BRUSHLESS MOTOR WITH MANUAL TRANSMISSION

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SARANSH MEHROTRA (17BTMECH020)

UNDER THE SUPERVISION OF

Dr. ANSHUKA SRIVASTAVA

Professor

Department of Mechanical Engineering

VAUGH INSTITUTE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

SAM HIGGINBOTTOM UNIVERSITY OF AGRICULTURE TECHNOLOGY AND SCIENCES

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DECLARATION

We, Gufran Ahmad and Saransh Mehrotra declare that the work presented in this thesis entitled **'BRUSHLESS MOTOR WITH MANUAL TRANSMISSION'** submitted to the Department of Mechanical Engineering, in the Faculty of Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj, for the award of the Bachelor of Technology in Mechanical Engineering is an original work. We have neither plagiarized nor submitted the same work for the award of any other degree. In case, this undertaking is found incorrect, our degree may be withdrawn unconditionally by the University.

Date:

Place: Prayagraj

Signature of the students:

GUFRAN AHMAD

17BTMECH032

SARANSH MEHROTRA

17BTMECH020

ABSTRACT

A brushless DC electric motor (BLDC motor or BL motor), also known as an electronically commutated motor. This project work focusses on the improvement of efficiency, top speed as well as performance of electric bike. It uses an electronic closed loop controller to switch DC currents to the motor windings producing magnetic fields which effectively rotate in space and which the permanent magnet rotor follows. The controller adjusts the phase and amplitude of the dc current pulses to control the speed and torque of the motor. This control system is an alternative to the mechanical commutator (brushes) used in many conventional electric motors. The construction of brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM). It develops torque by keeping the magnetic field of the rotor (the rotating part of machine) and the stator (the fixed part of machine) misaligned. One or both sets of magnet are electromagnets, made of coil of wire wound around iron core. DC running through the wire winding creates the magnetic field, providing the power, which runs the motor. BLDC motors are capable of high efficiency and is therefore of great use in electric vehicles, hybrid vehicles, personal transporters, and Most electric bicycles use brushless motors that are sometimes built into the wheel hub itself, with the stator fixed solidly to the axle and the magnets attached to and rotating with the wheel. The same principle applied in self-balancing scooter wheels. Most electrically powered RC models use brushless motors because of their high efficiency. Adding Manual Transmission with brushless motors can provide high power-to-weight ratio, high speed, nearly instantaneous control of speed (rpm) and torque, high efficiency, and low maintenance and a motor can pull a lot of weight as well as climb up the slope. Motor can travel a distance up to 30 km per charge as per the theory.

Keywords: Brushless DC motor, Gearbox, Axel shaft, Lithium-ion batteries, Motor controller, Throttle

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Signature of the students:

GUFRAN AHMAD

17BTMECH032

SARANSH MEHROTRA

17BTMECH020

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LIST OF ABBREVIATIONS

Abbreviations	**Description**
AC	Alternating Current
BEV	Battery Electric Vehicles
BLDC	Brushless DC Motor
CVT	Continuously Variable Transmission
DC	Direct Current
E-BIKE	Electric Bike
EMF	Electromotive Force
EMI	Electromagnetic Interference
H2SO4	Sulfuric Acid
IC	Internal Combustion
ICEV-	Internal Combustion Engine Vehicle
LED	Light Emitting Diode
LFP	Lithium Iron Phosphate
LI-ION	Lithium Ion Battery
NI-CD	Nickel – Cadmium Battery
NI-HM	Nickel- Metal Hydride Battery
PAEB	Power Assisted Electric Bicycles
PbO2	Lead Dioxide
PCV	Positive Crankcase Ventilation
PMSM	Permanent Magnet Synchronous Motor
PMW	Pulse Width Modulation
PTO	Power Take- Offs
RC-	Radio Controlled
RPM	Revolutions Per Minute
SO4	Sulfate
UG	Upgrade

LIST OF NOTATIONS

Symbols	Description
A	Ampere
AH	Ampere Hour
KM/H	kilometer Per Hour
KW	Kilo Watt
MPH	Mile Per Hour
V	Volt
W	Watt

CHAPTER-1

INTRODUCTION

INTRODUCTION

Carbon dioxide Emissions are one of the major cause of depletion of ozone layer, which is affecting the environment as well. A traditional Internal Combustion Engine is one of the biggest factor of concern for greenhouse gas emissions.

Brushless Motor with gearbox can be a direct replacement of Internal Combustion Engine. Brushless Motor with Gearbox is very pleasant to drive as compared to internal combustion engine vehicles. The main distinction is that they are extremely quiet, making them very soothing to move with. They also deliver power in an incredibly smooth manner, which eliminates the need for a balancer shaft or crankshaft

As petrol and diesel prices continue to rise and more stringent conditions come into effect on vehicle emissions, motor manufacturers are being encouraged to develop alternatives to traditional internal combustion engine vehicles (ICEVs).

The maintenance of Brushless Motor with gearbox should be less than internal combustion engine vehicles due to less moving parts than conventional petrol / diesel engine. The running costs of Brushless Motor with Gearbox are considerably less for the average commute to work.

1.1 Background and History of Brushless Motor

Brushed DC motor invented within the 19th century and are still common. Brushless DC motors could be possible by the development of solid-state electronics within the 1960. (Brushless DC motor has been shown in figure 1.1)

An electric motor develops torque by keeping the magnetic fields of the rotor (the rotating a part of the machine) and the stator (the fixed part of the machine) misaligned. One or both sets of magnets are electromagnets, made of a coil of wire wound around an iron core. Direct current running through the wire winding creates the magnetic field, providing the power, which runs the motor. The misalignment generates a torque that tries to realign the fields. As the rotor moves, and the fields come into alignment, it is necessary to move either the rotors or the stator's field to maintain the misalignment and still generate torque and movement. The device that moves the fields based on the position of the rotor called a commutator.

Figure 1.1 Brushless DC Motor

1.2 Brush commutator

A commutator is a rotary switch on the motor's shaft called a commutator. It consists of a rotating cylinder divided into multiple metal contact segments on the rotor. The segments connected to conductor windings on the rotor. Two or more stationary contacts called brushes, made from a soft conductor like graphite, press against the commutator, making sliding electrical contact with successive segments because the rotor turns. The brushes selectively provide electric current to the windings. As the rotor rotates, the commutator selects different windings and therefore the directional current applied to a given winding such that the rotor's magnetic field remains misaligned with the stator and creates a torque in one direction.

1.2.1 Disadvantages of commutator

The commutator has disadvantages that has led to a decline in use of brushed motors. These disadvantages are:

- The friction of the brushes sliding along the rotating commutator segments causes power losses that can be significant during a low power motor.
- The soft brush material wears down due to friction, creating dust, and eventually the brushes must replace. This makes commutated motors unsuitable for low particulate or sealed applications like hard disk motors, and for applications that need maintenance-free operation.
- The electrical resistance of the sliding brush contact causes a voltage drop within the motor circuit called brush drop, which consumes energy.
- The repeated abrupt switching of the current through the inductance of the windings causes sparks at the commutator contacts, which may be a fire hazard in explosive atmospheres and a source of electronic noise, which may cause electromagnetic interference in nearby microelectronic circuits.

During the last hundred years, high-power DC brushed motors, once the mainstay of industry, replaced by alternating current (AC) synchronous motors. Today, brushed motors only used in low power applications or where only DC is available, but the above drawbacks limit their use even in these applications.

1.3 Brushless solution

In brushless DC motors, an electronic servo system replaces the mechanical commutator contacts. An electronic sensor detects the angle of the rotor and controls semiconductor switches like transistors which switch current through the windings, either reversing the direction of the present or, in some motors turning it off, at the right angle therefore the electromagnets create torque in one direction. The elimination of the sliding contact allows brushless motors to possess less friction and longer life; their working life is merely limited by the lifetime of their bearings

Brushed DC motors develop a maximum torque when stationary, linearly decreasing as velocity increases. Brushless motors often overcome some limitations of brushed motors; they include higher efficiency and lower susceptibility to mechanical wear.

These benefits come at the value of probably less rugged, more complex, and costlier control electronics.

A typical brushless motor has permanent magnets that rotate around a hard and fast armature, eliminating problems related to connecting current to the moving armature. An electronic controller replaces the commutator assembly of the brushed DC motor, which continually switches the phase to the windings to stay the motor turning. The controller performs similar timed power distribution by employing a solid-state circuit instead of the commutator system.

Brushless motors offer several advantages over brushed DC motors, including high torque to weight ratio, increased efficiency producing more torque per watt, increased reliability, reduced noise, longer lifetime by eliminating brush and commutator erosion, elimination of ionizing sparks from the commutator, and an overall reduction of electromagnetic interference (EMI). With no windings on the rotor, they are not subjected to centrifugal forces, and since the windings are supported by the housing, they will be cooled by conduction, requiring no airflow inside the motor for cooling. This successively means the motor's internals are often entirely enclosed and guarded from dirt or other outside matter.

Brushless motor commutation often implemented in software employing, a microcontroller, or may alternatively be implemented using analog or digital circuits. Commutation with electronics rather than brushes allows for greater flexibility and capabilities not available with brushed DC motors, including speed limiting, micro stepping operation for slow and fine motion control, and a holding torque when stationary. Controller software often customized to the precise motor used within the application, leading to greater commutation efficiency.

The maximum power, which will applied, to a brushless motor restricted almost exclusively by heat. This is due to an excessive amount of heat weakens the magnets and can damage the windings' insulation.

When converting electricity into mechanical power, brushless motors are more efficient than brushed motors primarily due to the absence of brushes, which reduces energy loss due to friction. The improved efficiency is greatest within the no-load and low-load regions of the motor's performance curve.

Environments and requirements where manufacturers use brushless-type DC motors include - maintenance-free operation, high speeds, and operation where sparking is hazardous (i.e. explosive environments) or could affect electronically sensitive equipment.

The construction of a brushless motor resembles a stepper motor, but the two motors have important differences due to differences in implementation and operation. While stepper motors frequently stopped with the rotor during a defined position, a brushless motor typically intended to supply continuous rotation. Both motor types may have a rotor position sensor for internal feedback. Both a stepper motor and a well-designed brushless motor can hold finite torque at zero RPM

1.3.1 Application of Brushless DC Motor

Brushless motors fulfill many functions originally performed by brushed DC motors, but cost and control complexity prevents brushless motors from replacing brushed motors completely within the lowest-cost areas. Nevertheless, brushless motors have come to dominate many applications, particularly devices like computer hard drives and CD/DVD players. Small cooling fans in equipment are powered exclusively by brushless motors. They can found in cordless power tools where the increased efficiency of the motor results in longer periods of use before the battery needs to be charged. Low speed, low power brushless motors are utilized in direct-drive turntables for gramophone records.

1.4 Introduction of Electric Bike

An electric bike, also referred to as an e-bike is a bike with an integrated electric motor used to assist propulsion. Many kinds of e-bikes are available worldwide, but they typically fall under two broad categories: bikes that assist the rider's pedal-power and bikes that add a throttle, integrating moped-style functionality. E-bikes use rechargeable batteries and typically travel up to 25 to 32 km/h (16 to 20 mph). High-powered varieties can often travel more than 45 km/h (28 mph).

1.4.1 Background and History of Electric Bike

In the 1890s, electric bicycles documented within various U.S. patents. For instance, on 31 December 1895, Ogden Bolton Jr. granted U.S. Patent 552,271 for a battery-powered bicycle with "6-pole brush-and-commutator DC (DC) hub motor mounted within the rear wheel". There have been no gears and therefore the motor could draw up to 100 amperes (A) from a 10-volt battery.

Two years later, in 1897, Hosea W. Libbey of Boston invented an electrical bicycle (U.S. Patent 596,272) that propelled by a "double electric motor". The motor designed within the hub of the crankset axle. This model later re-invented and imitated within the late 1990s by Giant Lafree e-bikes.

By 1898 a rear-wheel drive electric bicycle, which used a belt along the surface fringe of the wheel, was patented by Mathew J. Steffens. Also, the 1899 U.S. Patent 627,066 by John Schnepf depicted a rear-wheel friction “roller-wheel” style drive electric bicycle. Schnepf's invention was later re-examined and expanded in 1969 by G.A. Wood Jr. together with his U.S. Patent 3,431,994. Wood's device used 4 fractional horsepower motors; connected through a series of gears.

