Generation of Electric Energy with Wind and Braking System

Bansi Raja[1], Hitarth Shukla[2], Aasav Sureja[3]

[1]Assistant Professor, Mechanical Department, Indus Institute of Technology and Engineering, Ahmedabad, Gujarat, India.
[2, 3]UG Student, Mechanical Department, Indus Institute of Technology and Engineering, Ahmedabad, Gujarat, India.

Corresponding Author: Hitarth Shukla

Abstract: **This research targets the design of an Electric car with wind turbine that will be installed to generate electrical power to charge the batteries when in motion. This wind powered car will have a wind turbine on its backside. During motion the wind flowing through wind ducts will rotate the turbine. This rotary movement is transferred to the mechanical component which will convert rotatory motion into electric energy. Along with the concept of wind turbine, Regenerative braking systems help to lower consumption in hybrid vehicles and reduce their carbon footprint. They can also increase the range of electric vehicles. Regenerative Braking System is the way of slowing vehicle by using the motors as brakes. Instead of the surplus energy of the vehicle being wasted as unwanted heat, the motors act as generators and return some of it to the overhead wires as electricity.**

Keywords: **Wind Turbine, Regenerative Braking System, Electric car, Carbon footprint, Green energy.**

I. INTRODUCTION

1.1 Wind Turbine

It is a device that converts kinetic energy of wind into mechanical energy. If the mechanical energy is used for electricity production, wind generators. The wind turbine may be divided into two main categories: the vertical and horizontal axis turbine ballet.

The right to receive the maximum amount of wind energy to electric vehicle power turbine is designed. Calculation of power produced by the wind, a significant amount of power (approximately 4.57 kW) to the battery, when the vehicle speed is 120 km / h will be restored.

1.2 Regenerative Braking System

When braking in the hybrid or electric vehicle, the motor generator is switched to generator mode. Wheels kinetic energy is transferred through the generator transfer driver. At the same time, the resistance of the generator to produce electricity, slows down the respected vehicle. If the braking torque of the generator is needed more, it is provided by generator with extra brake accomplishing friction brake.

II. RECOVER AND RESTORE ENERGY

With the invention of crude oil vehicle over two hundred years, it is only used as a medium of fuel. Any vehicle in some way or another, the crude oil as a primary fuel its own. Gasoline, diesel fuel, jet fuel, kerosene, heavy fuel oil, fuel oil, heavy gas oil, gasoline, etc., can be downloaded from the distillation of crude oil. Burning crude oil, carbon dioxide, menu carbon dioxide, sulphur compounds and other harmful gases generated much. All gases resulting from the combustion of oil, resulting in harmful and toxic products, due to the use of these products over the last century has led to global warming. Auto pollution is one of the most important pollutants that contribute to global warming and many other harmful effects on the earth through pollution. Alternative crude oil for the automotive industry consists of electricity (mainly used), the fuel cell, hydrogen, biodiesel, bio-alcohols (methanol, ethanol, butanol), a fuel derived chemicals that are stored (batteries and fuel cells), phosphorus, hydrogen, methane, minerals, non-fossil natural gas, oil, propane, and other sources of biomass. Electricity is mainly used and developed. The automotive industry is trying to nurture the use of alternative energy sources, and has been successful in some areas. In developing countries reliability is more on conventional energy sources for locomotives and generation of electricity, using electric powered cars in such developing countries will ultimately lead pollution and global warming.

III. PROPOSED STUDY AND SIGNIFICANCE

The idea of this project is to develop a self-sufficient locomotive to burn on the disc. Design project consists of wind turbines installed in the vehicle, so that it can move quickly by cross winding through turbines held and turbine car rotation charge, further with the concept of more regenerative braking concept, the battery is charged during an emergency mechanical brake, to reduce the stopping distance is applicable.

IV. DESIGN

4.1 WIND TURBINE

Fig 1. Design of turbine.

4.2 REGENERATIVE BRAKING SYSTEM ASSEMBLY

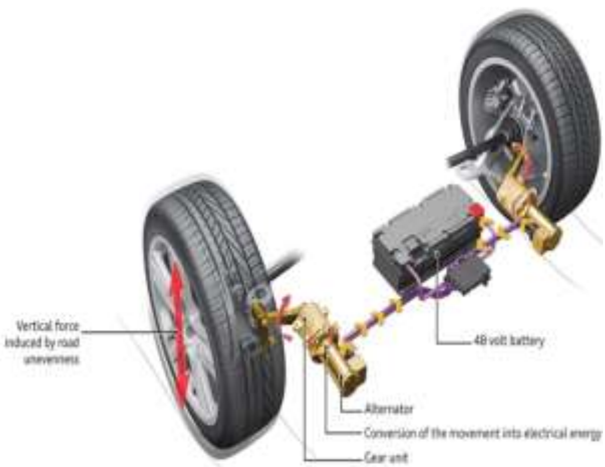

Fig 2. Design of regenerative braking system.

