Conversion of Two-Stroke Vehicle to an Electric Vehicle

Haroon Rayyan Harris¹, Ajay G Dev¹, Joel Jose¹, Ganesh Jithamanyu DV¹, Vishnu Sankar², Jibin Noble²

¹ Students of Mechanical Engineering, Rajagiri School of Engineering and Technology
² Assistant Professor of Mechanical Engineering, Rajagiri School of Engineering and Technology

Abstract. Amid the global pandemic of covid-19, fuel prices have soared a record high, crossing the Rs. 100 landmark for petrol and diesel. This leads to an increase in prices across all products, which cuts in deeper into the already thin bottom lines of ordinary citizens. Public outcry aside, the rise in fuel prices indicates an accelerating trend, which emphasizes the need to find alternative sources of fuel for transport; the ever growing sector. In recent years, reports of possible banning two-stroke engines, coupled with the emergence of a new emission standard in India, have re-ignited questions about how two-stroke vehicles, can be powered from alternative sources of energy. This project intends to address the above question, by assessing the feasibility of a different alternative, by designing an electric drivetrain for a two-wheeler, while aiming to be practical and economical for the ordinary man riding it. This project intends to be a cost-feasibility study, whose aim, to realize a full EV conversion of a two-wheeler, less than 50% of current market price of base level, original EV’s, thereby proving to be a feasible alternative to people who cannot afford the alternative; and also solving the logistical and environmental problems arising from a large number of abandoned or suboptimal use of such vehicles, when the shift happens.

1. Introduction

Electric Vehicles (EV) are vehicles that are powered by electric motors. The first conceptual vehicles were seen prolifically in the 1900’s in the US due, in part, to the large interest in emerging motor vehicles and electric motors. But, in those times, the technology used to make electric motors and batteries, was primitive and inefficient. High losses, low speeds and range along with expensive charging ports marginalised these vehicles. As petrol became cheaper and mass production was possible starting with the Model T Ford, the cheaper petrol vehicles started to dominate the market. Electric vehicles ceased to exist by the late 1930’s as more number of petrol vehicles inundated the market and could outperform EV’s in every aspect. After the energy crises of 1970 and 80’s along with the rising awareness of global warming, petroleum was beginning to be seen as volatile in price, and toxic to the atmosphere. Hence, interest in EV’s was revitalized in the late 80’s and 90’s. The 2000’s saw the rise of popularity of hybrids, as an alternative with commercially feasible and a serious contender to IC vehicles. Breakthroughs in battery technology, like Li-ion batteries, which made internal batteries possible for electronic devices, and improved technology in motors such as phase induction and BLDC motors, EV’s started gaining traction among consumers as a working alternative [6]. All this culminated with the release of the Tesla Roadster in 2008, with sleek design, high speeds and long range per charge, EV’s have finally matured to take on IC vehicles and to become the choice of the future. EV’s has been established as the future of transportation. Already countries like the US
and western Europe, with the US state of California being one of the highest numbers of registered EV’s in the world. Eventually, petroleum scarcity will occur and demand for the products India, reports on banning of two stroke vehicles have already raised questions on the future of those vehicles and it’s pollution effects. In the year 2030 Indian Govt. has taken a stance to deliver a fully functional infrastructure for EV’s, effectively banning ICE vehicles. Soon there will be a lot of material waste in our environment which could cause another pollution. Currently, the latest census of India (2011), puts the total two-wheeler population approximately at about 5.18 crores. Also, its emission composition shows higher levels of unburnt particles and NOx emissions compared to four-wheelers. Sooner or later when EVs accompany the market IC engine vehicle usage limits eventually. So the material waste increases. This waste, if not recycled, will accumulate with time, causing a major pollution problem to our nation, and the world at large. So here we present the topic of our project, ie; ‘KINETRON’. This project aims to limit the material waste pollution and also reuse and recycle the material [5]. The field of Electric Vehicles is poised to make huge impacts in the future, hence the technology and infrastructure that sustain it are in high demand. We hope to fold our project to the evolving framework of EV technology so that people may have the opportunity to adapt to the new normal of EV [1][12].

2. Objectives

- To fully convert the two-stroke vehicle to an electric vehicle.
- To optimize the conversion process cost with a target of not more than 50% of vehicle value.

3. Design

Conversion of I.C. Engine Powered Scooter

![Figure 1. Layout of Electric Scooter.](image)

Diagram represents the main parts of the vehicle. The battery is connected to the motor controller which will provide current to the motor according to the requirement.

4. Methodology

The vehicle is first analyzed visually, by measuring the dimensions of different parts of the vehicle. The different parts of the vehicle are then cataloged based on grade quality, and recycling criteria. Those parts with good grade quality are then used in the conversion process. Others are disassembled and recycled. The wheels and the suspension frame, including shock absorbers are removed and then fitted with a modified bracket to incorporate the hub motor. The ICE and fuel tank is cleared and space is made at the bottom for battery storage. The space needed for a motor controller is situated near the hub motor, preferably above the battery separated by a partition. Temperature sensors are connected near the battery space to monitor thermal conditions which can be monitored by the information panel fitted at the steering panel. Higher-end variants also have an option to use ECU chips along with motor controller to unlock more features in range, speed and torque [2].
4.1 Calculations

The curb weight of the vehicle will be considered as 99kg.

