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S.E.B-Super Capacitor Electric-Bicycle

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Abstract*: This literature review examines the research and development of electric bicycles equipped with super capacitors as a power source and . The review provides an overview of the current highlights key advancements of the field, and discusses the potential benefits and challenges associated with this technology. The objective is to provide a comprehensive understanding of the integration of super capacitors and self-made motors in electric bicycles and identify research directions in this domain.This literature review explores the integration of super capacitor battery type in electric bicycles, highlighting its potential to enhance performance, efficiency, and range and battery life. The objective is to provide a comprehensive understanding of the benefits and limitations of utilizing super capacitors in electric bicycles and identify future research directions in this field*.

Keywords: Direct Current Motor (DC Motor)

I. INTRODUCTION

The electric bicycles are innovative devices that combine the benefits of traditional bicycles with electric assistance. They provide riders with an easier and more enjoyable experience, especially when tackling challenging terrains like hills. Although electric vehicles, including electric bicycles, tend to be more expensive than gasoline-powered vehicles, this is due to the extensive research and development that has been focused on gasoline cars over the years. Despite the cost difference, electric bicycles offer cost savings in the long run as they primarily require battery charging instead of relying on expensive gasoline.

Electric bicycles are becoming increasingly popular for their sustainability and cost-effectiveness. While most electric bikes use batteries for energy storage, a new technology is emerging that utilizes supercapacitors. Supercapacitors, also known as ultracapacitors or EDLCs, store energy electrostatically and offer fast charging and discharging capabilities. Electric bicycles equipped with supercapacitors provide advantages such as faster acceleration, efficient regenerative braking, and shorter charging times. Although supercapacitors currently have lower energy density than batteries, ongoing advancements are improving their capabilities. This development in sustainable transportation offers the potential for more efficient and high-performing electric bicycles in the future.

II. DC MOTOR

A DC motor is a type of rotary electrical machine that performs the crucial task of converting electrical power in the form of direct current into mechanical power. These motors operate based on the principles of electromagnetic forces generated by magnetic fields. Various types of DC motors exist, and they often incorporate specific internal mechanisms, either electromechanical or electronic in nature, to facilitate periodic changes in the direction of current flow within specific motor components.

DC motors gained significant prominence historically, primarily because they could be easily powered by existing direct-current lighting power distribution systems. This compatibility made them widely used during the early stages of electrical power adoption. One of the advantageous features of DC motors is their ability to have their speed controlled across a wide range. This control can be achieved through varying the supply voltage or adjusting the strength of the current flowing through the field windings of the motor.

DC motors find diverse applications across various industries and sectors. In small-scale applications, such as tools, toys, and household appliances, tiny DC motors play a crucial role. They provide the necessary mechanical power to drive the operation of handheld tools, the movement of toys, and the functioning of appliances. Additionally, there is a specific type of DC motor known as a universal motor, which has the capability to operate on direct current. These lightweight motors are commonly used in convenient power tools and household appliances

2.1 Working Principle

The working principle of an electric DC motor relies on the interplay between magnetic fields and electric currents. When an electric current flows through the rotor winding, it generates a magnetic field. This magnetic field interacts with the fixed magnetic field produced by the stator, resulting in a rotational force known as torque. The commutator and brushes enable the motor to maintain continuous rotation by periodically reversing the current direction. By regulating the electrical input, the speed and torque of the DC motor can be controlled. In essence, DC motors convert electrical energy into mechanical motion by harnessing the interactions of magnetic fields and electric currents.

III. CONTROLLER

Speed Control Basics

The speed controller of an electric bicycle functions as both a speed regulator and a dynamic brake, operating through an electronic circuit. It receives power from the battery box and transmits it to the motor, effectively controlling its speed. Depending on the type of motor (brushed or brushless), different controller variations are utilized. In the case of adaptive e-bikes, a conversion kit is employed, with the controller serving as the central component of the kit.

Function

The electric bike speed controller is a vital component that plays a crucial role in regulating the speed and performance of the bike's motor. Its primary function is to send signals to the motor in various voltages, allowing the controller to determine the rotor's position relative to the starter coil. This information is crucial for maintaining proper synchronization and control of the motor.

