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E-World: Battery Management system in E-cycle

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Abstract:

As e-cycles gain popularity for their eco- friendly transportation and convenience, understanding the dynamics of these key systems is crucial. The report explores various braking mechanisms, such as mechanical and hydraulic disc brakes, and explains their operational principles and safety implications. Additionally, it examines the technologies used for acceleration in e-cycles, focusing on motor types, control systems, and throttle mechanisms. By utilizing the battery management system, we have the capability to optimize the efficiency of the battery to its maximum potential. This system allows us to effectively monitor and regulate the performance of the battery, ensuring that it operates at its peak level. In order to optimize the performance of the battery, it is essential to focus on monitoring and controlling various factors such as charging rate, discharging rate, and temperature. These elements are essential in determining the battery's overall efficiency and longevity. This paper discusses how battery life can be enhanced through the implementation of efficient battery management techniques, such as avoiding deep discharges, overcharging, and exposure to extreme temperatures. These factors have a significant impact on battery capacity over time. The battery management system helps reduce risks like thermal overcharging and ensures balanced protection for the battery.

Keywords*-Battery Efficiency, Charging, discharging rate, Battery Protection, control systems, cell balancing.*

I. INTRODUCTION

The battery management system oversees and safeguards the battery to optimize its performance, lifespan, and safety during charging. It monitors metrics such as SOC, SOH, and residual capacity, along with variables like current, voltage, and temperature. Apart from protection, the BMS also maintains the battery's environment by managing heating or cooling systems to maintain optimal temperature. Another essential component that guarantees consistent charging and discharging of every cell in the battery pack for enhanced longevity and performance is cell balancing[5]. The reliability and safety of modern rechargeable batteries are upheld by a comprehensive system of monitoring, reporting, and protective functions. Another essential component that guarantees consistent charging and discharging of every cell in the battery pack for enhanced longevity and performance is cell balancing. Without the BMS, there is a risk of overcharging or over-discharging the battery, both of which can significantly reduce its longevity and lead to battery failure[4]. The use of fuel-powered bicycles contributes significantly to carbon emissions, thereby polluting the atmosphere and generating greenhouse gases on a daily basis. These environmental issues are continuously escalating, prompting many industrialized nations to seek alternative energy sources in order to reduce their reliance on oil as the primary source of energy.Lead acid battery 12V, 7.5A, 25w is a viable alternative solution for fast travel with an electric bicycle, serving as the main power source due to its small size and light weight. This kind of battery has a positive electrode made of metallic lead oxide and a negative electrode linked to a grid of metallic lead. It is immersed in an electrolyte of sulfuric acid. Lead acid batteries are divided into two categories: flooded and valve regulated. Flooded batteries are less expensive but require more maintenance and ventilation compared to valve regulated batteries, which operate on an internal oxygen cycle [6], [7]. To maintain safe operation of electric vehicles, a Battery Management System (BMS) is necessary. It gathers data, regulates environmental conditions, balances the voltage across cells, and checks the State of Health (SOH) of the battery [8-10]

II. LITERATURE REVIEW

The author of this paper asserts that the solar battery connected to the supply line in parallel charges the solar battery, breaking the power supply. The 8051 microcontrollers are used to operate the solar battery charge, acting as a charge controller and converting the stored power in the batteries to a 12-volt DC and 110-volt AC output through an inverter. This technology is seen as a promising development for future life[1].

The paper also discusses the increasing popularity of Li-ion batteries as a power supply for electric vehicles (EVs). It highlights the advantages of Li-ion batteries, such as a long cycle life, high energy capacity, and high efficiency. Additionally, it emphasizes that Li-ion batteries are composed of eco-friendly materials, do not pose toxic gassing problems, and have a high safety level. The paper provides specific technical details about Li-ion batteries, including their cycle life, voltage, energy density, and charging efficiency[3].

The issues associated with battery-based energy sources in electric cars are also covered in the article. It focuses on the recovery in braking as a fundamental step to improve battery operation, promote energy efficiency, and implement efficient regenerative braking. The paper identifies two instruments, the HES and the BBS, as promising solutions for electric vehicle manufacturers, combining high energy density and high-power density[11].

