Hybrid Electric Bicycle a New Transportation for Future Smart Grid

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Abstract

There are many types of bicycle in the world such as normal bicycle that people need to paddle for it to move, motorized bicycle that uses fuel as its prime power and electric bicycle that can only be sufficient for an hour. Because of some weaknesses in the existence system, the idea of a solar bicycle came in mind. The idea is to make the bicycle last longer and can be automatically recharge when the bicycle is not in use by the renewable solar energy. The concept of the solar energy is that a high torque motor will be put on the bicycle which will be generated by the solar energy. The solar energy will be absorbed by the portable solar panel to generate the power. The power that had been absorbed by the panel can be used directly by the motor if the power matches the power requirement. If not, the motor will use the power from a battery.

The process of planning, designing, and testing a Hybrid Electric Bicycle it provides a lot of detail into the challenges of modifying an existing mechanical system to one that is based on both human propulsion as well as a set of electro-mechanical interfaces that provide assists. Through designing an electro-mechanical system, with various non-human inputs and feedback channels, a major challenge was centralizing the control of the system. After establishing criteria for speed, control, efficiency, and weight, we began a process of selecting parts and developing models for how the overall system including the rider could be integrated in a way that is both safe, and easy to use.

When the bicycle was not in use during the day, the solar panel will charge the battery. The system will make bicycle operate more efficiently.

Key words- Hybrid electric bicycle, Renewable solar energy, Permanent magnet DC motor, Dynamo, Batteries.

I. INTRODUCATION

The system we designed is a hybrid electric cycle. The project has a number of benefits to both the team members as well as external benefits through increasing awareness of alternative transportation modes. Despite the environmental friendliness of the project or the projected benefits of more people relying on non-polluting modes of transport, the main reason we selected the project was for the level of interaction between us, the engineers, and our product. Designing a transportation vehicle requires consideration of mechanical objectives, electrical objectives, safety criteria, comfort, user friendliness as well as an array of other objectives which may conflict under various circumstances. We hoped that through navigating our way through this vast set of criteria the satisfaction of completing the project would be much greater than other projects we could have selected.

Namely, we chose this project for the challenge of designing a mechanical system and implementing electronic control to dictate the response and performance of the system. The project seemed appropriate after having taken control theory and other courses that focused on design and feedback systems. Since, we have never had to design a complete electro-mechanical system of this magnitude; the project presented an interesting challenge. What made it even more challenging was the challenge of adapting an existing system to a set of criteria we determined.

II. MECHANICAL DESIGN AND SYSTEM

In common usage, electric vehicle refers to an automotive vehicle in which the propulsion system converts electrical energy stored chemically in a battery or other power source into mechanical energy to move the vehicle. There are three types of electric vehicles in current market: battery electric vehicles, hybrid electric vehicles, and fuel-cell electric vehicles.

A. Design targets

The obvious goals of our system are to ensure efficiency of operation, and to meet the drive requirements. Given the types of sprockets available, the size of the motor we anticipated, safety concerns, and legal limits on the speed of motorized bikes, we determined that the maximum speed of the bike would be. Given only these goals, the design would have been much easier. 28*mph*

An expanded set of goals included designing a system capable of regeneration, and to minimize the weight and size of components to maintain the character of a normal mechanical bike, when desired. Given the limitations of space, the design became much more difficult. The most critical of our objectives was to meet the forward drive requirements under a range of conditions (acceleration, hill-climbing, wet conditions). However, designing a system capable of regeneration determined the types of components we could use within our power-transmission system. Regeneration required that all the components be rigidly connected, so we could not use free-wheeling sprockets to reduce the effects of motor drag and maintain the character of a normal bike when the motor is turned off. We added another layer of complexity to the system by using an electromagnetic clutch to try and avoid the effects of motor drag.

B. Benefits of Two stage design

Essentially forward drive required only a motor and a set of sprockets to transmit the power from the motor to one of the wheels. Based on the available torque from the motor and the desired maximum speed, we determined we would use a two-stage reduction to minimize the size of the components in the system. By splitting the transmission into two stages the number of components increases as well as the overall system complexity. The advantage of a two-stage design is that the size of individual components decreases. This was more critical to our system, than minimizing the number of parts.

