Design and testing the functionality of Electric Motor cycle

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Abstract— Gasoline motorcycles have a number of drawbacks, including high running costs, pollution, noise, and need regular maintenance. As a result, the goal of this project was to convert a gasoline motorbike into an electric motorcycle that could address the issues mentioned above. This initiative aids in the transfer of technology as a transportation system, while also lowering emissions and operational costs. To accomplish the project's goal, applied research technique was used to demonstrate fully functioning EMC. The DC motor, battery, and battery charger were the primary components needed to convert a gasoline motor cycle to an electric motor cycle. The battery drained more at low speeds, according to the results of the road test. I came to the conclusion that, since our country's electric power supply is adequate, it is preferable to ride an electric motorbike rather than a gasoline motorcycle. The experiment demonstrated how a gasoline motorbike may be converted to an electric motorcycle with little technical expertise and widely accessible components. This contains a comprehensive description of a modification process, as well as alternatives and required attention to safety issues, comparisons of electric motorbike operating characteristics, and suggestions for improvements in the design and manufacturing process as well as further study.

Index Terms— Electric motorcycle, DC motor, Motor controller, Battery, Throttle handle.

1. INTRODUCTION.

The current trends in energy use, particularly gasoline consumption, cannot be maintained for much longer. These resources are, once again, playing a detrimental role in light of the potential of global warming. This is a stark message to nations like Ethiopia who are lagging behind in renewable energy technologies. As a result, it is imperative that a fresh investigation of natural energy resources be undertaken under these conditions. Exploration of natural energy sources must be efficient, low-cost, and independent of other countries. It should be a never-ending source of power. Hydroelectric power is an effective source, while wind turbines and solar panels are the best energy sources. Alternative-fueled vehicles are growing more and more popular as gasoline costs steadily climb, with a seasonal increase observed every summer in the United States. Many major automakers currently offer hybrid versions of their most popular models, and many more promise that all-electric cars will be available shortly. This is excellent news for the environmentally aware individual who wants to contribute to a cleaner world, reduce their reliance on fossil fuels, and, most significantly, begin saving money by visiting the gas station less often Muetze et al (2001) [1]. While gasoline combustion engines are the most prevalent form of contemporary personal transportation, they are also linked to a number of complicated issues. Petroleum-based fuels are a finite resource that cannot be replenished. Furthermore, when they are burnt, they produce a combination of hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide, all of which have been linked to global warming, ecological, and health-related trends in recent research. Furthermore, reliance on petroleum products has major socio-political consequences in both domestic and international relations. As a result, hybrid vehicle development aims to protect natural resources, decrease harmful emissions, and shift our worldwide reliance on petroleum to a mix of healthier fuel options. Hybrid cars are rapidly gaining traction as a high-performance alternative to gasoline-powered automobiles. In order to increase fuel efficiency and decrease hazardous emissions, several automakers are actively researching hybrid vehicle technologies Koslowsky et al (2002) [2]. A preliminary design phase with the creation of three distinct ideas in parallel that were pushed in various directions in the requirement space and computed and optimized to a reasonably high degree of refinement was utilized in the design process for the electric motorbike. The design space might be spanned in this manner, and solutions in the middle could be interpolated. In this manner, a suitable set of criteria for the subsequent design phases may be established Hallberg et al (2005) [3]. The article describes a new hybrid-electric motorcycle transmission system for controlling the power flow of parallel hybrid-electric motorcycles. This gearbox may work in four distinct modes to optimize performance and minimize emissions: electric-motor mode, engine mode, engine/charging mode, and power mode. In electric-motor mode, the motorbike is driven only by the electric motor at low speeds and during start-up. In power mode, the motorbike is driven by both the electric motor and the engine at the same time to produce maximum power. The arrangement of the engine, motor, battery, and gearbox determines whether the hybrid electric vehicle is serial or parallel. The engine of a parallel hybrid electric car provides both the power to move the vehicle and the energy needed to recharge the battery at the same time Liu et al (2007) [4]. Motorcycles' internal combustion engines may emit up to two times more pollutants than cars, according to research. This article proposes a novel concept for utilizing compressed air as a power source for motorbikes in order to enhance air pollution conditions and remove contaminants exhausting. This motorbike has an air motor instead of an internal combustion engine, which converts the energy of compressed air into mechanical motion energy. With the help of a fuzzy logic speed controller, a prototype is constructed and tested on the road. When the speed is above 20 km/h, the experiment data indicates that the speed inaccuracy is less than 1 km/h and the efficiency is more than 70%.Shen and Hwang (2009) [5]. The compressed air energy is converted into electricity by the air motors. Mechanical energy for transportation They are, on the whole, safer, cleaner, and more environmentally friendly. Compared to, it is less expensive and has a better power-to-weight ratio motors that are powered by electricity Zhang and Nishi (2003) [6]. Becton (2011) [7] designed a electric motorbike drive. The system is expected to have a maximum speed of 70 mph and a range of 40 miles. This driving system achieves the project's objectives by being able to carry a single commuter. With minimal roadside emissions, travel short to moderate distances. The driving system has yet to be installed. It has not been tested, but it has been completely built and is totally functioning. The HW/SW platform created for electric two-wheeled vehicles will be described in this article, as well as the fundamental ECU methodology that will be used to build next-generation electric two-wheeled vehicles. It will allow it to be used in the driving section, power section, integrated controller, and a variety of other applications. Thus, by adding unique characteristics to an existing platform, it is feasible to reduce total cost and time for the development of electric two-wheeled vehicles Jung et al (2012) [8]. Before designing the control system, the control systems were studied. The HW platform is designed for electric motorcycles. A high-performance 32-piece set 16-bit embedded system for power train control, bit embedded system for power train control vehicle system and an 8-bit integrated system. The ability to control one's body is needed vincentelli and Natale (2007) [9]. The PDP's experimental stage should include all of the experiments required to verify and validate a concept's structural requirements. The stiffness test is used to verify the findings of the numerical calculations given earlier in the PDP, whereas the fatigue test is used to validate the product or subsystem under circumstances that are comparable to the real load situations. The application of two finite element analyses (FEA1 and FEA2) bridges the gap between the load cases identification stage and the experimental validation stage, allowing for a stronger correlation between the findings of each relevant phase of the PDP Cristian and Desrochers (2014) [10]. An Internal Combustion Engine (ICE) is linked to a synchronous Electric Machine in the HEM power-train (EM). A conventional three-phase inverter is linked to a high-voltage battery pack to power the EM. HEMs must have low weight and volume, with the Energy Storage System (ESS) being the most important component. Different types of ESSs are evaluated in order to find the optimum balance of cost, volume, and weight. A research technique is provided in order to identify all of the data required to determine the ESS Morandin et al (2013) [11]. The primary aim of this article is to offer an electric motorbike design concept. A reader will discover a complete explanation of the components that make up an electric motorbike, as well as the key issues that must be considered, based on engineering research on electric motors for electric vehicles must consider while developing an electric motorbike idea, as well as the trade-offs that must be made Geometry, ergonomics, and performance issues must be addressed Maioglou (2017) [12]. The goal of this study is to describe the design and construction of a two-wheel drive electric motorbike prototype. The overall method described in this study comprises suggested changes to an existing motorbike chassis to safely and effectively supply power to both front and rear wheels through batteries and electric motors. The ultimate objective is to create a “bolt-on” system aimed at garage hobbyists who can buy all of the required components and complete the conversion in their own garage using standard hobbyist equipment Almeida et al (2018) [13]. The goal is to create an electric vehicle with proportions and capabilities that are similar to those of a commercial vehicle while still being modular and accessible. To accomplish this, component location, as well as vehicle size and geometry, are evaluated equally. To manage wiring, retain important performance characteristics from the donor motorbike, and integrate subsystems and related components into a coherent model, a 3D CAD model of the finished vehicle was developed. Drummond et al (2019) [14].

