Modelling and Structural Analysis of Hybrid Electric Vehicle using Solid Works and ANSYS

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Abstract—Fuel availability in recent days is getting depleted and increased gasoline consumption related environmental pollution is expanding. As the use of private transportation has increased significantly relative to that of the public transportation system, our current generation is confronted with numerous issues relating to global warming. In this paper, we propose an alternative approach to this problem that makes use of electrical energy sources. First of all, an old model bike was taken and was modeled using Solid Works. Themodelled chassis was subjected to various loading scenarios, such as static loads using ANSYS and its structural stability was assessed by using alternative materials and geometries while preserving strength.

Indexed Terms—Ansys, bike, chassis, design, hybrid electric vehicle (HEV), modelling, SolidWorks.

I. INTRODUCTION

A few financial and natural variables are adding to expanding interest in elective vehicle innovations. These variables incorporate rising worldwide interest for oil, associative expansions in fuel costs and anthropogenic environmental change. Rising worldwide interest for oil has both financial and political results. Expanding request has a direct monetary effect by means of expanded item costs just as a few international ramifications that make political difficulties for nations that depend on imported oil for financial action. Additionally, proof of the expanding perils presented by environmental change adds to the earnestness to diminish the Green House Gas (GHG) emanations from all sources.

A, Hybrid Vehicle

The idea of Electric-Electric crossover framework which consolidates two separate Brushless DC engines for its propulsion. This is the most regularly adjusted cross breed vehicle which consolidates drive well springs of an electric engine and an I.C.engine the power supply to the electric engine comes from on board batteries. In a HEV, the I.C.engine helps out an electric engine which prompts a more ideal utilization of the motor. During idling, the engine consumes more fuel without creating valuable work. The HEV tackles the issue by changing to control transmission through the motor and switching off the engine. This way no fuel will be consumed during standing by with no exhaust discharge.

HEV is similar to flow crossover electric vehicles outfitted with a gas-powered motor, an electric motor and a battery that can be charged both by a generator driven by the IC engine. HEVs have a lot more prominent battery Limit and above all, the ability to charge the battery from outer power sources, including the electrical network (grid system).

The capacity to charge straight forwardly from the electrical matrix implies that HEVs can uproot a piece of the non-renewable energy sources utilized in the transportation area.

II. LITERATURE REVIEW

1. Prasanna Rangan R, et.al., carried out the work on "Design and Fabrication of Hybrid Two-Wheeler"
A hybrid-electric vehicle (HEV) combines the advantages of gasoline engines and electric motors and can be customized to achieve a variety of goals, including better fuel efficiency, more power, and

lower emissions that contribute to a greener environment. Vehicle starts out running on fuel, it switches to electric mode begins, in dual mode, both the engine and the motor are employed when hauling. a heavy weight and travelling quickly. The motor powers the vehicle, and a rheostat regulates its speed. It successfully balances fuel consumption and pollutant reduction and can be optimized in next-generation vehicles. A hybrid motorbike is capable of mounting a hybrid type drive unit, which can be fitted underneath the seat near the rear mudguard and does not protrude in the vehicle in a sideways even in orientation.

2. Inzamam Ul Haq Rizvi, et.al., carried out the work on "Design and Fabrication of Hybrid Two-Wheeler"
As we are all aware, the population is growing every day, and with it, the number of vehicles and the number of people using them. As is generally known to everybody, automobiles can run on gasoline, diesel, CNG and LPG.All of these fuels are leftovers from fossil fuel production. As the number of vehicles grows, so does the consumption of fossil fuels; as a result, there is a shortage of this fuel on the market, which drives up the price of that fuel.In this case, the motor and gearbox will be connected directly. We come to the conclusion that using this strategy will result in high vehicle efficiency and allow us to achieve high speeds, which are the main limitations of hybrid vehicles. The volume of hazardous gases produced is also something we can regulate. By employing this technique, we can progress the car and increase its effectiveness and efficiency. The volume of hazardous gases produced is can beregulated. By employing this technique, we can progress the car and increase its effectiveness and efficiency.

