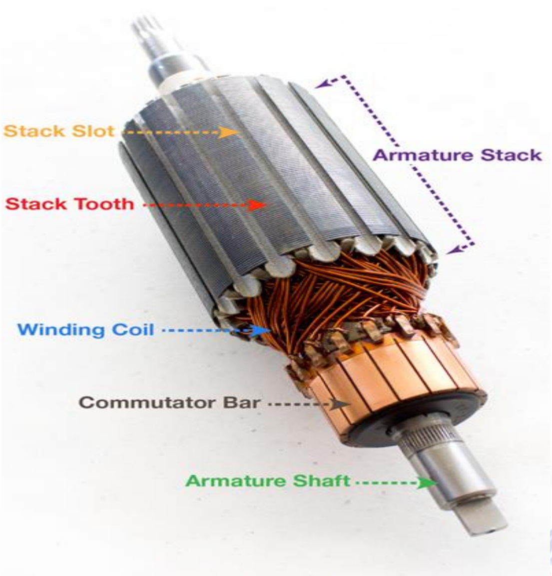


Fig.6.1.2 Armature

Armature: The power-producing component of an alternator, generator, dynamo or motor. The armature can be on either the rotor or the stator. Field**:** The magnetic field component of an alternator, generator, dynamo or motor. The field can be on either the rotor or the stator and can be either an electromagnet or a permanent magnet.

6.1.4 Blades :

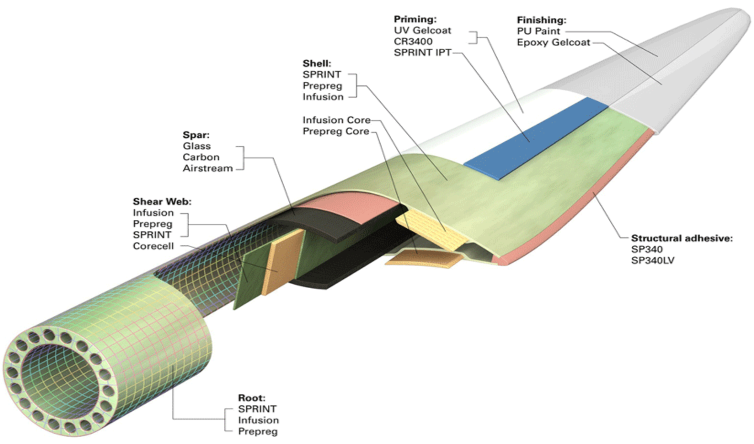


Fig.6.1.3 Blades

For small (novelty or urban) HAWT turbines manufacturers typically ship three-bladed turbines with three separate blades that must be assembled onsite, into a central hub. Without careful assembly ensuring accurate dynamic balance of the blades, the turbine can shake itself apart.

Most wind turbines have three blades. Very small turbines may use two blades for ease of construction and installation. Vibration intensity decreases with larger numbers of blades. Noise and wear are generally lower, and efficiency higher, with three instead of two blades.

Turbines with larger numbers of smaller blades operate at a lower Reynolds number and so are less efficient. Small turbines with 4 or more blades suffer further losses as each blade operates partly in the wake of the other blades. Also, the cost of the turbine usually increases with the number of blades.

6.1.5 Bearings :

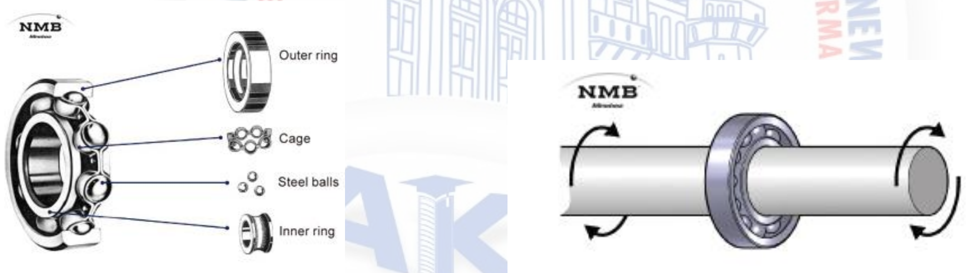


Fig.6.1.4 bearing

A **ball bearing** is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races.The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. Ball bearings support rotary parts and reduce friction to facilitate the smooth operation of machines. The size of ball bearings can range from smaller than a grain of rice — small enough to fit inside a wristwatch—to over one meter in diameter for factory and power plant applications. The main function of a ball bearing is to reduce friction and facilitate smooth rotation of an axis. Modern ball bearings test the very limits of precision.