Compared to other drive options, however, the two stage design is much more efficient, e.g. friction roller based approach. The advantages of a friction roller approach are its easy implementation, and high torque transfer from the roller to the much larger rear wheel. Unfortunately, there is a lot of inefficiency in this type of system due to the frictional losses of the tire rubbing against the roller. Using a single stage chain drive would have been preferable, but given the desired speed of the system and our torque requirements, we were limited by space. To reach the appropriate gear reduction given our speed requirement, we were limited by the space between the rear wheel and the chain stay which does not allow for a gear reduction greater than 3 (driven) or 4 (driven) to 1 (drive) using standard chain/belt sprockets. The two stage drive added to the complexity of the system, but provided a more elegant solution than the friction roller approach and a much more efficient solution.

The two stage design is also compatible with our goal of enabling regeneration, but also creating an efficient hybrid-electric solution. The two stage design enabled us to use a clutch in the system which would not have been possible in either the single stage or roller based drive system given our space constraints. The purpose of the clutch is to enable the rider to disengage the motor from the system during motor-less riding. By having a second stage, we created an appropriate mounting location for the clutch.

C. Fuel- cell electric vehicles

In this electrochemical device, the reaction between a fuel, such as hydrogen, and an oxidant, such as oxygen or air, converts the chemical energy of the fuel directly into electrical energy. The fuel cell is not a battery and does not store energy, although the fuel cell also has two electrodes separated by an electrolyte. When fuel cells are the primary power source in a hybrid vehicle, batteries provide secondary power. Fuel cells do not provide immediate output during a cold start. Until the fuel cells reach operating temperature, which may take about 5min, a battery pack supplies the power for initial start-up and vehicle movement.

III. MOTOR CHARACTARIZATION AND POWER TRANSMISSION SELECTION

This section of the paper deals with the mechanical design of the system and the various parts used in the system integration. The power transmission system consists of the motor, timing belt drive components, the clutch assembly, the chain sprockets and the rear wheel. However, before we could select these components, we performed some basic calculations relating energy transfer through the system. Primarily we focused on the current requirements of the system, and a number of torque-speed relationships. Both the acceleration on flat ground and hill climbing ability of the system depend on how much torque can be delivered by the various system components. Before we could size the motor and batteries, we needed to estimate when the motor would demand the most current and the duration that it would draw its peak current. These situations would be at start-up (acceleration) and when climbing a gradient. The main components affected by the following calculations are the motor and the battery. However, in order to maintain the order of the paper, we will focus on the motor, its characterization, and the subsequent power transmission components.

A. Acceleration Requirements

The external forces acting on the bicycle include drag due to the wind, the rolling resistance of the tires, and the force due to gravity. In order to expedite selection of the motor and the batteries, we neglected the drag forces acting on the system, and focused more on energy relationships, specifically the transfer of electrical energy into kinetic and potential energy.

In order for the bicycle to accelerate from a cold start, a sufficient amount of torque needed to be delivered by the motor and transmission components. As a result, we expected the motor to draw a large amount of current during the period of acceleration. We were able to approximate the amount of current required using the following set of energy relationships.

On flat terrain there is no change in potential energy which would cause the motor to need to deliver a counter torque to the force of gravity. As a result we only looked at kinetic energy for acceleration.

1) $kinetic\ energy = \frac{1}{2}mv^2$
2) $Electric\ enery = V \times I \times T$

Time to accelera te (s)	Velocity Δ	Voltage Availabl e (V)	Current Required (amps)	Power Consumed (Watts)
20	25mph (11.2m/s)	24	15.4	369.6
40	25mph (11.2m/s)	24	7.7	184.8
60	25mph (11.2m/s)	24	5.1	122.4

Table 1.Power requirements for various accelerations

B. Motor Selection

Using the results from above, we selected a 400 Watt motor. Furthermore, we chose a Permanent magnet DC motor for the following reasons:

1) Easy to control.
2) Ability to function as a generator and regenerate power
3) Good torque-Speed relationships.
4) High-power – weight ratio.
5) Past experience through Control Theory.
6) Ease of motor characterizations.

