Journal of Manufacturing Engineering, March 2020, Vol. 15, Issue. 1, pp 019-023

DEVELOPMENT OF WIND OPERATED BIKE

Chaitanya Chevli, Jash Prajapati, Yash Panchal, Saurav Kheni, Yash Modi, *Jayeshkumar Parekh and Umang Patel

Chhotubhai Gopalbhai Patel Institute of Technology, Gujarat - 394350, India

https://doi.org/10.37255/jme.v15i1pp019-023

Abstract

The basic aim of a wind-operated bike is to ensure safe and eco-friendly drive. Here, the bike is run with the help of the battery. When we accelerate the throttle, the electric current from battery passes to controller. Then controller will sense the electric power according to the throttle position. It transmits the electric current to BLDC motor. E-bike battery has limitation that it runs only around 70 km and after that, the battery will be discharged. Therefore, the interesting thing about the wind-operated bike is the battery will continuously charge with the help of the DC motor. The DC motor having 300 R.P.M. and it produces 14v and 0.40A by using of fan. The fan is directly attached to the DC motor, we get continuous power at specific speed of the bike, and battery will be charged continually. The wind-operated bike must be eco- friendly i.e. there should be no emission; there should be enough speed to travel, efficiency and comfort. Its body should be strong enough to withstand the road shocks or bumps. There should be less charging time for charging the vehicle whenever it is required.

Keywords: *Wind operated, Hybrid and Nonconventional.*

1. Introduction

An electric bicycle, also known as an e-bike, power bike or booster bike, is a bicycle with an integrated electric motor , which can be used for propulsion. Many kinds of e-bikes are available worldwide, from e-bikes that only have a small motor to assist the rider's pedal-power (i.e., peddles) to somewhat more powerful e-bikes which tend closer to moped-style functionality: all, however, retain the ability to be pedaled by the rider and are therefore not electric motorcycles. E-bikes use rechargeable batteries and the lighter varieties can travel up to 25 to 32 km/h (16 to 20 mph), depending on the laws of the country in which they are sold, while the more high-powered varieties can often do in excess of 45 km/h (28 mph). In some markets, such as Germany, they are gaining in popularity and taking some market share away from conventional bicycles, while in others, such as China, they are replacing fossil fuel-powered mopeds and small motorcycles [1][2].

Depending on local laws, many e-bikes (e.g., peddles) are legally classified as bicycles rather than mopeds or motorcycles, so they are not subject to the more stringent laws regarding their certification and operation, unlike the more powerful two-wheelers which are often classed as electric motorcycles. E-bikes can also be defined separately and treated as a specific vehicle type in many areas of legal jurisdiction.

E-bikes are the electric motor-powered versions of motorized bicycles, which have been around since the late 19th century. Some bicycle-sharing systems uses them.

Battery electric vehicles (BEVs), which use only batteries for energy storage and must be plugged in to be recharged. The electric motor is very efficient, using 90-95% of the input energy to power the movement of the vehicle, and offer zero vehicle emissions. However, the use of batteries poses the two main challenges for battery electric vehicles: their cost and driving range. Most current models of BEV do not store enough energy to provide "normal" driving range, and are limited to below 250 km (160 miles) per recharge. However, some new and forthcoming models offer substantially more range, up to 400 km., Electric vehicles need to be recharged on a regular basis, and this can occur either at home or at work. It can also be done while shopping or during other types of stops when travelling [3].

A general issue for EVs has been, the long duration charging typically up to eight hours are needed for a full charge when using slow chargers [4]. Faster charging is desirable though not needed in most situations. This is relevant since EVs interact with the grid via charging and discharging. There are different modes of interaction with the grid; the first mode is grid-to-vehicle (G2V) where the vehicle is charged from the grid, while V2G refers to when vehicles discharge power to the grid. The V2G mode could also be considered as a bidirectional charging where EV can

**Corresponding Author - E- mail: jayesh.parekh@utu.ac.in*

charge from and discharge to the grid at regular intervals. Other charging modes such as vehicle-to-building (V2B) and controlled charging are also available. EVs can be used to enable a higher share of variable renewable energy in the power system by:

(i) Actively using the mobile battery storage system in the vehicle in V2G applications.