4.3 DESIGN PROTOTYPE

Fig 3. Design of Prototype.

5.1 POWER GENERATION CALCULATION THEORY MATHEMATICAL MODEL

The following table shows the definition of various variables used in this model:

E = Kinetic Energy (J)

ρ = Density (kg/m3)

m = Mass (kg)

A = Swept Area (m2)

v = Wind Speed (m/s)

C_p = Power Coefficient

P = Power (W)

r = Radius (m)

dM/dt = Mass flow rate (kg/s)

x = distance (m)

DE/dt = Energy Flow Rate (J/s)

t = time (s)

Under constant acceleration, the kinetic energy of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance s under a force F, i.e.:

E=W=Fs

According to Newton's Law, we have:

F = ma

Hence,

$$E = mas \ldots (1)$$

Using the third equation of motion:

$$v^2 = u^2 + 2as$$

We get:

$$a = \frac{(v^2 - u^2)}{2s}$$

Since the initial velocity of the object is zero, i.e. $u = 0$, we get:

$$A = \frac{v^2}{2s}$$

Substituting it in equation (1), we get that the kinetic energy of a mass in motions is:

$$E = \frac{1}{2} mv^2 \ldots (2)$$

The power in the wind is given by the rate of change of energy:

a

$$P = \frac{dE}{dt} = \frac{1}{2} v^2 \frac{dm}{dt} \ldots (3)$$

As mass flow rate is given by:

$\frac{dm}{dt} = \rho A \frac{dx}{dt}$

And the rate of change of distance is given by:

$\frac{dx}{dt} = v$

We get:

$\frac{dm}{dt} = \rho A v$

Hence, from equation (3), the power can be defined as:

$P = \frac{1}{2}\rho A v^{3}$ … (4)

A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than 16/27 (59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the **Betz Limit** or **Betz' Law.** The theoretical maximum **power efficiency** of any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the "power coefficient" and is defined as:

Cpmax = 0.59

Also, wind turbines cannot operate at this maximum limit. The C_p value is unique to each

Turbine type and is a function of wind speed that the turbine is operating in. Once we incorporate various engineering requirements of a wind turbine – strength and durability in particular – the real world limit is well below the *Betz Limit* with values of 0.35-0.45 common even in the best designed wind turbines. By the time we take into account the other factors in a complete wind turbine system – e.g. the gearbox, bearings, and generator and so on – only 10-30% of the power of the wind is ever actually converted into usable electricity. Hence, the power coefficient needs to be factored in equation (4) and the extractable power from the wind is given by:

$P_{avail} = \frac{1}{2}\rho A v^{3} C_p$ … (5)

Where: P wind energy, ρ (Rho) air density in kilograms per cubic meter per cubic meter of rotor circle, the air flow velocity V in m / s or miles per hour and the power coefficient Cp which is the percentage of wind energy is converted into mechanical energy, typically from 0.35 to 0.45, (45-35%).

Then we can simplify the above equation for K.V3 where K is a fixed constant representing the region of the rotor blade fixed constant mass of air and turbine efficiency. This means that "wind energy is proportional to the cube of wind speed available" or wind speed, and this statement is very important, because a small change in wind speed results in significant changes in the power of it.

5.2 POWER GENERATION THEORITICAL CAALCULATION

5.2.1 PROTOTYPE

Let's assume that we live in an area slightly above sea level that has an air density of 1.225Kg/m^3 and we consider a 40% efficient wind turbine which has a rotor blade radius of 0.025meters. Calculate the output power from the turbine at a wind speed of 80KM/H which is 22.22 meters/second, and again at double the velocity of 100KM/H which is 27.77 meters/second and 60KM/H which is 16.2m/s

We are given the following data:

Blade length, l	=	0.025 m
Wind speed, v	=	22.22m/s, 27.77m/s, 16.2m/s
Air density, ρ	=	1.23 kg/m^3
Power Coefficient, C_p	=	0.4

Inserting the value for blade length as the radius of the swept area into equation (8) we have: $l = r = 0.025m$

$$A = \pi r^{2}$$

$$3.14 \times (0.025)^2$$

$$3.14 \times 0.000625$$

$$A = 0.001963\ m^2$$

We can then calculate the power converted from the wind into rotational energy in the turbine

1. at 27.77m/s

$P=0.5\times\rho\times A\times V^3\times C_P$

$P=0.5\times1.23\times0.001963\times21253.933\times0.4$

P=10.341W

2. at 22.22 m/s

$P=0.5\times\rho\times A\times V^3\times C_P$

$P=0.5\times1.23\times0.001963\times10970.64\times0.4$

P=5.299W

3. at 16.2 m/s

$P=0.5\times\rho\times A\times V^3\times C_P$

$P=0.5\times1.23\times0.001963\times4251.528\times0.4$

P=2.053W

Then we can see that at a wind velocity of 22.22m/s the theoretical output power is calculated to be 5.299W, 16.2m/s the theoretical output power is calculated to be 2.053W and at 27.77m/s is calculated to be 10.341W. Since the wind power, P and therefore the wind energy vary with the cube of the wind velocity, the difference in power is very large. By plotting different values of wind speed against theoretical power output calculated from the above equation we can produce a simple power curve of any wind turbine given the manufacturers operational characteristics of the turbine.