All of these reasons were critical for the project. Given the time constraint and the complexity of the other system components, a permanent magnet motor was ideal for our application. It would deliver adequate torque and rotate at a sufficient speed given several levels of gear reduction to improve the existing system. Another factor leading to our selecting a permanent magnet motor was its relative low costs compared to brushless motors, and the ease with which it could be integrated into the system.

The next stage of the motor selection was to determine the voltage of the motor. This is important because the speed of the motor is a function of the system voltage. By choosing a higher voltage, the motor would also be capable of producing more power. By choosing an appropriate voltage we can limit the current draw of the motor. This is important for limiting heating but results in a loss of torque. For a permanent magnet motor there is a trade off between speed and torque by the following relationship.

$$P = T \times RPM$$

We finally chose a 24 Volt motor. It is the most common selection for electric bikes and scooters, and was compatible with our goals for the system.

Fig.1 PMDC Motor

C. Motor Rating

Sr. No	Type	Rating
1.	Input voltage	24V
2.	Input current	15A
3.	Power	350W

Table 2.Motor ratings

D. Selecting Speed and Gear reduction

Given our desired top speed of between 20 and 30 mph, we determined that we would design the overall system for a gear ratio from the motor shaft to the rear wheel of 1 (drive) : 9 (driven). The calculations were based on the following equations. The exact maximum speed we designed for is both a function of the motor we purchased as well as the sprocket sizes available at the dealers we chose to patron. We were constrained by an upper limit of 30 mph due to concerns about torque, and legal limits on licensing for motorized bicycles and scooters. The lower limit of 20 mph was not significantly influenced by outside variables except our desire to enhance the bike's performance.

$$speed = \frac{3100\ revolution}{minute} \times \frac{27p}{revolution} \times \frac{60\ minutes}{1hr} = 249mph$$

Desired wheel speed= 27.7 mph

$$\frac{speedmotor}{desiredwheelspeed} = \frac{249\ mph}{27.7mph} = 9$$

Gear reduction
Chain drive = N1:N2 =1:3

IV. SOLAR PLATE

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating.

Fig.2 Solar Plate

A photovoltaic (PV) module is a packaged; connect assembly of typically 6×10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few commercially available solar modules that exceed 22% efficiency and reportedly also exceeding 24%. [A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter. A battery pack for storage interconnection wiring and optionally a solar tracking mechanism.

The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones are available, based on thin-film cells. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connector's type to facilitate easy weatherproof connections to the rest of the system.

Modules electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive [transition metals]. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated. Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

Sr. No	Specification	Rating
1	Maximum Power	20W ±3
2	Open circuit voltage (V_{oc})	21V
3	Short circuit current (I_{sc})	1.21A
4	Voltage at maximum power	18V
5	Current at maximum power	1.12A
6	Maximum operating voltage	DC 600V

Table 3.Rating of Solar Panel

V. DYNAMO

The electric dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current through Faraday's law of induction. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. Due to Faraday's law of induction the motion of the wire within the magnetic field creates an electromotive force which pushes on the electrons in the metal, creating an electric current in the wire. On small machines the constant magnetic field may be provided by one or more permanent magnets; larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils.

Fig.2 Dynamo (Alternator)

VI. Battery

When selecting batteries we were concerned primarily with cost, durability, energy density, and the number of recharge cycles. The most common solution for electric hybrid Cycles is BOSS batteries, specifically the EVP series, which are known for having a lot of recharge cycles. The most common batteries used are sealed lead acid batteries due to their low costs, and reasonably good energy density. These batteries are well suited to a hybrid electric application because they can be mounted in any orientation without the possibility of leakage or safety being compromised. After talking with an electric bike dealer, he advised us to select a battery with a higher rate of discharge, but also one with a high number of recharge cycles. Since we want to maximize the hill-climbing and acceleration performance of our hybrid electric cycle, we determined that the BOSS High rate of discharge batteries would meet our needs. These batteries can be recharged over 200 cycles. For the amount of use the vehicle will likely have, this is more than sufficient.