6.2 Model construction

Fig.6.2.1. Model of PMCRWPG

Fig.6.2.1, shows the Model of the low cost PMCRWPG. It is designed with special type
of permanent magnet machine, which is coupled with a domestic pedestal fan blade in its one side shaft (i.e., turbine1) and armature is coupled with the another domestic pedestal fan blade (i.e., turbine 2), The turbine 2 has larger diameter than the turbine 1. The turbine 1 is coupled with rotor 1 and turbine 2 coupled with rotor 2. All these arrangements are supported with an iron stand with adequate foot support. When the pedestal fan is stager with blows the wind(upwind) rotates the turbine1and rotor 1. The escaping wind(downwind), flows over the turbine 2, which rotates the rotor 2 in opposite to the direction of the rotor 1. Therefore, the overall magnetic flux cutting will be twice that of single rotor machine and the electro motive force (emf) produced in terms of voltage is also twice.

Chapter 7

Working of Project

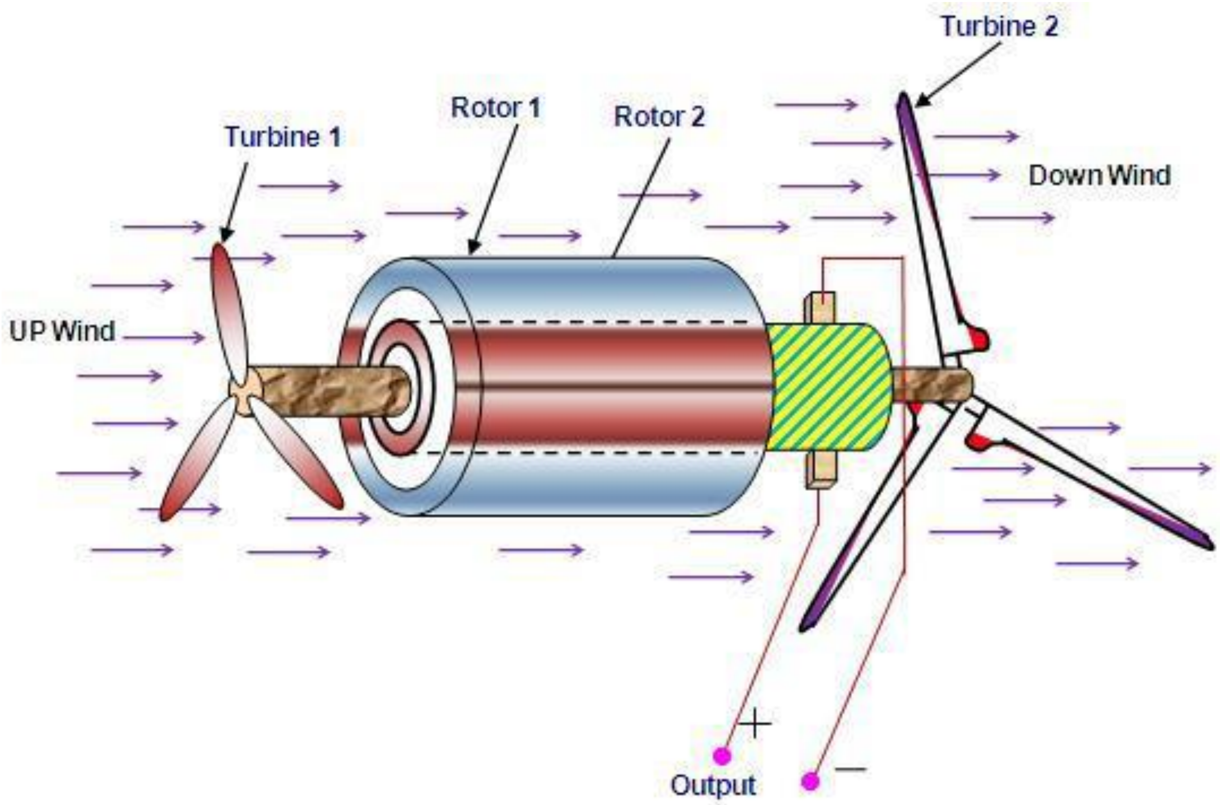


Fig.7.1. Schematic Diagram Of PMCRWPG

Above fig., shows the schematic diagram of (Hybrid system)PMSLCRWPG.It consists of turbine 1 and rotor 1, turbine 2 and rotor 2. When the wind blows to the turbine 1 means up-wind, which can rotate the turbine 1 and rotor 1 (field) in the clockwise direction, then the same wind escapes and flows towards the turbine 2 is called down-wind, it also rotates the turbine 2 and rotor 2 (Armature) in the anti-clockwise direction.

A contra rotating (CR) turbine comprises two sets of rotors one behind the other.One rotor rotates in a clockwise direction while the other rotor rotates in an anti-clockwise direction.

When wind flows,the blades of turbine rotate.When both the blades are rotating due to this relative speed is maximum which produce more power than conventional wind power plant.

There are six poles in armature and the armature poles are made up of laminated coresfor to reduce the core losses. These poles are wound with the armature windings. The field core has four number of projecting poles or salient poles, which are made up of a permanent magnet material, hence it is known as permanent magnet field poles. The field portion is called as rotor 1 and armature portion is called as rotor 2. The rotor 1 and rotor 2 are coupled with wind turbines on both sides of the shaft of the machine. These two wind turbines are made up of domestic type fan blades.

Chapter 8

Unit Cost Comparison