The specific operation of the speed control mechanism can vary depending on whether the electric bike is adaptive or purpose-built. In the case of an adaptive electric bike, which refers to a standard bicycle that has been retrofitted with an electric drive system, the speed controller may not include Hall effect sensors. These sensors are commonly used to detect the rotor's position accurately. Instead, the rotor orientation is calculated based on the electromotive force of the un-driven coil. This method allows for a cost-effective integration of the electric drive system onto an existing bicycle, making it an affordable and accessible option for those seeking to electrify their bikes.The electric bike speed controller is a vital component that plays a crucial role in regulating the speed and performance of the bike's motor. Its primary function is to send signals to the motor in various voltages, allowing the controller to determine the rotor's position relative to the starter coil. This information is crucial for maintaining proper synchronization and control of the motor.

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WORKING

The working of our project basically explains by using the five blocks as follows

a) Battery.

b) Motor Controller Circuitry.

c) Electric motor.

d) Chain and Sprocket.

e) Bicycle speed Rotation.

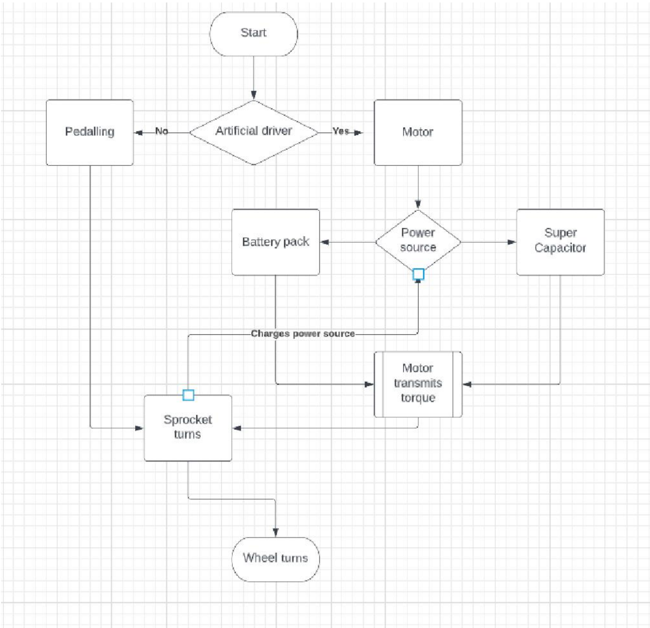

Fig 3: Block diagram of the Electric bicycle construction process

Battery: -

Part 1-Litihum Ions:

The common cell configuration for 18650 cylindrical cells is 7 cells in series and 4 cells in parallel to meet voltage requirements and provide sufficient battery life. Additional cells can be added in parallel to increase capacity. The battery stores electrical energy generated and powers the motor. It has a positive terminal called the cathode and a negative terminal called the anode. The cathode is at higher electric potential energy, while the anode is the source of electrons that flow through an external circuit to deliver energy. Rechargeable batteries can be charged multiple times for repeated use. The capacity of each individual cell is 1200mAh and the net capacity of the battery is 33.6 Ah.

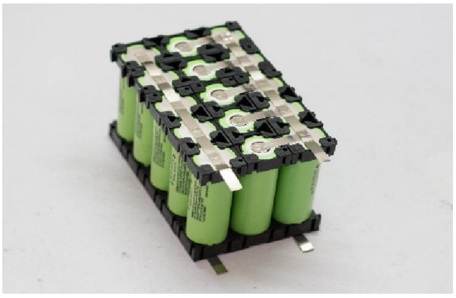

Fig 4: Lithium Ion Battery Pack

Part II-Supercapacitors:

8 supercapacitors in series of 3VDC 2000f for instant deployments.

Fig 5: Supercapacitor

Motor Controller Circuitry:-

Motor controller circuitry refers to the electronic components and circuitry responsible for controlling the operation of an electric motor. In this system it regulates the cycle's speed and torque based on input signals and manages the power supply to the motor.

Electric Motor:-

Using 250w 24v DC motor for having suitable power and torque according to design.

Chain and Sprocket:-

Take the suitable material & no. of teeth according to center distance.

Bicycle Wheel Rotation:-

Provide the torque and speed to the wheel throughout sprocket.

IV. MOTOR POWER CALCULATION

Step 1 :- Total Tractive Effort(TTE)

It is the sum of the forces required to push or pull a vehicle.

TTE = Frr + Fad + Fhc + Fa

[Total tractive effort = Rolling Resistance (RR) + Gradient Resistance (GR) + Acceleration force required (Fa) + Drag force (FD)]

Frr = Rolling resistance

Fad = Aerodynamic drag

Fhc = Hill climb force (gradient)

Fa = Acceleration force

Step 2:-Rolling Resistance:

Rolling Resistance is the force necessary to propel a vehicle over a particular surface. This is the force required to propel the bike from the frictional force offered by the surface on which it is moving. This depends on the weight of the bike and the friction coefficient of that surface.

