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Extension of Travelling Range by Powering Electric Vehicle with Wind Energy

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***Abstract*— One of the limitations of the electric vehicles is their short travel range compared to their excessive charging time. The travel range can be extended by charging the battery while in motion. This paper presents a design to charge the Electric Vehicle (EV) while running using renewable energy source. The proposed EV design utilizes wind energy to charge battery while the vehicle is being driven. An electric powered vehicle has a bank of batteries that runs the entire vehicle. This paper is on charging the batteries of the vehicle on the run. This is done by using the wind that acts opposite of a moving car. This process can go on till the vehicle is completely charged or the driver finds a charging station. This paper mainly focuses on the design of the wind powered car and to determine the power required for driving the system.**

***Index Terms*— Wind Power, Electric vehicle, Turbines, Battery, Travelling range**

I. INTRODUCTION

The transport sector is one of the main contributors of the air pollution as the pollution caused by the internal combustion of vehicles is very high. It produces almost a quarter of all the greenhouse gas emissions. To overcome this, governments all over the world are working diligently. EVs are touted as a one-stop solution to many problems. These include those related to air pollution and steep oil usage.

India consumes 29.4 per cent of the world's oil. According to a report by Niti Aayog and Rocky Mountain Institute, a reduction of 156 million tonnes of oil is possible by 2030 if EVs account for 40 per cent two-wheelers, cars and SUVs and 100 per cent commercial vehicles and three-wheelers. India is also the world's third-largest emitter of carbon dioxide (CO2) at two million kilotons behind the US and China. In the national capital of Delhi, pollution due to particulate matter regularly exceeds the World Health Organization's limits by a factor of 7-12.

Electric Vehicles have had recent breakthroughs in the transportation industry, shifting from fossil fuel energy to renewable. More EVs means less carbon emissions.

Renewable energy sources offer limitless resource and environment friendly operation compared to conventional energy sources. There are several forms of renewable energy such as solar energy, wind energy, geothermal energy, tidal energy, hydro energy and bioenergy. However, wind energy is the most valuable, safe and fastest growing renewable energy. At the end of 2020, worldwide installed wind power capacity was 733 GW. Wind-generated electricity met nearly 18% of global electricity demand till 2020, with nearly 63 GW of new wind power capacity installed. Wind energy was the leading source of new capacity in Europe, the US and Canada, and the second largest in China. Wind Energy is cheap (0.053USD/kWh approx.), has low carbon footprints (4gCO2e/kWh), has minimum sound pressure (50-60 dB from 30m) and can be easily combined with different energy sources.

However commercial wind turbine is not suitable for electric vehicles because of its requirements of larger land, high installation cost, and lack of energy storage. Moreover, in some places wind speed is not sufficient to run a commercial or domestic wind turbine. Hence, a modified wind power system is necessary which can be useful for our needs.

This paper is arranged in the following manner. Section 2 comprises of the calculation of wind energy and its conversion to electrical energy. Section 3 discusses about the assembly and development of the vehicle, furthermore the specific information of the components used is mentioned in section 4 and lastly the conclusion in section 5.

II. TURBINE AND POWER CALCULATIONS

2.1 Wind Power

Wind energy describes the process by which wind is used to produce electricity. The wind turbines convert the kinetic energy present in the wind to mechanical power. It is a source of energy that determines the total power in the wind. The wind turbines which convert kinetic energy to mechanical power, wherein the mechanical power is converted into electricity.

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$$P_w = 0.5 \times V^3 \times A \times T \times \rho$$

All quantities in P_w is constant except the Velocity of wind. Rotor blade fixed for air density and location. Hence, even a slight change in wind velocity causes a large variation in the power produced.

Wind power changes at a wide range of time scales. Power production is directly dependent on the speed of wind. The two are related by the power curve which resembles to all turbines. . In order to take the consideration of variability into the design of wind turbines, Aerodynamics helps us determine the right way to design rotor blades. The designing of this rotor is based on Bernoulli's law. In the wind turbine, blade behaves depending on the forces, flow and direction of flow of wind.

$$P.E + K.E = Constant$$

$$K.E = 0.5 \times \rho \times V \times A \times T$$

$$Constant = 0.5PV + P + \rho gh$$

Where,

P is the static pressure (in N/m^2)

ρ is the fluid density (in kg/m^3)

V is the velocity of fluid flow (in m/s)

h is elevation

g is the gravitational acceleration

This leads to the maximum point of stress for turbine and is called dynamic pressure equation. This deals with the basic aerodynamics of the rotor. Nevertheless, drag and lift force, tip speed ratio & solidity and Betz limit directly affect the performance of rotor.

$$Relative\ Wind\ Velocity = Wind\ Velocity - Blade\ Velocity$$

The relative wind velocity determines the power input to wind turbine. Maximum extractable power is

$$P_{Max} = \frac{16}{27} \times P$$

Where,

$$P = \frac{1}{2} \times \rho_{air} \times C_p \times A \times V^3$$

2.2 Tip Speed Ratio and Solidity

It is one of the most important factors in designing a Wind turbine. It is the ratio between the speed of wind and speed of the blade tip.

$$\text{Tip Speed Ratio} = \frac{\text{Speed Of Blade Tip}}{\text{Speed Of Wind}}$$