Torque sensors and power controls developed within the late 1990s. For instance, Takada Yutky of Japan filed a patent in 1997 for such a tool. In 1992, Vector Services Limited offered and sold an e-bike dubbed Zike. The bicycle included NiCd batteries that built into a frame member and included an 850 g permanent-magnet motor. Despite the Zike, in 1992 hardly any commercial e-bikes were available.

Yamaha, a Japanese automotive giant built one among the first prototypes of e-bike back in 1989 and invented the pedal assist system in 1993.

Production grew from 1993 to 2004 by an estimated 35%. Against this, consistent with Gartner, in 1995 regular bicycle production decreased from its peak 107 million units.

Some of the less costly e-bikes used bulky lead acid batteries, whereas newer models generally used NiMH, NiCd, and/or Li-ion batteries, which offered lighter, denser capacity batteries. Performance varies; however, generally there is a rise in range and speed with the latter battery types.

By 2001 the terms e-bike, power bike, "pedelec", pedal-assisted, and power-assisted bicycle were commonly wont to ask e-bikes. The terms "electric motorbike" or "e-motorbike" ask more powerful models that attain up to 80 km/h (50 mph).

In a parallel hybrid motorized bicycle, like the aforementioned 1897 invention by Hosea W. Libbey, human and motor inputs are mechanically coupled either within the bottom bracket, the rear wheel, or the front wheel, whereas during a (mechanical) series hybrid cycle, the human and motor inputs are coupled through differential gearing. In an (electronic) series hybrid cycle, human power converted into electricity and fed directly into the motor and mostly additional electricity supplied from a battery.

By 2007, e-bikes thought to make up 10 to 20 percent of all two-wheeled vehicles on the streets of many major Chinese cities. A typical unit requires 8 hours to charge the battery, which provides the range of 25 to 30 miles (40 to 48 km), at the speed of around 20 km/h.

1.5 Types of motors

- **DC Series Motor**

High starting torque capability of the DC Series motor makes it a suitable option for traction application. It was the most widely used motor for traction application in the early 1900s. The advantages of this motor are easy speed control and it can withstand a sudden increase in load. All these characteristics make it an ideal traction motor. The main drawback of DC series motor is high maintenance due to brushes and commutators. These motors used in Indian railways. This motor comes under the category of DC brushed motors.

- **Brushless DC Motors**

It is similar to DC motors with Permanent Magnets. It has called brushless because it does not have the commutator and brush arrangement. The commutation done electronically in this motor because of this BLDC motors are maintenance free. BLDC motors have traction characteristics like high starting torque, high efficiency around 95-98%, etc. BLDC motors are suitable for high power density design approach. The BLDC motors are the most preferred motors for the electric vehicle application due to its traction characteristics. You can learn more about BLDC motors by comparing it with normal brushed motor.

- **Permanent Magnet Synchronous Motor (PMSM)**

This motor is also similar to BLDC motor, which has permanent magnets on the rotor. Similar to BLDC motors these motors also have traction characteristics like high power density and high efficiency. The difference is that PMSM has sinusoidal back EMF whereas BLDC has trapezoidal back EMF. Permanent Magnet Synchronous motors are available for higher power ratings (photograph of a cut model of a permanent magnet synchronous motor has been shown in figure 1.2).

PMSM is the best choice for high performance applications like cars, buses. Despite the high cost, PMSM is providing stiff competition to induction motors due to increased efficiency than the latter. PMSM is also costlier than BLDC motors. Most of the automotive manufacturers use PMSM motors for their hybrid and electric vehicles. For example, Toyota Prius, Chevrolet Bolt EV, Ford Focus Electric, zero motorcycles S/SR, Nissan Leaf, Honda Accord, BMW i3, etc. use PMSM motor for propulsion.

Figure 1.2 PERMANENT MAGNET SYNCHRONOUS MOTOR

- **Three Phase AC Induction Motors**

The induction motors do not have a high starting toque like DC series motors under fixed voltage and fixed frequency operation. But this characteristic can be altered by using various control techniques like FOC or v/f methods. By using these control methods, the maximum torque made available at the starting of the motor, which is suitable for traction application. Squirrel cage induction motors have a long life due to less maintenance. Induction motors can designed up to an efficiency of 92-95%. The drawback of an induction motor is that it requires complex inverter circuit and control of the motor is difficult. (Three phase ac induction motors has been shown in figure 1.3)

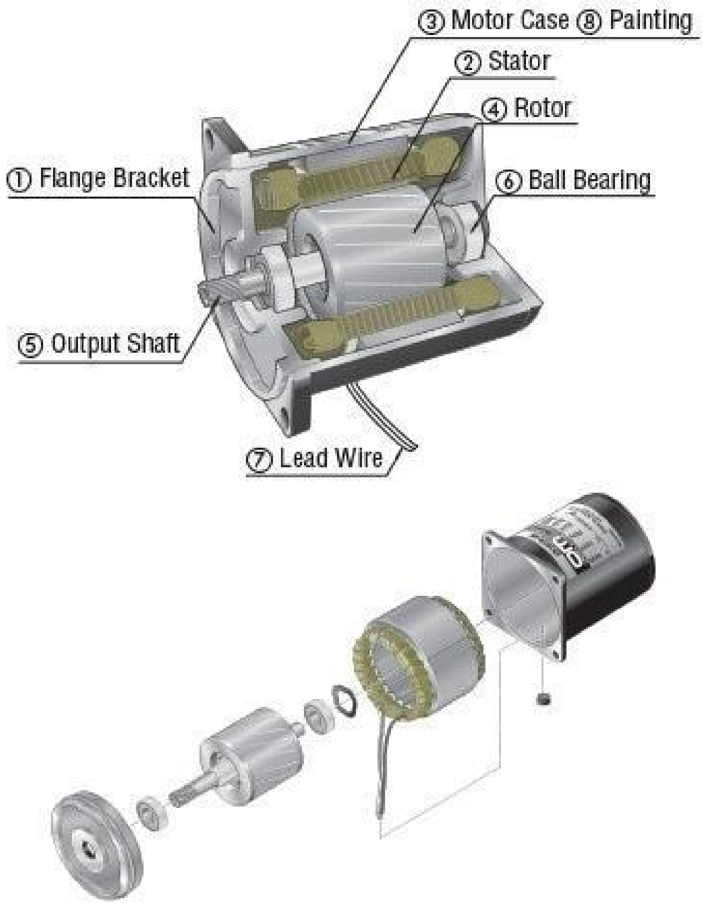

Figure 1.3 THREE PHASE AC INDUCTION MOTORS

In this project we use BLDC (Motor) (Brushless Direct Current motor) rated up to 48V and 150 amps.

We use BLDC (motor) because These BLDC motors are having high power saving advantage as compared to normal conventional motor.

The simple type of motor is a brushless DC motor in these the electrical current passed through the coils, which arranged by a fixed magnetic field.

In the magnetic field the current are generated cause coil assembly to rotate, each coil is being pushed away from the like pole and pulled towards the unlike pole of the fixed field where brushes that make contact with a rotating commutator that cause the reversal of the current through coil.

Fixed brushes supplies the rotating commutator with electric energy, as commutator rotates it continuously flips the direction of current into the coil for maintaining an appropriate rightward rotation. The commutator rotates because it attached with the rotor in which the coils being mounted.

This BLDC Motor have six holes in the end, which makes it easy to mount on flat surface of aluminum or steel. Some motor have foot on the bottom of them for mounting, which makes it difficult to use.

In BLDC motor the permanent magnets rotates and rotations achieved by changing the direction of magnetic field.

To control the rotation an adjustment is required in the magnitude and the direction of current in these coils.

Since in case of (BLDC) motor a rotor is the permanent magnet so it did not requires any electric or current, which eliminates the need of commutator and brushes. Current can be controlled from outside for fixed coils.

Advantage of BLDC motor

- One of the biggest advantage of BLDC motor is its efficiency and the other is these motors can be continuously controlled at maximum torque only at certain point of rotation.
- If brushed motor needs to deliver the same amount of torque as brushless motor than it would need to use the large magnet so that's why, even a small brushless motor are more powerful than conventional brushed motor of its same.
- BLDC motor is controllable with the help of BLDC controller or a feedback mechanism to deliver precisely the desired torque and rotation speed.
- Delivering the précised amount of energy can reduce excess consumption and heat generation and helps in preserving the battery life.
- These provides a very high durability and low electric noise generation because of unavailability of brushes while in case of brushed motors the brushes and commutator wear down in short interval as a result of continuous moving contact and also generates spark where contacts are made.

These days BLDC motors used in electric powered vehicles washing machine, air conditioner and other consumer electronics

However, in our case we are using this in our project and combining it with a 5-speed manual transmission gearbox.

Disadvantages of Brushless DC motor

Just like in all the other devices, brushless DC motors also have few shortcomings as compared to other motors. As brushless DC motor outperforms brushed DC motor in many cases, however, brushless DC motor also has few shortcomings, which discussed below:

- The cost of a brushless DC motor is comparatively higher as compared to brushed DC motor and the electronic controller also increases the cost of overall setup, as in a traditional motor, low-cost mechanical commutation setup involving brushes is used.
- When brushless DC motor operated at low speed, slight vibrations occur during low-speed rotation. However, vibrations reduce at high speed.
- Due to the inherent natural vibration frequency of brushless DC motor, sometimes this natural frequency can match or can come closer to the vibration frequency of the body or plastic parts resulting in the occurrence of resonance phenomenon. However, this resonance can minimized by adjustment, and it is common to observe resonance phenomenon in many brushless DC motor-based devices.
- Brushed DC motors are easy to operate having simple wiring as the positive terminal is connected to positive, negative terminal is connected to negative wire, and motor starts to rotate. However, in the case of brushless DC motor, wiring and operation of the motor are not that simple due to the involvement of electronic control and its link to all the electromagnets.

CHAPTER-2
REVIEW OF LITERATURE

RIVEW OF LITERATUTE

Bottiglione et al. (2014) examined battery electric vehicles (BEVs) represent a possible sustainable solution for private urban transportation. Presently, the foremost limiting characteristic of BEVs is their short range, mainly due to battery technology limitations. a correct design and control of the drive train, aimed toward reducing the facility losses and thus increasing BEV range, can contribute to form the electrification of urban transportation a convenient choice. This paper demosntrated a simulation-based comparison of the energy efficiency performance of six drivetrain architectures for BEVs. Although many various drivetrain and transmission architectures proposed for BEVs, no literature found regarding BEVs equipped with infinitely variable transmissions (IVTs).

Adnan, A., and Ishak, D. (2009) describes finite element modeling and analysis of 3-phase brushless DC motor for direct-drive application with low speed and high torque capability. The motor meant to use as traction drive in an electrical bicycle. The proposed motor has external rotor configuration with surface mounted NdFeB magnets. Motor transmission is gearless in order that it will increase motor efficiency and reduce overall system weight. Calculation of motor parameters are made by means of finite element method i.e. Opera 2d software. Three motor designs having fractional slot and pole numbers considered for this project. Their electromagnetic characteristics and performances like cogging torque, line-line back-emf, phase back-emf, torque output, torque ripples, inductances, and iron saturation level and magnet demagnetization issue computed and analyzed. From the FE results, it is observed that 9-slot/10-pole pm motor is that the most suitable option and will built as a prototype motor and configured into the wheel hub of an electrical bicycle.

Scrosati (2000) stated that lithium ion batteries are still the thing of intense research mainly aimed to the characterization of improved electrode and electrolyte materials.

The recent advances in carbonaceous and alternative anodes, in medium and high-voltage cathodes and in liquid and polymer electrolytes are here reviewed and discussed. It demonstrated that the lithium ion batteries is perfect for the electric vehicle.

Nagendran, R., and Kumar, K. S (2010) stated that ever-increasing rise in inflation, fuel costs and taxation; they endeavor to style and fabricate a fuel-efficient bike, which is of low cost and high efficiency. It has proposed to beat the drawbacks of existing electric bikes, which are currently available within the market. Our proposal `The Hybrid Bike with 3-speed transmission system' is an electromechanical system, which consists of two phases. Within the first phase, it works as an electrical bike, which is eco-friendly, and within the second phase, it works on an IC engine. The second phase employed only the battery discharged completely and through high-speed application. This paper analyze the importance of electric vehicle.

