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DESIGN AND DEVELOPMENT OF E-RODEO (A HYBRID ELECTRIC-CYCLE)

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Abstract
High increment of the human population has led to the use of more fuel-powered vehicles. This in turn causes an increase in global warming due to pollution and a drastic decrease in fossil fuels. Nowadays, even for short-distance travel, we are using our fuel-powered vehicles which are unnecessary. A simple solution to reduce pollution for short-distance travel is through the use of an electric bicycle. An electric bicycle also known as e-bike uses energy stored in the battery to run the vehicle. In this paper, an electric bicycle E-RODEO is proposed, which consists of a motor to run the vehicle which is connected to the motor controller. The speed of the e-bike is controlled using a throttle and electric brakes. Lithium-ion battery used to run the motor. The battery is integrated with a Battery Management System (BMS). We are using wind energy and pedal regenerative energy as an alternative power supply to charge the battery. A dynamo and a Personal Computer (PC) fan which acts as a wind turbine is used to convert mechanical and wind energy to electrical energy respectively. With the use of E-RODEO, we can overcome the problems like pollution, traffic and excessive use of non-renewable energy sources. E-RODEO can be used for both short and long-distance travel since there is an alternative power source to charge the battery. Use of renewable sources makes it zero Co2 emission and using it to power the battery makes the vehicle Eco-friendly.

Index Terms— *Battery management system (BMS), DC-DC booster converter, E-bike, Pedal regenerative energy, Wind energy conversion.*

I. INTRODUCTION

There is a wide range of e-bikes available all over the world, from e-bikes with a small engine to more powerful e-bikes, similar to bikes and the pedal power of the rider. They retain the ability for the driver to brake and are not hybrid bikes. E-bikes use rechargeable batteries and, depending on the local rules, the lighter batteries can travel for up to 25 to 32 km / h, whereas the more powerful varieties can often travel for more than 45 kilometers / h (28 mi / h). They have gained in popularity and are taking away some market share from conventional bicycles in some markets, such as Germany in 2013, whereas fossil motorcycles and small motorcycles have been replaced in others, such as China since 2010.In compliance with municipal laws, most e-bikes (e.g. E-bikes may also be uniquely described and regulated under specific E-bike regulations. E-bikes are often a form of fitness for those who have trouble cycling for a prolonged time (for example, because of disabilities or extra weight). The research performed by the University of Tennessee reveals that e-bikes absorb both electricity (EE) and oxygen (VO2) 24% of the e-cycles and 64% of the walk output. When these issues are taken into consideration, e-bikes have considerably smaller environmental costs than traditional vehicles, and they are commonly perceived in metropolitan areas as socially friendly. Compared to the larger electricity pack, the compact battery set

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on an e-bike makes them very well suited to charging with solar power or other alternative energy sources.

II. OBJECTIVE

Using wind power – The loop utilizes wind power to operate the device charge. Transforming wind energy into electric energy helps the consumer to store and transfer electricity in a battery over long distances. It is a one-charge option to expand the spectrum.

BMS in the cycle-The battery management program will effectively monitor the different parameters. An electronic device that controls a rechargeable battery (cell or battery pack) is a Battery Management Device (BMS). It is a machine that prevents the battery from working beyond its protected operation region, tracks its status, measures secondary data, records data, tracks its climate, authenticates it and/or equalizes the battery. A battery pack built in conjunction with an external communication data bus battery management system is a smart battery pack. An intelligent battery pack has to be powered with an intelligent battery adapter.

Efficient expense – expense per run with good reliability is almost insignificant. We can use pedal and wind power to recharge batteries, so that we don't have to fill the power source battery over and over again, which often decreases this expense.

Conservation of pedal energy-It is a machine power source regenerative. In addition to charging the battery, thus expanding its length, Dynamo transforms the energy used for pedaling into electric power. It also works when the battery charge drains out and we can charge a battery even if there is no power supply available.

Maintenance-battery and other parts are really simple to repair. The battery is fitted with a box, so that it is easy to remove and maintain the battery.

E-brakes – Any e-biker's existence is marked by high priority, especially in a world full of car drivers who so often don't even recognize fast moving bikers.