The research culminated in the Motor Ride Entertainment infotainment idea, which can be accessed through a keypad on the left handlebar, an eight-inch touch display, or a Bluetooth-connected headset. The presence of a display allows for the visual presentation of a variety of information and entertainment elements. A music player, navigation, GPS, and phone communication serve as sources of information and enjoyment. It is possible to access a smart phone's music and communication features by connecting it wirelessly through Bluetooth. To prevent the rider from exceeding mental burden, what functionality is available depending on whether the motorbike is in drive or neutral mode. The infotainment system is intended to make riding in metropolitan areas easier by providing real-time traffic information and alternate routes to avoid traffic congestion depending on the location entered into the navigation. The infotainment system may be linked to the internet at all times, even if it is not connected to a smart phone Kumnova and Imširović (2019) [15]. The researchers utilized inverse differential gear and power mode switching control to create a hybrid electric motorbike in this study (HEM). To provide single/dual power output, an inverse differential gear power splitter was fitted to integrate or disperse the power of an internal combustion engine (ICE). The transmission system was also set up with continuously variable transmission to regulate the transmission speed reduction ratio and maintain power output stability. As a consequence, three power modes may be easily swapped between one another. Finally, a chassis power gauge was used to evaluate our HEM Chen et al (2019) [16]. The effect of climate change on the transportation sector, particularly the power 2 wheeler, is discussed in the first section of this research report. It analyzes various fuels and technology and proposes that a hybrid electric power train might be commercialized. The design, manufacturing, and testing of a hybrid electric motor bike are the subject of this study. It includes the project's objectives, important criteria, methods, and technology. The study concludes with a review of the design, construction, testing, technology, and future concerns Stephens (2020) [17]. The design, fabrication, installation, and testing of a lithium-ion battery system, including a battery management system, for turning a 1999 Honda XR100R motorbike into a fully functioning electric motorcycle are all part of this project. The motorbike is powered by a battery system that provides adequate voltage and amperage to maintain the required power capabilities for a respectable range. The two biggest demands, the DC motor and controller, take approximately 48 to 60 volts from the battery for optimal functioning, providing an approximation of the voltage required Asfaw and Alexander (2020) [18].

