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Design and Development of Cost-Effective Solar Powered Electric Bicycle.

DR. SUMITHA C[1], BHAVANA BAI S[2], PRAMOD M[3], VISHWANATH S[4], GANESHA M[5]
[1]*Professor and HOD, Department of Electrical & Electronics Engineering, G Madegowda Institute of Technology, Bharathinagara, Mandya*
[2, 3, 4, 5]*B.E. Student, Department of Electrical & Electronics Engineering, G Madegowda Institute of Technology, Bharathinagara, Mandya*

Abstract- ***The design and development of a Solar Powered Electric Bicycle that uses solar energy along with battery power to drive the vehicle. Solar energy is a renewable, clean, and freely available energy source. By integrating a solar panel with an electric bike, the dependency on conventional charging methods can be reduced. The solar panel helps in charging the battery either partially or fully, depending on sunlight availability, thereby increasing the overall efficiency and sustainability of the vehicle. The proposed system mainly consists of a solar panel, rechargeable battery, PMDC motor, motor controller, throttle control, mechanical frame, wheels, and electrical wiring. The solar panel converts sunlight into electrical energy, which is used to charge the battery. The battery stores this energy and supplies power to the PMDC motor through the motor controller. The controller regulates the speed and torque of the motor based on the throttle input provided by the rider. A Permanent Magnet DC (PMDC) motor is used in this project due to its simple construction, high efficiency, good torque characteristics, and ease of speed control. PMDC motors are well suited for electric bike applications because they provide high starting torque and smooth operation at low speeds. The speed of the motor can be easily controlled by varying the voltage using the controller, which improves rider comfort and safety. The mechanical structure of the bike is designed to be strong, lightweight, and cost-effective.***

I. INTRODUCTION

With the rapid increase in fuel prices and environmental pollution, there is a growing need for alternative and sustainable modes of transportation. Electric bicycles (e-bikes) offer an eco-friendly solution for short-distance travel. However, conventional e-bikes depend on grid electricity for battery charging. To overcome this limitation, a solar-powered electric bicycle is designed, which utilizes renewable solar energy for charging, making it both environment-friendly and cost-effective.

With the rapid increase in fuel prices and growing concerns over environmental pollution, there is an urgent need to explore alternative and sustainable modes of transportation. Conventional vehicles, including cars, motorcycles, and buses, primarily rely on petrol and diesel, which are non-renewable resources. The continuous use of fossil fuels not only increases transportation costs but also contributes significantly to air pollution, climate change, and the depletion of natural resources. Vehicular emissions release harmful gases such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter, all of which have a detrimental impact on human health and the environment. This has created a pressing demand for transportation solutions that are both economically viable and environmentally friendly.

II. LITERATURE REVIEW

Several researchers have studied the concept of solar powered electric bikes as an alternative to conventional fuel-based and battery-only electric vehicles. Early studies mainly focused on converting normal bicycles into electric bikes by integrating a DC motor, rechargeable battery, and solar panel. These studies proved that solar energy can be effectively used to charge the battery either partially or fully, thereby reducing dependence on grid electricity. The results showed that solar powered e-bikes are feasible for short-distance travel, especially in urban and semi-urban areas with good sunlight availability.

Environmental benefits are strongly highlighted in most studies. Researchers agree that solar powered electric bicycle are eco-friendly as they produce zero tailpipe emissions, reduce air pollution, and help conserve fossil fuels. Literature also points out the

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social benefits of solar e-bikes in developing countries, where they can provide an economical and sustainable mode of transportation for short-distance travel.

Despite these advantages, the literature identifies certain research gaps. Limited work has been done on real- time performance testing under varying weather conditions. Long-term durability, battery degradation, and optimized power management systems such as MPPT controllers are not widely explored. Additionally, there is a lack of detailed cost–benefit analysis comparing solar e-bikes with conventional electric bikes. These gaps provide scope for further research and improvement in the design and development of cost-effective solar powered electric bikes.

III. PROBLEM STATEMENT AND OBJECTIVES

3.1 PROBLEM STATEMENT:

With the rapid increase in fuel prices, rising environmental pollution, and depletion of fossil fuels, there is a critical need for alternative and sustainable modes of transportation. Conventional vehicles, such as motorcycles, scooters, and cars, rely heavily on petrol and diesel, which contribute significantly to carbon emissions, air pollution, and global warming. Electric bicycles (e-bikes) have emerged as a potential solution for short-distance travel due to their energy efficiency, reduced emissions, and convenience.