Make sure you mount e-brakes while constructing an e-bike. E-brakes are a vital part of the machine that cannot be illustrated sufficiently when the engine is turned off (or if you have a direct hub engine, you should even use regenerative braking as you remove the heel).

III. PROBLEM DEFINITION

Electric vehicles are expensive due to expensive lithium ion batteries. The world just started moving towards electrification so there is not much availability of charging stations. The existing electric cycle have the limitation of only one power source to charge the battery so if the battery runs out of charge, we have to use mechanical power for pedalling or charge battery for hours. The new electric cycle requires one power supply cap to charge the batteries such that we need mechanical control for pedalling or charging of the system for many hours if the device falls off the voltage.

IV. PROBLEM EXISTING

Not a renewable power system – There is little usage of a clean power plant in current E-bikes to charge the tank. The electricity used to power the wheel is not being recovered.

No other power source to the battery – When the battery runs dry, we can refuel it for hours or use the mechanical strength to pedal it.

V. SOLUTION FOR PROBLEM

Use of the origins of renewable power –Hydraulic resources recovery used on pedals. Using cell backup control from pedals.

Renewable wind technology is seen as an additional source of electricity. To power the pump, mechanical energy is transformed into electricity.

VI. PROPOSED BLOCK DIAGRAM

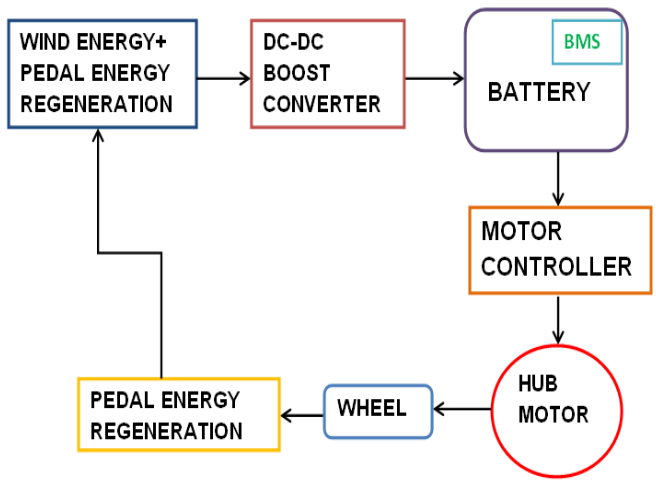

Fig. 1. Block diagram the entire process cycle

VII. DIFFERNET METHEDOLOGIES

There are a number of different technologies being used to develop a e-bike, which are given below

A) Wind Energy Conversion:
Wind turbine is a device which is used to convert kinetic energy of the wind to electrical energy which is stored in the battery. The blades of the wind turbine are components which are used to convert wind energy to mechanical energy. Then, the rotating blade will drive the generator to convert mechanical to electrical energy. We are using a PC fan as a wind turbine to convert wind energy to electrical energy. We removed the IC and soldered two wires at that place to draw the output power from the turbine to use the electrical energy obtained to charge the battery.

B) Pedal Regenerative Energy

In pedal regenerative energy we are using a dynamo to convert mechanical energy to electrical energy. People have been using pedal power for various day to day practices. But generating electricity from pedaling was not present until a few decades back. A 24V Dynamo is being mounted near the rim of the cycle. The rotation of the wheel when the tire rotates because of the application of force on the pedals is used to generate electrical energy from the dynamo to charge the battery.

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C) Battery Management System

A Battery Management System (BMS) is mainly used to control the battery performance and ensure safety for the battery. The main objectives which are common to all battery management systems are to protect the cells or the battery from getting damaged, to ensure better life of the battery and to maintain the battery in a state in which it can perform the functional requirements of the operation it is specified to do. We are using a 36V and 20ah lithium-ion battery which has a BMS integrated of 36V and 25A. The BMS protects the battery from overcharge and over-discharge of the battery, short circuit protection, reverse polarity protection and protection from over current. It also gives us a reading of power remaining in the battery.