It is to propose a low cost model and design of Permanent magnet contra rotor wind power generator (PMCRWPG). It is possible to design it as stand-alone model for low power applications like domestic use in remote areas, such as highly isolated locations like hilly areas, where it is not possible to transmit the electricity through overhead lines or underground cables.

This type of wind power generation has low production cost. Therefore, this model is viable for implementing in large scale electricity generation for meeting high power requirements. This model has capable to generate economical and efficient power than a single rotor type wind electric generation system. Also, it can produce power approximately twice that of a single rotor power generation.

The per unit generation cost of five types (including now under consideration) of power generating plants like hydro, thermal, nuclear, wind power and PMCRWPG based system are shown in the table I. In case of PMCRWPG power generation cost is very low compared to other types and hence, it is more economical than other types of power plants.

SR. No	**Power Generation Cost Comparison Per kwh**		
	Name of the power plant	***Cost per Unit (kwh)***	***Cost of operation and maintenance***
1	Hydro power plant	0.855	Low
2	Thermal power plant	1.215	High
3	Nuclear power plant	3.645	High
4	Wind power plant	1.35	Low
5	PMCRWPG	0.67	Very Low

Table 8.1 Power Generation Cost Comparison Per Kwh

As seen in Table I, there are three major power plants, namely hydro, thermal, nuclear and wind. The cost of power production through PMCRWPG is highly economical compared to other types of power plants.

Chapter 9

Environment Problems

The environmental impact of wind power when compared to the environmental impacts of fossil fuels, is relatively minor. According to the IPCC, in assessments of the life-cycle global warming potential of energy sources, wind turbines have a median value of between 12 and 11 (gCO_2eq/kWh) depending on whether off- or onshore turbines are being assessed. Compared with other low carbon power sources, wind turbines have some of the lowest global warming potential per unit of electrical energy generated.

While a wind farm may cover a large area of land, many land uses such as agriculture are compatible with it, as only small areas of turbine foundations and infrastructure are made unavailable for use.

There are reports of bird and bat mortality at wind turbines as there are around other artificial structures. The scale of the ecological impact may or may not be significant, depending on specific circumstances. Prevention and mitigation of wildlife fatalities, and protection of peat bogs, affect the sitting and operation of wind turbines.

