Low RPM Low Wind Velocity Aero-generator

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ABSTRACT

Nowadays, electric power supply of state electricity boards in India, particularly in rural areas, is very uncertain. There is frequent load shading, interruptions, voltage fluctuation and shutdowns usually without any notice to consumers. This results into stoppage of work and mental agony. Also, the cost per unit is increasing day by day. Especially, those, who own a small office with computers, small households and in agriculture sector, have to suffer a lot due to such uncertain supply of power. In houses and small offices, normally, generator run by petrol /diesel /kerosene is used to supply electricity when there is no grid power. The use of such appliances is not always satisfactory due to its pollution, vibrations, noise and maintenance.

To overcome the said problem, inverter and UPS system with large capacity batteries to give sufficient backup (time & wattage) is provided. This arrangement works well for some years even without changing batteries. But, even such an arrangement fails when the batteries do not get sufficiently charged due to scarcity of power.

At present there is no contrivance to overcome these shortcomings of the present situation of solar power and big capacity wind mills. The domestic windmills normally developed and available in market has cut-in speed of 3 m/s and with rated wind speed of 12 m/s. The wind speed available in most of the urban areas is not more than 4-5 m/s and hence the present wind mills are not economically and technically viable to cater to the need of normal household and agriculture requirements. Therefore, there is a dire need for a set of equipment, which will generate just sufficient electrical energy for domestic needs of 1 to 5 kW and that too at a very low wind speed which is mostly available all over the year throughout the world.

INTRODUCTION

It is well known that solar energy with the help of photovoltaic cells can be used. But, harnessing the solar energy is technologically too much involved and also very costly. The effective charging period available during a sunny day of almost 12 hours is hardly 5½ to 6 hours and for about 280 to 300 days in a year. The inclination of sun rays on the panels varies every minute as

the Sun traverses from east to west from sunrise to sunset. The efficiency of panels decreases every year. Wind is available for all 24 hours with varying speeds throughout the year. Wind energy has been harnessed in the windmill farms. These farms require large investments and at present are available mostly in MW range.

The wind energy, though not consistent, is comparatively cheaper to solar and other forms of non-conventional energy. This does not create any pollution, is environment friendly, totally free of running cost and almost maintenance free.

WINDMILL

The Windmill consists of:

1) Propeller Blades
2) Tail Vane
3) Alternator
4) Supporting Tower
5) Storage Batteries
6) Inverter

1) ***Propeller Blades:***

The blades of suitable size and shape are made up of either fibre glass/ PVC/ FRP/ Plastic material/ aluminium sheets/ carbon fibre etc., in the aero foil shape. The shape of blades is the most important factor. The blades are to be dynamically balanced. It should sweep maximum wind to produce sufficient torque to rotate the blades even at low wind speeds.

2) ***Tail Vane:***

The direction of wind is not same or uniform all the time. The tail vane is used to bring the blades in front of the wind so that the blades get maximum available wind force to keep rotating most of the time. The design of tail vane and blades depend on each other. Additionally, the tail vane is also used to balance the weight of blades.

3) ***Alternator or Electrical Generator:***

The alternator is the main component of the wind mill. It produces electricity. The idea of making an alternator was actually thought from the spinning toy, 'Bhingaree' i.e. large diameter with thin width, which the children play in villages.

The alternator consists of a stator and a rotor. The stator and a rotor comprise of two circular shaped, concentric rings. The inner ring is rotated by a shaft, which is connected to propeller blades. Bearings are used for smooth rotation of the shaft. The outer ring is stationary and does not rotate with the shaft. Permanent magnets of equal size, shape and magnetic strength are pasted on inner ring and copper wire coils of equal size, shape, turns and electrical characteristics are inserted in the electrical steel (stamping/ lamination) slots resting on outer ring, to generate electricity.

The rotating ring is dynamically balanced. This whole arrangement of the stator and rotor of the alternator is covered by aluminium /G. I. /m. s./ plastic sheet on both sides to protect the alternator from rain and weather. The three phase A. C. current output is obtained which is converted to D. C. current through bridge rectifier to store in batteries as the current generated is not constant and hence cannot be supplied to grid or used directly due to fluctuating frequency.

However, it is to be understood that such a distinction of arrangement with respect to placement of magnets and coils either on inner ring or outer ring is purely arbitrary and both the arrangements can be used in most of the cases. However, if the coils are pasted/ inserted on the rotating ring then slip ring with carbon brushes need to be used to avoid rotation of output wires. This becomes more clumsy, costly and requires periodic maintenance of adjusting carbon brushes or even replacement after some days.