3. Ponmurgan P, et.al., carried out the work on "Design and Development of Hybrid Two-Wheeler"
An advanced car with an ignition motor built in is a hybrid electric vehicle. When used as a generator, this motor not only propels the wheel ahead but also charges the battery system. Due to the hybrid vehicle's lower CO2 emissions, the hybrid electric two-wheeler has gained popularity in recent years. The goal is to make the present hybrid vehicle less expensive and complicated. There are conventional, hybrid, plug-in hybrid, and electric models of these hybrid electric vehicles. The primary goal of this work is to design and construct a hybrid two-wheel vehicle, like a scooter, that can run on both petrol and battery. A hybrid electric vehicle (HEV) uses a two-wheeler that runs on battery and gasoline. Battery drive is used for low power applications, while gasoline engines must be used for high power applications with stringent control requirements. It is noted that the internal combustion engine is used to achieve the vehicle's propulsion. Once the necessary speed has been reached, the BLDC motor and ICE propulsion are combined to propel the vehicle as a whole. By adjusting the controller, the combined torque produced by the ICE and electric motors is synchronised for the corresponding road grade.

4. Saurabh Kadima, et.al., carried out the work on "Improvisation and fabrication of HybridMotorcycle"
Fossil fuel availability is dwindling as a result of the daily increase in fossil fuel use. The environment is becoming more contaminated as a result of the over usage of fossil fuels. Therefore, the focus of our project will be a hybrid two-wheeler vehicle with an internal combustion engine and an electric drive system. Both power sources would be coupled so that power could be easily transferred to the steering wheel. Utilizing such technology in a two-wheel motorcycle will assist minimise dependence on fossil fuels to some extent and enhance the driving range of the vehicle because the driver will have the choice to pick either Electric mode or basic propulsion mode. By analysing the sales graph, we can determine that as motorbike sales rise daily, more fossil fuel is being consumed. In other words, fuel prices would rise in the future. That is the reason we are moving forward with this project. The hybrid concept seems to be the best option because it increases driving range while also lowering consumer costs per km.

5. Ganapati Naveen, et.al., carried out the work on "Design and Fabrication of Electric Bike"
Our Electric vehicle models come in a large variety of sizes, speeds, shapes, and other characteristics. Due toa lack of supply, gasoline engines won't be used in the future. Driving a tiny car is challenging compared to an electrical vehicle. Therefore, electrical vehicles with specified speeds and sizes are appealing to the public. The goal of this project is to create an "ELECTRIC BIKE" that can function

properly, needs less upkeep, has a longer lifespan, and is more affordable than any other product on the market.

6. R. Mr. Sagar D. Mayatra, et.al., carried out the Work on "A Review Paper on a Design and Development of Hybrid-Electric Luna Moped"
In terms of pollution, the green effect is the key issue in the twenty-first century. The manufacture of more environmentally friendly, low-emission vehicles as well as new or more energy-efficient vehicles has taken the automobile industry into a new realm. The IC Engine and electric motor are independently operated for a combined effort to propel the Luna Moped, which is the subject of the study. The front wheel is replaced with an electric hub-motor drive, powered by batteries, and the rear wheel will be designed similarly to a two-wheeler with an internal combustion engine (ICE). A mechanical transducer, the hub-motor transforms chemical energy into mechanical energy. The idea behind this project is to use a hub motor mounted on a bicycle to reduce the energy output a Luna moped's front wheel. Future profits from these kinds of vehicles are very high, and they also provide an eco-friendly Luna moped solution to the problem of natural resources. For families in the middle class, this kind of vehicle is quite cost-effective. Due to the exhaust emission-driven dynamo assembly, the main engine's speed and throttling can directly affect the fan, which in turn can drive the dynamo for the electrical hub motor.

7. Mr. Inzamam Mulla, et.al., carried out the work on "design analysis and optimization of two-wheeler chassis for weight reduction".
The chassis frame is the supporting structure or a vehicle, and its main job is to carry the maximum weight safely under all intended operating conditions. The main carriage system of a vehicle is its chassis. The chassis acts as a framework on which components Iike the engine and transmission are installed. There is a frame, suspension, wheels, and brakes on a two-wheeler. Steel is a common chassis material for two-wheelers since it is dense and having force absorbing properties.

III. OBJECTIVES

The main objective of this paper is to model and analyse a hybrid electric two-wheeler for allowing the common public for daily commutation with an eco-friendly vehicle by the electric motor and to use the same vehicle for long distance and emergency purpose by the help of conventional engine.