Table 1. Parts and their weights

| Parts          | Weight |
|----------------|--------|
| Fuel Tank      | 3 Kg   |
| Engine         | 30 Kg  |
| Oil tank       | 0.5 Kg |
| Battery        | 1.9 Kg |
| Center stand   | 1.5 Kg |
| Other parts    | 5 Kg   |
| **Total weight** | **41.9 Kg** |

The reduced weight of the vehicle is, $99 - 41.5 = 57.1$ kg

Table 2. Weight of the parts required for conversion

| Parts                        | Weight |
|------------------------------|--------|
| 4, 12v 24 Ah batteries       | 20Kg   |
| Motor Controller             | 1 Kg   |
| Hub motor                    | 8 Kg   |
| Others                       | 2 Kg   |
| **Total Weight**             | **31 Kg** |

Total weight of the vehicle = $57.1 + 31 = 88.1$ Kg

Weight of the rider assumed = 70 Kg

Thus, total weight of the vehicle = $88.1 + 70 = 158.1$ Kg ≈ 170Kg

4.2 Power Calculation

The drag force is calculated as shown below;
Table 3. Calculation of forces

Table 3(a): Calculation of drag force

| Coefficient of Drag | $C_d$ | = | 0.5 | - |
|---------------------|-------|---|-----|---|
| Density of air $\rho_{air}$ | = | 1.18 | kg/m$^3$ |
| Cross sectional area $A_c$ | = | height× width |
|                      | = | 0.6 | m$^2$ |
| Velocity $V$ | = | 8.33 | m/s |
| Drag force $F_d (at V = 30kmph)$ | = | $\frac{1}{2} \rho_{air} A_c C_d V^2$ |
|                      | = | 12.28 | N |

Table 3(b): Calculation of Rolling Resistance Force and Gradient Force

| Coefficient of rolling resistance $\mu_{rr}$ | = | 0.004 | - |
|---------------------------------------------|---|-------|-----|
| Weight of vehicle | = | 1667.7 | N |
| Rolling Resistance Force $F_{rr}$ | = | $\mu_{rr}$×weight |
|                      | = | 6.67 | N |
| Gradient Force $F_{gr}$ | = | $\sin \theta$×weight |
| $\theta = 2.85\%$ | = | 72.744 | N |

Total Tractive Effort (TTE)$[2][3][4] = F_{gr} + F_{rr} + F_{ma} = 12.28 + 6.67 + 72.74 = 91.69$ N
Total Power required$[2][5] = TTE \times Velocity = 91.69 \times 8.33 = 763.77$ W $\approx 800$ W

5. Fabrication

5.1 Selection of parts

5.1.1 Motor. There are several motors like Brushed DC motor, BLDC motors, Induction motors. Their differences are as follows Table 4: Comparison between BLDC motor, Brushed DC motor, Induction Motor
From the above table, it is clear that BLDC motors are the best option for electric vehicles. We are using an 800W BLDC hub motor. A hub motor also called a wheel motor incorporates the electric
motor into the hub of the vehicle. Thus it saves a lot of space while compared to other motors. Also it provides high efficiency and instant torque [6].

5.1.2 Batteries

![Comparison between batteries.](image)

**Figure 5.** Comparison between batteries.

![Battery compartment and batteries.](image)

**Figure 6.** Battery compartment and batteries.

Li-ion batteries are the best option for electric vehicles which gives high energy density and high performance. But the price is high as compared to other batteries [9]. Thus we select Lead-acid batteries which give moderate energy density and performance. Also, one of the objectives is to optimise the cost of conversion, we are using second hand batteries for the conversion. The electric scooter is powered by 4, 12 V 24 Ah Lead-acid battery pack[7][8].

5.1.3 Conversion to electric scooter. The parts such as: the engine, petrol tank, oil tank, battery, and other unwanted parts were removed. The motor was connected in the rear wheels, the swing arm was adjusted so as to fix the hub motor. A cabin was created with sheet metal in the space of the engine inorder to accommodate batteries. In the space allowable below the seats, the motor controller was mounted. Mechanical accelerator was replaced by an electrical accelerator. All the connections were made; that is batteries were connected in series to provide combined voltage of 48V. It was connected to the motor controller which is coupled with the hub motor. A charging port was also fixed. From the batteries connections were made to the lights and signals after converting 48V - 12V using a DC converter. The controller regulates the power transmitted to the motor according to the acceleration given by the rider and allows the motor to rotate. Mechanical brakes are used in the vehicle [10][11].
6. Performance Evaluation

Table 4. Tests conducted to evaluate speed of the vehicle according to battery percentage.