5.2.2 ACTUAL CAR

Let's assume that we live in an area slightly above sea level that has an air density of 1.225Kg/m^3 and we consider a 40% efficient wind turbine assuming rotor blade radius of 0.4 meters. Calculate the output power from the turbine at a wind speed of 80KM/H which is 22.22 meters/second, and again at double the velocity of 100KM/H which is 27.77 meters/second and 60KM/H which is 16.2m/s

We are given the following data:

Blade length, l	=	0.4 m
Wind speed, v	=	22.22m/s, 27.77m/s, 16.2m/s
Air density, ρ	=	1.23 kg/m^3
Power Coefficient, C_p	=	0.4

Inserting the value for blade length as the radius of the swept area into equation we have: $l = r = 0.4m$

$$A = \pi r^2$$

$$3.14 \times (0.4)^2$$

$$3.14 \times 0.16$$

$$A = 0.50265 \text{ m}^2$$

1. at 22.22 m/s

$P=0.5\times\rho\times A\times V^3\times C_P$

$P=0.5\times1.23\times 0.50265\times10970.64\times0.4$

P=1356.540W

1.3kW

2. at 27.77 m/s

$P=0.5\times\rho\times A\times V^3\times C_P$

$P=0.5\times1.23\times0.50265\times21253.933\times0.4$

P=2628.089W

2.6kW

3. at 16.2 m/s

$P=0.5\times\rho\times A\times V^3\times C_P$

$P=0.5\times1.23\times0.50265\times4251.528\times0.4$

P=525.709W

0.52kW

VI. ADVANTAGES

- Increased efficiency of an electric car.
- Increased range.
- Lowered drag force acting against of the vehicle.
- Lowered carbon footprint.
- Reduced heat losses.

VII. DISADVANTAGES

- Volumetric space loss.
- Increased complexity.

VIII. CONCLUSION

The prototype showed great potential in generating green and clean energy and reducing the carbon footprint, with development at every stage of the project many constrains where revealed. The concept focused with a perspective of creating an eco-friendly vehicle and in the testing phase nominal but positive output was observed which suggests furthermore better results can be obtained with more optimized and robust design. The size of turbine and low capacity generator was a prominent reason observed for minimal output, as the size of turbine will be far more bigger in an actual car suggested around 1meter radius of turbine theoretical results are sizeable as the calculations suggests the main advantage is the speed of the vehicle, the power generated from the wind is directly proportional to the cube of velocity of wind. The output increase to the eighth factor so at higher velocity the output are very useful. So by installation of turbine and regenerative braking system the range of the car be increased to great extent and carbon emissions can be lowered.

IX. FUTURE SCOPE

- Eliminating different loses to increase efficiency.
- Furthermore development to create robust design.
- Testing on actual car.

REFERENCES

[1]. Gipe, P. (2006, January 23). Generator Ratings and Capacity Factors. Retrieved December 2010, from Wind-Works.org: http://www.windworks.org/articles/generatorratingandcapacityfactors.html

[2]. J.F. Manwell, J. M. (2010). Wind Energy Explained. West Sussex: John Wiley and Sons, Ltd. NREL, Rebecca Meadows. (2009, December 7). Basics of Farm/Residential Small Wind Turbines. Presentation. Great Falls, MT: NREL.

[3]. Sagrillo, M. (2002, August & September). Apples and Oranges 2002: Choosing a Home-Sized Wind Generator. Home Power Mag

[4]. Sharifi, M.R.H. Nobari, Prediction of optimum section pitch angle distribution along wind turbine blade, www.elsevier.com, Energy conservation and Management 67(2013)342-350.Different Analysis on Wind Turbine Blade (PDF Download Available). Available from: https://www.researchgate.net/publication/286920953_Different_Analysis_on_Wind_Turbine_Blade_A_Review [accessed Apr 25 2018].

[5]. Basics of mechanical engineering by Pravin Kumar, Pearson publication, 2013.
[6]. Wind Turbine: Fundamentals, Technologies, Application, Economics, 2007 By Erich Hau.
[7]. Wind Power Technology, Dec 2015 By Joshua Earnest.
[8]. https://www.bosch-mobility-solutions.com/en/products-and-services/passenger-cars-and-light-commercial-vehicles/driving-safety-systems/regenerative-braking-systems/