

Study & Development of Wind Energy Powered Hybrid Cycle

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ABSTRACT: As the conventional sources of energy i.e. Fuel, Coal etc. are on the verge of extinction, there must be some other means to keep the world running. With intense research & study, an idea of running vehicles through wind energy has been formulated. Consequently, this paper is about our effort to shift the reliance from conventional sources to non-conventional sources like wind energy to deliver the power needs. To implement it, we thought of starting with & testing it on a bicycle first. The fundamental is simple, running a cycle with wind energy, like an automobile, such that the human effort is not needed. This would assist in imposition of green vehicles in daily life to make the surroundings cleaner & better for living as well as reduction in dependency on fossil fuels.

KEYWORDS: Green Technology, Hybrid Vehicle, Air Cycle, Renewable, Wind Energy, Eco-friendly.

I. INTRODUCTION

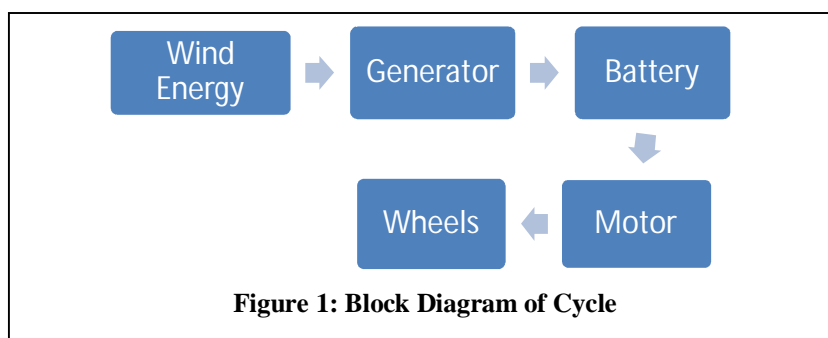
In this world of rapid energy consumption, the need for alternative energy sources has been felt. To feed this exigency we intend to develop a hybrid cycle. The basic idea behind manufacturing this cycle is utilization of wind energy for driving the cycle. This will have following advantages: -

- Driver is not required to paddle the wheels' every time i.e. easy driving & comfortable.
- Cycle is completely ecofriendly, because it uses non-conventional source of energy (WIND ENERGY).
- Zero pollution rate by an automated vehicle.

Components/ Items

- Bicycle
- Wind Turbine
- Electrical Generator
- Battery
- Throttle
- Regenerative Brakes
- Wheel hub Motor

II. SYSTEM DESCRIPTION



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Wind Energy Production

- Wind turbines are designed to exploit the wind energy that exists at a location. Aerodynamic modelling is used to determine the optimum tower height, control systems, number of blades and blade shape.

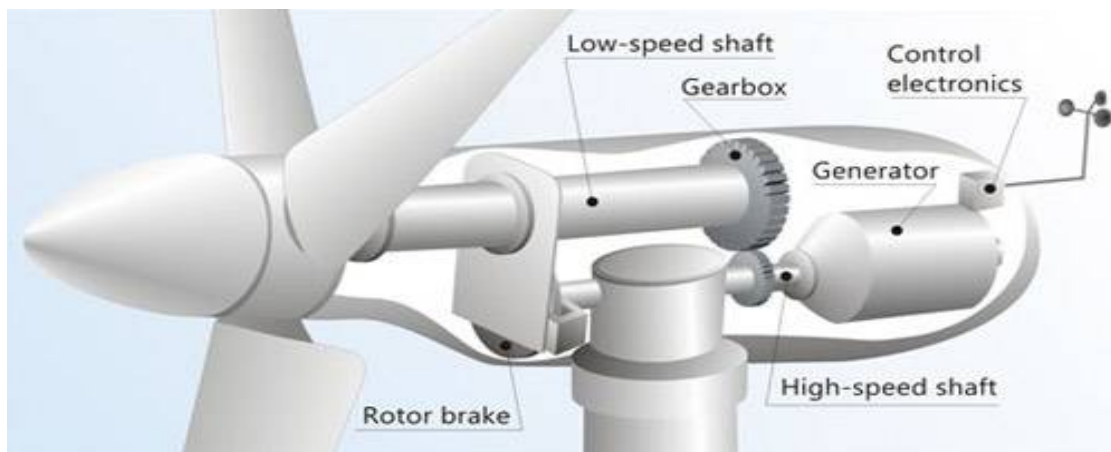


Figure 2: A Wind Turbine with Generator

- The wind turbine obtains its power input by converting the force of the wind into a torque (turning force) acting on the rotor blades.
- They are divided into two groups: -
 - **Vertical Axis Wind Turbine (VAWT)** → The main rotor shaft arranged vertically. One advantage of this arrangement is that the turbine does not need to be pointed into the wind to be effective. The generator and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, improving accessibility for maintenance.
 - **Horizontal Axis Wind Turbine (HAWT)** → Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind.