The starting RPM (cut-in speed) of alternator generating current can be lowered by either increasing number of turns of coil wire and/ or decreasing diameter of wire. This increases resistance of alternator and hence the current generated decreases. Also, due to thin wire the current carrying capacity of the wire is also low. This arrangement of thin wire/ more turns should be used only for areas of low wind velocities. Though, it produces small power output, it atleast produces something at low wind speed areas which otherwise would not have produced anything.

The starting RPM of alternator generating current can be lowered by increasing number of magnets i.e. number of poles (a pair of magnets forms a pole). In the same perimeter of rotor more number of magnets can be accommodated by smaller width of magnets and increasing length of magnets. Of course, this increases number of coils also. More power can be generated in the same alternator configuration by adopting **multi pole - multi path** system. First insert the coils in the slots of stamping as a first layer, then insert second set, third set by staggering the slots. First set has, say, thinner wire with more number of turns. This will start generating charging current at low RPM & low wind speed. The other two sets will not generate anything. As the wind speed increases, RPM increases and then second set of coils which has thicker wire & less number of turns starts generating current. That's how the third set will start generating current at still higher wind speed & higher RPM. At a quite high speed all the three sets will generate current. The output wires of all the three sets (multiple sets) are connected to bridge rectifiers and then to battery. Depending upon the fluctuation of wind speed the sets of coils (paths) start, continue or stop generation.

This system is activated and controlled by an electronic gadget with the IC based relays with RPM sensors. Initially when there is no wind at all the blades are standstill. At this stage the gadget disconnects the battery and windmill is at No Load condition (free). Even at a very small wind, say,

breeze, the blades start rotating and get momentum. Once the RPM (alternator voltage) reaches to generating condition the gadget connects battery (load condition). The blades get a mild jerk but since the wind speed is high and momentum achieved, the alternator starts generating current (power) and increases with RPM, wind speed.

A new design of non-circular or random shaped alternator has been developed where size of large diameter circular alternator has limitations. A conveyer belt type arrangement of magnets on belt with coils as cover is designed, developed and tested very successfully. This can be placed inside a shaft or tower of windmill and alternator can be extended as and when desired. A PATENT is pending for this design.

A software program has been written to design alternator with various parameters such as size & number of magnets, diameter of wire (combination of gauges), coils configuration, wind speed data for various intervals, number of coil paths, mechanical & electrical torque, cut-in & cut-off wind speed, power output, size of blades, rotor diameter, size of alternator, weight of windmill, final cost of whole unit etc etc. The same size alternator can be designed with different wire & path configuration for varying wind condition at a particular location. This gives maximum desired power from tailor made windmill.

The assembly consists of blades on one side, the alternator in middle and tail vane on the other side. The whole assembly is erected at a reasonable height from ground level on supporting tower. The windmill should be erected at a minimum height of 50 feet above ground level and/or at a height where it gets unobstructed wind. The whole assembly rotates in 360 degrees as per the direction of wind guided by the tail vane. The supporting tower could be placed on top of highest level of the building. Depending upon the generator capacity, it will be quite heavy and cumbersome to erect the same at such height.

If the total windmill weight is considerably more or the tower height is quite high then it becomes difficult to lower down the alternator for maintenance / repairs. Instead, an arrangement of erecting on top of tower the differential of a vehicle which has a beveled gear system i.e. transfer of rotations in perpendicular direction by a flexible shaft to an alternator keeping it at bottom of tower can be made.
Blades on one end, tail vane on other end of differential and alternator at the bottom of tower connected by flexible shaft works very well.

The basic design concept of alternator is to generate electricity at very low wind speed, i.e. low R.P.M. of the shaft. It depends on the optimized design of size & type of magnets, the number of turns, diameter, quality and current carrying capacity of wire, multi-path arrangement of coils etc.

4) ***Supporting Tower:***

The wind speed normally increases at greater heights from ground level. The supporting tower is designed considering its height, loads coming on it and the wind speeds encountered at the location and is suitably fabricated out of steel material with a foundation strong enough to support the tower. The steps are welded to structural members of the tower for easy climbing up/down and ease of working during erection.

5) ***Batteries:***

Since the availability of wind and the wind speed is very much fluctuating, the electricity generated needs to be stored in batteries. When the generating current is more than consumption current, the excess is stored in batteries and utilised when the reverse occurs. The number of batteries and their current capacity depends on generating capacity, wind condition, consumption, backup hours etc. More efficient, maintenance free, long life batteries, though initially little more costly, can be used for long life. Normally, deep cycle charge (tubular) batteries are used as the generated current is variable and not constant.