The main objectives of the research are:
1. Modelling and structural analysis of the existing chassis.
2. Selection and assembly of electric power drive which includes the battery, hub motor, and controller.
3. Replacing the rear wheel hub of the bike with a hub motor.
4. To analyse the effect of forces and stress on different members of proposed electric vehicle.
5. To extend the drive range of the vehicle.
6. Making a greener environment by reducing the emissions.

IV. METHODOLOGY

Research was aimed to design and Analyse eco-friendly hybrid two-wheeler vehicle. The research moved around the arena of designing an eco-friendly and economical two-wheeler with electric motor and battery coupled together, using Solid Works and for that, chassis model of an old bike was analysed for the load and stress and deformation using ANSYS. Then calculations of various vital force and stress indices were done. The research work was accomplished under the following steps:

A. Modelling of the Chassis

The modelling of the chassis was made using the Solid works software using the dimensions taken from the bike. The frame was split into two half and made the model, first we started from the fork and the T stem of the bike then moved on to the lower frame where the engine is placed and finally the rear part. Then Meshing of nodal points along with boundary conditions and the loads acting applied to the model fixed supports and the loads acting on the chassis due to the weight of the engine and the battery. It includes:

1. Selection of old bike

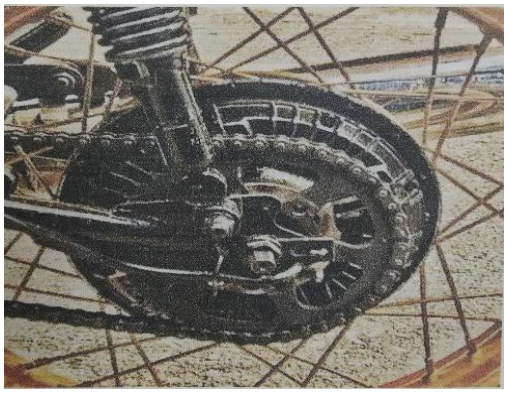
The bike put to use in force analysis is old used KAWASAKICALIBER, black in colour and of 2003 make with following specifications:

Fig. 1 Old Kawasaki Caliber Bike

Bike features	Specifications
Engine displacement	111.66 cc
Engine type	Air cooled;4 stroke
Number of cylinders	1
Valves per cylinder	2
Maximum Power	7.8 P.S@7000 rpm
Maximum Torque	8.1Nm @6000rpm
Compression Ratio	9.5: 1
Transmission type	Manual
Brakes	110 mm drum both front and rear
Suspension	Hydraulic Damped Telescopic (front) Swing Arm Hydraulic Shock absorber (rear)
Dimensions	Length (1995 mm), Height (1060mm), Wheel base (1245 mm)
Clearance	150 mm
Kerb Weight	116kg
Fuel Capacity	0lt.

2. Selection of Motor used and its specifications

A Brushless DC motor (otherwise called a BLDC motor or BL motor) is an electronically driven DC motor without brushes. The regulator gives beats of current to the motor windings which control the speed and force of the coordinated motor. In brushless motors, long-lasting magnets turn around a decent armature and defeated the issue of interfacing current to the armature. Substitution with gadgets has a huge extent of capacities and adaptability. They are known for smooth activity and holding force when fixed.



Fig,2 Brush less DC Motor

The brushes change the extremity of the post to keep the revolution on of the armature. In BLDC extremely durable magnets are appended in the rotor and move the electromagnets to the stator. The powerful semiconductors are utilized to initiate electromagnets for turning of shaft.

3.Battery selection

The battery used in the bike for the electric drive train is a Lithium-ion Battery. Hybrid Electric Vehicle involves battery as one of its power hotspots for vehicle movement during at low power conditions. Batteries are gadgets that comprise of electrochemical cells and give electrical energy changed over from put away synthetic energy. For the most part batteries are of two types: essential batteries that are expendable and auxiliary batteries that are battery-powered, optional batteries are first choice for vehicles as they can be battery powered.