Fig.3 Battery

Sr.No.	Name	Rating
1	Sets of battery	02
2	Current	9A
3	Voltage	12V
4	Amp-hour	15-20 AH

Table 4.Rating of Battery

VII. CONTROL CIRCUIT- POTENTIOMETER

A potentiometer, informally a pot, is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load. Potentiometers find their most sophisticated application as voltage dividers, where shaft position determines a specific voltage division ratio. However, there are applications where we don’t necessarily need a variable voltage divider, but merely a variable resistor: a two-terminal device. Technically, a variable resistor is known as a rheostat, but potentiometers can be made to function as rheostats quite easily.


Fig.4 Potentiometer

In its simplest configuration, a potentiometer may be used as a rheostat by simply using the wiper terminal and one of the other terminals, the third terminal left unconnected and unused

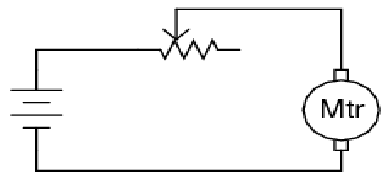

Fig.5 Equivalent Circuit of Pot and Motor

If the potentiometer is in good working order, this additional wire makes no difference whatsoever. However, if the wiper ever loses contact with the resistive strip inside the potentiometer, this connection ensures the circuit does not completely open: that there will still be a resistive path for current through the motor. In some applications, this may be an important. Old potentiometers tend to suffer from intermittent losses of contact between the wiper and the resistive strip, and if a circuit cannot tolerate the complete loss of continuity (infinite resistance) created by this condition, that “extra” wire provides a measure of protection by maintaining circuit continuity. You may simulate such a wiper contact “failure” by disconnecting the potentiometer’s middle terminal from the terminal strip, measuring voltage across the motor to ensure there is still power getting to it, however small.

VIII. WORKING OF PROJECT

This Solar bicycle is a two in one system. It is operating both the condition. They are

1) By using Normal pedaling

2) By using SOLAR-motor drive Arrangement.

The working of SOLAR-motor drive mechanism is explained below. The working principle of the system starts with the SOLAR connections. In SOLAR there are two terminals. One is the positive terminal and another one is the negative terminal. The wire connections were made for the flow of electrons from one part to another part. When the motor energize through the current, the stator field coil gets magnetized and induces the rotor shaft to rotate in the counter clockwise direction. At the end of the motor shaft relevant conditions were made for the seating of sprocket assembly. The sprocket -chain arrangement is a power transmission device, which gives drive to the rear wheel.