6) ***Inverter:***

An inverter of a suitable required capacity is used to convert the DC power from the batteries to usable AC power. Pure sine wave inverter, though costly, delivers quality current than cos-square inverter.

7) Lighting System: Since the electrical power generated by wind energy is very precious and hence has to be utilized very meticulously. The CFL tubes, LED bulbs consume very little power and its illumination is equally high compared to conventional lighting system available in the market. These energy efficient/ energy saving bulbs & tubes are initially costly but by way of saving power they turn out more economical. The power appliances like washing machine, air conditioner, refrigerator, electrical motors etc. require 4 to 5 times initial starting current and brings over load on batteries and hence not easily used. The 'soft start' technology can be effectively applied to start and use these appliances but it adds to cost.

Normally, in most of the affordable houses, the battery backup system (batteries & inverter/ UPS) and wiring is already done where the batteries are charged by grid power by investing almost 30% to 35% of the total cost of windmill system. The cost of windmill, even if taken only as an alternative charging media, is about 65% to 70% of the total system. However, with effective working of windmill system, one may not require grid power at all and can say GOODBYE to State Electricity Board. The cost can be substantially reduced if it is commercially manufactured on large scale and can be brought within a reach of a common man. This windmill can be erected at any normally windy place. This can be used at remote areas where grid power has not reached. It is best suited for residential colonies, apartments, schools, hospitals etc. The investment can be recovered depending upon the wind condition in a reasonable time as the running cost is almost zero. This gives pollution free, noise free, maintenance free constant power at constant voltage which safeguards electrical appliances too.

Technology

This type of windmill does not require a highly sophisticated technology or big industrial establishment. It can be manufactured in a small workshop with semi-skilled workers with a passion for innovation and devotion.

PATENT

Patent has been granted for the alternator by Govt of India for 20 years.

Applications of Low-RPM alternator

Once this low RPM alternator is at disposal it can be utilized for various other applications than only windmill.

1) Electricity generation by Wind, in a conventional method on roof top or in open areas as described above.
2) Electricity generation by animal power to run electric motor for farmers. The bullock are used in the farms for various agriculture activities hardly for 40-50 days in a year. Rest of the time they remain idle but required to be fed at high cost. These animals and also others like buffalos, donkeys etc. can be used to rotate the shaft of alternator through gear system to generate electricity, rather to charge batteries. The bulls rotate at the maximum 3-4 RPM and hence a gear system is required to achieve required RPM to generate charging current. This may not be viable for individual farmer but good for group of farmers.
3) Electricity generation by animal power for battery bank to create employment to rural unemployed youth. A group of unemployed rural youth can start a business as a startup or on a cooperative basis to supply charged batteries to run electric motor to pump well water. Farmers can bring their cattle to this work station as their contribution in lieu of battery use charges.
4) Electricity generation on free flowing water at streams, high rise buildings and farm pumping water. A small size alternator with pelton wheel in place of blades can be either carried or fixed at a stream with flowing water and generate electricity. Similarly same alternator can be fixed at a chamber where sewage pipes from kitchen & bath from each house in a multistoried building let out water in a drainage pipe at a high speed. The speed of water can be increased in a jet action by reducing the pipe area.
5) Electricity generation on cycle rickshaw. In cities like Kolkata, Delhi and most of the cities in south India ply cycle rickshaw for passenger and goods traffic. If a non-circular alternator system is fixed on chain of rickshaw electricity can be generated while peddling the wheel. The battery will get charged during whole day and can light up the house at night.
6) Electricity generation by Mahatma Gandhi's spin wheel (Charakha) in rural areas either by circular or non-circular alternator system.
7) Gymnasium bicycle – exercise & battery charging
8) Electricity generation on running car

9) Electricity generation on railway, below the chasis by non-circular alternator system
10) Hybrid Street Light System (Solar & Wind)
11) Window windmill for high rise buildings. There is very high wind velocity at upper floors and particularly at the mid-landing window of the staircase due to creation of draft. A small windmill can be placed at balcony and staircase to generate power.
12) Electricity generation on any moving device
13) Every house in rural & urban areas just like solar water heater or DTH dish
14) Tribal areas, forest & inaccessible, remote areas, Hilly areas
15) Areas where grid power electricity cannot be provided for cost of infrastructure, terrain or accessibility
16) Defence installations at high altitude mountain areas
17) Offshore small boats
18) Railways, cars & other vehicles
19) Agriculture farms
20) Electricity generation on highway dividers by moving vehicles
21) Electricity generation on railway side tracks by moving trains

…. And many more …..