(ii) Use of second-hand batteries in a "second life" role as stationary battery storage systems.

(iii) Widespread deployment of charging technologies and infrastructure.

(iv) Evolution in consumer behavior of EV owners, and

(v) Provision of other ancillary services from EVs to the grid.

This occurs by making use of EV batteries to store excess electricity and to provide ancillary services to the grid, such as frequency regulation, shaving peak demand, power support to enhance the operation, and reserve capacity to secure the grid. One of the main advantages of EVs is their high level of flexibility in charging times, which can efficiently support operation of the grid [5].

In battery-operated vehicle, 12*4=48-volt battery, having 24AH capacity is used. The vehicle motor runs maximum 850 to 900 RPM. The batteries are directly connected to the controller and through the controller, the motor will rotate.

1.1 Advantages of Wind Operated Bike.

- No Gas Required,
- Savings,
- No Emissions,
- Popularity,
- Safe to Drive,
- Cost Effective,
- Low Maintenance,
- Reduced Noise Pollution

2. Experimental setup

In wind-operated bike, the thrust of air on blades will rotate the fan or fans. These blades will have different angle, axis and appearance according to application. Dynamo, DC Motor, and Alternator are devices to generate required power. But for this experiment purpose dynamo is not suitable due to very less power producing capacity. In addition, alternator will require high torque so is not suitable in this application. E bike is having wheel having BLDC motor built in.

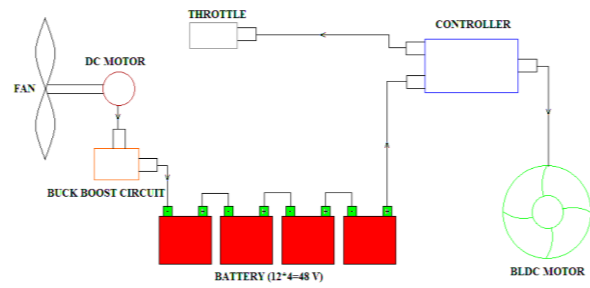

Fig. 1 Line diagram of experimental set up

2.1 Components of Wind Operated Bike

The component of wind operated Bike are presented below.

i. Batteries
ii. Controller
iii. BLDC Motor
iv. DC to DC Converter
v. Throttle
vi. Sensor
vii. Fan
viii. Motor
ix. Circuit

Fig. 2 Blades mounted on bike

2.2 Working of Wind Operated Bike

For wind operated e bike the fan or rotor blades are designed in such a way that they will get maximum thrust of wind on it. The thrust on the blades will rotate the motor sufficiently to charge the batteries. Now, to obtain maximum power output we have placed two fans, each of them having 8 blades. Their surface is medium rough to get more rotation of a fan.

Two circular plates and two sleeves are made to hold the fans properly. Plates are attached with fan blades hub, which will be mounted on the small gear motor shaft-using sleeve. The geared motor will work as generator. This will provide zero sleep at different speed. To give linear power input to the batteries for charging purpose the circuit is made using buck boost converter for each DC geared motor output. As variation in speed will generate the variable value of the voltage and ampere, to solve charging problems of batteries, linear power delivery to the batteries is required. One wind fan mechanism circuit will give minimum 14.02V and 0.40A to the battery

For this experiment DC geared motor having 300 RPM is used which also work as generator. After many trials we have chosen the 300 RPM motor. Because when the RPM of the motor is increased, the value of produced voltage is high and as compare to the voltage, the value of produced Ampere is low. So, the motor having 300 RPM has fulfilled both current and voltage requirement.

Fig. 3 Measurement of voltage and current

In this e bike, there are four batteries, which are connected in series connection (Figure 1). Each battery having 12V and 6 A. So overall, the power produced by the four batteries are 48V and 6 A. In convectional way this power unit takes three hours to full charge. These batteries are placed at the bottom area of the bike to obtain better balancing of the vehicle.