Astegiano et al (2015) stated that in recent decades different studies focused on environment. In this context, the electric bike is gaining more and more popularity. In this paper, they propose a preliminary analysis over the factors correlated with the ownership of an e-bike and an overview about how people changed their mobility habits after the acquisition of the e-bike. It can change the revolution of i.c engine bike

Mutyala, S., and Tech, M. (2019) analyzed that Modern world demands the high technology which can solve the current and future problems. Fossil fuel shortage is the main problem now a day. Considering current rate of usage of fossil fuels will let its life up to next five decades only. Undesirable climate change is the red indication for not to use more fossil fuel any more. Best alternative for the automobile fuels to provide the mobility and transportation to peoples is sustainable electrical motorbike. This paper demonstrated that the Future e-motorbike is the best technical application as a visionary solution for the better world and upcoming generation. E-motorbike comprises the features like artificial intelligence, noiseless operation, and low vehicle running cost, lightweight.

Spanoudakis et al. (2019) stated that the growth of electric vehicles share of total passenger-vehicle sales is evident and expected to be a very big market segment by 2030. Range of travel and pricing are the most influencing factors that affect their gain in market share. As so, powertrain development is a key technology factor researched by the automotive industry. To explore, among others, how the energy consumption of zero emission vehicles affected by different transmissions, they developed, built and installed a variety of them on a custom hydrogen fuel cell powered urban vehicle. In this work, we present a comparison of the effect, on the energy consumption of the proposed testbed, of a prototype custom build 2-speed gearbox and a single stage transmission. It demonstrated Results presented show a reduction of the overall energy consumption with the use of the 2-speed gearbox, compared to single stage, as well as the effect of gear change speed, related to speed, in energy consumption.

Kumar et al (2013) stated Brushless Direct Current (BLDC) Motors are gaining rapid popularity and used in many applications. One such application is automobiles where the BLDC (motors) used to run the electric vehicles such as e-bikes and e-cars. For commutating a BLDC (Motor), Trapezoidal Algorithm used ubiquitously. However, Trapezoidal Algorithm has limitations such as utilizing the motor's efficiency to the maximum. In theory, it known that the sinusoidal and FOC algorithms can overcome the limitations of Trapezoidal commutation. In order to implement sinusoidal and FOC algorithms, the exact position (angle) needed. In this paper, measurement of the position (angle) information along with a new sensor drive scheme of BLDC Motor for commutation using Magnetic Rotary Encoder AS5048A fabricated at ams presented. The paper review on the (BLDC) motor are main application of electric bikes.

Mantriota, G (2005) examined continuously variable transmissions have made notable progress, especially in the automotive industry, in recent years. In this work we study the performance of a mid passenger car provided with an original Power Split CVT (PS-CVT) system. The main advantage of the proposed solution is to improve the efficiency of the CVT by means of a power flow without recirculation using two separate phases of operation. It demonstrated that the means of a simulation model, they evaluate the vehicle's fuel consumption with the hypothesis to consider the value of transmission ratio speed that minimizes the specific fuel consumption.

Jones et al. (2013) examined many Asian cities are experiencing rapid growth in the ownership of personal gasoline powered motorcycles, a shift away from relatively low-emitting modes of transportation that is contributing to deteriorated air quality. Electric two-wheelers have the potential for significant air pollution reductions as an alternative to gasoline-powered motorcycles; however, they have yet to penetrate many Asian markets. While previous research has examined the adoption of cleaner alternatives to gasoline-powered automobiles (e.g., hybrid electric cars), similar work on motorcycle alternatives is lacking. This study uses a stated preference survey of households in Hanoi, Vietnam to analyze adoption of electric two-wheelers, while focusing on the effects of economic incentives (e.g., differential sales taxes and fuel prices) and technological improvements (e.g., more efficient batteries). A choice model estimated and market shares calculated for scenarios involving different levels of electric two-wheeler technology, gasoline prices, and sales tax rates. Results indicate that technological improvements and economic incentives, particularly sales taxes, have significant effects on adoption.

Chlebosz et al. (2010) described the comparison and optimization of a drive system used in an electric bike with outer and inner rotor permanent magnet brushless motor based on theoretical and experimental analysis of e-bike drive. The analyzed e-bike was equipped with the permanent magnet brushless synchronous motor with mechanical output power in range of 250W. The electric motor together with a planetary gear mounted in a hub of 26-inch bike wheel. This kind of e-bike can reach maximum speed up to 25km/h. The aim of this paper is to investigate drive system used in the commercial e-bike with outer rotor, and theoretical analysis this same system combined with permanent magnet brushless motor with inner rotor. Because of work, the optimized motor topology with inner rotor presented.

Matey et al. (2017) the main aim of this paper is to give the exact view by bridling the various sources of energy available to people. In today's modernized world, travelling is very essential for human beings in order to protract in this world. In addition, to do so his travelling should done in minimum possible way. This paper details about the Electric Bike, which runs on the battery thereby providing voltage to the motor. This paper compromises with design and fabrication of Electric Bike, which makes use of Electric energy as the primary source and solar energy if possible by attaching solar panels. It also highlights on the design aspects of the bike. There is a provision for a charging the battery by ejecting it from the main system. It shows the electrical power generated which used to run the bike can give better fuel economy compared to conventional vehicle, better performance and causes less pollution.

Inte, R. A., and Jurca, F. N (2016) described that the design and analysis of the performance of an electrical machine proposed to use for the propulsion of an electric bike. The electrical machine under study in this paper is a flux synchronous reluctance machine (with outer rotor. The study design requires the analytical analysis in SPEED program, followed by a numerical one (Flux 2D) in order to obtain the performances of the proposed machine. It shows the motor can get the better performance.

Parab et al. (2015) described that the Increasing demand for non-polluting mechanized transportation has revived the interest in the use of electric power for personal transportation and reduced reliance on automobiles. Electric bike is a low cost alternative to an automobile. The project based on the fabrication of an electric bike that will help to commute the last mile. The system consists of a battery power source. A BLDC (motor) controller to control a 350W 60V 2.2A DC hub motor, which runs off by a 60V 2.2Ah Lithium Ion battery for better performance, controls the power module. A Folding Mechanism is also available which makes the E Bike compact in size. The final system has features that will appeal to a broad spectrum of users.

Sindhwani et al. (2014) this paper based on the longer-term needs of one normal being. A shift away from conventionally fueled land transportation vehicles towards greater use of renewable energy fuel sources is required to manage increasing vehicle usage. Moreover, associated adverse environmental and human health impacts. Power assisted electric bicycles (PAEBs) provide a way to scale back vehicle emissions within urban areas first stated by Graham S. Akenhead. The paper represent the improvement of fifty in efficiency of e-bike with hub motor incorporated within the rear wheel for producing the initial torque required to set the vehicle from rest to motion and main motor incorporated along with the chain drive for further power transmission which can eventually lead improvement that might be visible within the final model.

Lu, L et al. (2012) described to compared with other commonly used batteries; lithium-ion batteries was featured by high energy density, high power density, long service life and environmental friendliness and thus have found wide application within the area of consumer electronics. However, lithium-ion batteries for vehicles have high capacity and enormous serial-parallel numbers, which, including such problems as safety, durability, uniformity and price, imposes limitations on the wide application of lithium-ion batteries within the vehicle. The narrow area during which lithium-ion batteries operate with safety and reliability necessitates the effective control and management of battery management system. This present paper, through the analysis of literature and together with their practical experience, introduces the composition of the battery management system (BMS). In addition, its key issues like battery cell, voltage measurement, battery states estimation, battery uniformity and equalization, battery fault diagnosis and so on, within the hope of providing some inspirations to the planning and research of the battery management system.

Liu, K et al. (2018) stated that Lithium-ion batteries (LIBs) considered one among the foremost important energy storage technologies. As the energy density of batteries increases, battery safety becomes even more critical if the energy released unintentionally. Accidents associated with fires and explosions of LIBs occur frequently worldwide. Some have caused serious threats to human life and health and have led to numerous product recalls by manufacturers. These incidents are reminders that safety may be a prerequisite for batteries, and high issues have to be resolved before the future application of high-energy battery systems. This Review aims to summarize the basics of the origins of LIB questions of safety and highlight recent key progress in materials design to enhance LIB safety. This paper Review inspire further improvement in battery safety, especially for emerging LIBs with high-= energy density.

Hazari et al. (2014) Growing need for top productivity is placing new demands on mechanisms connected with electrical motors. The demand for low cost Brushless DC (BLDC) motor has increased in industrial applications. An easy BLDC motor control algorithm for low cost motor drive applications using general-purpose microcontrollers has created and presented during this paper. Proposed design will allow the user to rotate the motor either clockwise or counter clockwise direction. Counting on the rotor position the sensor will give response to the controller circuit. Then the controller circuit will fix the direction of current following to the stator. The design controller circuit additionally implemented. The general design consists of microcontroller circuit, logic gates, switching devices (MOSFET/BJT), BLDC (motor), and sensors.

Yu, L et al. (2019) the comprehensive fault diagnosis method has been developed to research the failure of the multi-disc clutch. The mechanical buckling model developed to research the connection between the resistance torque and therefore the periodic circumferential bright spots. The contact pressure and temperature on the friction surfaces obtained with the consideration of the concentrated reactive load of the circle. The friction and wear characteristics of the friction disc under different temperature conditions was explored by the pin-on-disc test, and then the surface morphologies of tested discs are observed by the metalloscope. The results demonstrate that both the thermal buckling and therefore the mechanical buckling may result within the mechanical-thermal buckling. As the temperature varies from 15 °C to 400 °C, the disc experiences the abrasive wear; ploughing wear; adhesive wear and delamination wear so as. Finally, the mechanical-thermal safety boundaries are proposed. Moreover, the paper provides some suggestions for better design of clutch: the circlip should optimized to avoid stress concentration; the teeth number of separate plates should increase to enhance the torque transmission capacity; the thickness of separate plates should vary which may determine by their axial positions within the clutch pack.

Kumar, A et al. (2014) the main objective of this research work is to review the effect of mechanical properties of materials on natural frequency and mode shapes of heavy vehicle gearbox transmission casing. Material mechanical properties play a crucial role for evaluation of frequency, deformation, stress and strain. Four materials have different density and therefore the origin of fabric different. Grey forged iron has damping property, steel has high density and rigidity, Al and Mg alloys have low density. Free vibration study performed for the vibration response study of casing. Grey forged iron grade FG 260, Structural Steel.

Morcos et al. (2000) author presents a comparative study of the performance of two sorts of battery chargers developed for electric vehicles. The primary charger may be a microprocessor-based Ferro resonant battery charger, mentioned because the Ferro resonant charger. The power delivery section of this charger may be a Ferro resonant transformer, which exploits the saturation of magnetic materials through its capacitor winding to supply a well-regulated output that resembles a square wave. The control section periodically places a resistive load across the battery under charge that permits this alteration in resistance to detect. A microprocessor controls the timing and executes the gating of the needed switches within the circuit then gathers and analyzes data from the battery charge monitor. The monitor circuit measures the drop across the battery, which is proportional to the battery internal resistance when the load introduced.

Spagnol et al. (2012) introduced energy and environmental considerations, new paradigms for urban mobility and transportation increased within the past few years the interest on Light Electric Vehicle (LEV). Therein context, Electrically Power Assisted Cycles (EPACs) received an excellent attention: several efforts made to enhance their performance in terms of autonomy, weight, esthetic and feeling with the driving force. During this work, project and realization of a full hybrid electric bike (HEB) presented. the most idea, borrowed from the more explored 4-wheel world, is to use the possible energy fluxes between cyclist and motor so as to enhance the efficiency of the first engine (the human body) being completely self-sustaining and grid-independent (differently to all or any the opposite EPACs). Collected biometric data that cause the algorithm design presented intimately focusing particularly on human metabolic efficiency measurement. Finally, the experiment performed in cycling track compares the mechanical and metabolic results between traditional and hybrid electric bike.

Chawrasia et al (2020) stated that the inner rotor and outer rotor brushless dc motors are hip nowadays as they currently used in designing electric bikes. BLDC motors have a good range of benefits (like higher efficiency smaller size). The E-Magnetic analysis and Lab model analysis are a crucial a part of designing an outer rotor BLDC Hub motor because the motor attached to the wheels of the bike. It is significantly different from a petroleum engine motorbike as during a petrol engine motorbike, the engine and therefore the wheel are separate. So, any heating of the engine wouldn't heat the wheel except for the case of an electrical bike, so the hub motor and therefore the bike wheel aren't separated from one another , heating of the hub motor would produce an identical sort of heating within the wheels.