Figure 3.1: Vertical Axis Wind Turbine



Figure 3.2: Horizontal Axis Wind Turbine

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- We will use Horizontal Axis WT, as it is easy to install, cheaper as well as widely used for commercial purposes where, less power is required (100 Watts to some Kilowatts)

DESIGNING of Windmill

- The design of a windmill is an integral part of how efficient it will be.
- For consistent production of power & electricity from generator required for driving the wheel motor design consideration is necessary.
- A 250 W - 300 W power production is sufficient for this purpose
- 250 W = 0.25 kW can be produced by a rotor of diameter = 1m.
- The rotor area determines how much energy a wind turbine is able to harvest from the wind.

III. CALCULATIONS

- For determination of power required to move the cycle, power calculation is needed.
- To calculate the amount of power a turbine can actually generate from wind turbulence, we need to know wind speed at the turbine site & turbine power rating. Most turbines produce their maximum power at wind speeds around 15 meters per second (33 miles per hour, mph).
- The equation for calculating the power exploited by a wind turbine is:

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

- Here, P = Power Output (Watts)
- C_p = Maximum power coefficient, ranging from 0.25 to 0.45,
- ρ = Air density (kg/m^3) = 1.225 kg/m^3
- A = Rotor swept area (m^2) or $\frac{\pi}{4} D^4$ (D is rotor dia in meter) = 1 m^2
- V = Wind speed (m/s) = 10 m/s (average, when riding the cycle)
- Therefore, P = (0.40*0.5*1.225*1*1000)
= **252 Watts**

IV. TRANSMISSION SYSTEM

1. Permanent Magnet Generator

- A generator is an electrical device which is utilized to convert or exploit electrical energy from mechanical energy (shaft power).

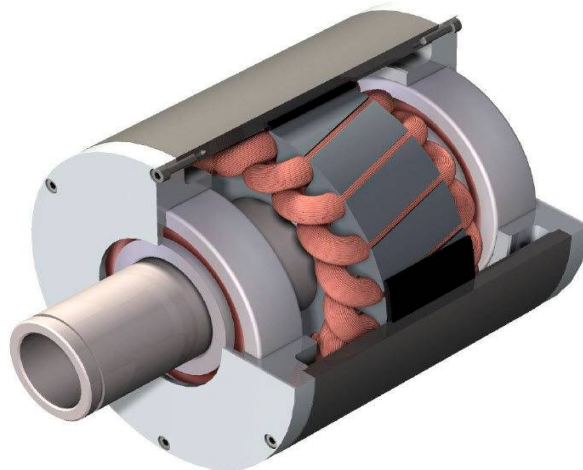


Figure 4: Cross section of a Permanent Magnet Generator

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- There are various types of generators available but in this system, Permanent Magnet Generator (PMG) is used.
- Permanent magnets alternators (PMA) have one set of electromagnets and one set of permanent magnets. Typically, the permanent magnets will be mounted on the rotor with the electromagnets on the stator.
- PMG is attached at one end to the wind turbine, which provides the mechanical energy.
- At the other end, the generator is connected to the electrical grid or battery.
- As a generator, they do not require a controller as a typical three phase motor would need. It is easy to rectify the power from them and charge a battery bank or use with a grid tie.
- Permanent magnet alternators can be very efficient, in the range of 60%-95%, typically around 70% though.

2. Battery

- The lithium iron phosphate (LiFePO₄) battery, also called LFP battery (with "LFP" standing for "lithium ferrophosphate"), is a type of rechargeable battery, specifically a lithium-ion battery, which uses LiFePO₄ as a cathode material.

Advantages →

- LFP chemistry offers a longer cycle life than other lithium-ion approaches.
- Like nickel-based rechargeable batteries (and unlike other lithium ion batteries), LiFePO₄ batteries have a very constant discharge voltage. Voltage stays close to 3.2V during discharge until the battery is exhausted. This allows the battery to deliver virtually full power until it is discharged.
- One important advantage over other lithium-ion chemistries is thermal and chemical stability, which improves battery safety.