2. BATTERY

Dr. John Lowitz, the project's customer and stakeholder, met with the team in the fall of 2011. The Team was commissioned, as well as a second Engineering Capstone. The Vehicle Integration Team—to create an electric vehicle On a motorbike capable of covering 150 kilometers at 70 mph, a single battery charge While the client's goal is to build the first of its kind, The Team's aim over the next several years is to develop an electric "tour" motorbike. He had two years to develop a battery pack that would enable him to travel to fulfill his dream A single battery subpack was created by the team. at the conclusion of the project There are 32 sub-packs in all. a full-size battery pack, and the customer has the option of building it themselves at the same time as integrating a full-size battery pack inside the motorbike at a later time. Sheu and Hsu (2006) [19]. Existing and planned battery/fuel cell motorcycle designs are underpowered and are unlikely to replace gasoline motorcycles anytime soon Chau et al (1999) [20]. At this point, using a hybrid idea of internal-combustion engine and battery to decrease emissions and improve performance is another option. Hybrid electric vehicles (HEVs), mainly cars, have been actively developed and sold in recent years Nagasaka et al (1998) [21]. The technique for sizing battery packs for electric vehicles is presented in this article and applied to the example of an electric motorbike. It is presented a new method of evaluating battery pack performance in a single graphical tool. Its purpose is to assist engineers in gaining a better understanding of the impact of design choices from the outset of the engineering process. Energy, power, volume, and mass are proportional to the total number of cells in multi-cell battery packs, while voltage and current are depending on the series and parallel configuration LeBel et al (2018) [22].

2.1. Lead Acid

Lead acid batteries are made up of lead and lead oxide plates, and sulfuric acid. The electrical energy is created in a reaction between lead and lead oxide, which takes place between the plates suspended in sulfuric acid. This is by far the most common large battery chemistry, and also the best understood. Lead acid batteries, like all battery chemistries, have varying properties depending upon how the battery is constructed internally. These batteries are constructed with many thin lead plates rather than a few thicker plates. This allows them to expose a higher reacting lead surface area, thereby producing more current. This also means that there is less active material in each plate, which results in the battery reacting very badly to a high depth of discharge. This type of battery is only designed to operate within 20 % of a full charge, and will be permanently damaged if discharged more than 50%.

2.2. Nickel Based

Nickel cadmium batteries typically have about twice the energy density of lead acid batteries5, and are capable of very high discharge rates without damage. These facts, paired with a much longer lifecycle of 2500-3000 cycles5 and an ability to discharge more fully on every cycle than lead acid and lithium-ion batteries, make this chemistry a good alternative to deep cycle or AGM lead acid batteries. This type of battery can be charged and discharged very quickly and is more rugged than most other chemistries. Unfortunately these batteries contain high levels of cadmium, which is very environmentally harmful, and they suffer from memory effects under charging and self-discharge when in storage. Nickel metal hydride batteries possess properties similar to those of nickel cadmium batteries, but have approximately two to three times the energy density, and reduced memory effects in comparison. This is the type of battery in many consumer electronics products, and was the type of battery used in the GM EV1 electric vehicle, as well as many other pioneering electric vehicles.

2.3. Lithium-Ion Based

Lithium-ion batteries use carbon based anodes (negative electrodes) and typically use either lithium-cobalt-oxide or lithium-manganese-oxide for the cathode (positive electrode). These metal oxide lithium-ion chemistries are present in most consumer electronics, and are one of the most popular types of rechargeable battery due to their high energy density, lack of memory effects and low self-discharge. This type of battery typically has almost twice the energy density of NiCd cells, and needs very little maintenance over its lifetime, which is in the range of 2000-3000 cycles. High continuous discharge and pulse currents are also possible with lithium-ion chemistries. A few drawbacks to this battery chemistry are its high upfront cost, and the fact that a battery management system to maintain the battery health is absolutely necessary.

3. DESIGN OF ELECTRIC MOTOR VEHICLE

There are three main modes of functioning for the vehicle: Engine, electric, and hybrid switching modes are all available. Two options are available. Regenerative braking mode and Continuous braking mode are other options. method of help Aside from that, the vehicle is self-contained. Set of three gearboxes for electric motors, designed for three different modes of operation. Low speed (high torque), medium speed, and high speed operations suited for high-inclined, urban, and highway environments when in electric mode, this is the case. The greatest speed that may be achieved in city driving, the electric mode has a top speed of 25 km/h and a top speed of 40 km/h on the highway. In electric mode, the range is 50 kilometers per charge. The target range is in hybrid mode, a 100-kilometer run is possible. A two-wheeler with an engine capacity of 80cc. is selected for a specific reason. The car is twelve years old and runs on gasoline. cycle with two strokes. The vehicle has been successfully tested to satisfy the requirements. a planned goal Throughout the project, there is a strong focus on to the greatest degree feasible, on safety, simplicity, and dependability Krishnan and Wani (2015) [23].

3.1. Selection of materials

One of the most challenging jobs for a designer is choosing the right material for technical reasons. The best material is one that accomplishes the intended goal for the least amount of money. When choosing materials, take into account the following aspects Kurmi and Gupta (2005) [24]:

Availability of materials
Material suitability for the working environment, and
Material cost
The aforementioned considerations are taken into account while selecting materials for different components of this project.
The mild steel is the most often utilized material in this project for the following reasons:

The material should have light in weight.
The material able to resist corrosion.
The material should have enough strength.
The material should not distort by heat.
The material should fatigue resistant.
Easy machining
Welding ability

Table 1. List of selected material for the project

Sl.No	Component name	Selected material
1	Battery holder frame	Mild steel
2	DC motor holder frame	Mild steel
3	Outer body cover	Aluminum(sheet metal)
4	Drive shaft	Carbon steel
5	Sprocket gear	Mild steel

3.2. Motorcycle modification Process

The components are installed on the original Honda frame with no modifications. The motorcycle's total weight was reduced due to the use of light weight components. The removal of all superfluous components is the first stage in the motorbike modification procedure. The internal combustion engine, the gas tank, the twist throttle, the transmission system, and the wiring are all included. The braking system, lights and horn, tires, and brake and steering wheel controls are all still on the frame. Figure 1 shows the before and after views of the motorbike.