In the experiment setup, two wind units are used (Figures 2,3 & 4). The fans will rotate at different speed due to the air, trap on the fan's blades and produce the variable power output at different speed in the DC motor. The output of the DC motor will be supplied to buck boost convertor which will convert linear power input for charging the batteries. When throttle is given it will actuate the controller proportionally and will supply current to BLDC motor fitted in wheel.

Fig. 4 Experimental set up

2.3 Advantages

i. No Fuel Required
ii. Very Low Maintenance
iii. No Harmful Emission
iv. Driving Comfort
v. Preservation of Natural Resource

3. Mathematical Model

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 distance *s* under force *F*, i.e.:

$$E = W = Fs$$

According to Newton's law, we have:

$$F = ma$$

Hence,

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

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=o, we get:

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

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

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

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

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

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, the equating no. (3), the power can be defined by:

$$P = \frac{1}{2} \rho A v^3 \dots \dots \dots (4)$$

A German physics 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. 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 wind 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 *Cp* 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:

$$Pavail = \frac{1}{2}\rho A v^3 Cp \ldots\ldots\ldots(5)$$

Where the radius is equal to the blade length as shown in the Figure 5.

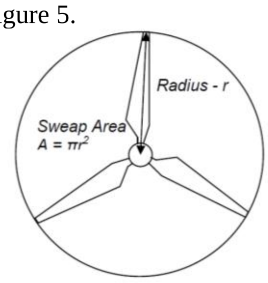

Fig. 5 Blade swept area

The swept area of the turbine blades can be calculated using the equation for the area of a circle [4].

$$A = \pi r^2 \ldots\ldots\ldots(6)$$

Where,

$E = Kinetic\ Energy\ (J)$

$m = mass\ (kg)$

$P = Power\ (W)$

$\rho = Density\ (\frac{kg}{m^3})$

$Cp = Power\ Co.efficent$

$A = Area\ (m^2)$

$r = radius\ (m)$

$x = Distance\ (m)$

$t = Tme\ (S)$

$\frac{dm}{dt} = Mass\ of\ flow\ rate\ \left(\frac{kg}{s}\right)$

$\frac{dE}{dt} = Energy\ flow\ rate$

4. Observations and Calculation

4.1 Result in Air Direction

The generation of current along the air direction is presented in Table 1 for various speed.

Table 1: Generation of current in Air Direction

Sr. No.	Speed	Voltage	Ampere
1	10km/hr	4.5V	0.10A
2	20km/hr	9.0V	0.20A
3	30km/hr	15.5V	0.33A
4	35km/hr	18.0V	0.40A

4.2 Result in Opposite Direction

The generation of current against air direction are presented in Table 2 for various speeds.

Table 2. Generation of current against Air Direction

Sr. No.	Speed	Voltage	Ampere
1	10km/hr	6.0V	0.15A
2	20km/hr	10.5V	0.22A
3	30km/hr	18V	0.40A
4	35km/hr	25V	0.60A

4.3 Calculation in Air and Opposite of Air Direction

The calculation of torque for the different conditions are presented below.

- **Speed=30 km/hr in Air direction.**

$*\, u_0 = 16 \frac{km}{hr}$

$= 16 \times \left(\frac{1000}{3600}\right)$

$= 4.4166\ m/sec$

$*\, A = \pi r^2$

$r = 24\ cm$

- **Speed=30km/hr opposite Air Direction.**

$*\, u_0 = 20.5 \frac{km}{hr}$

$= 20.5 \times \left(\frac{1000}{3600}\right)$

$= 5.6944\ m/sec$

$*\, A = \pi r^2$

$r = 24\ cm$

$$= \pi \times \left(\frac{24}{100}\right)^2$$
$$= 0.1809 \ m^2$$
$$* Po = \frac{1}{2} \times \rho \times A \times u_o^{\ 3}$$
$$= \frac{1}{2} \times 1.226 \times 0.1809 \times (4.4166)^3$$