Ameta et al. (2021) research on the producing a decisive amount of electricity from a bicycle or converting the energy into electricity while travelling protracted distances has always been a myth. During this context, we are asserting a unique idea of generating electricity employing a hybrid bicycle. This paper aims at developing a piezoelectric generator, which harvests energy through pedaling; a piezoelectric transducer is an electro-mechanical converter that converts mechanical vibrations into pulsating EMF. This voltage harvested by a micro energy harvester and stored by suitable circuitry. In addition, this paper presents a scientific design of proposed circuit that permits us to harness energy under both ideal and realistic constraints. By taking this appropriate mechanism to an entire new horizon, they will finally achieve this facet and produce a replacement electric bike concept.

Lin et al (2010) described a bi-directional converter applied in electric bike. the most structure may be a cascade buck-boost converter, which transfers the energy stored in battery for driving motor, and may recycle the energy resulted from the rear voltage (BEMF) to charge battery by changing the operation mode. Moreover, the proposed converter also can function a charger by connecting with AC line directly. Besides, the single-chip DSP TMS320F2812 adopted as an impact core to manage the switching behaviors of every mode and to detect the battery capacity. This paper demonstrated the equivalent models of every mode and complete design considerations are all detailed. All the experimental results are wont to demonstrate the feasibility.

Pellitteri et al. (2013) stated that academic and industrial research is concentrated on innovative battery charging methods to make sure complete mobility of both handheld devices and electric vehicles. Wireless power transfer is really the leading strategy albeit efficiency related issues solved for a successful marketing. During this paper, a wireless battery charging station proposed for electric assisted pedal bikes. If compared with existing wireless solutions, the proposed system architecture improves power conversion efficiency of the charging equipment. The simulation model of the entire charging station described intimately. The transmitter, receiver and inductive coupling circuits described and style criteria given for further applications. The model implemented in SPICE simulation environment and simulation results presented to check the efficiency of the proposed topology.

Hatwar et al. (2013) stated that the marketplace for electric bikes, scooters and bicycles is growing. There are numerous brands of E-bikes emerging locally. All most all incorporate a rear wheel BLDC (Brushless DC) hub motor; lead acid battery pack, a lightweight weight chassis, and a controller. The Vehicle achieves average speed of 30-50km/hr, range of 70km/charge. The opposite drawback is that the long charging time of 6-8 hrs and short lifespan of battery pack i.e. around 2 years. Considering some limitations authors are modifying the prevailing design of an electrical bike which can provides a better performance with the utilization of a hybrid system of battery and super capacitor. The authors during this paper have tried to deal with the drawbacks observed in e-bike operations and have presented the results of their experimentations. Super-capacitor modules are wont to provide the high current required during starting and acceleration, and eventfully will help increasing lifespan of battery. A secondary source, like regenerative braking or little solar array module might be availed onboard so on charge battery/ super capacitor.

Shreya et al. (2021) introduce proposed model comprises a CUK converter fed resonant LLC (Inductor Capacitor) converter based charging solution for an e-bike battery pack, wherein the CC/CV (Constant Current/Constant Voltage) charging algorithm is implemented through the LLC converter. Heretofore, modifications made in DCDC converter topology to include bridge-less topology to extend efficiency to eliminate current inrush issues and involve galvanic isolation. Moreover, bypassing the switching losses presented by a half-bridge converter. The presented topology operates a pulse-width modulated CUK converter in DCM (discontinuous conduction mode), which serves natural current shaping without an input ripple filter. The LLC converter eliminates switching losses by undergoing ZVS (zero voltage switching) and allows high-frequency operation. The closed-loop control of the trigger pulses of the CUK and LLC converters is liable for the CC/CV charging of the battery and hence the reduced charging time. An 800 Wh CC/CV charger with a current rating of 16 A is developed to charge a 48 V, 20 Ah Li-ion battery, where the battery is predicted to charge in but 2 hours. This paper clearly shows the way to fast charging of battery.

Chacko et al. (2012) stated that the time-dependent, thermal behavior of a lithium-ion (Li-ion) polymer cell modelled for electric vehicle (EV) drive cycles with a view to developing an efficient battery thermal management system. The fully coupled, three-dimensional transient electro-thermal model has been implemented supported a finite volume method. To support the numerical study, a high energy density Li-ion polymer pouch cell tested during a climatic chamber for electric load cycles consisting of varied charge and discharge rates, and an honest agreement found between the model predictions and therefore the experimental data. The cell-level thermal behavior under stressful conditions like high power draw and high ambient temperature predicted with the model. high temperature increase was observed within the stressful condition, like a repeated acceleration and deceleration, indicating that an efficient battery thermal management system would be required to take care of the optimal cell performance and also to realize a full battery lifespan.

Carter et al. (2012) stated that novel energy of control strategy for a battery/super capacitor vehicle, which meant to be tunable to realize different goals, described. Two possible goals for adding a pack of super capacitors examined for a test vehicle using lead-acid batteries: 1) improving the vehicle's efficiency and range and 2) reducing the height currents within the battery pack to extend battery life. The advantages of hybridization compared with those achievable by increasing the dimensions of the battery pack by a comparable mass to the super capacitors. The supply of energy from regenerative braking and therefore the characteristics of the super capacitors considered as impact factors. Super capacitors found to be effective at reducing peak battery currents; however, the advantages to range extension found to be limited. A battery life extension of a minimum of 50% is important to form super capacitors cost effective for the test vehicle at current prices.

Bowkett et al. (2013) stated that the planning of an optimal battery management system for hybrid electric vehicles to permit performance improvements. Battery management systems are a crucial subsystem for hybrid electric vehicles, which make sure that the batteries are operating within the required safe operating conditions. Thus, the planning of a battery management system plays a crucial role on battery life preserving and performance improvement of hybrid electric vehicles. Battery management systems are suffering from many factors and therefore the key one being cell unbalancing. This paper presents a summary of various cell-balancing topologies and their impact on system performance. Furthermore, the appliance of cell balancing topologies for Lithium-ion battery pack with the view of improving battery management systems for the hybrid electric vehicles additionally investigated. Real-time implementation of an optimal battery management system discussed with references to the University of South Wales (USW) hybrid electric vehicles.

Maggio et al. (2003) described that analysis of time-optimal
maneuvers of a race motorcycle within the circuit of Adria (Italy) with different choices of gearbox ratios. The minimum lap time is found by means of the Optimal Maneuver Method, whose theoretical basis is presented in the tactic essentially solves two-point boundary value optimal control problem by finding the driver's inputs that minimize an objective function (i.e. the minimum-lap time). The good agreement between the tactic results and data acquired by a measurement system mounted on board motorcycle driven by expert drivers justifies its use as atoll for vehicle found out and style parameters analysis. In the past, the tactic was extensively wont to analyze the influence, on racing vehicle performance, of geometry, mass properties distribution, and tire and engine power characteristics as shown in papers.

Ianniciello et al. (2017) stated that Battery thermal management is important for electric vehicles (EVs), especially for Li-ion batteries, due to the warmth dissipation effects on those batteries. Usually, air or coolant circuits employed as thermal management systems in Li-ion batteries. However, those systems are expensive in terms of investment and operating costs. Phase transition materials (PCMs) may represent an alternate, which might be cheaper and easier to work. In fact, PCMs often used as passive or semi-passive systems, enabling the worldwide system to sustain near-autonomous operations. This paper presents the previous developments introducing

PCMs for EVs battery cooling. Different systems reviewed and solutions proposed to reinforce PCMs efficiency in those systems.

Thakur et al. (2020) described about electric powered based gearing and their design for a motorbike. Design consideration of chassis, gearing, and choose of battery pack with "Battery Management System". Motor and Battery tested characteristic are to described. The aim is to style an efficient electric motorcycle that helps to scale back pollution from environment. The electrical motorcycle designed and built. Electric Motorcycle is in Prototype Mode for further Testing that shows in this paper.

Rangkuti et al. (2020) reported in the article "Design of Efficient Electric Motorcycle Using Brushless DC Motor" that transportation tool that human need from the past until now; it is an important device in human life. Alongside the event of transportation during this world, more and more energy used coming from fossil energy, which is restricted, and therefore the number of its availability decreases over time. Therefore, we must preserve the environment and limit the utilization of fossil energy. The answer to beat the utilization of fossil energy is to exchange the consumption of energy, mainly employed by vehicles, by consuming electricity within the means of transportation. Electric vehicles are a superb solution to stay the environment, apart from reducing the utilization of fossil energy.

Kandiban, R., and Arulmozhiyal, R (2012) stated that Brushless DC motors (BLDCM) are widely used for several industrial applications due to their high efficiency, high torque and low volume. This paper proposed an improved Adaptive Fuzzy PID controller to regulate speed of BLDCM. This paper provides a summary of performance conventional PID controller, Fuzzy PID controller and Adaptive Fuzzy PID controller. It is difficult to tune the parameters and obtain satisfied control characteristics by using normal conventional PID controller. Because the Adaptive Fuzzy has the power to satisfied control characteristics and it is easy for computing. The experimental results verify that an Adaptive Fuzzy PID controller has better control performance than the both Fuzzy PID controller and traditional PID controller. The modeling, control and simulation of the BLDC motor done using the software package MATLAB/SIMULINK.

Vyshakh et al. (2020) described that the primary objective of the project is to style an electrical motorcycle powered using BLDC (brush-less DC motor). Because the number of combustion engine powered vehicles on the roads throughout the planet increases at an increasing rate annually, the dependence on oil-based fuel grows almost unchecked. The increased use of non-renewable fossil fuels causes environmental problems such as the "greenhouse effect" and health problems. To maneuver faraway from this dependence on fuel an efficient and non-pollution effective vehicle has to develop. This paper presents a study of BLDC powered electric motorcycle and different battery packs utilized in it. The aim of this study is to research the way to design an easy, cost effective model of electrical motorcycle with BLDC (motor) as engine and high-powered battery packs

Adli et al. (2018) the author stated that the presents affect scheme for speed system in brushless dc (BLDC) motor to utilized for electric motorbike. While conventional motorbikes require engine and fuel, electric motorbikes require DC motor and battery pack to power up. The limitation with battery packs that it will get to recharged after a particular period and distance. As there charging process is time consuming, a PID controller meant to maintain the speed of the motor at its optimum state, thus ensuring an extended lasting battery time (until subsequent charge).The controller meant to trace variations of speed references and stabilizes the output speed accordingly. The simulation results conducted in MATLAB/SIMULINK® shows that the motor, equipped with the PID controller was ready to track the reference speeding 7.8x10-2 milliseconds with no overshoot. The result shows optimistic possibility that the proposed controller are often wont to maintain the speed of the motor at its optimum speed.

Casals et al. (2016) stated that the electric vehicles are considered the foremost promising alternative to combustion engine vehicles towards a cleaner transportation sector. Having null tailpipe emissions, electric vehicles contribute to fight localized pollution, which is especially important in overpopulated urban areas. However, the electrical vehicle implies greenhouse emission emissions associated with its production and to the electricity generation needed to charge its batteries. This study focuses the analysis on how the electrical vehicle emissions vary in comparison to combustion engine vehicles.

Soeprapto et al. (2019) described that the Electric bike driven using an electrical motor and uses batteries because the energy source. It is environmentally friendly as no exhaust gas is resulted during its operation. Quite one battery is generally required, being arranged serial or in parallel connection. Over limit or overloaded conditions of battery usage will reduce the lifecycle of battery, speed up its replacement and increase the upkeep cost of electrical bike. This paper proposes the prevention of such degrading condition employing a tool to manage the battery usage during both the charging and discharging process. The proposed electronic Battery Management System (BMS) serves to regulate, monitor, and maintain the condition of batteries to stop any possible damage. The resulted BMS design could provide a well balancing action during a battery system consisting of 13 cells utilizing the cell-to-cell active balancing method. The test results showed that the proposed BMS could monitor the individual cell voltage with a mean error of 0.032 V (0.824%), while reading the charge and discharge current with a mean error of 0.04 A (6.25%), and therefore the battery pack temperature with a mean error of 1.21o C (2.9%). Additionally, the BMS could offer a functional battery pack protection system from conditions like under voltage, overvoltage, overheat, and overcurrent

Syafra et al. (2020) author said that the research was using scientific method. Tests administered on electric bicycles with 250 Watt Brushless DC motor drive. The entire power consumption obtained through testing the utilization of electrical bicycles, which starts from the utmost battery condition until the bike cannot move. The battery used may be a sort of lithium ion assembly with a complete capacity of 29.12 Volt 20Ah. In testing, the bike driven at maximum speed, with a 65kg rider. Within the first test, a distance of 30.6 Km reached with an influence consumption of 1041.1 Watt, 112 minutes of time-period. The second test as far as 31.1 Km requires 1090.8 Watts of power takes 117 minutes. Therefore, the third test reached a distance of 35.9 Km with

1178 Watts of power and 128 minutes of time. it had been also found that the battery was unable to maneuver the bike at rock bottom voltage of twenty-two .1 Volt.