Before removal of unnecessary components

After removal of unnecessary components

Figure 1. Before and after picture removal of unnecessary components

3.3. DC Motor installation

In order for the two sprockets in the transmission system to be aligned, the motor must be positioned in the proper position. When the engine and gearbox were removed from the motorbike, the DC motor holder was attached to the frame. For stiffness, it was connected to the motorbike frame at five points. The position of the DC motor must be as near to the original drive sprocket location as feasible to avoid the chain from rubbing against the swing arm or frame as shown in figure 2.

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Figure 2. Installed DC motor on the frame

3.4. Battery Installation

After that, the batteries were placed in the frame. It was important to allow enough space between the battery connections and wires. The constructed sub frame was attached to the frame in four places once the batteries were finalized, as illustrated in Figure 3.

Figure 3: Prepared sub frame with motor and batteries installed

3.5. Motor Controller and Charger Installation

After the sub frame was built and the motor and batteries were installed, it was time to decide where the motor controller and charger would go. Because of the additional space between the battery levels and towards the front and top of the motorbike, there were numerous options. On a prepared mounting board, the optimum position was found to be above the top battery level. To prevent a short, the board offered a mounting surface as well as isolation from the top layer of battery connections as sown in figure 4.

Figure 4. Mounting board showing motor controller and charger

The bottom of the gasoline tank was taken out to ensure there was enough room in this area. Because the tank had clearly not been filled with gasoline in a long time, it was filled with water and the bottom was cut out as indicated in figure 5.

Figure 5. Before and after: fuel tank with bottom removed to make room for components

3.6. Cable and Electrical Installation

After removing all superfluous circuits from the wire harness, electrical components such as the rectifier, starting solenoid, and ignition control unit were removed as well. After the primary fuse was blown, the voltage converter input was spliced into the 60 volt wiring system, and the output was spliced into the point that was initially attached to the motorbike starting battery. In lieu of the original battery, this supplied a 12 volt supply to the factory electrical harness. The key switch circuit was spliced into the contactor through a normally open relay, and the side stand switch was spliced into the relay to interrupt the key switch circuit while the side stand was down, preventing the motorbike from moving involuntarily while the rider was not ready.

Two manual disconnect switches were added for safety. The 60 volt circuit that turns on the motor controller is enabled on the EMC left side, while the charging circuit linked to the battery pack is enabled on the EMC right side. Only the open circuit state allows the switch key to be removed.

The existing side stand switch was also kept to allow the "interrupt" relay that was connected into the circuit to shut the contactor. If the side stand is in the down position, this opens the battery pack circuit. After that, the electronic throttle was fitted. Another option for achieving the same functionality is to utilize the current motorbike throttle wire and connect it to a potentiometer box with a variable resistor; however, although this approach saves money, it takes considerably longer to install.

3.7. Safety

It should be emphasized that all component connections were simple to comprehend, requiring just a basic understanding of DC voltage and component sizes for acceptable current amperage. There were no components that needed to be disassembled, dismantled, rewired, or changed in any manner. This was not something to try if you had no experience with DC electricity or if you were uncertain of your ability to read and comprehend electrical component installation instructions. The major dangers involved were shorting circuits, which may have resulted in arcing and very high current.

This project did not utilize a chassis ground system to minimize this danger. All circuits were connected to the wire harness and then to the battery pack's common ground.

This "floating" ground, although not common among car manufacturers, avoided the danger of an exposed "hot" wire coming into touch with the metal frame and creating a short. Incorporated into the motorbike wiring were four major safety measures. A manual disconnect switch that must be turned on in order to energize the motor controller and voltage converter, a key switch that must be turned on in order to partially enable the contactor, and a side stand switch that must close the "interrupt" relay in order for the key switch circuit to enable the contactor. The 80-amp main fuse, which melts and opens the battery pack circuit if any shorts occur, is the fourth safety element.

4. COST ESTIMATION FOR MODIFICATION

The value engineering technique or concept was explored throughout the design process.

Table 1. Modification cost break down

Sl. No	Items	Specification	Cost (ETB)
1	DC motor	2.5 kW and 60V	5,000.00
2	Motor controller	60V and 80A	950.00
3	DC/DC convertor	60V	450.00
4	Contactor	60V	150.00
5	Potentiometer	5 kΩ	200.00
6	Lithium ion battery	60V and 15Ahr	4,500.00
7	Battery charger	60 V and 3A out put	350.00
8	Chain	1473.20 mm length and chain link of 116	180.00
9	Sprockets	14 and 70 teeth	600.00
10	Fuses	Different rating	80.00
11	Wires	Different sizes and color	230.00
12	Switches		400.00
13	Battery holder		326.00
14	DC motor holder		175.00
15	Labor cost		2,000.00
16	Others		900.00
Total costs			**16,491 ETB**

Leitman and Brant (2009) [25] define value engineering as a systematic technique for identifying unnecessary expenditures in design and construction in order to save money without sacrificing quality or performance. The project's design excludes accessories that aren't required for converting a GMC to an EMC. The cost of converting a Honda GMC to an EMC without any changes to the existing frame was estimated to be about 16,500 ETB (Ethiopian Birr). The modification expenses are broken out in Table 1.