| Sl. No. | Battery Percentage (%) | Vehicle speed |
|---------|------------------------|---------------|
| 1       | 80 - 100               | 29 – 30       |
| 2       | 50 - 80                | 27            |
| 3       | 40 - 50                | 25 – 27       |
| 4       | <40                    | 20 – 25       |

7. Cost of the conversion

Table 5. Cost of conversion.

| Sl.No | Components     | Price(Rs) |
|-------|----------------|-----------|
| 1     | Hub motor      | 6000      |
| 2     | Batteries      | 2000      |
| 3     | Motor controller| 1200     |
| 4     | Charger        | 1000      |
| 5     | Others         | 3000      |
|       | Total          | 13,200/-  |

8 Results

8.1 Range Calculation

Approximate range calculation

The converted two wheeler has an estimated range of 45km (pessimistic value), as calculated by theoretical approximations. The theoretical calculation was done by accounting for peak power rating.

\[
\text{Approximate range} = \frac{\text{Battery pack capacity}}{\text{Peak power rating of the controller}} \times \text{Top speed}
\]

\[
\text{Approximate range} = \frac{1.152 \text{ kWh}}{0.8 \text{ kW}} \times 30 \text{kmph} = 43 \text{km}
\]

9. Conclusion

The price of electric scooters available in the market ranges from Rs.40,000 to Rs.1,50,000 which is not affordable for a common man. Apart from that, if we are retrofitting the existing vehicles it will be more economical. After many tests, observations and calculation the IC engine powered scooter has been successfully converted to an electric powered scooter which in turn has reduced the cost of components tremendously .This method is even cheaper than the standard method of conversion which is to order a conversion kit from abroad. The converted scooter now requires only 17 percent of the
original fabrication cost. If we can do charging from a renewable source of energy such as a solar power station, the scooter can be run free of cost. Also, we can add regenerative methods like regenerative braking, regenerative shock absorber system, in order to extend the range of the vehicle. This way the initial investment made can be recovered effortlessly. The use of regeneration features in the scooter makes it more user-friendly. As we are using second hand components for this conversion, the efficiency is comparatively less. Even though we can rectify the problem by using high quality and more efficient components such as using Li-ion batteries rather than Lead-acid batteries [9].

References

[1]. C. Sukcharoen, T. Kulora, Modeling and Simulation of an Electric Scooter Driven by a Single-Phase Induction Motor 7th WSEAS international conference, Beijing (proceedings), 79-84(2007)

[2]. Lorenzo Nasarre Cortés, Joaquin Mora Larramona, Marcos Ruperez Cerquedaa and Luis Correas Usón, “Reva Electric Vehicle Conversion to a Hydrogen Fuel Cell Powered Vehicle”, Elsevier(2012), Energy Procedia 29 325 – 331 [3].Gage, T.B. Lead-acid batteries: key to electric vehicle commercialization. experience with design, manufacture and use of EVs, The 15th Annual Battery Conference on Applications and Advances, 217 – 222 (2000)

[3]. A. Eydgahi, “Converting an internal combustion engine vehicle to an electric vehicle”, American Society for Engineering Education (2011).

[4]. Najmuddin Jamadar, Suhani Jamadar, “Retrofitting of existing scooter into Hybrid electric scooter”, Journal of Automation and Automobile Engineering Vol 4, Issue 2(2019), 6 - 13.

[5]. Ji-Young Lee, Byung-Chul Woo, Jong-Moo Kim, Hong-Seok Oh, “In-wheel motor design for an electric scooter”, Journal of Electrical Engineering and Technology, 2307 - 2316(2017).

[6]. Saurabh Chauhan, “Motor Torque Calculations for Electric Vehicle”, International Journal of Scientific & Technology Research, Volume-4, Issue-08(2015), ISSN 2277-8616.

[7]. Geoffrey J. Maya, Alistair Davidsonb, Boris Monahovc, “Lead batteries for utility energy storage: A review”, ELSEVIER, 145 - 157(2018).

[8]. Hardik Keshan, Jesse Thornburg and Taha Selim Ustun, “Comparison of Lead-Acid and Lithium Ion Batteries for Stationary Storage in Off-Grid Energy Systems”, IEEE - 4th IET Clean Energy and Technology Conference,(2016).

[9]. Cheng-Hu Chen Ming-Yang Cheng, “Implementation of a Highly Reliable Hybrid Electric Scooter Drive”, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 54, NO. 5.(2007)

[10]. H. L Mohamed-Nour, Design Considerations In An Efficient Electric Motorcycle, IEEE, 283-288(1997)

[11]. Fred Schafer, Richard van Basshuysen, “Reduced Emissions and Fuel Consumptions in Automobile Engines”, Springer, 9-205 (1995), doi: 10.1007/978-3-7091-3806-9.

[12]. Lorenzo NasarreCortés “Reva Electric Vehicle Conversion to a Hydrogen Fuel Cell Powered Vehicle”, ELSEVIER, Vol. 29, 325 - 331(2012)