LeBel et al. (2018) described a way for battery pack sizing for electric vehicles, applied to the case of an electrical motorcycle. a completely unique way of analyzing battery pack performances during a single graphical tool is proposed. It has intended to assist engineers get a broader understanding of the influence of design decisions from the first stages of the engineering process. In multi-cell battery packs, specifications like energy, power, volume and mass are proportional to the entire number of cells, while voltage, current are dependent of the series and parallel arrangement. Thus, presenting results as functions of the amount of cells serial and parallel allows matching quickly the varied performance metrics of a pack. By applying the planning constraints of the technical requirements as limiting functions, one can easily select an appropriate solution that meets design goals, or assess the effect of design constraints. This graphical design tool might be wont to size other electric energy storage devices like lithium-capacitors, super-capacitors or battery pack of other chemistries than lithium- ion.

Drummond et al. (2019) stated that focuses on development of system performance parameters, design of major components including chassis and battery pack/BMS enclosure, and signal interactions between powertrain components. Previous iterations of electrical motorcycle conversions developed at JMU were constrained by the donor chassis, which designed for support of combustion engines. Although teams worked to optimize the fitment of powertrain components within existing frame members, compromises were necessary. Other limitations of previous iterations include discharge rates of battery pack and delicate battery management systems. Although electric motorcycles are commercially available, their powertrain components are generally proprietary and inaccessible (not available for hacking or other educationally appropriate activities). The present iteration developed to deal with these limitations. Results include benchmarking results, estimation of performance, and physical iterations of design choices. The ultimate iteration of the modular battery pack, designed for student interaction, consists of seven sub-pack modules with visible and intuitive wire routing. The finished powertrain meant to favor accessibility of components also as optimize available space within the frame while closely matching the middle of gravity and suspension also as steering capabilities of the donor motorcycle.

Matsuda et al. (2014) stated that as for automobile, the production period of electrical Vehicle (EV) has begun by the rapid progress of the battery performance. Except for EV- Motorcycle (MC), it is limited for the venture companies' releases. The design and evaluation methodologies are not yet established or standardized thus far. This paper provides the practical and therefore the experimental examples. to review the feasibility of EV-MC, we developed the prototypes within the present technical and suppliers' parts environments, and evaluated them by the sensible view of the MC usage. The developed EV-MC has the equivalent driving performance of the 250cc combustion engine (ICE)-MC and a cruising range of 100km in normal use.

Rege et al. (2017) introduced motorcycle frame may be a non-standard structural component of a motorbike linking various components of the vehicle systems and providing the vehicle rigidity and strength while running on various road conditions.

This study aimed toward designing the frame of a two-wheeler, two-seater motorcycle for an electrical mobility purpose, while considering strength, safety and optimum performance of the vehicle. Study has administered with a twostep approach. the primary step includes modelling of the frame as per structural and ergonomic considerations, the planning constraints governed by the front and rear suspension, steering and transmission systems and assemblies also because the determination of loads working on the frame. The second step is that the stress analysis using finite element analysis software and design modifications for weight reduction without affecting structural strength.

Ibanez et al. (2019) described that the Electric motorcycles use a battery storage system and a controlled inverter (motor drive) to drive the wheels. As long as the sale of electrical motorcycles predicted to grow significantly over subsequent decade, the aim of this research is to feature a super capacitor storage system to the present simple network to increase the autonomy of the motorcycle. This paper analyzes and demonstrates the advantages of two different structures for adding a super capacitor bank to a lithium-ion battery pack: a passive filter and a buffer for the battery. The benefits of every structure presented and style guidelines provided. Additionally, we propose an artificial inductor filter typology supported the two analyzed structures to extend the autonomy of the motorcycle. Simulations and experimental results using real data validate the analysis. This paper then uses real data extracted from an electrical motorcycle to match the four topologies: batteries only, the passive filter, the buffer, and therefore the synthetic inductor semi-active hybrid storage system. The comparison shows that battery capacity extended up to 7.8% with a smoother current profile. However, due to the losses from the added converter in cascade, internet capacity of the entire system is extended only up to three .7%. Therefore, improvements within the dc/dc converter can further increase the whole system capacity.

Hieu et al. (2021) described that how input parameters affect the dynamic characteristics and electric consumption characteristics of an electrical motorcycle. To realize this goal, a simulation model of the electrical motorcycle, including dynamic models and battery models established supported mathematical models and using the MATLAB SIMULINK software (Parnas Tower 14th Floor 521 Teheran-street Gangnam-district Seoul 06164 Korea). The simulation model was wont to determine the speed, propulsion torque, electric consumption characteristics with variable electric motorcycle mass, driver mass, wheel radius, frontal cortex, and transmission ratio. The experimental study conducted to look at the dynamics of the electrical motorcycle. The experimental results have an equivalent trend with simulation within the same initial condition. Through combination simulation and experiment, the researcher can optimize the dynamic and electric consumption of an electrical motorcycle.

Guerra, E. (2019) presented the results of a choice experiment to evaluate the extent to which electric motorcycles are a possible replacement for gasoline-powered motorcycles in Solo, Indonesia. Survey respondents faced five choice scenarios where they chose between a standard motorcycle, an electrical motorcycle, and no motorcycle supported price, speed, range, and charge time. Approximately 1200 individuals completed all five choice scenarios, fully skilled socio economic, and preference questions. As in much of Southeast Asia, motorcycles dominate the transportation and supply inexpensive, relatively safe, and convenient point-to-point travel.

Weigl et al. (2015) presented the event and performance test of electrical motorcycle in South East Asia i.e. in Singapore and Malaysia. National University of Singapore (NUS) team converted ICE based motorcycle (Honda CBR400) into battery electric motorcycle using lead acid battery pack and lithium polymer battery pack. Cell Vehicle Group in University Teknologi Malaysia (UTM) built a cell electric motorcycle, which used hydrogen cell system, lithium polymer battery pack and ultra-capacitor module. Road tests conducted to check the performance of both electric motorcycle types. Performance of H2Motive® cell motorcycle done by participating South African Solar Challenge 2008 in technology class. Results showed that H2Motive® cell motorcycle was ready to travel about 2400 km. Some roads were at steep and hilly climb and therefore the motorcycle could stand during heavy rain. The converted CBR400 tested in World Advanced Vehicle Expedition with 1600 km travel distance. NUS team's e-bike claimed third spot therein rally. Both sort of electric vehicle performed well during the rally. It concluded that two of them were ready for gaining road-legal status.

Jeyapandiarajan et al. (2018) described that this project was to style a structurally stable chassis for an electrical motorcycle. With the increasing pollution and stricter emission norms, there is an urgent have to switch to green technology. In India, motorcycles consume 62% of petrol. Therefore, there is a serious scope of reducing pollution through electrically driven motorcycles. There are not any electric motorcycles in India at the time when this project was initiated, whatsoever. Therefore, present work attempted to style the chassis for motor driven motorcycle for street legal transportation. The planning is not complete without proving it structurally stable. Hence simulated real time forces on the frame and suspension geometries. Within the simulation, compared the strain, factor of safety and therefore the deformation of an equivalent structure with different materials to finalize the simplest suitable material for the chassis on the idea of strength, cost and weight of the chassis.

Esparza et al. (2020) described the evaluation of the energetic performance of the battery-pack from the motorcycle prototype EME 16E. This racing prototype developed by a student team from the Universidad Politécnica de Madrid (UPM) to participate within the Moto Student competition during 2015–2016. This study includes the sizing and assembly of the motorcycle's battery-pack under strict regulations and a limited budget. The prototype tested under different performance conditions, like laboratory tests and racing circuits. Experimental results show that the proposed battery-pack is capable of supplying the energy and power necessary to drive the motorcycle altogether cases analyzed

CHAPTER-3
MATERIALS AND METHODS

Materials and Methods

Materials used-

- Chain Drive
- Sprocket Drive and Driven
- Brushless Motor (BLDC)
- Crankcase i and ii
- Axle Shaft
- Clutch Assembly
- Gear Assembly (Gear Box)
- Clutch or Engine Housing i and ii

All parts used in making electric bike with manual transmission have been shown in figure 3.1. These parts have been described in details have also been given in the following sections in this chapter itself.

3.1 Chain Drive

The term chain drive defined as a mechanical system, which helps in transmitting the power from one source to other. A chain drive made by number of links where the links connected with the help of pins. The chain runs over a mechanical gear wheel, which is having number of teeth on it known as sprocket. These chains are known as power transmission chains and are made of steel and sometimes it heat-treated to minimize the wear and tear. These chains built for heavy-duty purpose and having high strength and accuracy to run over a sprocket. A chain drive is a mechanically operating system where we used different types of chains to transmit the power or for movement of something (Chain drive has been shown in figure 3.1).

Generally, chain drive typically employed when the distance between the source of power and the destination of the power is less; however, this is not applicable for all. In some circumstances, a chain drive can used to convey power across greater distances.

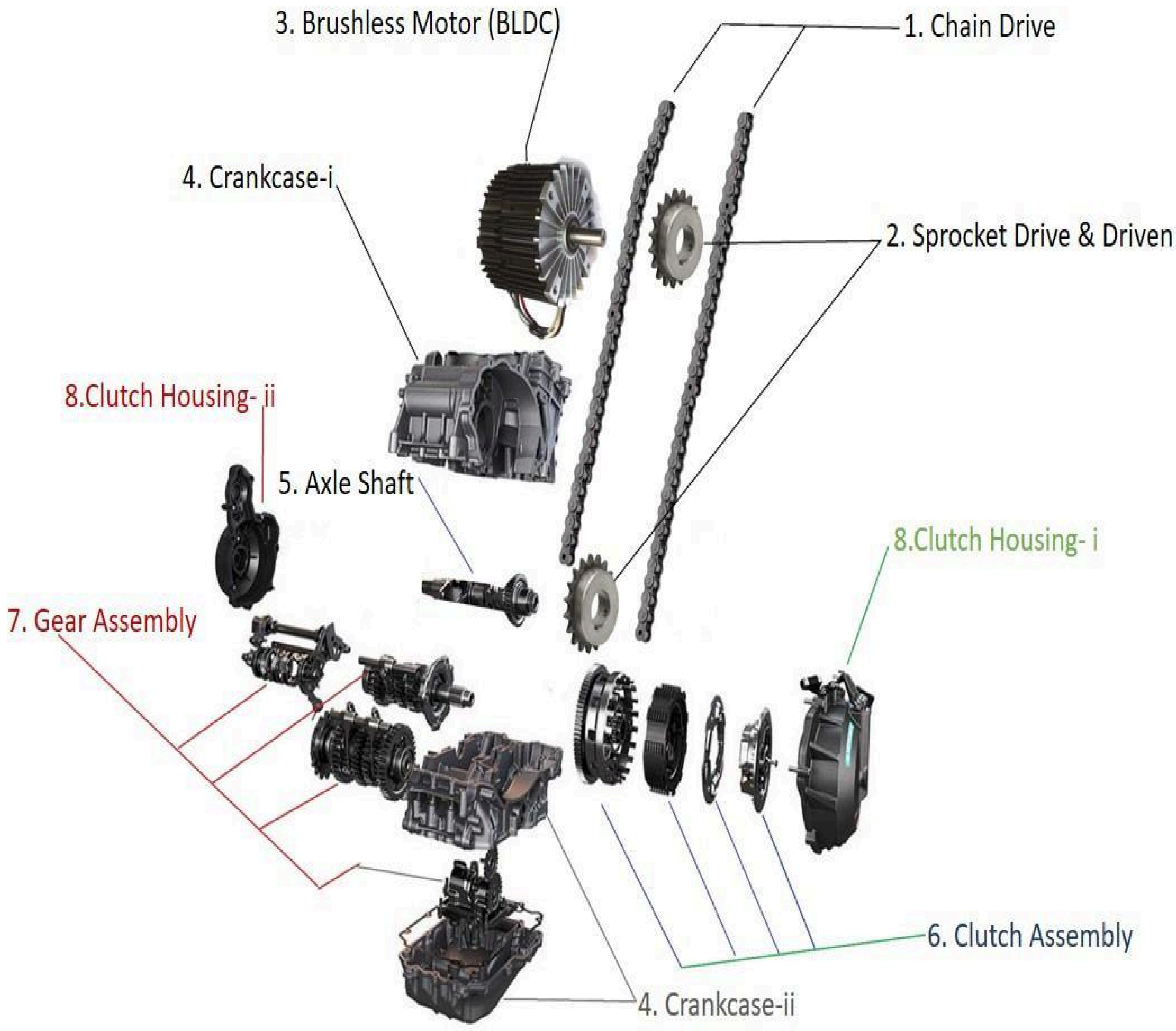

Figure. 3.1 ALL PARTS USED IN MAKING ELECTRIC BIKE WITH MANUAL TRANSMISSION.