4.1. Operating cost of EMC

1. When calculating the cost of owning an electric motorcycle, there are two types of operating costs to consider. The first is the cost of electricity to charge the batteries. In this project, it was assumed that the batteries would never be allowed to dip below 40% charge, necessitating charging to restore electric current to the battery pack. Since electricity is sold by the kilowatt hour (kWh), Christopher and Simcoe (2009) [26] recommend determining the charging cost.
2. The cost of replacing the batteries throughout the length of their useful lives is the second operating cost. Based on riding frequency, Buchmnn (2006) [27] used a lithium ion battery with a 2000 cycle life and a four-year usage duration. The battery pack's $4500 cost would be spread out over the four years of travel.

Determining charging cost per day

$$C_{day} = \frac{I \times V \times t \times C_c}{1000} \quad (1)$$

Where,
Cday is charging cost per day in ETB.
I is charging current in Ampere

V is charging voltage in Volt
t is charging time per day in Hour
CC is charging cost of one kWhr in Birr = 0.5 ETB [ELPA]

In this project once the battery is fully charged the EMC could travel 60 km and it takes maximum 4 hours to recharge those batteries.

$$C_{day} = \frac{2.25 \times 220 \times 4 \times 0.5}{1000}$$

$$= 0.99 \text{ ETB per day}$$

$$C_{km} = \frac{C_{day}}{60} \qquad (2)$$

Where Ckm is charging cost per kilometer in ETB

$$C_{km} = \frac{0.99}{60}$$

$$= 0.017 \text{ ETB per km}$$

Determining charging cost per month

$$C_{month} = C_c \times day\ per\ month \qquad (3)$$

$$= 0.99 \times 30$$

$$= 29.4 \text{ ETB per month}$$

Determining battery cost per day

The operational cost is made up of the cost of renewing the batteries throughout the course of their useful lives. The batteries are expected to be recharged once a day in this project. Since lithium ion batteries have a life cycle of more than 2000 [Linden and Reddy (2002)] [28], and the cost of such batteries is 4500 birr for a four-year estimate based on riding frequency. The cost of replacing the batteries each day throughout the course of their lifetime was estimated using an equation.

$$\mathrm{B_c} = \frac{\text{Cost of battery pack}}{\text{Life cycle}} \qquad (4)$$

Where Bc is cost of battery pack per day

$$B_c = \frac{4500}{2000}$$

$$= 2.25 \text{ ETB per day}$$

Determining total operating cost of EMC per month

$$C_T = \left(C_{day} + B_C\right)30 \qquad (5)$$

$$= (0.99 + 2.25)30$$

$$= 97.20 \text{ birr per month}$$

4.2. Operating cost of gasoline motorcycle

Cost per day to operate an equivalent gasoline motorcycle for 60 km was calculated as follow.

$\mathrm{CG_{day}}$ = Gasoline fuel cost per 60 km

Let Honda motorcycle consume 1 liter gasoline fuel in 30 km driving, it requires 2 liter gasoline fuel per day to drive 60 km.

$$\mathrm{CG_{day}} = \text{fuel consuption in liter} \times \text{gasoline cost per liter} \qquad (6)$$

$$= 2 \times 22$$

$$= 44 \text{ birr per day}$$

So to drive gasoline motorcycle for 60 km per day the operating cost would be 44 RTB.

4.3. Maintenance cost

When comparing costs of maintenance of EMC it is greatly less than the GMC for the same kilometer driving.

4.4. Comparison of modification and operating cost of EMC with cost of GMC

Table 2 below illustrates the comparison of modification and operating cost of EMC with operating cost of GMC. The point at which there is neither loss nor gain of this EMC around 12 month as observed from the graph of figure 6, this point is called breakeven point.

Table 2. Operating cost comparison of EMC with GMC

Month	EMC operating cost (ETB)	GMC operating cost (ETB)
0	16500	0

1	16597.2	1320
8	17277.6	10560
16	18055.2	21120
24	18832.8	31680
32	19610.4	42240
40	20388	52800
48	21165.6	63360

MONTHS

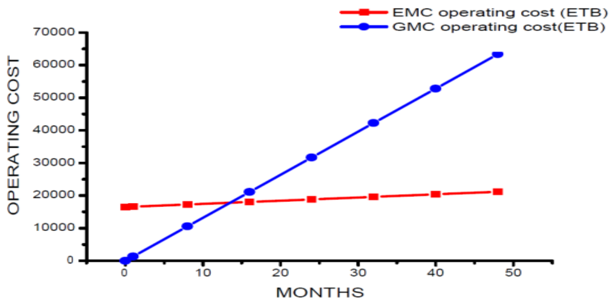

Figure 6. Modification and operating cost of EMC Vs. operating cost of GMC graph

5. RESULT AND DISCUSSION

5.1 Testing the functionality of EMC

Because the intended DC motor is not available in Ethiopia's local market, the following products mentioned in table 3 with different specifications from the designed one are utilized in this project to demonstrate EMC functioning.