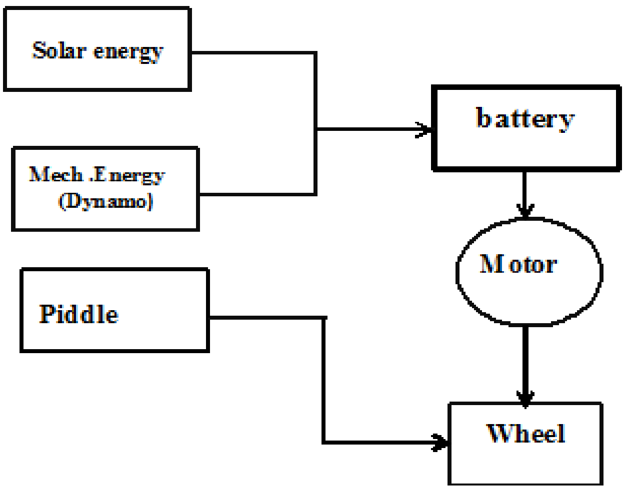

Fig.6 Block Diagram of Hybrid Electric Bicycle

IX. RESULTS

A. *Health Benefits*

Hybrid Electric Bicycle can be a useful part of cardiac rehabilitation programs, since health professionals will often recommend a stationary bike be used in the early stages of these. Exercise-based cardiac rehabilitation programs can reduce deaths in people with coronary heart disease by around 27%; and a patient may feel safer progressing from stationary bikes to Hybrid Electric Bicycle. They require less cardiac exertion for those who have experienced heart problems Environmental Effects. Hybrid Electric Bicycle is zero-emissions vehicles, as they emit no combustion by-products. However, the environmental effects of electricity generation and power distribution and of manufacturing and disposing of (limited life) high storage density batteries must be taken into account. Even with these issues considered, Hybrid Electric Bicycle will have significantly lower environmental impact than conventional automobiles, and are generally seen as environmentally desirable in an urban environment. The environmental effects involved in recharging the batteries can of course be minimized. The small size of the battery pack on an Hybrid Electric Bicycle, relative to the larger pack used in an electric car, makes them very good candidates for charging via solar power or other renewable energy resources. Sanyo capitalized on this benefit when it set up "solar parking lots," in which Hybrid Electric Bicycle riders can charge their vehicles while parked under photovoltaic panels. A recent study on the environment impacts of Hybrid Electric Bicycles other forms of transportation found that e-bikes are about:

1) 18 times more energy efficient than an SUV.
2) 13 times more energy efficient than a sedan.6 times more energy efficient than rail transit and, of about equal impact to the environment as a conventional bicycle. One major concern is disposal of used lead batteries, which can cause environmental contamination if not recycled.

B. *Road Traffic Safety*

In India experience, as the leading Hybrid Electric Bicycle world market, has raised concerns about road traffic safety and several cities have considered banning them from bicycle lanes. As the number of Hybrid Electric Bicycle increased and more powerful motors are used, capable of reaching up to 30 miles per hour (48 km/h), the numbers of traffic accidents have risen significantly in China. Hybrid Electric Bicycle riders are more likely than a car driver to be killed or injured in a collision, and because e-bikers use conventional bicycle lanes they mix with slower-moving bicycles and pedestrians, increasing the risk of traffic collisions

C. *Performance Evaluation*

The combined centre of mass of a bicycle and its rider must lean into a turn to successfully navigate it. This lean is induced by a method known as counter steering, which can be performed by the rider turning the handlebars directly with the hands or indirectly by leaning the bicycle.

1) Speed: Average speed 12 mi/h 19 km/h
2) Travel range 10–50 mi 10–18 km (Full charge)
3) Batteries Charging time 2–8h
4) Cycles of charge/discharge Up to 400 Power
5) Power consumption 100–400 Wh.
6) (Each full charge) On-board power supply 12–36 V
7) Weight Electric bicycle kit 10–50 lbs. 4.6–22.8 kg

X. ADVANTAGES

1) No Fuel cost. No pollution & No fuel residue.
2) Easy starting.
3) Less wear & tear because no reciprocating parts.

4) Lubrication is not necessary.
5) It will run both the conditions (Manual pedalling, SOLAR running).
6) Easily speed control.
7) Easily maintenance

XI. FUTURE SCOPE

A hybrid electric bicycle is a bicycle designed to fold into a compact form, facilitating transport and storage. Air pollution is the term used to describe any harmful gases in the air we breathe. Pollution can be emitted from natural sources such as volcanoes, but humans are responsible for much of the pollution in our atmosphere. Currently, in India, air pollution is widespread in urban areas where vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas. From above discussed points hybrid electric bicycle will be helpful to reduced pollution and also helpful for human exercise.

XII. CONCLUSION

The issues associated with electric bicycles may be addressed by custom-designed drives that are most efficient over a given operating cycle. These include city bicycles, hill bicycles, distance bicycles, and speed by bicycles. The results of the studies listed here can serve as a platform to improve electric bicycle performance if new drive systems are design parameters that will result in improvement of the system performance. Furthermore, they can be used for comparison of existing drives in a systematically, comprehensive and technical way.

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