The process of generating electricity from solar energy is discussed in paper by Waghmare A., The author explains how the energy in solar radiations is converted into electricity through the use of PV cells, which convert sunlight into heat and then into electricity[12].

To make sure that the energy is used as efficiently as possible, a charge controller is used to control the electricity coming from the solar panel. This controller also helps in preventing any damage to the solar panel by controlling the flow of energy. The system is then connected to an inverter, which converts the direct current (DC) generated by the solar panel into Alternating Current (AC) for use in various applications [2].

III. METHODOLOGY

A specialized technology called the Battery Management System (BMS) is used to monitor a battery pack, which is made up of several battery cells. These cells are arranged in a specific matrix configuration to ensure the delivery of a precise range of voltage and current for a specific duration, tailored to meet the demands of various load scenarios.

The design of a Battery Management System is not rigid and can vary based on several factors such as the cost, complexity, and size of the battery pack. Additionally, considerations like the intended application of the battery, its expected lifespan, and warranty concerns play a crucial role in determining the features that need to be incorporated into the BMS design. Compliance with certification requirements set by government regulations is also essential to ensure safety and reliability, with a focus on cost-effectiveness and penalties for inadequate safety measures. There are numerous design features that can be included in a BMS, including battery pack protection management and capacity optimization. These features are essential for ensuring the efficient and safe operation of the battery pack, while also maximizing its performance and longevity. Develop a control algorithm for the BLDC motor system to regulate speed, torque, and energy consumption based on user input and environmental conditions. Implement control logic to optimize energy efficiency, manage battery charging/discharging, and coordinate with the solar power generation system. Solar Power Integration: Integrate the solar panels into the cycle design, ensuring efficient capture and utilization of solar energy. Connect the solar panels to the charge controller and battery pack, implementing MPPT (Maximum Power Point Tracking) algorithms to optimize power conversion and charging efficiency.

Cell Monitoring: The process of monitoring the voltage and temperature of individual cells within the battery pack is crucial to ensure that they remain within safe operating limits, preventing any potential damage or safety hazards. State of Charge (SoC) Estimation: Precisely estimating the battery's remaining capacity is necessary to give users accurate knowledge of how much charge is available, allowing them to schedule their usage appropriately. Monitoring the State of Health (SoH): Predicting a battery's lifespan and performance over time requires tracking its overall health and degeneration, which enables users to make well-informed decisions about replacement or maintenance.. Balancing: Equalizing the charge among cells is necessary to prevent overcharging or undercharging, which can lead to capacity imbalances and ultimately reduce the overall lifespan of the battery. Thermal Management: Regulating the temperature of the battery pack is crucial to prevent overheating, which can damage cells and significantly impact performance.

Block Diagram: Block Diagram of proposed system is shown in Figure 1.

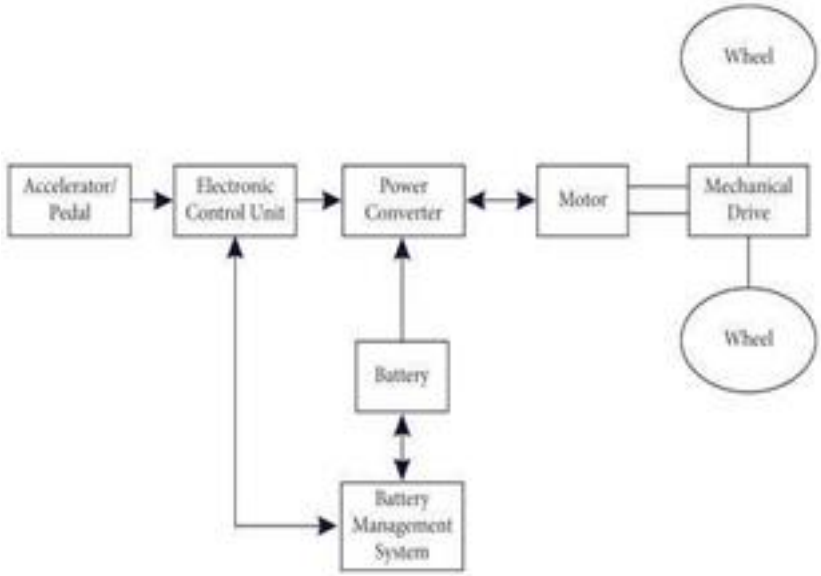

Fig. 1- Block Diagram

Components: The Components used in this study have been shown below.