3.2 OBJECTIVES:

The objectives of this project are as follows:

1. To create an electric bicycle that provides a sustainable and eco-friendly mode of transportation.
2. To develop a system that automatically recharges the electric bike's battery by using solar panel.
3. To design a lightweight and compact electric bike that is easy to maneuver and store.
4. To ensure the electric bike has a long-lasting battery life and efficient power management system.

IV. SYSTEM OVERVIEW

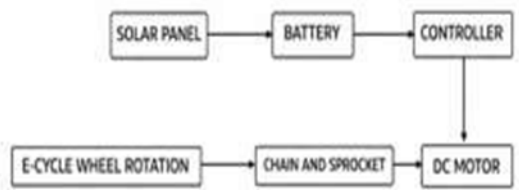

Fig: - Block diagram of solar powered Electric Bicycle.

Solar Panel: The solar panel is the main source of energy in this system. It absorbs sunlight and converts it into electrical energy using the photovoltaic effect. The output of the solar panel is DC power, which is suitable for charging batteries. The amount of power generated depends on sunlight intensity, panel area, and efficiency. Using a solar panel reduces dependency on conventional electricity and makes the vehicle eco-friendly.

Battery: The battery stores the electrical energy produced by the solar panel. It supplies power to the system when sunlight is not available, such as during night or cloudy conditions. The battery ensures continuous operation of the vehicle. Commonly used batteries include lead-acid or lithium-ion batteries. It acts as a backup power source and helps in maintaining a steady supply of energy to the motor controller.

Motor Controller: The motor controller is an important control unit between the battery and the motor. It regulates the amount of voltage and current supplied to the PMDC motor based on the rider’s input. By controlling the electrical power, it helps in smooth starting, speed control, and safe operation of the motor. It also protects the motor and battery from overload and short-circuit conditions.

PMDC Motor: The Permanent Magnet DC (PMDC) motor converts electrical energy into mechanical energy. It uses permanent magnets instead of field windings, which improves efficiency and reduces size. When current flows through the armature, a magnetic force is produced that causes the motor shaft to rotate. PMDC motors are commonly used in electric vehicles due to their simple construction, good torque

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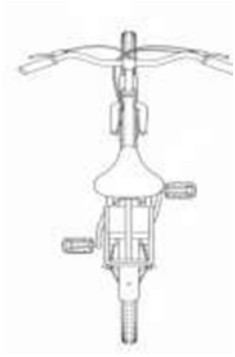
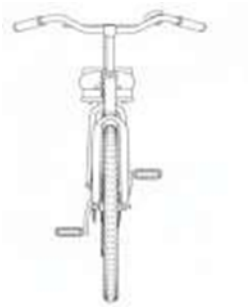
characteristics, and ease of control. Vehicle Movement:

V. EXPERIMENTAL SETUP

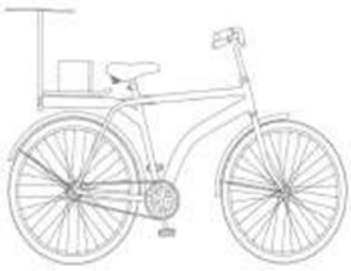
CAD Modelling and Engineering Drawing



Fig(a)



Fig(b)



Fig(c)

Fig 1: Fig(a), Fig(b) and Fig(c) are represents Front View, Top view and side view

The bicycle uses a two-wheel configuration, with a smaller front wheel connected to a long steering column and handlebar for smooth control, and a larger rear wheel that supports the drive system. The handlebar assembly is ergonomically designed to provide comfortable steering and balance during riding. A flat footboard platform is provided at the centre of the chassis, allowing the rider to stand or rest their feet securely. Above the rear section, a single seat is mounted to offer riding comfort for longer distances. The seat height and placement are designed to maintain proper riding posture. The rear section accommodates the electric drive system, including the motor, battery box, and transmission components. These are placed close to the rear wheel to ensure better weight distribution and efficient power transfer. A side stand is included to allow stable parking when the scooter is not in use. The design also shows clear dimensional views (front, side, and isometric), indicating attention to proper proportions, ground clearance, wheel alignment, and overall balance.

VI. HARDWARE COMPONENTS

6.1 SOLAR PANEL

A solar panel is a device used to convert solar energy into electrical energy by using the photovoltaic effect. It consists of a number of solar cells connected in series and parallel combinations to obtain the required voltage and current. Solar panels are mainly manufactured using semiconductor materials such as silicon, which is doped with impurities to form p-type and n-type layers.