Table 3. Components specification for functional testing

Sl. No	Items	Specification
1	Batteries (48 V)	Four 12 volt and 12Ahr capacity battery
2	DC motor	48V, 500 Watt and efficiency of 90%
3	DC motor controller	48V
4	Battery charger	48V and 2A

5.2. No load Testing

The no load test was carried out in this project at Adama Science and Technology University's mechanical and automotive engineering department's work shop. The motorbike was now ready to be put through its paces. For safety concerns, the back wheel was still not attached to the road surface. The first step was to turn on the system and check that it worked.

Figure 7. EMC on safety stand

The sequence for turning on the system is as follows:
Raise the rear wheel and secure the back side frame to the safety stand, as shown in Figure 7.
To turn on the motor controller, turn on the main key switch.
Then, using your right hand, crank the throttle to change the speed of the DC motor.
The battery pack voltage was tested before beginning no load measurements, and it was found to be 51.8 V. The no load test was completed on May 23, 2014, and it took nearly 3 hours to complete. The residual battery voltage after the test was 45.8 V. The following tests are conducted under 1st, 2nd, and 3rd shifts in no load testing of the EMC.

Wheel revolution was measured by using photo type tachometer while wheel was rotating freely and the required rpm was obtained by turning throttle handle.
Current drawn by DC motor was measured by using ammeter
III. Voltage supplied to DC motor from controller was measured by using voltmeter
IV. Power developed by DC motor was calculated by using $P = I \times V \times \eta$ [Vogel , 2009] [29].

5.3. Relation of wheel revolution with current, voltage and power at no load condition

To show the relation the following test results are obtained and listed in table 4.

Table.4. No load test results in 1st shift

Scale 1:1	1:10	1:1	1:1
Wheel Revolution (N) in RPM	Current (I) in A	Volt (V) in V	Power (P) in (watt)
50	1	3.6	0.324
100	2.1	8.8	1.6632
150	3.6	14.6	4.7304
200	5.2	23.2	10.8576
250	6.8	32.3	19.7676
270	5.6	40.1	22.456

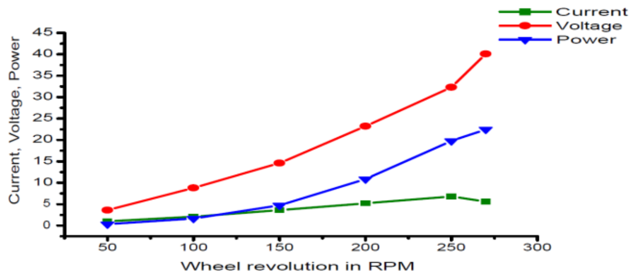

Figure 8. Wheel revolutions Vs Current, Voltage and Power developed graph in 1st shift

When shown in table 4 and figure 8, as the wheel rotation rises, the current provided to the DC motor climbs practically linearly until the maximum power is produced, after which it progressively declines until the wheel revolution reaches its maximum revolution. However, the voltage delivered to the DC motor is proportional to the number of revolutions of the wheel. In the first shift, the maximum wheel revolution was 270 rpm.

Table 5. No load test results in 2nd shift

Scale	1:1	1:10	1:1	1:1
Wheel (RPM)	Revolution	Current I (A)	Volt V in (V)	Power in (watt)
50		0.6	4.4	0.2376
100		1.8	12.3	1.9926
150		3	19.5	5.265
200		4.7	26.9	11.3787
250		5.9	34	18.054
300		6.3	43.4	24.6078
320		5.6	47.8	24.0912

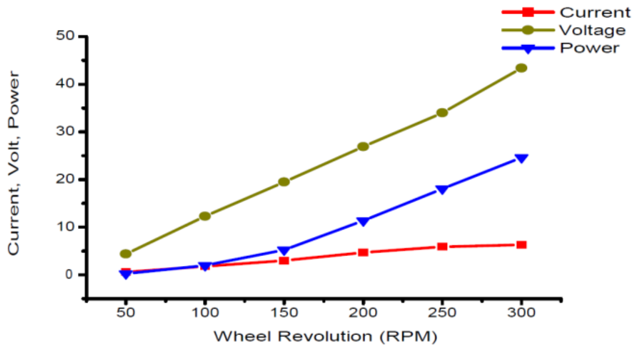

Figure 9. Wheel revolutions Vs Current, Voltage and Power developed graph in 2nd shift

The relationship between wheel rotation and current and voltage is the same with 1st shift, as shown in table 5 and figure 9. In the second gear, the maximum wheel revolution was 320 rpm.

Table 6. No load test results in 3rd shift

Scale	1:1	1:10	1:1	1:1
Wheel (RPM)	Revolution	Current I (A)	Volt V in (V)	Power in (watt)
100		1.15	6.1	0.7015
150		2.2	18.1	3.982
200		4.1	30.5	12.505
250		5.4	40.2	21.708
300		6	48.1	28.86
360		5.6	51	28.56

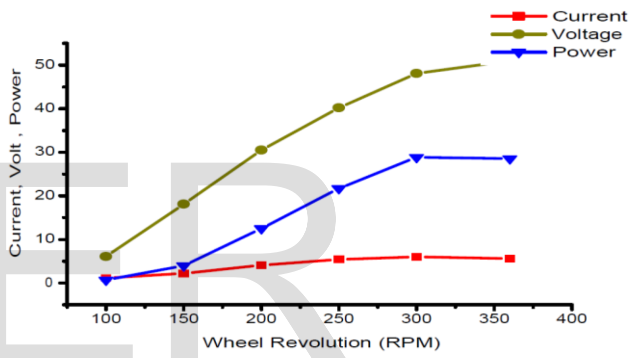

Figure 10. Wheel revolutions Vs Current, Voltage and Power developed graph in 3rd shift

The relationship between wheel rotation and current and voltage is the same for 1st and 2nd shifts, as shown in table 6 and figure 10. However, in the third shift, the wheel begins to spin at nearly 100 rpm, which is why the data at 50 rpm is not included in table 4.4. In third gear, the maximum wheel rotation was 360 rpm.