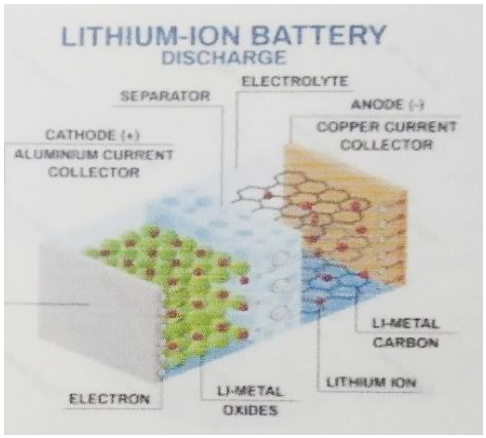


Fig.3 Lithium-ion battery

Table 2: Battery specifications used in experiment

Parameters	Values
Voltage	48V
Current	32Ah
Number of Cells	220V
Voltage per cell	4.5 V
Life cycle	500 cycles
Operating Temperature	-20°C to 60°C

4. Controller used and its specifications

Present day controllers change speed and speed increment by an electronic communication called beat width balance. Trading devices, for instance: silicone-controlled rectifiers rapidly frustrate (turn on and switch off) the power stream to the engine. High power is obtained for short ranges.

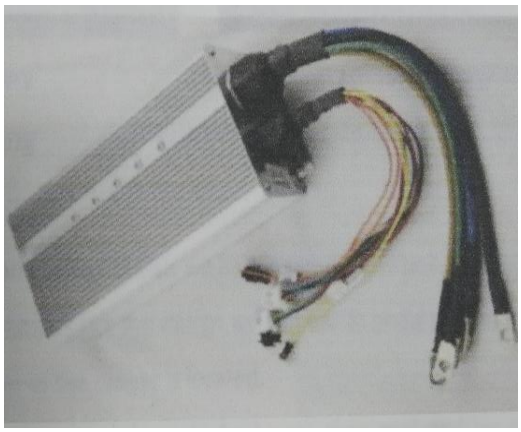


Fig.4 Controller

The controllers on works on the principle of regenerative braking, a portion of the dynamic energy routinely consumed by the brakes is converted into heat is regenerated and extracted over to drive by the Engine/controller and is used to re-charge the batteries.

5. Design of Parts in solid Works:

Finally, all parts pertaining to the proposed electric bike were assembled using Solid works as in Fig. 5 and Fig.6.

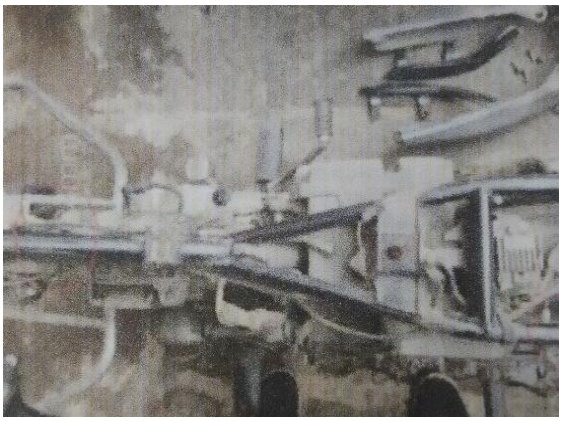


Fig. 5 Original Bike Chassis used in modelling.

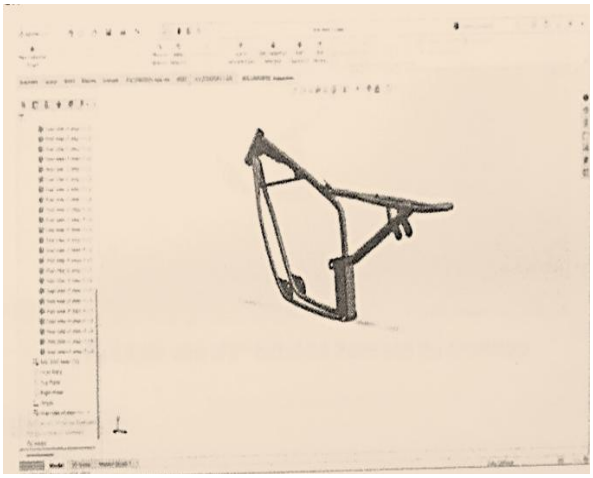


Fig.6 Modeling chassis of bike in Solid Works (upper half)

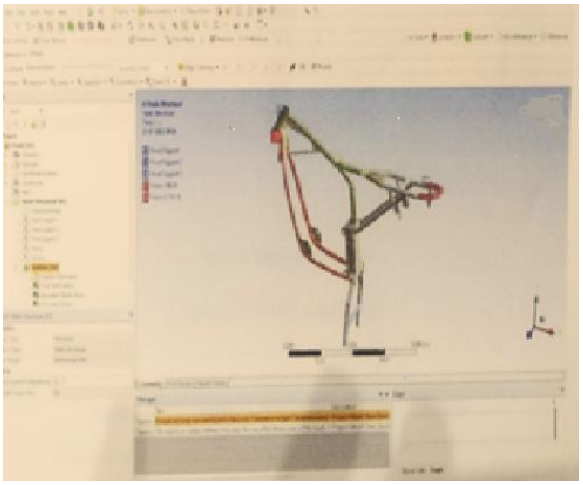


Fig.7 Modeling chassis of bike in Solid Works (full)

B. *Analysis of the Chassis*

The analysis was carried out using the ANSYS software by importing the model obtained from Solid works as shown in Fig.8 .