Frr = μ * m g

Frr = 0.015 * 150

Frr = 2.25 N

Step 3:-Aerodynamic Drag

This is the drag force offered by the air in our surrounding. This depends on the density of the air through which it is moving, area of the bike with rider and on the bike's velocity.

Fad = ρ * A * cd * v2

Fad = (1.25) * (0.625) * (0.9) * (5)2

Fad = 17.578 N

Step 4:- Hill Climb Force

This is the amount of force necessary to move the up a slope or a grade. This depends on the angle of accent the bike is climbing and the net weight it is carrying.

Fhc = m * g * sin θ

Let gradient be 30%

Fhc = 150 * sin (30)

Fhc = 75N

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Acceleration Force:

Fa = flinear + frotational

For linear component:

Flinear = m * a

Use velocity equation for 10 m stretch to get:

V2 = U2 + 2*a*100

a (For gradient) = 0.488 m/s2

a (For flat surface) = 1.25 m/s2

Flinear = 15.3 * 0.488

Flinear = 7.4664 N

Flinear = 15.3 * 1.25

Flinear = 19.125 N

Frotational = ω * a

Frotational = (5% of m*g) * m * a

Frotational = 20.81 N

Thus, net acceleration is:

Fa = 20.81 + 19.125

Fa = 39.935 N

Total Tractive Effort:

TTE = Frr + Fad + Fhc + Fa

TTE = 2.25 + 17.578 + 75 + 39.935

TTE = 134.763 N

Step 5:-Wheel Torque

This is the amount of torque required at the wheels to move the bike from a stand-still. This depends on the tractive effort required and on the wheel's radius

Tw = TTE * Rwheel

Tw = 134.763 * 0.30

Tw = 40.4289 N

(Radius of wheel = 12 inches or 0.3 m)

Power:

This is the power that the electric motor should capable to deliver for e-bike's propulsion. This is compute as following:

$$\boldsymbol{P = \frac{2\pi * N * T}{60}}$$

Here, in equation, Rpm is the only unknown that can be calculated as: Distance travelled per revolution of the wheel is equal to the circumference of the wheel

1 revolution = 2π * 30 = 1.885 m

$$n = \frac{300}{1.885}$$

n= 159.15

Gear ratio to be set is 0.25

N = n * gr

N = 159.15 * 0.25

N = 40

Now plugging in the value in P:

$$\boldsymbol{P = \frac{2\pi * 40 * 40.4289}{60}}$$

P = 169.3481808watt

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Including frictional losses in motor to be about **30% - 35%**

P = 169.348 * 1.35

P = 228.62watt

V. MATLAB SIMULATION

DATA AFTER ONE HOUR OF SIMULATION:

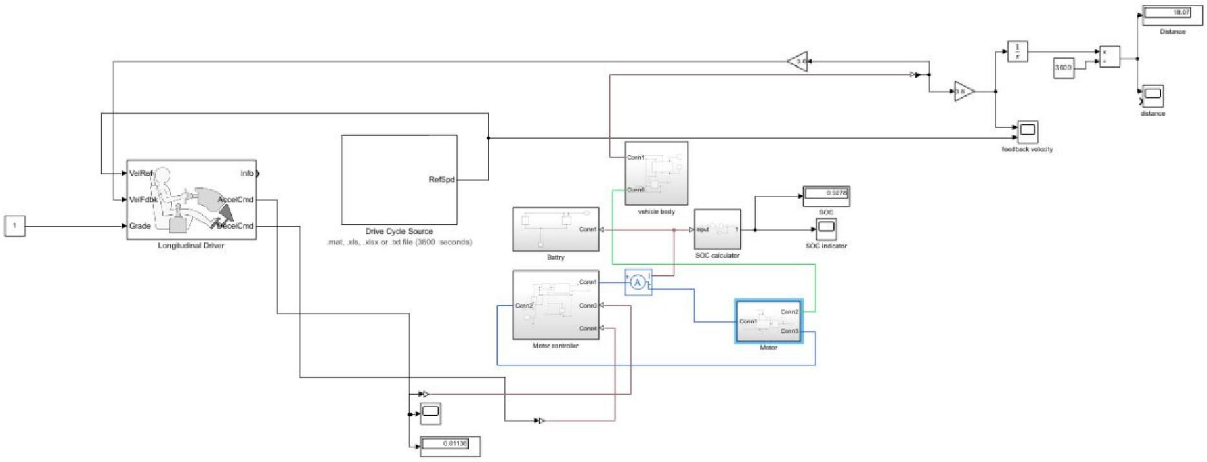

Fig 6: MATLAB Simulation schematic

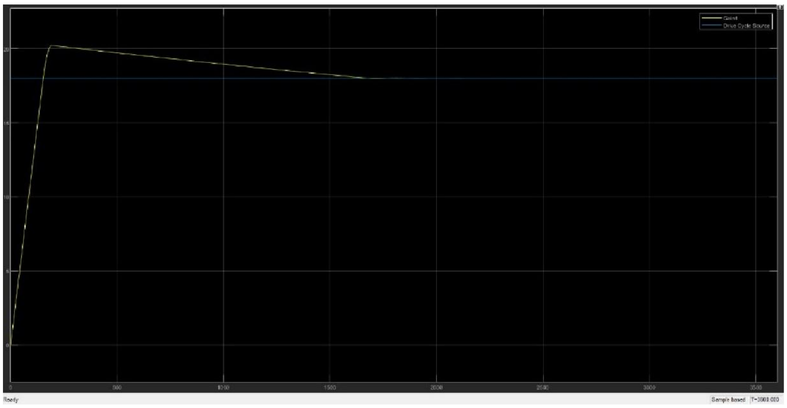

Fig 7: Acceleration time graph

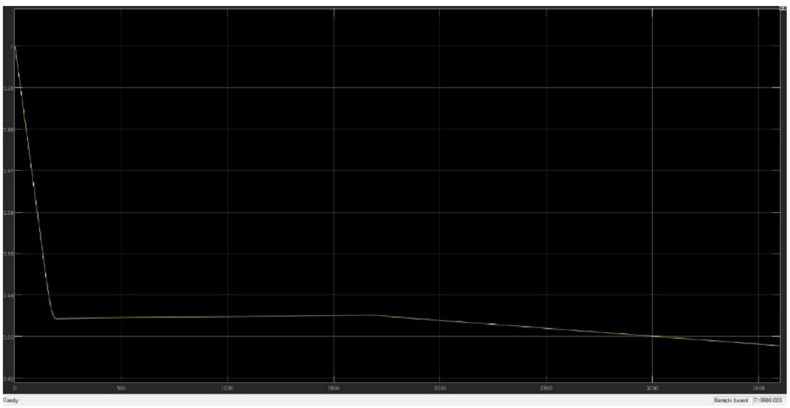

Fig 8: Battery depletion graph

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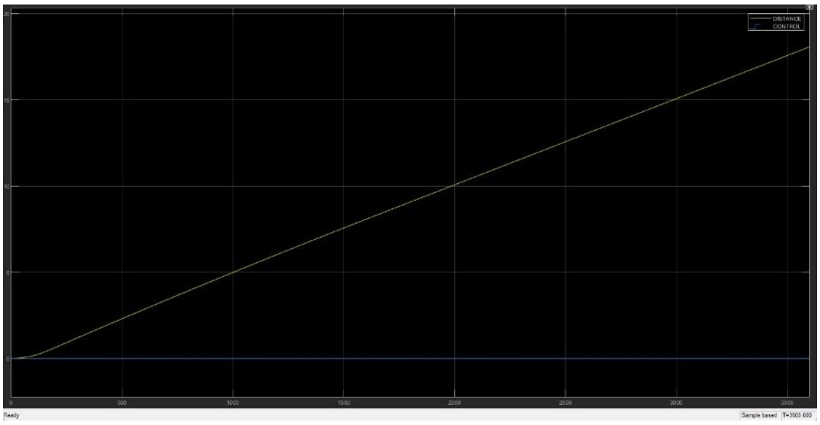

Fig 9: Distance vs Time Graph

VI. CONCLUSION

This project is designed to improve the normal bicycle and make it extra efficient. the utilization of supercapacitors in electric bicycles holds great promise for the future of sustainable transportation. While their energy density may currently be lower than that of batteries, supercapacitors offer notable advantages such as rapid charging and discharging capabilities. Electric bicycles equipped with supercapacitors deliver enhanced acceleration, efficient regenerative braking, and reduced charging times, providing superior riding experience. Although further advancements are necessary to improve the energy storage capacity of supercapacitors, ongoing research and development endeavors are actively addressing these challenges. With continued progress, electric bicycles utilizing supercapacitors have the potential to offer more efficient and high-performance options for environmentally conscious commuters and enthusiasts, ultimately contributing to a cleaner and greener transportation ecosystem.

The calculated motor power is=228.62watt

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