VIII. CONSTRUCTION AND WORKING

We started the project by studying about electric cycles and about all the things to be considered to build one. We selected Hercules Rodeo A-100 cycle to convert it into an electric cycle E-RODEO. First we decided the approximate weight of the cycle from studying the existing e-cycles. Next the necessary calculations are done in order to understand the specifications of the parts for an e-cycle. Motor average power is calculated; it is the power required to run the motor continuously. Average power required is 289.35W. Input power required for the motor is 414.285W, battery should exude this power in order to start the motor. Hub motor is chosen, which is incorporated into the hub of the wheel also called wheel motor. It directly drives the wheel and it is commonly used in electric cycles. Motor selected is 36V 350W and it fits correctly for the wheel size of the cycle. After the selection of motor, the next thing selected is a motor controller which controls input power given to the motor from the battery, so it has the same configurations as motor. Motor controller is connected to the throttle which regulates the motor speed. Electric brakes are also connected which controls the cycle wheels as well as motor rotation. The battery should also have 36V and should provide a minimum of 415W, so the battery selected is 36V 20Ah Lithium-ion battery incorporated with Battery Management System (BMS). Alternative power sources are used to charge the battery while using it. Dynamo is used for pedal energy regeneration and old pc fans are used for wind energy conversion. DC-DC Booster converter is used to provide a battery with 36V DC supply in order to charge the battery. Power module shows battery charge and different modes to use the motor. Gear system is removed hence the motor is used to run the cycle as there is not much necessity of the gear system. In the place of the gear system, freewheel is used to connect the motor to the wheels.

The CAD model drawings of the components used is as show below:

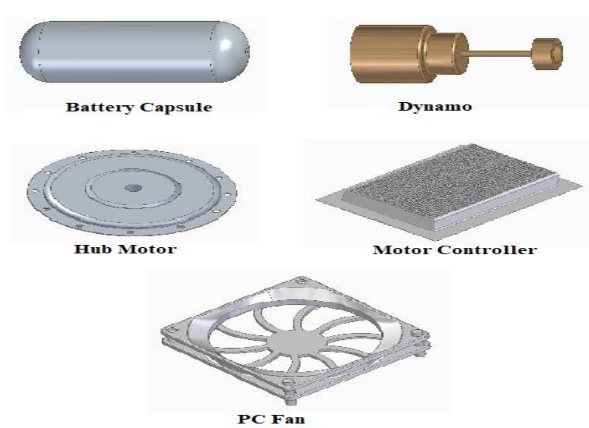

Fig. 2 CAD designs of the components

The electric bicycle working system involves three main parts which are battery, motor and alternative power supply. These three units are explained in detail in the following subsections.

A) Battery

A lithium-ion battery with an integrated Battery Management System (BMS) is being used to run the motor. The specifications of the battery are 36V and 20Ah. The BMS of 36V and 25A gives protection to the battery by identifying any faulty conditions and protecting the battery from getting damaged during the charging and discharging process. The protection of battery includes overcharge and over-discharge of the battery, short circuit protection, reverse polarity protection and protection from over current. A 36V 4A smart charger is used as a primary way to charge the battery. The alternative way to charge the battery is by the use of wind and mechanical energy being produced by the wind-turbine and dynamo.

B) Motor

We are using a 36V and 350 W hub motor to run the cycle. The lithium-ion battery is connected to the motor controller. The speed of the cycle can be changed using the throttle and electric brakes which are connected to the motor controller. An increase in throttle sends a signal to the motor controller to increase the motor speed and vice versa. In the electric brake as the brake is applied, it stops the rotation of the wheel mechanically. It also sends an electrical signal to the motor controller to slowly stop the rotation of the motor. A power module is also connected to the motor controller for battery level identification and three level power adjustments are used for adjusting the power being supplied to the motor to shift from manual pedaling to electrically driven.

C) Alternative power supply

The alternative power supply which is being used to charge the battery is by using a dynamo and a wind turbine to generate mechanical and wind energy, which is converted into electrical energy and stored in the battery. A DC-DC Booster Converter is used to integrate both mechanical and wind energy to charge the battery. The DC-DC boost converter takes an input range of 3V to 35V and gives output range between 4V to 40V.