In belt or rope drive, we see there is some percent of slip occurs, but in the chain, there will be no slip. However, this does not mean that 100% power transmitted from one to another device due to friction loss some amount of power loss we can generally see.

In chain drive, the speed ratio remains constant, which is a major advantage of chain drive, and here there is no slippage and in case of belt drive, there is slippage so speed ratio changes as per slippage.

- Low maintenance
- Efficiency up to 97%
- Required less space and transmit higher power as compared to a belt drive system
- Can used for lifting heavy loads.

3.1.1 **Advantages of chain drive**

1. No slip and creep during the power transmission, it ensure the perfect velocity ratio. The output side rotate at precise speed.
2. Friction drive has a lower transmission efficiency.
3. They can work in a variety of temperature and climatic conditions.
4. It can operate under wet conditions.
5. It can use in both short and long-distance power transmission.
6. It transmit more power than belt and rope drive.
7. In a single step, the chain drive allows for a high velocity ratio.
8. In low speed drives, chain drives are more practical than belt.
9. Since all parts are made of metal, it occupy less area than belt drives.
10. Shafts not subjected to as much stress...

11. Far less frictional loss
12. One chain can used to transmit motion to more than one shafts.
13. The Chains are frequently smaller than belts, allowing for easier gear shifting. (varying gear ration)

3.1.2 Disadvantages of chain drive

1. There may be velocity fluctuation and under excessively stretched chain conditions.
2. Due to the chordal effect, traditional chain drive suffers from vibrations.
3. Chain drives have a higher production rate than belt drives.
4. The chain drive requires precise and cautious installation...
5. The chain drive need careful maintenance, lubrication and slack adjustments.
6. If there is no frequent proper lubrication the chain wear out faster than belts and ropes

3.2 Sprocket Drive and Driven

The term sprocket defined as a mechanical device or we can say a gear, which is having number of teeth's in its circumference.

A sprocket drive is one way of converting power in a vehicle. It's a 100 years old technology chain and sprocket are still widely used in bicycles and motorcycle till date and other forms of machinery (Sprocket Drive and Driven has been shown in figure 3.1)

In our project the one sprocket (36 teeth) is attached with the brushless DC motor is the driving sprocket and the other one which is connected to axial shaft with the engine gearbox is the driven sprocket (The axial shaft which we have built to replace conventional crank shaft)

In brushless motor with manual transmission with driving sprocket is bigger (36 teeth) than the driven one (14 teeth), this helps in increasing the sprocket ratio. It makes harder for BLDC motor to run or we can say it will increase the load of BLDC motor while increasing the rotational speed of driven sprocket.

For every one spin of driving sprocket (attached to the BLDC motor) 36 teeth, the driven sprocket spins 2.57 times. The calculation is done as under-

Number of driving sprocket is 36.

Number of driven teeth is 14.

36/14= 2.75 rotation of driven sprocket for every single movement of driving sprocket.

3.3 Brushless Motor (BLDC)

The term motor was defined as a device, which converts electrical energy into mechanical energy, Today various types of motor are available for common use among these brushless DC motor are having high efficiency and having effective controllability and due to these features, it is used in many applications (Brushless Motor hass been shown in figure 3.1).

These BLDC motors are having high power saving advantage as compared to normal conventional motor.

The simple type of motor is a brushless DC motor in these the electrical current are passed through the coils, which arranged by a fixed magnetic field.

In the magnetic field the current are generated cause coil assembly to rotate, each coil is being pushed away from the like pole and pulled towards the unlike pole of the fixed field where brushes that make contact with a rotating commentator that cause the reversal of the current through coil.

Fixed brushes supplies the rotating commentator with electric energy, as commutator rotates it continuously flips the direction of current into the coil for maintaining an appropriate rightward rotation. The commentator rotates because it attached with the rotor in which the coils are mounted.

3.4 Crankcase I and II

A crankcase is the housing for the crankshaft in a reciprocating internal combustion engine. The crankcase integrated into the engine block in most modern engines.

Two-stroke engines typically use a crankcase-compression design, resulting in the fuel/air mixture passing through the crankcase before entering the cylinder(s). This design of the engine does not include an oil sump in the crankcase.

Four-stroke engines typically have an oil sump at the bottom of the crankcase and the majority of the engine's oil held within the crankcase. The fuel/air mixture does not pass through the crankcase in a four-stroke engine, however a small amount of exhaust gasses often enter as "blow-by" from the combustion chamber (Crankcase has been shown in figure 3.1)

The crankcase often forms the lower half of the main bearing journals (with the bearing caps forming the other half), although in some engines, the crankcase surrounds the main bearing journals.

An intrinsic component of an internal combustion engine, the crankcase is a drilled metal frame that houses several parts, notably the crankshaft. Its main universal function is to shield the crankshaft and the connecting rods from debris. In simple two-stroke engines, the crankcase serves several roles, and used as the pressurization chamber for the fuel-air mixture. In more complex four-stroke designs, it sealed off from this mixture by the pistons, and instead works mainly to store and circulate oil. In a four-stroke engine, it sits below the cylinder block, and in both types comprises the largest physical cavity of the motor.

Most modern crankcases made out of aluminum, which provides a lightweight yet strong design capable of withstanding the pressures exerted during normal engine use. In normally aspirated four-stroke engines, that is engines that do not feature *a* turbocharger, a small level of pressure in the case is desirable to keep out dust and other potentially damaging particulates, while keeping the oil properly situated. All engines, as part of their normal operation, allow a small amount of unburned fuel and exhaust gas to escape into the crankcase. This collective material known as *blow-by*.

A positive crankcase ventilation valve, or PCV valve, typically employed as part an overall pressure control system, to regulate the amount of blow-by ejected from the crankcase. Passing through the PCV valve, the expelled blow-by returned through the system, back to a part known as the *intake manifold*, where it re-used in the combustion process. This design adopted in part by legislative impetus, because earlier designs were not enclosed and allowed blow-by to escape directly out of the engine, generating significant environmental damage. PCV systems not used in two-stroke engines, as all blow-by burned in the normal flow of air and fuel.

Proper care of the crankcase and its internal components is essential to the smooth running of an engine. Maintaining a proper amount of clean oil is crucial, and is measurable by using a simple tool known as a *dipstick*, a simple length of metal that visibly shows the level of oil. While checking it regularly will, show how much oil is present, unburned fuel that collects in the crankcase can negatively affect the lubricating quality of the oil, so regular oil changes are vital. Additionally, an improperly broken-in engine or one with dry, cracked piston seals can allow too much gas to leak past the pistons into the crankcase, generating dangerously high levels of pressure that can cause engine damage and failure. Early symptoms of failing seals include oil leaking out of the PCV valve or past the dipstick.

In our project Brushless, motor with 5-speed gearbox the crankcase plays a very important role. In our case crankshaft completely removed and replaced by an axil shaft, which transfers the energy from outer sprocket (power transmitting through BLDC motor) to the clutch assembly, where further the power smoothly transferred to gearbox.

In our project, an axil shaft inserted through bearing which act as support for axil shaft to revolve and crankcase hold each part together in its respective place and at the same time it is also provides lubrication.

3.4.1 Advantage of Crankcase

- Very strong and high build quality ability to hold engine components and parts in its specific place and absorb high stress even at high speed or rotation
- One of the major part act as a backbone for any engine

3.4.2 Disadvantage of Crankcase

- Oil spillage after a certain period, If a proper periodic maintenance should not be provided than it start spilling oil from joints which also leads to wastage of oil or further engine seizure
- Take more time to cool down as compared to any other engine part

3.5 Axle Shaft

Axles are an essential element in providing the stability and strength that allows motorized vehicles to safely carry people, cargo, and their own bulk (Axle Shaft has been shown in figure 3.1). These components built to bear immense amounts of weight. However, overloading an axle beyond its capacity can cause it to warp or break. Jarring from potholes and other road obstacles also endanger the axle's integrity

The axle shafts used in vehicles—also called half shafts or CV axles—allow the transmission to transfer motion to the vehicle's wheels. Axle shafts also regulate changes in drive between the differential sun wheel and rear hub. In a simple rear axle system, the road wheel attaches to the axle shaft, which supported by bearings located in the axle's casing. Movement from the wheel shifts the axle in the corresponding direction, guiding the wheels to the desired path.

3.6 Clutch Assembly

Clutches used to connect the prime mover (motor or engine) to the load in a manner that allows torque transmission to interrupt**.** Clutches used to engage a wide range of pumps, fans, and conveyors in industrial, mobile and business machine applications (Clutch assembly has been shown in figure 3.1).

The main purpose of a clutch assembly is to connect and disconnect two rotating shafts. One shaft connected to the power source, or engine, and the other shaft, which driven by the power source, provides the power, or torque, that drives the vehicle or machinery. The clutch assembly connects the two shafts in three different ways:

- **Engaged:** the shafts are locked together to rotate at the same speed.
- **Slipping:** the shafts are locked together but move at different speeds.
- **Disengaged:** the shafts are not locked together and rotate at different speeds.

There are many types of clutch assemblies available for different applications. Most clutch assemblies are friction clutches that work using frictional forces to synchronize speeds between the two shafts. Some friction clutches can also work with a little bit of slippage.

3.6.1 Clutch Assembly Parts

Clutch assemblies consist of several component parts including the flywheel, clutch disc, pressure plate, cover, springs, and bearings. The exact configuration of a clutch assembly depends on its specific application. In a basic clutch assembly, the clutch disc and pressure plate direct the power from the power source to the driven shaft by pressing tightly against the flywheel. The springs and bearings ensure that these discs are pressed tightly together. The discs used in a clutch assembly are typically lined with asbestos or resin for friction. Ceramic materials are used to create friction in heavy-duty applications.

3.6.2 Clutch Assembly Types

- **Belt Clutch:** A belt clutch consists of a set of belts and pulleys that tighten the belts to help increase friction. These types of clutch assemblies used in lawn mowers, agricultural equipment, and snow blowers.
- **Dog Clutch:** This positive engagement, non-slip clutch assembly used in applications in which there can be no slipping. These clutch assemblies most commonly used for manual transmissions in vehicles.
- **Hydraulic Clutch:** In a hydraulic clutch, the driving and driven members do not make contact. The function of the clutch is driven by the motion of the hydraulic fluid. Hydraulic clutches used in some automobiles, diesel locomotives, industrial machinery, and forklifts.
- **Electromagnetic Clutch:** Electromagnetic clutch assemblies contain an electromagnet that engages the clutch. These clutch types are very smooth.

- **Overrunning Clutch:** Overrunning clutch, or freewheel, clutch assemblies have the ability to disengage if an external force causes the driven shaft to rotate faster than the drive shaft.

3.7 Gear Assembly (Gear Box)

A gearbox is a mechanical driver that utilizes gears to transfer the movement of a motor or PTO to its matched machine or implement (Gearbox has been shown in figure 3.1). Gearboxes can either increase or decrease the speed of the input drive shaft and/or change the direction of the drive.

