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Electric Bike-Advantages and Challenges: A Review

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Abstract

In daily life travelling becomes vital for human being. Time taken for travelling should be less; it should be economical and easily available. The growing use of travelling vehicles has increased the problem of air pollution, global warming issue and increased use of petroleum[1]. The human awareness for energetic and environmental problems is encouraging the research in alternative solutions for the automotive field, as multiple fuelling, hybridization and electrification. Electric bike can be considered good alternative for both personal and good transportation especially for small and medium distances. Electric bike is normally powered by rechargeable battery and their practical performance is influenced by motor power, battery capacity, road type, operation weight, control etc. Electric bike can be classified into two main categories: First one is pure electric bike which integrates electric motor into bicycle frame or wheels and driven by motor force just using a handle bear throttle. Second one is human-electric hybrid bicycle that supports the rider with electric power only when the rider is pedalling. This paper focus on concept of electric vehicle, major constructional parts, manufacturing companies, market survey, advantages, problems, government initiatives in India, future scope etc.

Keyword: Advantages, Challenges, Electricbike, Electricvehicle, Motor

1. Introduction

The electric bike is nothing but the bike which is driven with the help of battery which is coupled to electric motor. Portable Electric Bike (PEB) was first developed in 1890's in US and also documented in various US patents. On 31st Dec 1895 Ogden Bolton designed a battery powered cycle. Six pole brush and and Commuter DC hub motor connected to the rear wheel used to design cycle. He was also granted US Patent. Couple of years later, Hosea W. Libbey invented electric bike driven by double electric motor. This motors design was such that it was attached with the crank setaxle. Later in 1990's torque sensors and power controls were developed carrying modifications in bike version with NiMH, NiCd and/or Li-ion batteries. But this bike faced decrease in production when petrol and diesel resources came in existence[2] Initially e-bike manufacturers failed because of supplying motors of less than 250 watts which found to weak and to slow for consumers. Also these motors were brushed motors which further reduces the efficiency of motor by 20-25%[3]. Now trend is again going to change and electric vehicle is in demand to solve major problems related to pollution, economy and fuels availability.

Figure 1. Electric bike.

2. Major Components of E-Bike

2.1 Electric Motor

Electric motor is used to drive the bike. Presently the trend is to supply larger powered brushless motor of larger wattage which can keep an e-bike travelling with higher speed and easily go up high skills[3]. Induction

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motor, Switched reluctance motor, Brushed DC motor and BLDC motors are preferred for electric bikes. Induction motor drives are best suited because of their low cost, high speed, high reliability, low torque ripple/ noise, established converter/manufacturing technology and absence of position sensors[4].

BLDC motor is preferred because of no maintenance, high efficiency, low noise, high starting torque, high no-load speed and also because of the absence of brushes we don't find sparking in BLDC motor which increases the life of motor[5,6]. Hub motors are preferred for light weight electric vehicle. It is the compact electric motor placed inside the wheel and is directly connected to the rotating wheel. It generates high torque at low rpm[7].

Table 1. Comparison between different types of motor is given below[7]

Type of motor	Advantages	Limitations
Induction Motor	Simple construction, Low Maintenance, High reliability, Low cost, Ability of operating in hostile environment	Higher cost of controller than that of DC motor, Presence of breakdown limits its extended constant power operation, Less efficiency than Permanent magnet and Switched Reluctance Motor
Switched Reluctance Motor	Simple control, Simple and rugged construction, Fault tolerant operation, Higher starting torque, can operate with an extremely long-distance power range	Suffer from Torque ripple, Acoustic noise is present
Brushed DC Motor	High initial torque, Easy to control and suitable to propel the vehicle	Low efficiency, Bulky construction, High maintenance cost, Low reliability, Heavy and expensive
Brushless DC Motor	High efficiency and power density, Longer life, Higher starting torque, High power to volume ratio, No load speed is high, Small energy loss.	High initial cost, High magnet cost, Suffer from field weakening capability, Poor high speed capability, Mechanical strength of magnet is difficult

Table 2. Specifications of battery as an example are given below[5]

Parameter	Value
Type	Li-ion
Number	three Batteries
Voltage	12 V
Expected cycle life	2000 times
Max. Continuous Discharge current	15A
Max charge voltage	14.6 V
Connection	Series
Amp-Hour Rating	20 Ah
Discharge cut off voltage	

The specification of BLDC motor as an example are given below:

Figure 2. BLDC motor.