A 24V dynamo is attached near the rim on the wheel. When there is a rotation of the shaft due to wheel rotation during movement of the vehicle, power is being generated by the conversion of kinetic energy into electrical energy in the dynamo. We are using an old PC fan as a wind turbine. PC fans run from an external power source, this happens because of the IC present. We removed the IC and soldered two wires at that place to draw the output power from the turbine. When there is a rotation of blades of the wind turbine, there is a generation of power by conversion of kinetic energy into electrical energy. Both the outputs from dynamo and wind turbine are connected in parallel so that even when one source is working there will be an output voltage. This is given as an input to the DC-DC boost converter. Battery charging voltage is 36V, so the output voltage should be equal to 36V from the DC-DC booster converter. We can set the output voltage value to 36V. The output from the DC-DC booster converter is connected to the battery.

IX. RESULTS AND DISCUSSION

Wind energy is utilized as an alternative source of energy to charge the battery. A PC fan is used as a wind turbine which converts wind energy into electrical energy and it is given to the battery through a DC-DC Boost converter. Battery is incorporated with BMS which performs functions like over charge protection, over discharge protection, short circuit protection, overcurrent protection, cell balancing, and so on. Energy spent on the pedal is regenerated and utilized to charge the battery through dynamo. E-

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brakes are incorporated in the cycle. Maintenance is easy as the battery is mounted using a casing and other parts are also easy to maintain and repair.

An effective mode of transportation is presented in this paper. At 100% efficiency we get 58.282 Km range on one charge cycle from the battery. At 90% efficiency we get 52.4538 Km range on one charge cycle from the battery. At 80% efficiency we get 46.625Km range on one charge cycle from the battery. At 70% efficiency we get 40.797 Km range on one charge cycle from the battery. The battery used has 1000 cycles. If we consider 70% efficiency, we get around 41km range on one charge.

We have 36V 20Ah battery
Energy = 36x20 = 720 Wh =0.720kwh
Consider Rs.7 per unit, electricity bill is measured in units 1unit =1 kWh
Bill = 7*0.720 = Rs.5.04
Consider range = 41km
Cost per km = 5.04/41 = Rs. 0.122
Battery life depends on charging and discharging cycles. After certain charging and discharging cycles the battery will no longer remain capable to store the energy and it's called dead battery. Lithium ion batteries have cycles 500 to 1000; our cycle gives 41km range per cycle. Hence, running cost of cycle is negligible as compared to battery replacement cost.

Battery is 36V, 20Ah with 1000 cycles.
Range is 41km.
One charge serves = 1000x41 = 41000km
Cost of 41000km is Rs.11000

$$\text{Cost per km} = \frac{11000}{41000} = \text{Rs.}0.268$$

We can see that this is one of the cheapest means of transport. This is useful for a single person to travel, to go buy groceries, to go to office, picnics, to have a healthy choice and many others. All these calculations are for just an electric cycle. We have designed a hybrid cycle which has both on board and off- charging. The on board chargers provide range extension and can be used to recharge battery when there is no availability of a charger board. The overall cost of the on-board charger is less than 1200 Indian rupees. This makes e-rodeo an effective means of transport and also cheaper means of transport.
The CAD model of E-Rodeo along with the mounting of the components is as shown below:

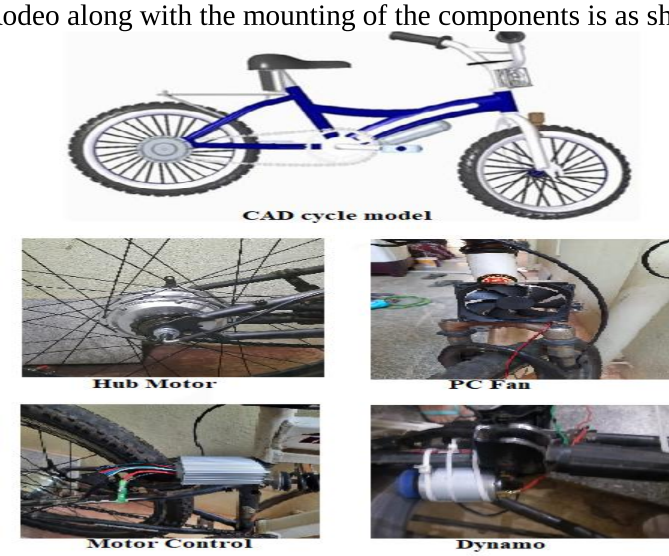

Fig. 3 Mountings

X. ADVANTAGES AND APPLICATIONS

Advantages

- Fast and Flexible –The electric cycle 'E-Rodeo' is a great means of transport in today's scenario. With the inceasing traffic everywhere, it is the fastest and most flexible way to travel from one place to another. The maximum speed that E-Rodeo has is 25 kmph.
- Improves Fitness –Electric cycles are the best way to improve fitness as there is a manual mode as well in the cycle in which no electric mode is provided and thereby the personnel driving can improve his fitness.
- Cut back expenses –E-Rodeo helps to cut back the expenses as there is no need to use petrol or diesel. Even the batteries of the electric cycle are needed to be serviced after 2-4 years depending on the usage, thus making it an inexpensive option for travelling.
- Nature Friendly –E-Rodeo is completely an eco-friendly cycle as it runs on electric power and thus doesn't require petrol or diesel, thereby no emission of harmful gases and making it nature-friendly.
- Prolonged application –E-Rodeo has prolonged application due to its different modes of charging the battery that is by, dynamo and wind turbine which helps to keep the battery charged for longer duration and thus can give a long ride.
- Easy to get –Electric cycles are very easily available in the market with a rather good cost. Therefore, it is pretty easy to get an electric cycle in the market

Applications

- Rental Business –Electric bikes like 'E-Rodeo' can be very well used in rental businesses where people who need to travel from one place to another can easily rent an electric bike and traverse. This is a very efficient and cost friendly method of travelling.
- Mountain Trekking –One of the most astonishing applications of electric cycles is mountain trekking. E-Rodeo will make mountain trekking a piece of cake due to its high power.
- Ease of Intracity Communication –The process of travelling within the city becomes very tranquil with the help of E-Rodeo. There is no need to fill petrol or diesel, one can easily charge the battery of E-Rodeo by just pedaling, thus making intracity communication easy

XI. CONCLUSION AND FUTURE SCOPE

The electric bicycle initiative has been offering the chance during these days to grasp the full scope of what design means. The strategy develops and shifts with the accomplishment of team limitations and financial constraints. The initial design was accompanied by limitations that had to be regulated around the electric vehicle. Such constraints limited the willingness of the team to build a "modern" program. Once all the weaknesses were known, the development goals were clearly understood. The goals were discussed with team leaders. Progress was periodically tracked and the goals were revised as necessary to reach the final project deadline. It has helped the team leaders develop expertise that will be useful in potential efforts.

As innovative technologies are increasingly relevant in the automotive industry, it is no surprise that two-wheelers are heading in that direction. Today in India, electric drivers are not very common with low speed, range and poor performance of two-wheelers.

If the electric drive and chain drive synchronize, lower batteries can consume petrol (long-lasting). When a car is able to save about 30% on oil fuel, the type of vehicle can store about 40 to 60% of the national

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fuel on average. This type of vehicle can increase the reliability and comfort of the customer. During car propulsion, lithium-ion battery charging can also be done. The battery technology has advanced over time and electric cycles are now a reality.

The usage and combination of solar energy to power the battery with the principle of pedaling is a recent idea and work in this field has been much reduced. The other innovative piece of work which can be incorporated is a device to keep a check of the calories burnt while driving so as to keep a check on the health of the person as well.

ACKNOWLEDGMENT

The paper is based on conversion of ordinary cycle into an electric cycle. Electric cycles can be very effective means of transportation both in terms of money and health. Here we chose a cycle and did the necessary calculations in order to select the components for the electric cycle. Then for range extension we are using an alternative source of energy to charge the battery and also reduce the money spent on charging the battery. This way we introduce a hybrid- electric cycle which is a very reasonable means of transportation.

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