Specification of Battery

- Quantity: **12 Cells**
- Voltage: **3.3 volts per cell**
- Capacity: **7 Ah**
- Weight: **320 g/cell**
- Total battery wt.: **3.8 Kg**
- Battery Life: **10 years**
- Internal Impedance: **≤ 8mΩ**
- Dimension: **32*56*80mm**

Charging Characteristics of Battery

During the conventional lithium ion charging process, a conventional Li-ion Battery containing lithium iron phosphate (LiFePO₄) needs two steps to be fully charged: step 1 uses constant current (CC) to reach about 60% State of Charge (SOC); step 2 takes place when charge voltage reaches 3.65V per cell, which is the upper limit of effective charging voltage. Turning from constant current (CC) to constant voltage (CV) means that the charge current is limited by what

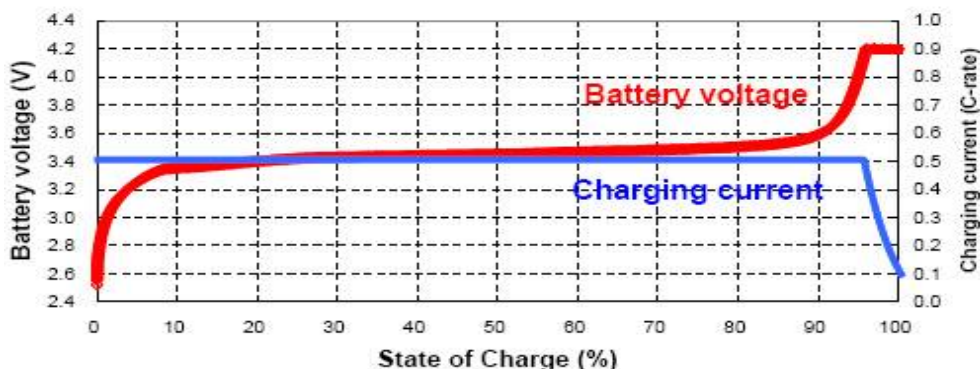


Figure 5: Charging Characteristics of Battery

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the battery will accept at that voltage, so the charging current tapers down asymptotically, just as a capacitor charged through a resistor will reach the final voltage asymptotically.

3. WHEEL HUB MOTOR

- **Principle:** When a current carrying conductor is placed in a magnetic field it experiences a mechanical force.
- **Working:** In DC Hub motor, the magnets are on the axle & windings are actually spinning. Lacing the bicycle rim into this spinning motor body, will rotate the wheels with it & move the cycle.
- Typically, radial flux is used in Brushless DC Machines(BLDC)



Figure 6: Illustration of Wheel Hub Motor

TECHNICALITY OF W.H.M

- Power density available from an electric machine directly depends on speed between magnets & windings.
- One way to increase relative speed is to move to a larger radius.
- In these motors, regenerative braking is also possible.
- Current from supply directly depends on torque of shaft.
- Back emf is also proportional to speed of shaft

$$V = k_2 * \text{rpm}$$
 When rotational speed is given in rpm

$$K_1 = K_2 * 2P_i/60$$
- When motor connected to voltage supply & shaft left to spin freely:-
 Considering, initially large current, which generates large torque causing shaft to accelerate

$$T = K_1 * I$$
 where, K_1 = motor torque constant, Nm/A
- As shaft spins faster & faster back emf increases, this reduces current through the windings. The current speed relationship is simply given by a straight-line equation.