As the shift is increased, the torque produced by the DC motor decreases. Tables 4, 5, and 6 show that when the shift increases, the current decreases, and because torque and current are directly related, the DC motor torque decreases as well. As the shift rose, the voltage supplied to the DC motor increased as well, resulting in a higher maximum rpm.

5.4 Relation of throttle twist with wheel revolution, current and voltage at no load

To show the relation at different shift position the following test results are obtained and listed in table 7

Table 7. Throttle twist Vs wheel revolution, current, voltage and power developed at no load in 1st shift

Scale 1:1	1:1	1:100	1:5	1:10
Throttle twist in %	Wheel Revolution in rpm	Current in Ampere	Voltage in Volt	Power developed in watt
20	0	0	0	0
40	84	16	35.5	10.224
60	172	42	107.5	81.27
80	225	64	178	205.056
100	270	56	200.5	202.104

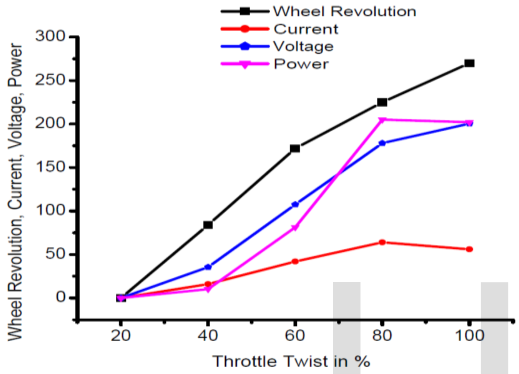

Figure 11. Throttle twist Vs wheel revolution, current, voltage and power developed graph at no load in 1st shift

When the throttle is twisted further, the current provided to the DC motor practically linearly rises up to the point where maximum power is produced, then progressively drops up to the maximum rotation of the wheel, as shown in table 7 and figure 11. However, the amount of throttle twist is exactly proportional to the voltage provided to the DC motor and the wheel rotation.

Table 8 Throttle twist Vs wheel revolution, current, voltage and power developed at no load in 2st shift

Scale 1 .1	1:1	1:100	1:5	1:10
Throttle twist in %	Wheel Revolution in rpm	Current in Ampere	Voltage in Volt	Power developed in watt
20	40	25	0	0
40	140	41	41	30.258
60	230	54	131	127.332
80	280	62	210	234.36
100	320	56	229	230.832

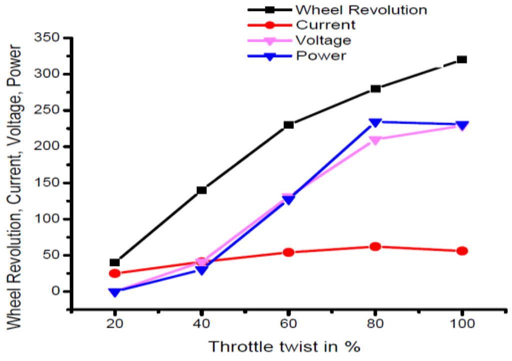

Figure 12. Throttle twist Vs wheel revolution, current, voltage and power developed graph at no load in 2nd shift

As observed from table 8 and figure 12 above the relation of throttle twist with wheel revolution, current and power developed was the same with the 1st shift.

Table 9 Throttle twist Vs wheel revolution, current, voltage and power developed at no load in 3rd shift

Scale 1:1	1:1	1:100	1:5	1:10
Throttle twist in %	Wheel Revolution in rpm	Current in Ampere	Voltage in Volt	Power developed in Watt
20	0	0	3	0
40	122	22	98	43.12
60	234	41	201	164.82
80	302	66	239	315.48
100	360	56	244.5	273.84

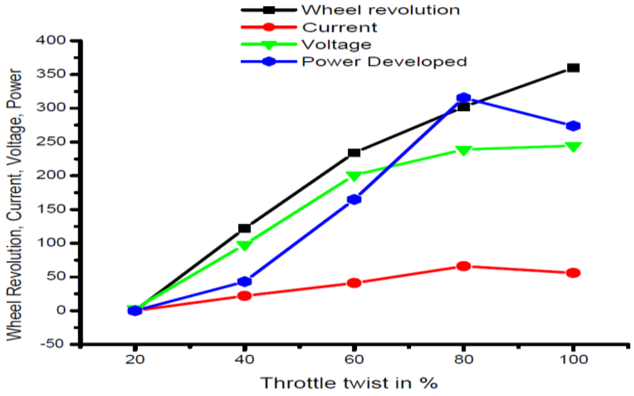

Figure 13 Throttle twist Vs wheel revolution, current, voltage and power developed graph at no load of 3rd shift

The relationship of throttle twist with wheel rotation, current and power produced were the same with the 1st and 2nd shift, as shown in table 9 and figure 13.