BLDC Motor specifications:
Power rating: 500W
Rated voltage: 36V
Weight: 5kg
Efficiency (%):80
Torque: 12 N-m
Speed (rpm):300[5]

2.2 Battery

Battery is the heart of electric bike. It supplies the energy to motor. Battery acts as a condenser by storing the electric energy produced by generator due to electrochemical transformation and supplying it on demand. It is also known as accumulator of electric charge. This generally occurs while starting the system. Lead-acid, Nickel-Cadmium. Nickel-Metal Hydride and Lithium-ion batteries are currently used for electric bike[6]. Battery should deliver high energy during its discharging period.

Batteries used for electric bike should have following properties:

- Higher cell voltage.
- High specific energy.
- Higher specific power (kW/kg).
- Higher Specific energy (Wh/kg).
- Low self-discharge.
- Longer life-cycle.

2.3 Frame

Frame skeleton of the E-bike which acts as back bone of the bike and it is designed in such way that it can sustain the weight of driver, weight of load to be conveyed and also capable to hold the accessories like motor. It is designed in such way that it should bear and overcome the stresses which may arise due to different driving and braking torques and impact loading across the obstacles. Support plates are holded by drilling and tapping. Mild Steel (M.S.) along with some additional light weight components are used to build the frame[2]. Frame of e-bike should be light in weight and it must accommodate battery pack[6].

Table 3. Following table gives the idea about specifications of frame[6].

Sl.No.	Specifications	Dimensions (mm)
1	Overall length	1400
2	Seat width	250
3	Seat height from ground	500
4	Wheel base	1210
5	Overall height from ground	525

2.4 Platform

The platform with robust base is designed so that it can hold the load along with the weight of driving person. Platform alignment is kept horizontal irrespective whether it is loaded or unloaded. This is directly bolted and welded to the frame[2].

2.5 Chain Drive

Chain drive is used to transmit rotary motion from one gear to another. Chain is nothing but an array of links held together with each-other with the help of steel pins. This arrangement helps to make chain more enduring, long lasting and better way of transmitting rotary motion from one gear to another[2]

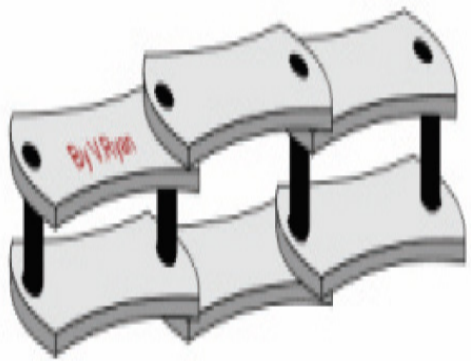

Figure 3. Chain links.

2.6 Braking System

It is convenient to use braking system which consists of spring loaded friction-shoe mechanism, which is driven with the help of hand lever.

2.7 Sprockets

Chain engaging with sprocket converts rotational power in to rotary power and vice versa. The sprocket looks like a gear but differs in three different ways:

- Gear have only one or two engaging teeth but sprockets have many
- Teeth of gear touch and slip against each-other but there is no slippage in case of sprocket.
- Gears and Sprockets are having different shapes of teeth's[2]

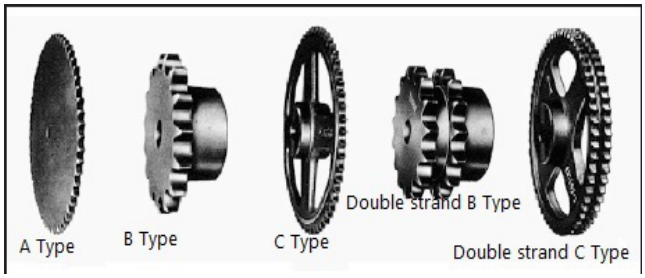

Figure 4. Various types of sprockets.

2.8 Controller and Throttle

Controller and throttle allow the driver to drive the motor linearly from zero speed to high speed. Throttle which is attached to your right handle on the handle

bar and it is connected to the controller. Controller is nothing but variable speed drive that converts constant DC voltage from battery to an alternating voltage with variable amplitude and frequency that will drive the motor at different speeds. It is mainly consisting of Power Electronic MOSFET transistors and a small microprocessor. Insulated Gate Bipolar Transistors (IGBTs) are the most suited power semiconductor devices for AC drive converters at present stage[5]. Controller monitors the amount of voltage required by motor and also supply to head light is given through it[6].

