JCAI

Journal of Cognition and Artificial Intelligence (JCAI)
2025, Vol. 01, No. 2,PP 07-12
https://doi.org/10.33322/jcai.xxx

Real-Time Prototype Development of a Hybrid Electric Motorcycle with Intelligent Power Mode Switching

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Abstract

In this study, the development of a real time Hybrid Electric Motorcycle is considered, including the fabrication of a prototype of the Hybrid Electric Motorcycle. The method of power switching mode and transformation of a usual combustion engine motorcycle into a hybrid Electric Motorcycle is also discussed. To convert a conventional combustion engine motorcycle into a hybrid electric motorcycle, a brushless DC drive was assembled in the forward-facing wheel of a conventional combustion engine motorcycle. The combustion engine is responsible for powering the motorcycle in the conventional way, whereas the brushless DC drive is responsible for powering the motorcycle using electric power. Both powering systems can be used alternatively to drive a motorcycle. This hybrid electric motorcycle can also recharge the battery when it is driven in the combustion engine mode. The pollution emitted while driving a combustion engine motorcycle can be reduced to an extent, and it helps reduce the noise pollution generated by conventional combustion engine motorcycles. Another advantage of the hybrid electric vehicle is that the cruising range can be extended compared to purely electric motorcycles, which have a lower cruising mileage range than conventional combustion engine motorcycles. For future work, Artificial Intelligence (AI) and Machine Learning (ML) methods will be implemented via using real time datasets are logged for upcoming application of machine learning models includes Decision Tree and Random Forest tool and techniques.

Index Terms: *Brushless DC Motor, Electric Vehicle Conversion, Hybrid Electric Motorcycle, Motorcycle Hybridization, and Power Mode Switching.*

I. INTRODUCTION

The worldwide move in the direction of sustainable transport increases, Hybrid vehicles developed as a favorable substitute to conventional fuel based vehicles. Attaining greater power efficacy, dropping emissions, and refining general automobile routine mainly depends on innovative controller procedures that can efficiently achieve optimal energy solution. This study presents a original machine learning founded controller procedure for Hybrid Vehicles, incorporating Artificial Neural Network based systems [1]. The 'Hybrid Electric Motorcycle'(HEM) has electric and fuel power. It has more benefits than ever before because conventional combustion engine vehicles only drive using fuel energy, and these motorcycles are also responsible for the emission of pollution. The idea is to design and build a HEM powered by batteries and fuel. The HEM is supplied with electricity from batteries and fuel. It uses less fuel and creates less pollution than conventional motorcycles. HEM contains a battery, which drives the motorcycle as an optional source of power, allowing the reduction of harmful emissions through a combustion engine motorcycle. In addition, there is a grant to recharge the battery using a generator when it is driven in the combustion engine mode [1-5]. The priority over the environment with admire to pollution and conservation of gasoline assets in the world as the automobile industry is specialize in manufacturing fuel efficient and low emission automobiles with superior generation. One of the vital goals of modern-day layouts is to reduce gasoline consumption and exhaust emissions. One such innovation is the Hybrid Electric Motorcycle (HEM). The hybridization of a traditional combustion engine motorcycle with an electric motor power can also substantially enhance the general performance and attain better fuel efficiency with decreased emissions. The primary goal was to design and manufacture a HEM that can be operated using both petrol and battery, which would reduce the cost and complexity of the current hybrid motorcycle technology and solve the problem of the limited battery range of electric motorcycles [5-8]. The capability to alteration among petrol and electric is a main feature of hybrid automobiles, which offers frequent profits over traditional gasoline-powered automobiles. In electrical method, hybrid automobiles produce zero emissions, assembly them an ecologically welcoming selection. Furthermore, the electrical mode delivers a noiseless and smooth driving capability, while the petrol mode compromises improved power and kind. The capacity to shift amongst modes also permits the vehicle to improve its power utilization, support fuel, and