$$= 9.5535 \ W$$
$$* Pt = Po \times C_{pmax}$$
$$= 9.5535 \times 0.59$$
$$= 5.6365 \ W$$

$$* Pg = \eta g \times Pt$$
$$= 0.8 \times 5.6365$$
$$= 4.5092 \ W$$
$$* T = \frac{Pt}{u_0} \times r$$
$$= \left(\frac{5.6365}{4.4166}\right) \times 0.24$$

$$= 0.3062 \ N.m$$

$$= \pi \times \left(\frac{24}{100}\right)^2$$
$$= 0.1809 \ m^2$$
$$* Po = \frac{1}{2} \times \rho \times A \times u_o^{\ 3}$$
$$= \frac{1}{2} \times 1.226 \times 0.1809 \times (5.6944)^3$$

$$= 20.4758 \ W$$
$$* Pt = Po \times C_{pmax}$$
$$= 20.4758 \times 0.59$$
$$= 12.0807 \ W$$

$$* Pg = \eta g \times Pt$$
$$= 0.8 \times 12.0807$$
$$= 9.6645 \ W$$
$$* T = \frac{Pt}{u_0} \times r$$
$$= \left(\frac{12.0807}{5.6944}\right) \times 0.24$$

$$= 0.5091 \ N.m$$

5. Results

The comparison of parameters was done and presented in Tables 3 & 4 at the speed of 10km/hr, 20km/hr, 30km/hr, 35km/hr

Table 3. Parameters obtained at speed of 10km/hr and 20km/hr

Data	10km/hr.		20km/hr.	
	In air direction	**In opposite air direction**	**In air direction**	**In opposite air direction**
u_0	1.401 m/s	1.88 m/s	2.083 m/s	3.13 m/s
p_o	0.3060W	0.7472 W	1.0025W	3.4004 W
p_t	0.1805W	0.4408 W	0.5915 W	2.0062 W
p_g	0.144W	0.3526 W	0.4752W	1.6064 W
T	0.02463 N.m	0.0567 N.m	0.06814 N.m	0.1538 N.m

Table 4. Parameters obtained at speed of 30km/hr and 35km/hr

Data	30km/hr.		35km/hr.	
	In air direction	**In opposite air direction**	**In air direction**	**In opposite air direction**
u_0	4.416 m/s	5.694 m/s	4.416 m/s	5.694 m/s
p_o	9.5535 W	20.475 W	9.5535 W	20.475 W
p_t	5.6365 W	12.080 W	5.6365 W	12.080 W
p_g	4.5092 W	9.6645 W	4.5092 W	9.6645 W
T	0.3015 N.m	0.5091 N.m	0.3015 N.m	0.5091 N.m

6. Conclusion

i. The electric bike was having average of 70 km per full charging of battery by using wind power in assistance. 2% of increase in average is achieved.
ii. It is observed that minimum 12-14v is required for starting the charging of battery, which is achieved after 30km/hr speed.
iii. Vehicle moving in opposite direction to wind will give more wind power as the result shown in experiment.

References

1. *Harold S. Potts & Healdton, Okla., "Wind moto wheel", United States Patent, Ser. No. 640,263 Int. Cl. F03d 9/00*
2. *R. Dell Hull, "Automobile with wind driven generator wheel", United States Patent, Ser. No. ,4168,759*
3. *Mario Pena, "Wind powered battery charging system", United States Patent Patent Number: 5,680,032*
4. *John Friedmann, "Wind powered battery energized electric vehicle", United States Patent, Patent No.2 US 7,802,641 B2*
5. *Rahamlm Haddad, "Wind driven generator for vehicles", United States Patent, Patent No.: US 8,710,691 B2*

Nomenclature

Symbol	Meaning	Unit
u_0	Wind speed	m/s
p_0	Power generated by wind	W
p_t	Power generated by fan	W
p_g	Generated Power	W
T	Torque	Nm