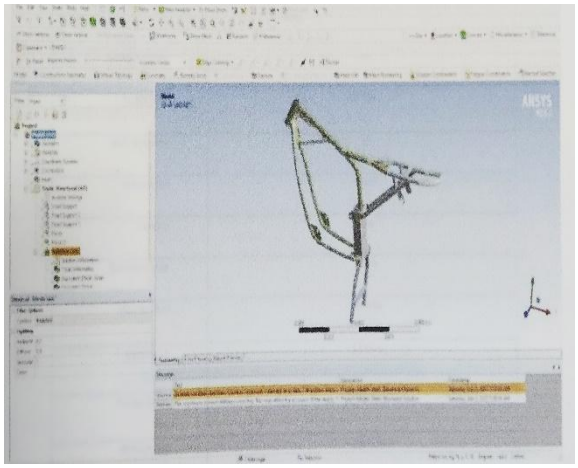


Fig.8 Imported Solid work model for force analysis

The task of force analysis was accomplished on ANSYS software as per following steps:

1. Selection of Engineering materials.

After importing list of materials that is used to manufacture the bike chassis was generated namely structural steel, aluminium alloy, carbon steel etc. as shown in Fig. 9

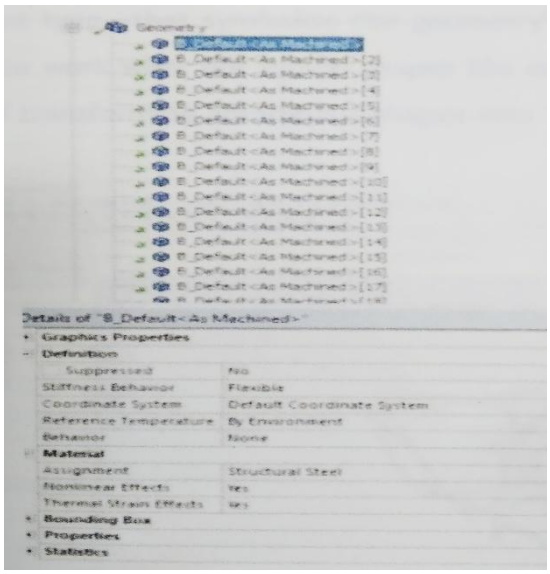


Fig. 9 Selection of material list in ANSYS

2. Geometry of modeled vehicle obtained from Solid works.

The modeled chassis was converted to .Step file format and was imported for further analysis.

3. Final model analysis in ANSYS

After file importing from solid works, force analysis is done using ANSYS.

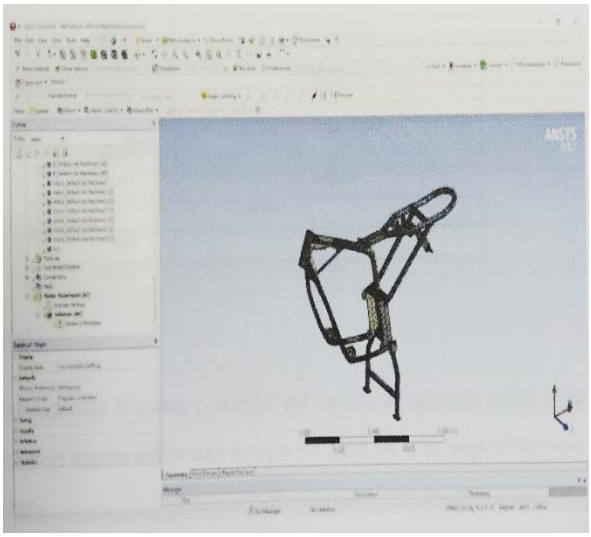


Fig.10 Final model ready for analysis

V. RESULTS

The following table shows solution of vital indices pertaining to ANSYS model so obtained