decrease functioning prices. Furthermore, by converting to electric mode throughout low-speed driving in traffic, the hybrid vehicle be able to lessen fuel usage with zero emissions. The competence to conversion among modes also recovers the total driving repetition by provided that the driver with longer switching and elasticity in the use of the vehicle. In over-all, the competence to switch among gasoline and electric power is a energetic feature of hybrid vehicles, sanctioning them to deliver superior performance, effectiveness, and ecological assistance. The hybrid electric motorcycle is a progressive method of transportation that can significantly rise the change in discovery potentials for personalities. By joining electric and petrol based systems, hybrid electric motorcycles suggestion a variety of benefits that are not available with traditional bikes. Hybrid electric motorbikes are a real purpose for dropping exhaust releases and refining air cleaning associated with traditional oil-based motorbikes. By mixing both electric and petrol-based systems, hybrid electric motorcycles decrease the quantity of exhaust emissions produce into the ground. After the motorbike is driven in the electrical power mode, the hybrid electric motorbike produces zero emissions, creation it a clean and environmentally friendly high-quality for urban and short-distance travel The hybrid electric motorbike also consumes the electrical potential to lessen sound pollution, as the electrical mode produces fewer sound than fuel-powered engine. This kind of sound smog is an alarm for exhaust emissions, and hybrid electric motorbikes give to purifying air quality and dropping the damaging possessions of smog on humanoid suitability and the troposphere. By reducing the running costs of vehicles, hybrid vehicles can provide an additional reasonable and economical choice for drivers, while encouraging sustainability and reducing the ecological impact of transport. In general, hybrid vehicles are a valued asset for drivers who want to save money on petroleum and maintenance costs. The public's maximum estimation of automobiles with internal combustion locomotives is static, considered the maximum robust transport source; an additional 250 million road transport automobiles in the United States still depend on them [1]. Diesel and gasoline are considered the primary sources of fuel for internal combustion engines; however, alternative fuels are also being used, including natural gas, propane, biodiesel, and ethanol. These combustion engines are also combined with hybrid electric powertrains to increase fuel economy and reduce fossil fuel consumption. In addition, hybrid powertrain vehicles can play a vital role in reducing global warming by reducing the harmful gases produced by the burning of fossil fuels. Internal combustion engines and hybrid electric systems are also combined to increase the range of hybrid electric vehicles [9], and [10].

II. MATERIAL AND METHODS

To design a hybrid electric motorcycle, this study used a 70cc super power 2014 motorcycle. It is an air-cooled motorcycle with a single cylinder, and it is basically a combustion engine motorcycle in which BLDC motor integrated to make it hybrid. The components are associated and the proposed system is the sustainable solution integrated with both fossil fuel and electric power to operate the motorbike.

A. Gear Box

The gearbox is the main part of a 70cc motorcycle engine, which transmits the power of the engine to the wheels of the motorcycle. In the gear box, a combination of gears is formed to increase and reduce the torque upon shifting the combination of the gears using the gear lever. The gear box of a 70 cc motorcycle has four gear shifts. The gears of the gear box of the 70 cc motorcycle are shown in Figure 1.

Figure 1: The Gears of 70cc Gearbox

B. BLDC Hub Motor

A BLDC hub motor system utilized to drive the motorcycle using electric power. A BLDC hub motor is designed in the shape of a hub A BLDC motor does not have brushes in it. It is one the major components to drive via electric power.

Figure 2: BLDC Hub Motor

This motor is powered directly through wires. The commutation of this motor is performed through electronics instead of brushes. The BLDC motor is shown in Figure 2.

The BLDC Hub drive was mounted on the front wheel of the motorcycle. The BLDC hub motor was connected using spokes. It is balanced properly; therefore, there

should be no wobbling in the wheel. The wheel throwing process is shown in Figure 3, in which a technician mounts the BLDC Hub motor on the rim.

Figure 3: The Wheel Throwing Process

After the wheel throwing process, the tire and tube were mounted on the rim, and a standard-size tire and wheel of a 70 cc motorcycle were used. No changes were made to the rim tires and tubes. Then, there was a new challenge of mounting the front wheel in the stock front suspension of the 70-cc motorcycle because the BLDC Hub motor is wider than the original hub of the motorcycle. Therefore, some changes were made in the front suspension, which are discussed in the header front suspension.