The wheel rotation, current, voltage, and power all raise as the shift increases at the same throttle twist position.
In the work shop, I was testing the no load test, as shown in Figure 14

Measuring the current drawn to DC motor by using multimeter

Measuring wheel revolution by using tachometer

Figure 14. Picture captured during no load test

5.5. Road test

After the no load test has accomplished the road test was performed under the following conditions:
The test has performed after battery was fully charged
In the level road
EMC was loaded by driver and one passenger of 130 kg.
Test has accomplished after the functionality of EMC is checked in the road.
Because the gradient angle is not displayed along the road for informational purposes, the road test was not performed on the inclined road.
The display has an empty battery indication for safety purposes, which informs the driver if the battery is about to die. However, once the empty sign was turned on, the battery was capable of driving EMC for 4.8 kilometers, according to the results of a road test. The highest EMC velocity achieved in the road test was 30 km/hr on a flat road.

5.6. Relation of distance traveled Vs remaining battery voltage

The relation between distance traveled and remaining battery voltage was given in a table 10.

Table 10 The relation between distances traveled by EMC and remaining battery voltage

Distance in Meter	Remaining battery voltage in Volt
0	51.3
800	50.7
1600	50.4
2400	50
3300	49.6

Generally, as observed in the above figure 15, when the distance traveled increased the remaining battery voltage was decreased.

5.7. Relation between EMC velocity with current, voltage and power developed

The relationship between EMC velocity with current, voltage and power developed was illustrated in the table 11 below.
Table 11 Relation between EMC velocity with current, voltage and power developed
Scale: 1:1 1:1 1:1 10:1

Speed in Km/hr	Current in Ampere	Voltage in Volt	Power in Watt
5	14.45	16.4	21.3282
10	12.8	22.8	26.2656
15	12.6	31	35.154
20	12	37.9	40.932
25	11.1	44.7	44.6553
30	10.8	45.1	43.8372

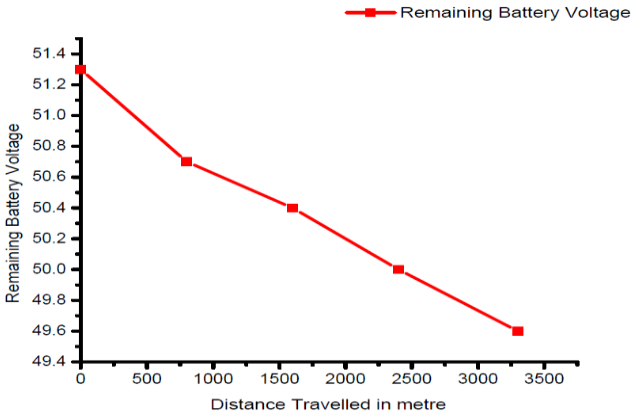

Figure 15. The relation between distances traveled by EMC and remaining battery voltage graph

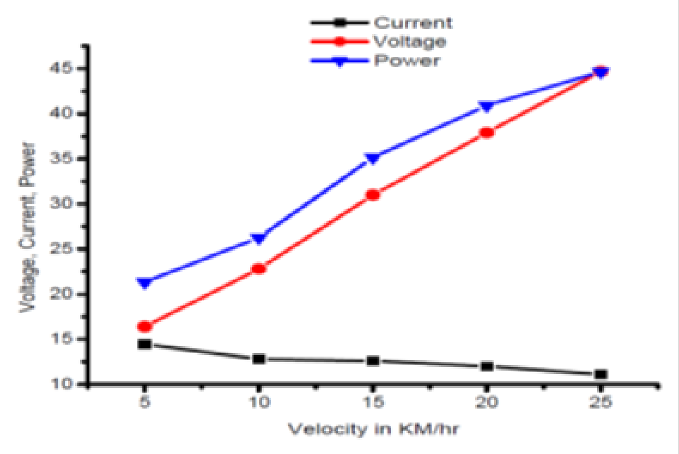

Figure 16. Relation between EMC velocity with current, voltage and power developed graph

When seen in table 11 and figure 16, as velocity increases, the current flow to the DC motor decreases due to the lower torque needed. However, the power produced and the voltage supplied were raised until they reached their maximum power, after which they were somewhat decreased.

6. CONCLUSIONS

This study explains how to convert a gasoline motorbike into an electric motorcycle. As a conclusion to the project, the following points were made. The various kinds of DC motors were compared, and it was discovered that the BLDC motor was chosen for this project since it is more efficient and has higher performance than other motors. Different kinds of batteries for electric motorcycles are reviewed, including the lithium ion battery, which is a good fit for this project because of its efficiency and light weight. Because the electric power supply in my country's cities is enough, it is more appropriate to utilize an EMC rather than a GMC because of the benefits mentioned in the project. The weight and engine of the electric motorbike were calculated. According to estimates, This EMC weighs about 367kg, including the driver and one passenger, and the motor power is 2.5kW, allowing to reach a maximum speed of 50km/h on a flat road. The block diagram for EMC speed control was developed and drawn. The control design includes a DC motor controller, fuse, switch, relay, and potentiometer. The EMC's power transmission components (such as the sprocket and chain) were developed using the proper driving mechanism and calculations. As a result, the conclusion reached is that electric cars have a lot to offer and will play an important role in the future.

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