Table 3: Solution obtained by ANSYS:

Indices	Minimum Value	Maximum Value	Average Value
Deformation (in 10^{-6}m/m)	0.7931	7.6507	4.219
Equivalent Strain (in 10^{-6}m/m)	4.403	1.067	2.740
Equivalent Stress (in 10^{5} m/m)	5.7945	2.1122	4.621
Fatigue Life (in cycles)	100000	100000	100000

VI. CALCULATIONS

Data referred during performing calculations involved in the hybrid two-wheeler:
Volts (V)= 48V
Power (P) =1000W
Speed (v)= 60 kmph
Velocity = 60* (5/ 18) = 16.6 m/s
D= Wheel diameter in cm= d=45.72cm
Density of material (Aluminium)= 1.16 Kg/m^3
Mass of vehicle (m) =215 kg
Acceleration due to gravity(g) = 9.81 m/s^2
Coefficient of Drag (C_d)= 0.5
Coefficient of rolling friction tire on asphalt road (C_{rr})= 0.004
Angle of Friction imposed by gravity = 2.5°

1.Amount of Current needed for Electric Drive:
Power= Current x Voltage
Current= 1000/48 =20.833 amps

2. Speed of Motor in RPM
N_{motor} = Speed / (d*0.001885)
N_{motor} = 60/(45.72 x 0.001885)=696.86 RPM

4. Motor Torque

T_{motor}=P x 60/ (2 xπ x N_{motor})
= 1000 * 60/ (2 x 3.142 x 696.86)
T_{motor} = 13.703 Nm
5. Rolling Resistance
$F_{rolling}$ = C_{rr} x M x g
$F_{rolling}$ =0.004 x 215 x 9.81 =8.436 N
6. Grade Resistance
F_{grad} = M g x sin (2.5°)
= 215 x 9.81 x sin (2.5°) =91.99 N

7. Aerodynamic Drag
$F_{aerodynamic}$ = 0.5 * C_d * A_f* ρ * V^2
=0.5 x 0.5 x0.7 x 1.16 x $(16.6)^2$ =55.93 N

8. Total force F_{total}
F_{total} = 55.93+91.99 +8.43 =156.35 N

VII. BENEFITS OF THE RESEARCH WORK

The following are a couple of the top benefits of proposed crossover vehicle: -

1. *Harmless to the ecosystem:*
Perhaps the greatest benefit of hybrid vehicle over a gas-controlled vehicle is that it runs cleaner and has better gas mileage, which makes it harmless to the ecosystem. A mixture vehicle runs. On twin-controlled engine (gas motor and electric engine) that cuts fuel utilization and rations energy.

2. *Monetary Benefits*
Mixture vehicles are upheld by many credits and motivators that assistance to make them reasonable. Lower yearly duty bills and exception from clog charges come as less measure of cash spent on the fuel.

3. *Less Dependence on Fossil Fuels*
A Hybrid vehicle requires less fuel to run, and that implies less discharges and less reliance on petroleum derivatives. This assists with diminishing the cost of fuel in the home-grown market.

4. *Regenerative Braking System*
Each time the brake is applied while driving a half and half vehicle, it assistswith reenergizing your battery a little. An inside instrument kicks in that catches the energy delivered and utilizes it to charge the battery, which thus disposes of how much time and need for halting to re-energize the battery intermittently.

5. *Worked from Light Materials*
Hybrid are comprised of lighter materials, and that implies less energy is needed to run. The additionally more modest and lighter, which likewise saves a lot of energy.

6. *Help from Electric Motor*
The electric motor helps the gas-powered engine in the event of speeding up, passing or climbing a slope. In hybrid vehicles, the engine is naturally turned down when the vehicle is inactive and begins when the gas pedal is squeezed.

CONCLUSION

One of the most popular daily modes of transportation has been the two-wheeler, which runs on gasoline. However, the rising cost of gasoline and the fact that it is not renewable have been issues. In this project, we propose an alternative approach to this problem that makes use of electrical energy sources and converted a conventional old bike into hybrid electric bike which can function properly, needs less upkeep, has a longer lifespan, and is more affordable than any other product on the market.

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DISCLOSURE OF INTEREST

It is declared that there is no relevant or material financial interests of both authors pertaining to the research work. The data used in this research is proprietary in nature.

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