C. Front Suspension System

As mentioned in the previous paragraph, the BLDC hub motor is wider than the stock hub 70CC motorcycle. To mount the BLDC hub motor in the front suspension, some changes were made in the front suspension, as shown in Figure 4.

Figure 4: Front Suspension System

D. The Stock Front Suspension

These suspension bars were cut into half, the dampers were removed, and the bar was separated by cutting. See Figure 5.

Figure 5: Front Suspension Bars

E. Bike Throttle

An electric bike throttle is a device used to switch the speediness of an electric bike. It typically operates independently of pedaling, allowing the rider to control the speed of the bike by turning the throttle with their hands. Some e-bikes have a twist-grip throttle on the handlebar, whereas others use a thumb or trigger throttle. The throttle provides a convenient way to control the power delivery from the e-bike's electric motor, making it easier to ride and maneuver. In this case, a thumb throttle with an LCD mounted on the handlebar was used, as shown in Figure 6. The LCD shows the voltages of the BLDC hub motor.

Figure 6: Electric Thumb Throttle

F. Battery

In this study, to power the BLDC hub motor, a battery was fabricated and installed in the bike. The battery was made using 3.7 volt and 6 A lithium-ion cells. Of these, 160 were used to fabricate the battery pack. Sixteen cells were connected in series to obtain 60 volts and 6 A. Twenty sets of 60 volts and 6 A were connected in parallel to obtain a total of 60 A. This battery pack can store approximately 3600 watts of electric power. The battery pack is shown in Figure 7.

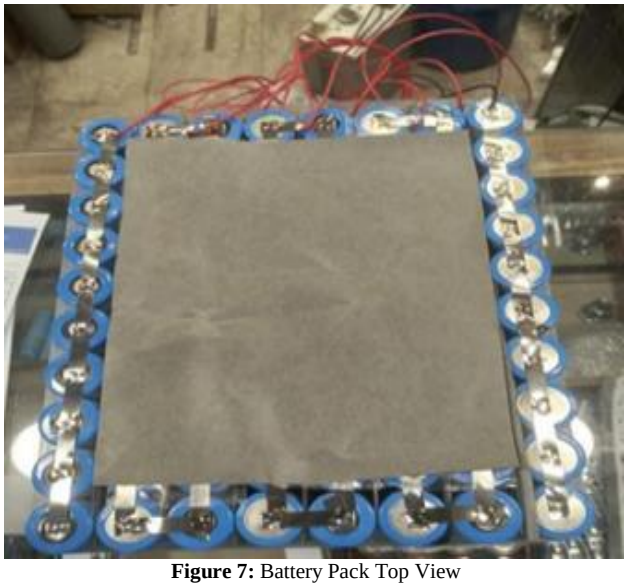

Figure 7: Battery Pack Top View

G. Battery Management System (BMS)

A Battery Management System (BMS) is a type of control system used to monitor and manage the performance of a rechargeable battery. The main functions of a BMS are to protect the battery from damage, extend its lifespan, and improve its performance (Figure 8).

Figure 8: Battery and Controller Junction

A BMS typically performs several key functions, including:

i) Monitoring the battery voltage, current, temperature, and other performance parameters.
ii) Balancing the voltage and capability of the individual cells in multicellular batteries.
iii) Protecting the battery from over-charging, over-discharging, over-temperature, and other conditions that can damage the battery.
iv) The charging and discharging of the battery are managed to maximize its performance and extend its lifespan.
v) Communicating battery status and performance data to the user or other control systems.

H. Performance Parameters at Different Speeds

The performance of any mechanical system varies significantly with speed. Evaluating performance parameters across a range of speeds is essential for optimizing efficiency, safety, and reliability (see Table I).