6.2 LEAD ACID BATTERY

A lead-acid battery is one of the oldest and most widely used rechargeable battery technologies, known for its simplicity, reliability, and low cost. It was invented by Gaston Planté in 1859, and even today it remains a major energy storage device in automobiles, power backup systems, solar energy systems, and industrial applications. The battery works based on a chemical reaction between lead, lead dioxide, and sulfuric acid. Inside the battery, there are multiple cells connected in series, and each cell produces around 2 volts.

6.3 MOTOR CONTROLLER

A motor controller is an electronic device used to regulate the operation of an electric motor by controlling its speed, torque, direction, and braking. It acts as an interface between the power source and the motor, ensuring efficient and safe motor operation. Motor controllers are widely used in electric vehicles, industrial automation, robotics, and renewable energy systems.

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6.4 MOTOR PMDC (Permanent Magnet DC Motor)
A Permanent Magnet Direct Current (PMDC) motor is a type of DC motor in which the magnetic field is produced by permanent magnets instead of field windings. This construction eliminates the need for external field excitation, resulting in a compact, efficient, and low-cost motor. PMDC motors are widely used in applications where precise speed control and high starting torque are required.

6.5 THROTTLE
A throttle is a device used to control the power, speed, or output of an engine or motor by regulating the amount of fuel, air, or electrical signal entering the system. In simple words, a throttle decides how fast or how slow an engine or motor should run. In traditional internal combustion engines like cars and bikes, the throttle controls the airflow entering the engine.

6.6 CHAIN
A bike chain is an essential mechanical component that transfers power from the rider's pedalling to the rear wheel, making the bicycle move forward. It is made up of a series of interconnected metal links that rotate smoothly around the chainrings in the front and the sprockets or cassette in the back. When the rider pedals, the chain engages with the teeth of the gears and pulls the rear wheel, converting human energy into motion. Most bike chains are made from high-strength steel to withstand heavy tension, friction, and environmental conditions. They are designed to be flexible enough to bend sideways slightly, allowing smooth shifting between gears.

VII. RESULT

The working principle of the cost-effective solar-powered electric bicycle is based on the conversion of solar energy into electrical energy and its efficient utilization to assist or drive the bicycle using an electric motor. The system integrates renewable solar energy with electrical and mechanical components to provide an eco-friendly, economical, and sustainable mode of transportation. The main components involved in the working of the system include a solar panel, battery, controller, DC motor, and mechanical transmission system.

The regulated electrical power is then supplied to the DC motor, which converts the electrical energy into mechanical energy. The motor generates torque that assists in propelling the bicycle forward. This assistance reduces the physical effort required from the rider, especially during uphill rides or long-distance travel. The motor can operate in different modes, including electric-only mode, pedal-assist mode, or hybrid mode, depending on the design and user preference.

The mechanical energy produced by the motor is transmitted to the bicycle wheel through a chain and sprocket mechanism. This transmission system ensures efficient transfer of torque and rotational motion to the wheel, resulting in smooth and controlled movement of the bicycle. Proper selection of gear ratios helps achieve optimal speed and torque, improving overall performance and riding comfort.

Fig 7.1: Project of the model in Solar powered electric Bicycle

The design and development of the cost-effective solar powered electric bicycle were successfully completed, and the system was tested under various operating conditions. The experimental results demonstrated that the solar panel effectively converted sunlight into electrical energy and charged the battery efficiently during daylight hours. The stored energy was sufficient to power the electric motor and assist the bicycle during normal riding conditions, thereby reducing dependency on grid electricity.

VIII. CONCLUSION

The project "Design and Development of Cost-Effective Solar Powered Electric Bicycle" was successfully designed and implemented to address the growing need for sustainable, economical, and eco-friendly transportation. The developed system effectively integrates solar energy with an electric bicycle to reduce dependence on fossil fuels and grid electricity. The solar panel efficiently converts sunlight into electrical energy, which is stored in the battery and used to power the electric motor, ensuring reliable operation for short-distance travel.

The experimental results demonstrated smooth and stable performance of the bicycle in electric and pedal-assist modes. The controller efficiently regulated power flow, ensuring safety and optimal energy usage. The overall system proved to be cost-effective, easy to operate, and environmentally friendly, making it suitable for daily commuting in urban, semi-urban, and rural areas. This project confirms that solar-powered electric bicycles can serve as a practical alternative to conventional fuel-based transportation, contributing to reduced pollution and lower operating costs.

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