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Design of Hybrid Vehicle Using Wind Energy

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Abstract:
Nowadays fossil fuels produces highly toxic and colourful exhaust gases which is very harmful to all living beings and also in future the engines which are using these fuels become obsolete due to this aspects. Hence this project is developed for the purpose of using wind energy to power and run a hybrid (electric) vehicle. A wind mill generates power from wind energy and this electric power is stored in a battery, meanwhile another battery powers the vehicle alternatively. In the both the ways, the vehicle get the power from a battery. This project could be stated as there is a compulsory need for an alternative source of fuel to power the vehicle; we can use this system as a beginning for a futuristic alternative for fossil fuels and harness the wind energy in vehicles around the world.

Keywords: Fossil fuels, Toxic Exhaust gases Hybrid Vehicle, Wind Turbine, Wind Energy, Battery and Electricity.

1. INTRODUCTION:

Natural energy resources such as solar, wind, tidal and thermal are used to generate the power. This energy often provides energy in 4 significant aspects: Production of electricity, heating/ cooling of air and water, transportation, and rural areas energy production. Renewables energy contributed 19.3% to global energy consumption and 24% to their generation of electricity according to survey in 2014 and 2015, respectively. This energy utilization is separated as approximately 9% coming from biomass, circa 4% as various forms of energy obtained from heat (modern biomass, geothermal and solar heat), anther 4% from hydroelectricity from Dams, Rivers and OTECs and 2.2% is electricity from wind, solar, geothermal, and biomass. Now considering Wind energy, it is the most efficient and best mode of electricity generation due to its easier and quicker availability. Steam flow of air can be used to run wind turbines efficiently. Modern developed wind turbines produce energy range from around 500 kW to 5 MW of maximum rated power, however smaller turbines with average rated output of 1.5–3 MW have become the most common for commercial use and used in several states across the world. Numerous attempts and experiments are taken to produce electricity by vehicle as a number of literatures are already exists. However, these proposals and projects never meet the threshold of the practical implementation due to several implications and issues. Therefore, electricity being harvested from vehicle is still avery dynamic area yet to be explored. This paper proposes a customized, transportable and distributed wind turbine for vehicles to generate electricity on-the-go and to get a safer environment. It is possible to increase the input wind speed for a wind turbine artificially by using the vehicle speed with the help of aerodynamic designing of the vehicle. Hence, a wind turbine is mounted with vehicle to use the benefit of moving vehicle's given speed, thus with this we can use the energy for running the vehicle as well for various other purposes. For the places, within cities, where the wind speed is not recommended to run a single, small wind turbine, wind energy produces on motion by the running vehicle can be an alternate better solution for producing electricity. Thus this paper particularly concentrates on the production of energy using a wind turbine as a solution for a hybrid vehicle. Although an alternative source of energy or fuel is provided by primary battery, a secondary battery is powered by the wind turbine and once the primary battery gets completely discharged, the secondary battery can be used to run the vehicle for some more time. Thus giving us excess amount of energy harnessing with the advantage to charge wherever possible.This paper is arranged in an organised manner as follows. Section 2 comprises of the conversion and calculation of wind energy to electrical energy, while section 3 discusses about the design and development of the hybrid vehicle and the specific information of the components used is mentioned in section 4. Section 5 focuses on the advantages and disadvantages of this project along with a detailed analysis of the vehicle performance in section 6 and finally concludes with the future perspectives of this vehicle and its applications in section 7.

2. CONVERSION AND CALCULATION:

2.1 Wind Power (Pw)

Wind power is extracted from the wind which is used to drive the turbine blades. The wind power is determined by the velocity and density of the air which hits the rotor blades. The theoretical value of the power is calculated by using the equation given below,

$$P_W = O.5 \text{ X } \rho \text{ X } V^3 \text{ X } Cp \text{ X } A \text{ (Watts)}$$

Here Power (P) in Watts and the density of air is in Kg/m^3. C_p the power coefficient. Even a small difference in the wind speed gives us drastic change in the power production. The rotor blade area is fixed based on the air density and the location of installing the wind turbine. It must be noted here that even a small difference in the wind speed will produce a big difference in the power consumption. As we can see that the rotor area of the turbine in m2 is fixed, and the air density is fixed for a given location, the energy contained in the wind is only dependent upon the wind speed.

2.2 Wind Turbine

Power production from a wind turbine is related to the speed of wind. The connection between wind speed and power is defined by a power curve, which resembles same to each turbine model.