Wind turbines generate some noise. At a residential distance of 300 meters (980 ft) this may be around 45 dB, which is slightly louder than a refrigerator. At 1.5 km (1 mi) distance they become inaudible. There are anecdotal reports of negative health effects from noise on people who live very close to wind turbine

Fig.9.1 Environmental Problems

Chapter 10

Future Scope

In normal wind power generator we get less power, but by using this PMCRWPG we get more (double power) power than normal wind power generator. When the wind blows into a conventional three-bladed, single rotor wind turbine less than 40 percent of its energy is converted into electricity. The rest escapes, much of it in the air wale that's created behind the blades. That wake spins in the opposite direction (i.e. counter-clockwise) to those blades. If a second rotor with another set of blades is right behind the first rotor, and if it is designed to also spin counter-clockwise, it can capture energy from that wake.

The end result is a turbine system that harnesses much more energy from the initial flow of wind. With this contra rotation wind power generator system it is possible to generate double amount of power which will be beneficial for future use to the next generation. As compared to conventional sources of energy, by making the use of non-conventional sources we can satisfy our electricity need.

For future scope different time period has been use for calculating the power and efficiency. This method motivates the engineers to install small scale solar wind hybrid system.

Chapter 11

Advantages & Application

11.1 Advantages:

- The wind is free and with modern technology it can be captured efficiently.
- Once the wind turbine is built the energy it produces does not cause green house gases or other pollutants.
- Although wind turbines can be very tall each takes up only a small plot of land. This means that the land below can still beused. This is especially the case in agricultural areas as farming can still continue.
- Many people find wind farms an interesting feature of the landscape.
- Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply.
- Wind turbines have a role to play in both the developed and third world.
- Wind turbines are available in a range of sizes which means a vast range of people and businesses can use them. Single households to small towns and villages can make good use of range of wind turbines available today.

11.2 Applications:

- Placed in Hilly areas.
- It is placed in Oceans.
- Considerable amount of wind power flow areas.
- Zero Energy House

Chapter 12

Estimation And Costing Of Project

12.1 Estimation

SI No	Description of material	Quantity
1	Blades	6 (1ft.)
2	Shaft	1 (2 ft.)
3	Nut bolts	10
4	Copper Windins	10 meter
5	Permanent Ferro Magnets	2
6	Enclosure	1 (12 cm)
7	Rod	5 (1 ft)
8	Insulator	2 (E class)
9	Extra requirement Charges	-

Table.12.1 Estimation

12.2 Costing

SI No	Item Description	Oty.	Rs./Qty.	Estimate (Rs)
1	Blades	6	500	3000
2	Shafts	1	500	500
3	Nut Bolts	10	10	100
4	Copper Winding	10/M	50	500
5	Permanent Ferro Magnets	2	750	1500
6	Enclosure	1	500	500
7	Rod	5	100	500
8	Insulator	2	30	60
9	Extra Requirement Charges	-		4000
Total Estimated Cost Of The Project			2240/-	10660/-

Table.12.2 Costing

Chapter 13

Conclusion

The new mantra of the 21st century is sustainable development, which means that the local population should be able to absorb the development of a country or region. The people should be financially, mentally and physically able to support the improvement in the quality of their lives. We want the entire population to have access to uninterrupted supply of electricity. This puts a huge burden on the limited fossil fuel resources. The benefits of using wind power over other resources lies in its minimum operational cost.

Depending on field of applications, various schemes can be adopted to get optimum output. Various option of storage facility makes it versatile source of energy. Modern turbines are totally controlled by computers that are totally safe. Since wind is clean source of energy, the power conversion does not pose any environmental hazard.

This Model will be enhancing as a large scale and better solution for future energy crises all over the world. The output of Single Pmslcrwpg will be equivalent to the output produced by two single- rotor generator.

References

Books And Journals

1. Renewable energy sources and conversion technology – N.K. Bansal

2. Electrical India- 15th May 2001 (Wind power special)

3. IEEMA Journal – May 2005 (Wind power special)

4. Non-Conventional Energy Sources- G.D. Rai

5. Janakiraman.R and Paramasivam.S ,"A Novel Method for Modeling, Simulation and Design analysis of SEIM for Wind Power Generation," 3rd Int. Conf. on Control, Communication and Power Engineering-CCPE 2012, 27th & 28th April 2012, 2012, pp.496-502.

Websites

- www.solardyne.com
- www.windpower.org
- www.otherpower.com
- www.eere.energy.gov