Table I: Performance Parameters of the System at Different Speeds

S. No.	Speed (km/h)	Input Power(W)	Output Power (W)	Efficiency (%)
1.	15	220.66	109.98	0.416
2.	20	293.89	219.94	0.415
3.	25	367.50	292.98	0.415
4.	30	440.99	403.69	0.416
5.	35	514.50	473.35	0.416

I. Design Calculations and Equations

Design calculations form the analytical backbone of any engineering or performance study (Table II). The related equations are shown in Table III.

Table II: System Parameters and Calculated Values

S. No.	Parameter	Value	Unit
1.	Battery + Controller Mass	6.5	kg
2.	BLDC Motor Mass	5.5	kg
3.	Tire + Frame Mass	35.0	kg
4.	Normal Person Mass	65.0	kg
5.	Factor of Safety (FOS)	1.5	–
6.	Total Mass (with FOS)	175	kg
7.	Total Weight	1715	N
8.	Tire Radius	0.304	m
9.	Normal Reaction per Tire (Fn)	857	N

Table III: Design Calculation Equations

S. No.	Formula	Description	Eq. No.
1.	$Ff = \mu \cdot F$	Friction Force on Each Tire	(1)
2.	$T = Ff \cdot r$	Torque	(2)
3.	$\omega = v / r$	Angular Speed	(3)
4.	$P = T \cdot \omega$	Power Required for Plane Road	(4)
5.	$F = \mu mg \cos\theta + mg \sin\theta$	Net Tractive Force Considering Friction and Slope	(5)
6.	$Pin = F \cdot v$	Input Power	(6)
7.	$Pout = T \cdot \omega$	Output Power	(7)

III. RESULTS AND DISCUSSION

In the results and outcome phase, the system was constructed and verified for the e-bike prototype. Tables IV and Tables V demonstrate the test cases for the proposed system. The Figure 9 shows the real-time dashboard parameters for the hybrid motorcycle.

A. Test Cases

Table IV: Test Case 1

S. No.	Field	Description
1.	Preconditions	Displays on the Connected Screen
2.	Expected Result	System Works Properly
3.	Actual Result	Pass

Table V: Test Case 2

S. No.	Field	Description

1.	Preconditions	Activate the Bike for Testing
2.	Expected Result	System Tested and Verified
3.	Actual Result	Pass

Figure 9: Real-Time Dashboard

B. Characterization

i) Working of an Internal Combustion Engine:

Combustion is referred to as burning; it is a chemical process in which air and fuel are mixed together to generate energy. This burning of a fuel and air mixture is done inside the combustion engine itself. Then, using some energy transformation methods, the energy of the combustion is converted into mechanical work. The fixed cylinder and the moving piston are responsible for transferring the combustion energy into the mechanical work. The piston is pushed due to the expanding gases, which then rotate the crankshaft. The crankshaft is then connected to a system of gears, and these gears are associated with the wheels of the automobile using a drive shaft. The motion of all these parts due to combustion drives the vehicle [8]. Two types of internal combustion engines are being produced, which include the spark ignition gasoline engine and the compressed ignition diesel engine. These engines have a stroke cycle. Each cycle represents a process. The first process is the intake, the second process is the compression, the third process is the combustion, and the final process is the power stroke. These four strokes work in a sequence to make the combustion engine work. These engines, i.e., spark ignition gasoline engines and compression ignition diesel engines, are different from each other on the basis of the supply and ignition of the fuel. In a spark ignition gasoline engine, the air is mixed with the fuel before entering the combustion chamber, and then it is ignited using a spark, while in compression ignition diesel engines the air enters the combustion chamber first then it is compressed and then the fuel is sprayed at a suitable, measured rate which cause the ignition in the combustion chamber [9]. The recent uses of Deep Learning (DL) methodologies for the prediction and analysis of student performance. They have examined diverse research that utilized the modern techniques, e.g., including deep learning and deep learning with conventional Machine Learning (ML) techniques, as well as those that have used ML and DL alone. Their review showed how well DL models can handle the high-dimensional and complicated educational data for enhanced prediction accuracy. The analysis also highlighted various difficulties and need for the sizable datasets for the training of DL models. They also made inferences that resolving these issues would enhance the process of DL-based strategies to promote educational interaction and tailored learning environments [10-14].