Working of Gear Box- Inside of a gearbox, the counter shaft is mashed to the clutch with a use of gears. The counter shaft is always in running state. When the counter shaft is in contact with the main shaft by use of meshing gears, the main shaft starts to rotate according to the gear ratio. When driver changes the gear, clutch pedal disconnects the counter shaft with engine and connect the main shaft with counter shaft by another gear ratio by use of gearshift lever.
Gear box' gear teeth and other moving metal cannot touch. They must be continuously separated by a thin film of lubricant. This prevents excessive wear and early failure. Therefor a gearbox runs partially filled with lubricant oil.

- **Types of Industrial Gearboxes:**
  - Helical Gearbox
  - Coaxial Helical Inline
  - Bevel Helical Gearbox
  - Skew Bevel Helical Gearbox
  - Worm Gearbox

- Main components of a gear box:
  - Counter shaft
  - Main shaft
  - Gears
  - Bearings

3.8 Clutch or Engine Housing I and II

The term engine housing is define as an engine outer shell or a protective shell. Which provide protection to the internal components of engine from outer environment where the parts not exposed with the environment and hold the internal components in its respective place (Engine Housing I and II are shown in figure 3.1).

It reduce internal engine noise also work as a reservoir for storing the engine oil.

3.2 METHODS

In this project, we have studied the gearbox of Bajaj Pulsar 150 UG 1. Because its housing is made of thick aluminum as well as it contains some oil seals towards the magnet side of the gear box which prevent the oil spillage from the engine, Adapter or supporter can also be installed in respective place which provide counter support at the time of axel movement or engine operation. While the same technique is cannot be able to apply in any other motor cycle engine due to unavailability of respective parts, which provide oil spillage and counter support.

3.2.1 Selection of Bike and Disassembling

It all started with engine of an old pulsar motorcycle. The idea behind this project is to create a brushless motor with manual transmission, which easily be installed, and work as a direct replacement of IC engine with the electrical engine. It will be economy friendly, zero emission street bike that can easily carry two person and can cruise at decent speed, also climbing more than 35 degree of slopes. A photograph of an electric motor with gearbox has been given in figure 3.2.

Points of consideration while selecting the Bike for present study.

- Overall good condition

  Not all engines part should quite good, rusted out. Indicators and horn should be working properly. Engine should in good shape.

- Driveshaft, Belt Drive or chain.

  Most of the motorcycle used in India driven by chain, but some uses driveshaft and also belt. We get a bike with chain because chains are cheap, easily available, easy to change gear ratio and easy to repair. Electric bike can we built with belt or drive shaft but chains have more advantage.

- Double cradle chassis frame and Perimeter chassis frame

  We use double cradle chassis frame as it has significant advantage of down tube counter parts in terms of strength rigidity, space and do not cost high as much as perimeter chassis frame. It also have more space, which makes it easy to mount batteries and motor in bike.

- Dissembling the bike.

  We can remove the parts, which were not in use to get more space for fitting it with motor.

- In the engine the first and for most step is to remove the crankshaft and connecting rod by dismantling the engine.
- If the crankshaft removed than there is no use of cylinder block, piston, cylinder head valves timing chain and carburetor, these things are need to remove completely.
- Assembling bike with motor.

  The easiest way to assemble the motor in bike was to put it where the cylinder was.

- We install a custom-made axel shaft also with a thick motor plate, which needs to fabricate for mounting the motor in place of cylinder block above the gearbox.
- Here, the brushless DC motor directly connected with the custom-made axel shaft with the help of chain (520 pitch) and sprockets (14/36 in 1:3 ratio). Every single rotation of motor shaft will rotate axial shaft 3 times, which provide more speed to gearbox.

Figure 3.2 ELECTRIC MOTOR WITH GEAR BOX

3.2.2 SPECIFIC ELECTRIC MOTOR TO POWER OUR MOTORCYCLE

To power our motorcycle, we need a motor. But what type and what size. Brushless type DC motor and the size of the motor have been selected for our motorcycle was dependent on the requirement. The requirement depends on use of the motorcycle such as mounted bike, dirt bike, racer bike etc.

- **Brushless DC Motors**

It is similar to DC motors with Permanent Magnets. It is called brushless because it does not have the commutator and brush arrangement. The commutation is done electronically in this motor because of this BLDC motors are maintenance free. BLDC motors have traction characteristics like high starting torque, high efficiency around 95-98%, etc. BLDC motors are suitable for high power density design approach. The BLDC motors are the most preferred motors for the electric vehicle application due to its traction characteristics. You can learn more about BLDC motors by comparing it with normal brushed motor (brushless motor has been given in figure 3.3).

Figure 3.3 BRUSHLESS MOTOR

3.2.3 MOUNTING THE MOTOR ON THE PLATE

As we have selected our motor, we needed to find some way to mount our motor physically in motorcycle. To do this we needed to build a mounting plate.

Therefore, we take a piece of scrap 1/15” aluminum plate. The plate need to have a hole in the middle of it for the axel to pass through and four holes in the measured locations for the bolts to mount the motor to the plate. (Mounting plate has been shown in figure 3.4).

The plate also need a measured point to connect it to the frame of the motorcycle. For that, we re-use the existing mounting points in the chassis of the motorcycle where the engine and crankcase originally bolted in place. Those holes are already just about, where we need them and it meant we did not have to make any new holes in the chassis.

We made a design of mounting plate in solid work; we simply made sure that the measurements on the solid works matched up to 100% actual scale of motor

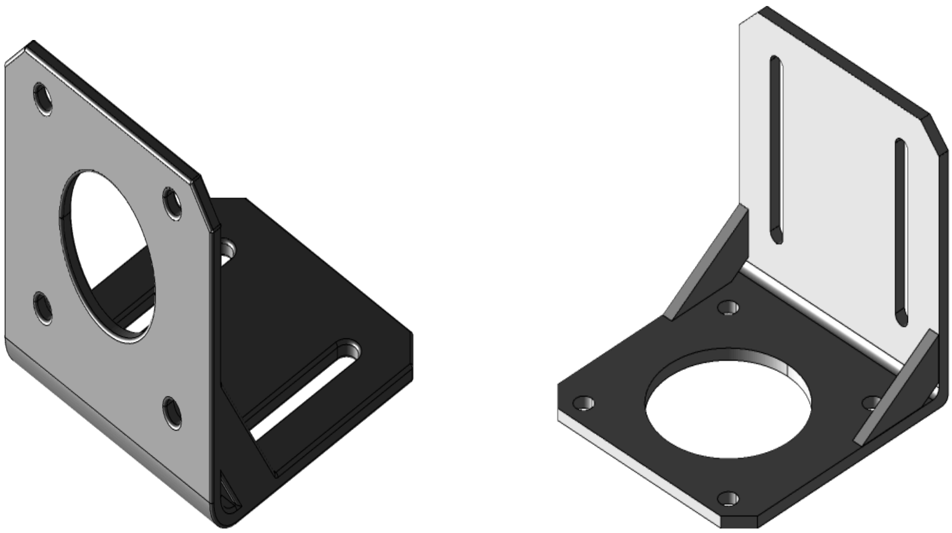

Figure 3.4 MOUNTING PLATE

Using a drill press, we drill holes of appropriate size as measured which would then connected to a motor. That give us a plate of aluminum with a central hole for the motor shaft, and four holes to mount the motor to the plate. We trail-fit the plate in place on the motorcycle, with the motor-shaft hole lining up with the marks on the frame indicating where the chain originally went.

At that point, we could just put the motor and plate together to confirm that all the holes lined up. We also traced the outline of the motor on the plate. Once we round off all the edges, we put the plate in the motorcycle, and ran threaded rods (3/8" and 5/16", which matched the holes in the frame) through the frame attachment points, through the plate, and through the matching attachment point. Stainless steel nuts and washers went on both sides of the adapter plate and on the outsides of the motorcycle chassis. If we ever need to adjust the position of the motor side-to-side, we can loosen the nuts on either side of the plate and move it one direction or the other.

3.2.4 ANALYSIS OF BATTERIES

For running our motor, we need to have constant power supply, in order to select the battery perfectly fit for our work we have studied the types of batteries. And our findings have been given as under.

- Types of Batteries

- **Lithium ion battery**

A lithium-ion battery or Li-ion battery is a type of rechargeable battery Lithium-ion batteries are commonly used for portable electronics and electric vehicles and are growing in popularity for military and aerospace applications In the batteries, lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. (Lithium ion battery shown in figure 3.5). The batteries have a high energy density, no memory effect (other than LFP cells) and low self-discharge. They can however be a safety hazard since they contain flammable electrolytes, and if damaged or incorrectly charged can lead to explosions and fires.

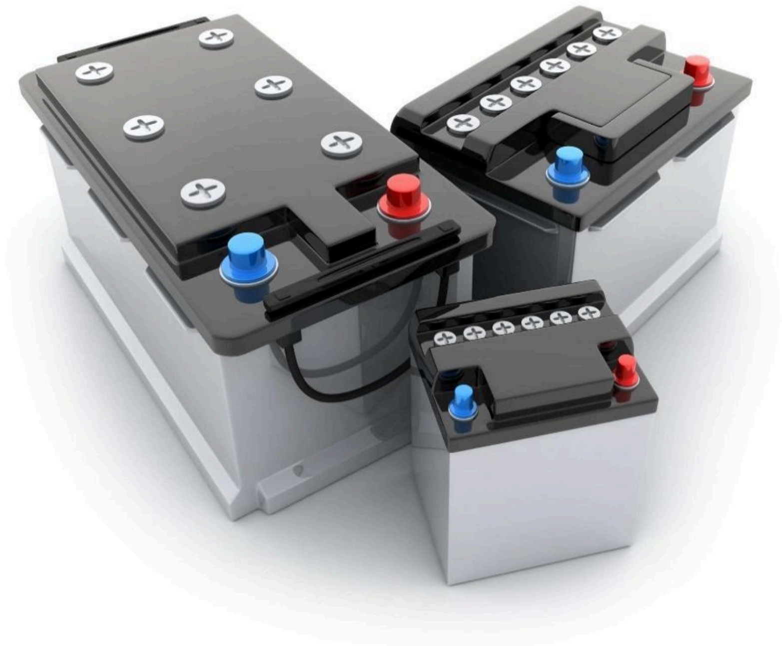

Figure 3.5 LITHIUM ION BATTERY

- **Lithium air battery**

Metal air batteries have been around for a while. You might find a little zinc air button cell in hearing aid, for example, but scaled up aluminum and lithium air chemistries are also promising for the automotive and aerospace industries (Lithium air battery has been shown in figure 3.6). The potential for lightweight batteries with high-energy storage makes this batteries technology promising. Lithium air batteries could have a maximum theoretical specific energy of 3,460 W h/kg, almost 10 times more than lithium ion. NASA researches have also been investigating lithium air batteries for use in aircraft.

Figure 3.6 LITHIUM AIR BATTERY

- **Lead acid battery**

The lead–acid battery is a type of rechargeable battery first invented in 1859 by French physicist Gaston Plante It is the first type of rechargeable battery ever created. Compared to later types of rechargeable batteries, (lead acid battery shown in figure 3.7). Lead-Acid batteries have the lowest energy density. Despite this, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by starter motors.

Figure 3.7 LEAD ACID BATTERY

In this project, we use Lead Acid Battery because they have a long lifetime and low costs compared to other battery types. One of the singular advantages of lead acid batteries is that they are the most commonly used form of battery for most rechargeable battery applications (for example, in starting car engines), and therefore have a well-established, mature technology base.

- **Operation of Lead Acid Battery:**

  A lead acid battery consists of a negative electrode made of spongy or porous lead. The lead is porous to facilitate the formation and dissolution of lead. The positive electrode consists of lead oxide. Both electrodes are immersed in a electrolytic solution of sulfuric acid and water. In case the electrodes contact with each other through physical movement of the battery or through changes in thickness of the electrodes, an electrically insulating, but chemically permeable membrane separates the two electrodes. This membrane also prevents electrical shorting through the electrolyte. Lead acid batteries store energy by the reversible chemical reaction shown below.