$$W = V/K - R * T/K^2$$

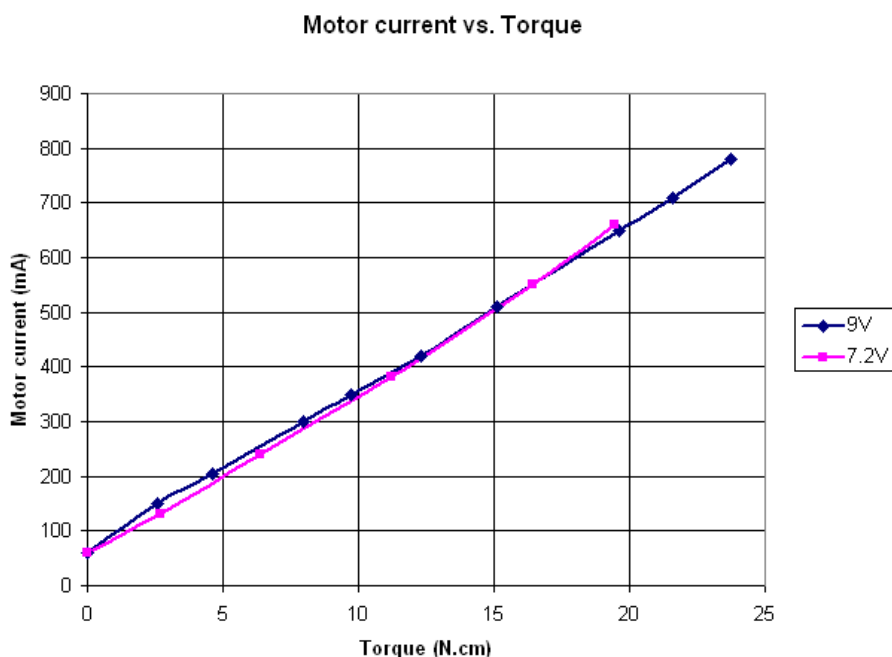


Figure 7: Characteristics of Motor Current vs Torque

Amount of power into a motor = battery voltage* current

- Amount of electrical energy converted into mechanical energy = back emf * current
&, Conversion Ratio = back emf/applied voltage
- There are only two parameters needed to characterize this model of motor.
 - One is motor constant (K).
 - Winding resistance(R).
- For a given K smaller the R then less is the speed drop when motor is loaded
- K determines how much voltage is required to make the motor spin at certain speed.

Motor Specification: -

36 V, 250 – 300 Watts for a 16-inch wheel.

4. THROTTLE

- A throttle is an electrical device which is used to regulate the speed of vehicle by controlling the supply current to hub motor.

Specifications of Throttle Used: -

- 36V Electric Bicycle Throttle.
- LED Battery indicator Twist Grip.
- Red wire: +5V
- Blue wire: GND
- Green wire: Signal
- Yellow wire: Battery Positive Pole
-

5. REGENRATIVE BRAKES

- A hybrid electric vehicle reclaims energy by converting the energy of a moving object, called **kinetic energy**, into electric energy.
- Regen Brakes uses the momentum of the body and converts it into the useful electrical energy, which can be stored in the battery and later be used to power the bike.

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- Employing Regen Brakes will decrease the overall charging time of battery which consequently helps in seamless performance of cycle.

V. EXPERIMENTAL RESULTS

The most important factor in this project is sufficient generation of electrical power through wind energy to run the wheel hub motor. The size of turbine we are using (single rotor of 1m diameter or 2 rotors with 0.5m diameter each) has been tested to easily produce around 300 watts of power at wind turbulence of 10 m/s, which is our required aim. This energy is then being efficiently transferred to hub motor through battery to run the cycle.

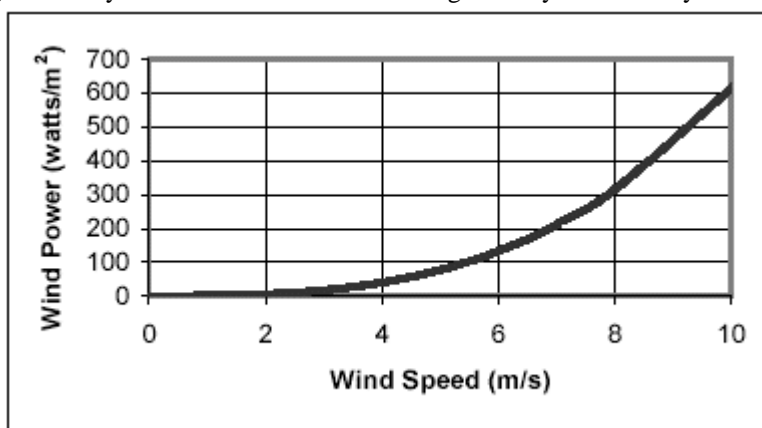


Figure 8: Wind Speed VS Power Generated

VI. CONCLUSION

- **Ecological Aspect:** - Harnessing power from the wind is one of the cleanest and most sustainable ways to generate electricity, as it produces no toxic pollution or global warming emissions. Wind is also abundant, inexhaustible, and affordable, which makes it a viable and large-scale alternative to fossil fuels.
- **Economical Aspect:** - The wind resource how fast it blows— plays a significant role in its power generation. The power output from a wind turbine rises as a cube of wind speed. In other words, if wind speed doubles, the power output increases eight times. Therefore, higher-speed winds are more easily and inexpensively captured.
- With the throttle mode ON, the cycle assists in automated comfortable ride without the need of pedalling. Alternatively, the rider may pedal as distant as he/she wants & may later turn the throttle ON.

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