

THE CALCULATION OF ELECTRIC MOTOR AND LITHIUM BATTERY CAPACITY OF SPU E- BIKE

¹Vinesh S. Prajapati, ²Krunal B. Prajapati, ³Mahesh N. Patel, ⁴Prakash K. Patel

¹Lecturer, ²Lecturer, ³Lecturer, ⁴Lecturer

¹Mechanical Engineering Department,

¹Swami Sachchidanand Polytechnic College, Visnagar, Gujarat, India

Abstract: The world is moving closer to the point when fossil fuels may someday run out due to the ongoing increase in their consumption. Industries and research communities are turning more and more toward alternative powered by renewable energy to allay this worry. The design and performance evaluation of an electric two-wheeler with a brushless DC (BLDC) motor and a lithium-ion (Li-ion) battery as the main propulsion and energy storage system are discussed in this work. The study focuses on an equation-based approach to battery electric vehicle development that includes driveline evaluation, motor simulation, battery modeling, tractive force estimation, as well as evaluation of energy system losses. The suggested structure allows for effective selection of motor ratings and battery capacity based on the vehicle's performance needs. Because the motor's size and efficiency are directly related to its rating, careful consideration of load and traction characteristics is required. The results of this study give useful guidance for constructing optimal electric two-wheelers that fulfill specific operating requirements.

Index Terms - Electric bike, BLDC, lithium-polymer battery, battery modeling, motor rating, tractive force, driveline losses, renewable energy, and electric vehicle design.

I. INTRODUCTION

The present transportation sector heavily relies on fossil fuel-based vehicles, which are neither cost-effective nor environmentally sustainable in the long term. To overcome these challenges, the Government of India has initiated policies and roadmaps for the development of the electric vehicle (EV) sector, aiming to replace nearly 70% of conventional internal combustion engine (ICE) vehicles with electric alternatives by the year 2035. Such a transition is expected to significantly reduce greenhouse gas emissions, improve energy efficiency, and lower the dependency on fossil fuels [10].

Among the various components of an EV, the electric motor and battery play a crucial role in determining the overall performance of vehicle. Brushless Direct Current (BLDC) motors are widely adopted in electric two-wheelers due to their outstanding features such as high starting torque, compact design, lightweight construction, high reliability, and exceptional efficiency in the range of 94–98%. Their superior power density and operational characteristics make them more suitable compared to conventional motors for propulsion applications in modern EVs [11].

On the other hand, the energy storage system of an EV primarily depends on the type of battery employed. Rechargeable lithium-based batteries are the most widely used due to their high energy density, long cycle life, and better efficiency compared to other alternatives such as lead-acid or nickel-metal hydride batteries. Common lithium-based chemistries include Lithium-ion (Li-ion), Lithium Polymer (Li-Po), and Lithium Iron Phosphate (LiFePO₄). Among these, Lithium-ion batteries are most preferred for electric two-wheelers and long-distance applications owing to their higher capacity, lightweight design, and ability to deliver sustained performance.

In this project, a Lithium-ion battery pack has been designed according to competition guidelines to provide the required energy for the BLDC motor. The selection of this battery technology ensures optimized efficiency, improved energy storage capability, and suitability for extended travel ranges, making it a reliable choice for electric mobility applications.

II. METHODOLOGY

2.1 Calculation of Motor

2.1.1 Vehicle Mechanical Calculations & Motor Selection:

- Gross Vehicle Weight = GVW = 230 Kg
- Gross Vehicle Mass = GVM = $230/9.81 = 23.44$ Kg
- Radius of Tyre = $r = 0.2921$ meter
- Circumference of tyre = $C = 2\pi \times r$
 $= 2 * 3.14 * 0.2921$
 $= 1.835$ meter
- Velocity of Vehicle = $V = 45$ Km/hr = 12.5 m/s
- Acceleration = $a = v^2 = u^2 + 2as$
 $u = 0$ m/ sec
Consider, $s = 50$ m
 $a = 1.56$ m/s²

$$\text{Now, } s = ut + \frac{1}{2}at^2$$
$$t^2 = \frac{100}{1.56}$$

$$t = 8 \text{ sec}$$

g. Rolling Resistance Force = F_{rr}

The rolling resistance coefficient (C_{rr}) depends strongly on the road surface:

Concrete Road = 0.006 – 0.010

Asphalt Road = 0.012 – 0.015

Rough Road = 0.02 – 0.03

$$F_{rr} = C_{rr} * GVW * g$$

$$F_{rr} = 0.006 * 230 * 9.81$$

$$F_{rr} = 13.53 \text{ N}$$

h. Aerodynamic Drag Force = F_d

For calculation of aerodynamic drag force (F_d) on a bike, we need the frontal area (A_f) and the drag coefficient (C_d).

$$F_d = \frac{1}{2} * C_d * \rho * A_f * v^2$$

Where, ρ = air density ($\approx 1.225 \text{ kg/m}^3$ at sea level)

C_d = drag coefficient (typically 0.6 – 0.9 for motorcycles)

A_f = frontal area (m^2)

v = velocity (m/s)

$$F_d = 0.5 * 0.9 * 1.22 * 0.68 * 12.50^2$$

$$F_d = 52.10 \text{ N}$$

i. Acceleration Force = F_{acc}

$$F_{acc} = GVM * \text{Acceleration}$$

$$F_{acc} = 23.44 * 1.56$$

$$F_{acc} = 36.56 \text{ N}$$

j. Total Force F_t = Sum of Rolling Resistance, Aerodynamic Drag Force and Acceleration Force

$$F_t = F_r + F_d + F_{acc}$$

$$F_t = 13.53 + 52.10 + 36.56$$

$$F_t = 102.19 \text{ N}$$

k. Electrical Power Required = $\frac{\text{Total Force} * \text{velocity}}{\eta_{\text{Motor}}}$

$$= \frac{102.19 * 12.50}{0.93}$$

$$= 1373.52 \text{ Watt}$$

l. Torque Required for the System = T

$$T = r * F_t$$

$$= 0.2921 * 102.19$$

$$= 29.84 \text{ N.m}$$

- For Power of Motor, choose motor whose power is between 1200 watt to 1500 watt.
- For RPM, choose motor whose RPM is between 500 to 700.

2.2 Calculation of Battery:

1. Cell voltage: 3.6 V

2. Capacity: 2500 mah

3. Charging voltage: 4.2 V

4. Weight per cell: 45 gm

5. Specific energy density: 9.13 Wh

a. Volume of NMC cell = $V_{cc} = \pi * \text{radius of cell}^2 * \text{length of cell}$

$$= \pi * 9^2 * 65$$

$$= 0.0000165 \text{ m}^3$$

b. Each cell energy = Battery Cell Capacity \times Battery Cell Nominal Voltage

$$= 2.5 * 3.6$$

$$= 9 \text{ Wh}$$

c. Battery Cell Energy Density = $\frac{\text{Each Cell Energy}}{\text{Battery Cell Mass}}$

$$= \frac{9}{0.045}$$

$$= 200 \text{ Wh/kg}$$

d. Total Energy of Battery Pack = $\frac{\text{Motor Voltage} * \text{Amp Drawn} * \text{Distance}}{\text{Speed}}$

$$= \frac{72 * 16 * 73}{45}$$

$$= 1.8 \text{ Kwh}$$

e. Number of Cells in Series = $72/3.6 = 20$ Cells

f. Energy Content of String = Cells in Series \times Energy of Each Cell

$$= 20 * 9$$

$$= 180 \text{ Wh}$$

g. Number of Cell in Parallel = $25/2.5 = 10$ Cells

h. Total Battery Pack Capacity = Number of Cells in Parallel \times Battery Cell Capacity

$$= 10 * 2.5$$

$$= 25 \text{ Ah}$$

- i. Total Number of Cells = $20 \times 10 = 200$ cells
- j. Battery Pack Total Mass = $200 \times 0.045 = 9$ Kg
- k. Peak Current = C Rate \times Current Capacity
 $= 2 C \times 2.5 \text{ Ah}$
 $= 5 \text{ Amp}$
- l. Peak Current of Battery Pack = $5 \times 10 = 50$ Amp
- m. Peak Power of Battery pack = $50 \times$ Battery pack Voltage
 $= 50 \times 72$
 $= 3600 \text{ Watt}$