The designing of this rotor is based on Bernoulli's law, where we must understand that the wind turbine blade behaves depending on the forces, flow and direction of flow of wind. It can be found using the known formula.

$$K = \frac{1}{2} \rho V^2 + P + pgh$$

Where **P** is static pressure, **ρ**is air density, **V** is velocity of fluid and **g** is acceleration due to gravity.

$$P_{in} = 0.6 \, X \rho \, X V^3 \, X \, A$$

$$P_{out} = P_{in} \, X \, Cp$$

Where **P** is the power, **Cp** is the rotor efficiency, **N** is the Efficiency of the transmission or driven machinery, **A** is swept area of the blades and **V** is the velocity of the wind (m/s)

$$CP = \eta_{Rotor} \, x \, \eta_{Mechanical} \, x \eta_{Electrical}$$

Where **η** is the Efficiency of rotor, mechanical and electrical respectively.

Thus, we can know the power produced by the turbine. Also we must know revolutions per minute of the turbine.

R (rpm): (60 x V X TSR)/ (6.28 X Ra)

Where **R** is the revolutions, **TSR** is the Tip Speed Ratio and **Ra** is the radius of Turbine. Using this method, we can design a wind turbine correctly and achieve power production. However, there are other factor to consider while dealing with the aerodynamics of the wind turbine, such as Tip Speed Ratio (TSR), Solidity, Rotor efficiency, Swept area, drag and lift forces and importantly, Betz law.

2.3 Tip Speed Ratio (TSR)

It is determined as one of the important factor in designing a Wind turbine. It is basically the ratio between the speed of wind and speed of the blade tip.

$$\text{Tip Speed Ratio (TSR)} = \frac{\text{Speed of Blade Tip}}{\text{Speed of Wind}}$$

2.4 Forces (Drag and Lift)

These are the necessary forces for the wind turbine to spin as the wind hits them. Lift force is a force that must be strong as possible for the turbine while drag force must be less.

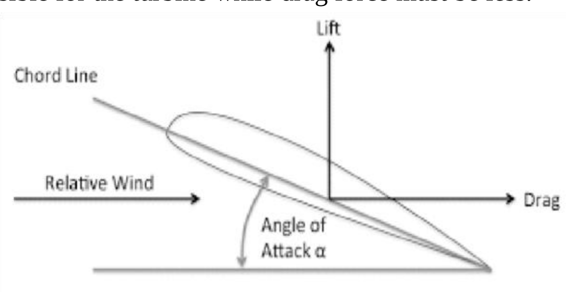


Figure.1 Lift and Drag force

2.5 Betz law

Betz's law indicates the maximum power that can be extracted from the wind, independent of the design of a wind turbine in open flow. According to Betz's law, no turbine can capture more than 16/27 (59.3%) of the kinetic energy in wind. The factor 16/27 (0.593) is known as Betz's coefficient. Practical utility-scale wind turbines achieve at peak 75% to 80% of the Betz limit. The wind energy hitting the blades are converted into mechanical power which generates power. The theoretical utmost power efficiency of any design of wind turbine is 0.59. Thus this is an important factor to consider during the calculations, designing and fabrication.

3.DESIGN AND DEVELOPMENT:

The vehicle used is a Go-Kart, an open wheel car. The frame of the chassis used is a ladder frame, the simplest and oldest of all designs. This proposed plan offers good beam resistance because of its non stop rails from front to back, but poor resistance to torsion if simple, perpendicular cross-members are used. However, the cross member and chassis material, the weld type and the weld quality is a factor to decide in terms of determining the strength of the overall chassis.

For this purpose, we have selected Mild Steel members as the chassis material, have used Tig welding to strengthen the attached members and frame members. Primarily the driver is given sufficient space for better ergonomics and control, then the steering rack; a simple mechanical steering, is designed along with the vehicle's braking system; using master cylinder, brake calipers, hydraulic fluid line and brake fluid (DOT 4). Then in the rear, the turbine is fixed along with the motor and generator connected to the battery (Lead – Acid). Whilst on the other side of the chassis, parallel to the former one, another battery is fixed to power the vehicle. However, a switch for the batteries will be provided within the driver reach along the chassis. The ground clearance of the chassis is low, since it is a go-kart, it eliminates the need for building a roll hoop making it simpler to build. But this same method can be used in different types of chassis and the vehicles.

4. COMPONENTS AND SPECIFICATIONS:

There are certain components required for constructing the hybrid vehicle. These are:

4.1 Turbine

It is very well known that the calculated value will always differ with respect to various factor, this is due to the reason for difference in wind speed, wind temperature and direction, turbine efficiency with wind consistency. So when practically tested, the results were very much different than the calculated results. The turbine being made of mild steel was able to sustain the speed and force exerted by the wind.

Moreover the Power of the Wind Turbine is also considered with two more variable, Ng: the generator efficiency and Nb: the gearbox efficiency. While Ng is considered as 0.604 and Nb is 0.9.