A. CONTROLLER

Fig. 2- Controller

The speed and direction of an electric motor in an e-cycle are controlled by a DC motor controller, as seen in Figure 2. Usually, Pulse Width Modulation (PWM) methods are used to regulate the power given to the motor. The rider provides input signals to the controller, which modify the motor's speed based on the position of the throttle and level of pedal assistance.Additionally, certain controllers include regenerative braking, which increases efficiency by recovering energy used during braking and feeding it back into the battery. A signal is delivered to the controller when you depress the throttle, and the controller then works with the in-hub engine to adjust the speed as needed. The pedalling aid level can be manually or automatically modified, indicating to the motor how much assistance it can provide to a rider based on the resistance measured or the technique entered into the controller. The controller allows many smart devices and interfaces to communicate with one other, including the accelerator, brake systems, speed settings, connected screens, and applications[4]. With more sophistication comes greater capabilities for a controller.

B. MOTOR

Fig. 3- Motor

BLDC stands for Brushless DC motor as shown in Figure 3. BLDC motors are direct current (DC) motors that substitute electronic commutation for brushes. Because they don't have brushes, they are very dependable and efficient, requiring little maintenance over their extended lifespan. BLDC motors offer smooth operation with minimal noise and electromagnetic interference[8]. They are widely employed in many different applications, including electric vehicles, robotics, industrial automation, and HVAC systems, and they offer accurate speed control.. BLDC motors can be operated with or without sensors for rotor position feedback, allowing for sensor less or sensor-based control methods. Overall,

C. BATTERY

Fig. 4- Battery

One popular kind of rechargeable battery that provides electricity at a nominal voltage of 12 volts is the 12V battery. A 12V battery provides electrical energy at a voltage of 12 volts, suitable for powering a wide range of electronic devices and systems[3]. It can be constructed using various chemistries, such as lead-acid, lithium-ion, or nickel-metal hydride, each with its own characteristics in terms of energy density, weight, and cycle life.12V batteries are widely used in automotive applications for starting engines, as well as in marine, RV, and off-grid solar systems.

D. THROTLE

Fig. 5- Throttle

Throttle: a handlebar-mounted gadget that, as seen in Figure 5, is capable of engaging and occasionally adjusting the motor's power output. Turbines equipped with throttles allow for full self-propulsion, as they direct their motors to deliver power without requiring pedal motion or rider input.

An accelerator on a bike, also known as a throttle, works by controlling the flow of fuel and air into the engine, which in turn regulates the speed of the bike. When you twist the accelerator grip on the handlebar, it opens the throttle valve, allowing more fuel and air to enter the engine, leading to an increase in speed. Conversely, releasing the accelerator reduces the flow of fuel and air, slowing the bike down. This system is commonly found in motorcycles and motorized bicycles.

IV. RESULTS & DISCUSSION

Electric cycles (e-cycles) require Battery Management Systems (BMS) since they are vital to maximize the longevity and performance of battery packs. To guarantee effective operation, the BMS keeps an eye on important parameters including voltage, current, and temperature. It prevents overcharging and over-discharging, thereby enhancing safety and safeguarding the battery from potential damage. Additionally, the BMS actively balances individual cells in the battery pack, maximizing usable capacity and maintaining consistent performance over time. This increases the battery's range on a single charge and lengthens its lifespan, which lowers the need for frequent replacements and the related expenses. Through real-time monitoring, the BMS provides users with valuable information on battery health and remaining capacity, enabling informed decisions and improving the overall riding experience. Ultimately, a well-implemented BMS in e-cycles guarantees reliable performance, efficiency, and safety, making electric biking a sustainable and convenient transportation choice.

V. CONCLUSION

The conclusion regarding batteries used in electric vehicles (EVs) is that they are vital for the success and widespread adoption of electric mobility. While facing these difficulties, innovation for battery technology with reference to energy density and efficiency will be continuous and still a mystery which can be resolved in future.

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