2.9 Voltage Regulator

There are three power levels for e-bike system as follow:

- 5V for supply to microcontroller and other devices
- 48V capable to drive the MOSFET directly
- 15V for supply of MOSFET driver IC's in power bridge.

Power levels are oriented from battery of 48V rating.

Table 4. Comparison between conventional fuel bike and electric bike[7].

Sr.No.	Conventional fuel bike	Electric bike
1	Conventional fuel is used for operation	DC Battery is used for operation
2	Average High Speed (40-80 kmph	Less average speed (20-40 kmph)
3	High cost of purchase and maintenance	Low cost of purchase and maintenance
4	Licenses required	Licenses not required
5	Taxes need to be paid	No taxes need to be paid
6	Pollutes environment	Environment friendly
7	Low efficiency	High efficiency
8	Fuel capacity (300-600 kms)	Battery capacity (50-70 kms)

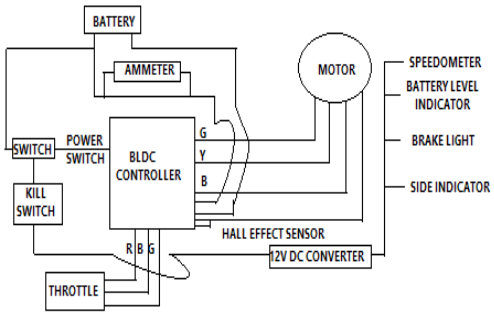

Figure 5. Wiring diagram of E-Bike.

3. Current Market Scenarios in India

In India government planning to use only electric vehicles only for all transportation by end of year 2030. Government of promoting the mass adoption of electric vehicles through the FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles scheme). Electric scooters are provided with incentive ranging from Rs 1700 to Rs 39000.

Some of the electric bike manufacturing companies in India are provided below:

- Tork (Tork T6X)
- TVS (TVS Creon)
- 22 Motors (22 Flow)
- Menza Motors (MenzaLucat)
- UM (UM Renegade Thor)
- Emflux Motors (Emflux 1)
- Tejasgreen Automotive Pvt Ltd
- Jitendra New Ev-Tech Pvt Ltd
- Mirakle 5 Automobiles Pvt Ltd,Pune
- Nibe Motors Pvt Ltd
- Benling India Energy and Technology Pvt Ltd
- Victory Electric International
- Evauto
- Hero Electric (Optima e5)
- Honda (Honda PCX)

4. Advantages of e-bike

- Good efficiency: BLDC motors in e-bikes are above 90% efficient than IC engines which are nearby 40% efficient[8].

- Eco-friendly: Electric bikes are eco-friendly if the required power to charge the batteries is derived from non-conventional sources[8]
- Cheaper: Running cost of e-bike is less as compared to conventional bikes[8].
- Quiet journey: E-bikes are noiseless of all transportation[8]

5. Challenges in e-bike

Personal electric bikes could help public transit systems to manage the first-mile-last-mile problem, encouraging ridership and lowering mass transit costs. But like many possible solutions to this problem, electric bikes still face some challenges[5,8]. Some of the challenges of e-bike are provided below:

- Light Weight
- Low-Speed
- Longer charging time
- More weight of battery
- Short-range vehicle
- Poor acceleration.
- Wireless power charging system is not available
- Development of economical drives with high efficiency, high reliability, high power density, good controllability, good dynamic performance.

6. Future Scope

Electric bike needs more advanced technology to improve performance and reduce cost. Electric bike project will be successful with more research work in following area:

- Wireless power charging system for electric battery
- Design of motors with high efficiency, high t000 00orque at low speed
- Design of battery with longer running hours, lighter weight with respect to its high energy density and high output voltage[9]
- Design of intelligent controller
- Cost reduction
- Remove drawback of poor acceleration

7. Conclusion

Electric vehicles are one of the important solutions for major problems like air pollution, global warming and increased use of fuels. Government need to take initiative for mass production of electric vehicles. Electric bike production was started by many manufacturing companies but there is a need for more research work in this field to improve the performance of electric bikes.

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