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

Power of Turbine = 4.32 KW

Betz power: [½ X 1.225 X 7.06 X 10 ^{3}]

Betz Power = 2.59 KW

This is the maximum power produced by this turbine at wind speed 10 m/s. The real and actual power produced is close to 500 to 600 W, although with the increase in the size of the swept area and radius of turbine, we can achieve more efficiency. The table shows the power value for the wind speed.

4.2 Battery

The battery used is a lead acid battery, however a lithium ion battery could be used for lasting and increased duration of the battery. Two batteries are used here. While one powers the vehicle, other is charged by the wind turbine and vice versa.

Thus, for one battery the specifications include 12V and 62Ah.

Battery Power is the product of the voltage and the current capacity of the battery and this equals to:

Battery Power = 12V X 62Ah = 744 Watt hr.

For two batteries = 744 + 744 = 1488 KWh.

Now using this value we can find the total time to discharge for the battery.

Time Taken = 1488 / 620 = 19 minutes

4.3 Motor

We have used the DC Motor in this project. This motor has voltage of 12V and 600W and runs around 3000 rpm. The output current could be found as:

I = Power of Motor/ Voltage of Motor

I= 600 W/ 12V = 50A

The Output speed can be found as:

N = Speed of motor / input voltage of motor:

N = 3000 RPM/ 12V= 250RPM.

4.4 Generator

The Generator is used to extract energy from the turbine and supply it to the battery. We have used a DC Generator of 40 W and voltage of 100 V with a rotating speed of 390 per minute.

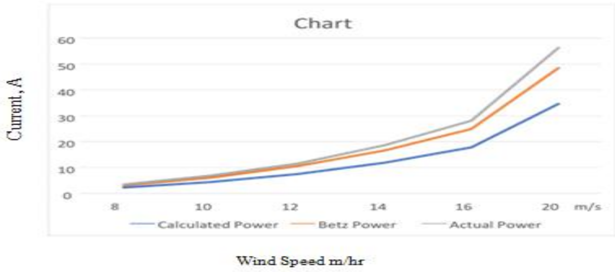
I, Current = 40W / 100V= 0.4 amps per minute.

P_B, Power into Battery = VI = 100 X 0.4 = 40 Watts

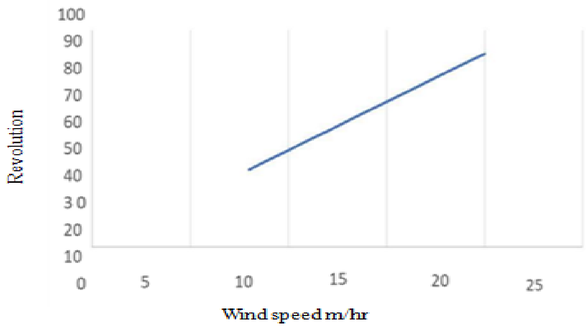
P_B= 40 X 3 = 120 watts per 3 phase.

5. RESULTS AND DISCUSSION:

It is found from the graph when the wind speed increases the current production also increases and rpm of the turbine also increases. So it is confirmed that the production of current depends only on the wind speed.



Graph 1. Current Vs Wind speed



Graph 2. Revolution Vs Wind speed

6. CONCLUSION:

A suitable design for energy harvesting with vehicle is projected in this title as “Design of Hybrid Vehicle using Wind Energy”. The construction and design of Wind energy hybrid vehicle have been discussed in detail. Moreover, it possesses several bright and futuristic features including increased rpm and torque for the vehicle mounted wind turbine, along with light weight, miniature size chassis. Moreover, this vehicle has low-priced installation cost and very less maintenance cost. From experiment it is marked that the turbine when in motion can produce up to 150W- 300W of electricity from a single vehicle (< 30 km/hr).With a proper use of this technology with better performance components, it will be very useful in future. With the design of the turbine blade to efficiently produce better lift, some drag force is originated evidently. It is suggested to follow up the Betz limit. In conclusion, using proper designing and calculation, this system might produce sufficient energy power.

7. APPLICATION AND FUTURE SCOPE:

This vehicle can be used in Highways and in windy regions to reduce the emission of toxic gases produced by burning of fossil fuels. With this implemented idea, we could reduce the use of fuels to power the vehicles and furthermore help in a more eco – friendly environment. Although the usage for these system is less probable, being able to use in highways and windy regions, it can be implemented in many systems such as trains and buses etc. to consume fuel. Also we can harness the wind Power while the vehicle is stationary, thus preserving our time for the charging the vehicle.With a more aerodynamic and with accurate aerofoil structure the turbine could be designed specifically for this in order to generate more power. The turbine could be designed to reduce drag and increase the lift forces significantly by using an airliner aerofoil structure or Propeller aerofoil structure. Moreover with a powerful battery we could charge in less time and by using Li- ion battery the discharge could be very less then Lead- acid. This will increase the efficiency of the vehicle. Also Solar Panels could be added to increase the charging capacity of the battery along with the wind energy.

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