The overall chemical reaction is:

$$PbO_2 + Pb + 2H_2SO_4 \Leftrightarrow_{charge}^{discharge} 2PbSO_4 + 2H_2O$$

At the negative terminal the charge and discharge reactions are:

$$Pb + SO_4^{2-} \Leftrightarrow_{charge}^{discharge} PbSO_4 + 2e^-$$

At the positive terminal the charge and discharge reactions are:

$$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \Leftrightarrow_{charge}^{discharge} PbSO_4 + 2H_2O$$

As the above equations show, discharging a battery causes the formation of lead sulfate crystals at both the negative and positive terminals, as well as the release of electrons due to the change in valence charge of the lead. The formation of this lead sulfate uses sulfate from the sulfuric acid electrolyte surrounding the battery. As a result, the electrolyte becomes less concentrated. Full discharge would result in both electrodes covered with lead sulfate and water rather than sulfuric acid surrounding the electrodes. At full discharge, the two electrodes are the same material, and there is no chemical potential or voltage between the two electrodes. In practice, however, discharging stops at the cutoff voltage, long before this point. The battery should not discharged below this voltage.

In between the fully discharged and charged states, a lead acid battery will experience a gradual reduction in the voltage. Voltage level commonly used to indicate a battery's state of charge. The dependence of the battery on the battery state of charge.

If the battery left at low states of charge for extended periods, large lead sulfate crystals can grow, which permanently reduces battery capacity. These larger crystals are unlike the typical porous structure of the lead electrode, and are difficult to convert back into lead.

- **Figuring Range**

Going back to some simple math, we can get an estimate of motorcycle range. We have four batteries, each of which is 12 volts, but they wired up in one series string of all four of them, so it is really 48V in total. The batteries rated at 55Ah.

So, in theory, 48V x 40AH = 1920 watt-hours capacity. 100 watt-hours per mile is a typical ballpark number for energy consumption per mile on an electric motorcycle. (Of course, that does vary by weather, speed, riding style, etc.) However, this is just a rough estimate.

2640/100 = 19.2 miles

In kilometers,

19.2 X 1.6 = 30.72 km

- **Advantage of lead acid battery:**

- It is available in all shapes and sizes.
- It does not require any maintenance.
- It is best in terms of reliability and working capabilities.
- It withstands slow, fast and overcharging.
- It is capable to withstand long-term inactivity with or without solvent.
- It offers best value for power and energy per KWH.
- It offers longest life cycle.
- About 97% of lead can be recycled and reused in new batteries.
- It is inexpensive and simple to manufacture; low cost per watt-hour
- It offers low self-discharge, which is lowest among rechargeable batteries.
- It offers good performance at low and high temperature.

- **Disadvantage of lead acid battery:**
    - Lead is heavier compare to alternative elements.
    - It has low specific energy, poor weight to energy ratio.
    - It can be charged slowly i.e. fully saturated charge takes 14 to 16 hours.
    - It must be stored in charged condition in order to prevent sulfation.

- It has limited cycle life. Moreover, repeated deep cycling reduces battery life.
- Flooded version of battery requires watering.

3.2.5 ANALYSIS OF BATTERY RACK

For making a rack, we have to keep in mind that the batteries need to be securely mounted on frame of motor cycle.

We have to keep in mind that the batteries are the heaviest part of the motorcycle, so we have to keep it in center of motor cycle for front and back balance as well as low as possible for best center of gravity.

By using cutting, welding and grinding process, we make a rack essentially using four metal pieces.

1**. Bottom piece**. Connects to the bottom of the frame of the motorcycle. The two bottom batteries sit on top of it.

2**. Lower-middle piece**. This sandwiches down to hold the bottom batteries in place and connects to the front of the cycle frame.

3**. Upper-middle piece**. Holds up the top two batteries and connects to the front of the cycle frame. Sits directly above the Lower-Middle piece.

4. **Top-Straps.** These are just two pieces of steel that go over the top of the top two batteries to hold them down. Threaded rod goes through the ends to tie them down to the other parts of the battery rack. This is very similar to a typical tie-down for a car battery. (The top straps are insulated and do not go near the top posts of the top batteries.)

Besides just being a square ring under the bottom two batteries, the bottom piece also had to directly connect to the bottom of the frame. To do that, we have to run two pieces of angle iron the length of the motorcycle's engine bay, so that it bolted right to the frame, again, through existing mounting points and our rack will be finished.

3.2.6 CHARGER

For charging the batteries, (charger has been shown in figure 3.8). We use a very compact 5-amp 48V charger, as it would be simple to hook up one twelve-volt charger to each of the four batteries. A 48V charger has an advantage in that ONE charger tends to take up less space than FOUR chargers. Higher voltage chargers tend to be more expensive in general that 12V chargers However, 48V is a common voltage for golf carts, forklifts, and electric scooters.

Figure 3.8 CHARGER (48VOLT)

3.2.7 MOTOR CONTROLLER AND THROTTLE

- **Motor controller**

Direct Current (DC) motor controllers typically all work the same way. They "chop" the current from the Batteries to the motor. Essentially, they are a big fancy switch that turns power to the motor on and off Very quickly, typically thousands of times per second. The controller varies how long the circuit is on vs. off, depending on the signal it gets from the electronic throttle, or "potentiometer". The technique of turning the motor full on and off quickly called PWM or Pulse Width Modulation. Besides controlling the speed of DC motors, it used to dim LEDs on sports scoreboards and digital billboards, and used in many other facets of industry and electronics. By always providing, the full voltage to the motor, but turning it on and off quickly, the motor has full torque at any speed. The speed of a DC motor is directly proportional to the voltage provided to it. More voltage (such as having more batteries in series) makes the motor spin faster. With PWM, the AVERAGE on/off of the pulse width modulation controls the speed. But there is still full voltage, and voltage times amperage = HORSEPOWER. Using a modern electronic PWM controller gives an amazing effect of all the power you want at even very low speeds (motor controller has been shown in figure 3.9).

Mounting the controller

The motor controller needs to be mounted solidly to the frame of the motorcycle, near the batteries and motor. It does produce a small amount of heat, so we use aluminum frame, as it work as a heat shrink. On our motorcycle, the best place for the controller was behind the batteries and above the motor. This kept the power cables short and everything was still easily accessed. It also shows the controller off nicely. We use a scrap aluminum plate to mount the controller. Aluminum makes a nice heat sink, and it is lightweight and easy to cut and drill. The controller has four mounting holes on its base. We mark and drill machine holes on the mounting plate, and attached the controller with typical nuts and bolts. Adding that plate to hold the controller also gave me room on the other side of the plate to mount the "balance of system" components.

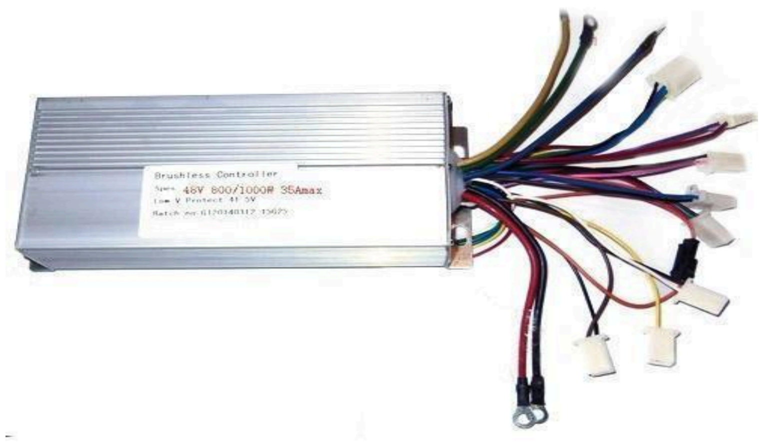

Figure 3.9 MOTOR CONTROLLER

Throttle

The throttle (figure 3.10) is a "potentiometer" - a variable resistor that sends a signal to the controller, based on its rotation. The throttle comes with three bare wires, but there are only two connections for throttle on the controller).

Figure 3.10 THROTTLE

3.2.8 STUDY OF SPROCKETS AND GEAR RATIO

- **Drive sprockets**

14-tooth sprocket and a hub with a 7/8" center hole to match the motor's drive shaft used. These are two parts, bought separately, which allows greatest flexibility in driveshaft diameter and sprocket tooth count. The sprocket and hub had to be welded together.

- **Gear ratio**

  It is the ratio of the number of revolution of pinion gear to one revolution of ideal gear. We are going to use 14- teeth sprocket (pinion gear) and 36-teeth sprocket (ideal gear) which gives us the gear ratio of 1:3.

CHAPTER-IV

RESULTS AND DISCUSSION

4.1 RESULTS AND DISCUSSION

In this project we have studied about the brushless motor in combinantion with gearbox for manual transmission in electric bike. It has been revealed from the study that a brushless motor connected with gearbox can sucessfully be used for manual transmission in electric bike. From the study we have observed that, the brushless dc motor in combination with gearbox for manual transmission in electric bike, four batteries, each of 12 volt, and a series connection provide 48 volt in total the pack rated at 55 AH can be used.

SPECIFICATIONS OF BRUSHLESS MOTOR:-

Voltage	48v
Rated Power	1000w
Rated rpm	3000
Rated operating voltage	48V
Rated current	25A

As per our study

$$48V \times 40\ AH = 1920\ \text{watt- hours}$$

As per our study, 100 watt- hours per mile implies. 100 W energy consumption per mile/hour of an electric motor

So,

$$1920/100 = 19.2\ \text{miles}$$

in Km,

$$19.2 \times 1.6 = 30.72\ \text{km}$$

This indicate that by fully charging the batteries one can ride our motorcycle up to 30 km.

SPECIFICATIONS OF LEAD ACID BATTERY :-

Voltage	12w
Rated current	40A

Discussion

the study revealed that using the brushless DC motor by connecting it with I.C engines gearbox will not only improve the efficiency but also the torque. Electric bikes are typically cursed for lower traction up hilling or climbing a slope that will be eliminated by adding manual transmission in it. As well as it, increase the capacity to carry higher loads due to gears.

The idea behind study on the electric bike was to make a street bike with an economy, green, zero-emission street bike that can easily carry any person, two persons and can cruise at a decent speed. It can also carry loads while climbing slopes.

For using four-speed gearbox on an electric bike, we replace the main crankshaft with the customized one. Also, a thick motor plate was fabricated for mounting the motor on the gearbox to make it a complete electric engine with four gears

Selection of lead acid battery found to be suitable as they are rechargeable battery, have long lifetime and are inexpensive.

As per the increasing price of petrol and higher carbon deposit, people will be switching themselves towards electric bike thus helping the environment. Electric bike would give the average of 30 km; it would help in reducing use of fossil fuel (petrol)

Comparative study between the I.C Engine and Brushless DC Motor -

	I.C Engine	Brushless DC Motor
1	I.C engine produces carbon	Bldc are environment friendly
2	I.C engine produces vibration	Bldc produces less noise
3	I.C engine needs high maintenance	Bldc needs low maintenance

4	Fuel used in i.c engine are very costly	Bldc offers financial saving in fuel cost as it uses only electricity
5	In case of reciprocating internal combustion, noise generated due to detonation of fuel.	As there is, no combustion happens inside electric bike, so very less amount of noise generated due to the movement of electric motor.

CHAPTER-V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSIONS

5.1 **Summary**

This project is based on the study of "**Brushless Motor with manual transmission"** we study on gearbox of IC engine, brushless DC motor, 12V four batteries, controller, mounting plate, chain(520 pitch), sprockets(14:36 teeth)

It all start with engine of old pulsar motorcycle. Where we remove crankshaft, connecting rod, cylinder block, piston, cylinder head, valve, timing chain, and carburetor by dismantling the engine. Then we install a custom-made axel shaft inside the gearbox where crankshaft installed before. Also with thick mounting plate that needs to fabricated for mounting the motor in place of cylinder block above gearbox.

Then the brushless DC motor will directly connected with the custom-made axel shaft with the help of chain (520 pitch) and sprockets (14:36 teeth in 1:3 ratio).

Every single rotation of motor shaft will rotate axel shaft 3 times, which will provide more speed to gear box.

With the help of five speed clutch and different gear, the power can easily be utilize in different ratio.

We use a controller to connect batteries and motor together so that we can able to control speed of motorcycle.

5.2 **Conclusion**

Our purpose for making this project is to stop producing carbon emission that ejected from bike into our natural atmosphere. In order to positively help the environment we live in, our project will be a great step forward.

By making, this project there will be-

- Safe fuel, No emission.
- Running cost will be less in comparison of I.C engine.
- Low maintenance will be there.
- There will be less noise as well as minimum vibration in the motorcycle.
- Very responsive and will have very good torque.

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