ii) Importance of Electric Vehicles:

As humans are evolving and new technologies are being adopted. The demand for and today's need for electric vehicles is also increasing because of their benefits. If we compare electric vehicles to conventional combustion engine vehicles, we find that with electric vehicles human kind could take many advantages [15-18]. The concept of electric vehicles is relatively new in the automotive industry, but some companies are designing their future vehicle models fully based on electricity, while there are also some companies that are offering hybrid vehicles. These hybrid vehicles work on both electricity and fuel. Some electric car companies are manufacturing fully electric cars, which are a great way for consumers to save money and also contribute towards building a healthy and pollution-free environment. Combustion engine cars produce a lot of carbon, which is emitted in the environment which leading to air pollution and greenhouse gases. This kind of pollution is also responsible for the weakening of ozone layer. Electric cars are a great way to save the environment. The main source of power for the electric vehicle is the battery. These batteries are also responsible for powering other features of the car. In electric cars, many battery cells are combined together to form a battery pack, which provides the power to the car and its other features. [19-21]. Electric vehicles are ensured to operate as they are power-driven by electric drives and rechargeable batteries. As an alternative to a combustion engine, electric vehicles utilize an electric drive that transforms electrical power from the batteries into mechanical power to energize the wheels. The batteries are charged by plugging them into a charging station, which can be driven by renewable power sources such as wind or photovoltaic power. Electric automobiles offer numerous benefits over oil-powered cars, including lower operating costs, reduced emissions, and better performance. They are also soundless and smoother to ride, with instantaneous torque and acceleration. However, electric cars require a dependable and reachable charging organization, which is not easily accessible in some zones. Furthermore, the variety of electric cars is characteristically partially associated with fossil fuel-powered vehicles, while this is consistent with developments in battery expertise. In general, electric vehicles suggest a cleaner, more well-organized, and additional supportable mode of transport that is gradually an attractive selection for drivers [21]. Electric vehicles can be charged from a typical electrical socket in a home, utilizing a particular charging cable that is typically provided with the automobile. This type of charging is identified as Level 1 charging and characteristically takes a considerable amount of time to completely charge an electric vehicle, depending on the battery size and charging rate. However, it is significant to communicate that charging an electric vehicle from a normal domestic socket may necessitate a devoted circuit to escape congestion and initiate damage to the electrical organization. Moreover, Level 1 charging is characteristically slower than other charging techniques, such as Level 2 charging, which utilizes a particular

charging location that can deliver faster charging periods. However, Level 1 charging is a suitable and available method for charging an electric automobile [14].

IV. CONCLUSION

Real-time Hybrid Electric Vehicles are automobiles that integrate a conventional internal combustion engine with an electric drive and battery. The main objective of a hybrid electric motorbike is the development of fuel efficiency and a drop emissions accompanying with old oil-based automobiles. Some of the chief constructions and profits of hybrid systems comprise:

- Improved Quality Fuel Effectiveness: By mixing an electrical and fuel-based hybrid system, profits from the energy to achieve healthier fuel efficiency. The electrical drive offers provision throughout acceleration and is also able to recall power during deceleration, enhancing the battery duration.
- Lessen Emissions: By dropping the amount of fuel essential to energize the motor of automobile, this approach drops the amount of releases produced associated with traditional fuel-based powered vehicles.
- Improved Performance: The electrical motor provides additional torque and energy, which can improve acceleration and whole efficacy.
- Dual Energy Source: With a hybrid electric vehicle, the motorist is able to select to energize the vehicle on energy, fuel, or a mixture of both technologies, liable on driving circumstances and other factors.

Acknowledgment

We would like to acknowledge Nazeer Hussain University for the practical provision of conducting this study.

Authors Contributions

All the authors equally contributed to this research study.

Conflict of Interest

The authors state no conflicts of interest.

Data Availability Statement

The testing data is available in this paper.

Funding

This research received no external funding.

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