Solidity is the ratio of total rotor platform area to total swept area and can be stated as follows

Solidity is the ratio of total rotor platform area (a) to total swept area (A).

$$Solidity = \frac{3a}{A}$$

2.3 Forces acting on the blades-Drag and Lift

These are the necessary forces for the turbine to spin. Lift force is considered as the force that works as perpendicular to the direction of motion. Lift force is very essential for a turbine and should be as strong as possible. Given by:

$$\Delta L = 0.5 \times C_l \times \rho \times C \times W^2 \times D_r$$

Where,

ΔL is Lift force

C_l is Constant of lift force

Drag force works as parallel to the direction of motion, and should be as low as possible, given by

$$\Delta D = 0.5 \times C_d \times \rho \times C \times W^2 \times D_r$$

Where,

ΔD is drag force

C_d is Constant of drag force

2.4 Betz Limit

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.

III. ASSEMBLY AND TESTING

First, the components required for Electric vehicle are identified. Its driving system is made up of three main parts: the motor, the controller and the battery.

1. **Electric motor**: The motor is the most important part of the vehicle, it is the part responsible for the propelling of the car. There are three different types of electric motors: DC wound, Permanent magnet DC and AC motor.
2. **Battery**: One of the major components of an electric car is the battery. While some cars would use the standard car batteries as a source of energy, the more advanced ones use the Li-ion batteries as more efficient energy source that gives extra range of operation for the vehicle. They require less time to be charged and provide more energy for the motor attached.
3. **Controller**: This part is responsible for power management; it senses the amount of energy needed by the motor and supplies it directly from the batteries in order to get the car moving. The controller is very

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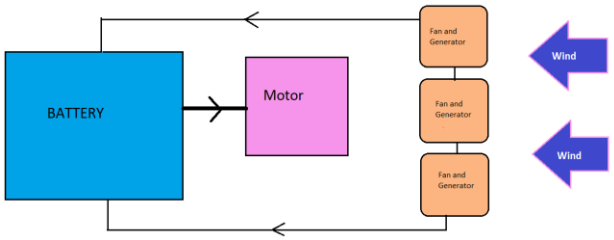
important because it synchronizes the operation of both the motor and the battery.

There are three major components that make up a wind turbine. These include, the rotor, the generator and the tower.

1. **Rotor**: The portion of the wind turbine that collects energy from the wind is called the rotor. The blades are attached to the hub, which in turn is attached to the main shaft.
2. **Generator**: This part is what converts the turning motion of a wind turbine's blades into electricity. Inside this component, coils of wire are rotated in a magnetic field to produce electricity.

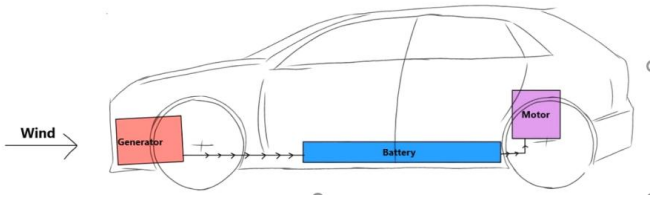


Components that are required for Wind-Powered Electric Vehicle are describe below.

1. **Rotor**: The rotor collects the kinetic energy from the wind and converts it to rotational motion. The rotor consists of three blades and a hub made of fiber glass which rotates about an axis (horizontal) at a rate determined by the wind speed.
2. **Main Shaft**: The main shaft, transmits the rotational energy of the rotor to the generator with the help of the main bearing.
3. **Generator**: A high speed brushless alternator is used for the design. This is because, it has fewer moving parts, hence a longer life span.
4. **Battery**: The battery used is a lead acid battery, however a lithium-ion battery could be used for increased duration of the backup. Two batteries are used here. While one powers the vehicle, other is charged by the wind turbine.
5. **Motor**: DC Motor has voltage of 12V and 600W and runs around 3000 rpm

3.1 Working of the Wind Powered EV

Turbines catch the wind's energy with their propeller-like blades. When the wind blows, a pocket of low-pressure air forms on one side of the blade. The low-pressure air pocket then pulls the blade towards it, causing the rotor to turn. The generator, takes the kinetic energy of the shaft and converts it into electrical energy. The electric current produced by the generator flows through a cable. The current that passed from the cables helps to charge the battery. Hence, the battery starts recharging.



IV. CONCLUSION

The future of the automotive industry depends majorly on Electric Vehicles due to the main factor of reducing the polluting gases that is emitted from the IC (Internal Combustion) Engine vehicles.

But the main drawback of those Electric Vehicles is that the range of operation is very less when compared with those of the IC (Internal Combustion) Engine vehicles and another important drawback is the charging of those huge capacity batteries. The battery charging time is very high, and these reasons are being an obstacle for implementation of these non-polluting Electric Vehicles in operation. Thus, with the employment of this proposed battery charging system in the Electric Vehicles the range of operation of those vehicles could be increased and also the time required to charge those batteries can also be reduce

EVs represent one of the best technologies for green and sustainable transportation systems. Wind powered electric cars have extended range than plain electric powered cars, recharging the battery takes lesser time as they are being charged continuously also they are not dependent on finding a charging station. Thus, with the employment of this proposed battery charging system in the Electric Vehicles the range of operation of those vehicles could be increased and also the time required to charge those batteries can also be reduced.

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