So, 72V and 25ah Battery pack should be used in this bike model.

III. RESULTS AND DISCUSSION

3.1 Parameters of Cell and BLDC Motor

Table 3.1: Parameters of Li-ion cell

Nominal voltage	3.7 V
Rated charge voltage range	4.1 V
Nominal Capacity	2500 mAh
Energy Density	200 wh/kg
Charge Voltage (End Current)	4.2 V
Max discharge Current	2C (5 A)
Cell Dimension	Diameter: 18.0 ± 0.2 mm Length: 65.0 ± 0.2 mm Volume: $\approx 16.6 \text{ cm}^3$
Internal Resistance	$\leq 35 \text{ m}\Omega$

Table 3.2: - Parameters of BLDC Motor

Type	BLDC
Voltage	72 V
Rated Current	20 Amp
Rated Speed	740-850 RPM
Operating Temperature	(-20 to 80) (°C)
Protection class	IP54
Motor weight	7 Kg
Output Power	1500 watt
Efficiency	93 %

IV. CONCLUSION

The present work illustrates a systematic approach to the design and performance assessment of an electric two-wheeler powered by a BLDC motor and a Lithium-ion battery system. Based on the detailed mechanical and electrical calculations, the proposed configuration of a 72 V, 25 Ah Lithium-ion battery pack comprising 200 cells is found to be well-suited for delivering the required energy and peak current to operate a 1500 W BLDC motor efficiently. The force analysis, which accounted for rolling resistance, aerodynamic drag, and acceleration demands, validates that the selected system ensures reliable propulsion, adequate torque, and stable operation under the specified design conditions.

The BLDC motor, with an efficiency of approximately 93%, provides high torque density, compactness, and consistent performance, reinforcing its suitability for modern electric mobility applications. Simultaneously, the Lithium-ion battery pack, with its superior energy density and lower weight, offers extended operational range, reduced charging cycles, and enhanced reliability compared to traditional battery technologies.

Overall, the study confirms that the proposed motor–battery integration not only achieves the desired performance outcomes but also contributes towards the broader goals of sustainable transportation. By minimizing dependency on fossil fuels and reducing greenhouse gas emissions, this work supports the Government of India’s roadmap to achieve large-scale adoption of electric vehicles by 2035. The findings demonstrate that the designed system is not only technically feasible but also environmentally responsible, thereby underscoring the potential of electric two-wheelers as a viable solution for future urban mobility.

REFERENCES

- [1] Samant, A. G., Patil, S. J., Patil, A. S., & Abhyankar, R. (2021). *The calculation of electric motor and lithium battery capacity of IURED E-Bike* (Vol. 1, Issue 4, Article 136, pp. 1–4). *VIVA-Tech International Journal for Research and Innovation*. Computer Engineering Department, VIVA Institute of Technology.
- [2] Nugraha, M. R., & Kartini, E. (2022, November 14). *The analysis of Li-ion battery pack 48 V 15 Ah performance for electric bike*. AIP Conference Proceedings, 2708, Article 070007. AIP Publishing. <https://doi.org/10.1063/5.0123489>

- [3] avia, D., Tewari, K., Budarapu, P. R., & Natarajan, S. (2023). *Design of lithium-ion battery packs for two-wheeled electric vehicles*. *Energy Storage*, 5(7). <https://doi.org/10.1002/est2.458>
- [4] Biljannah, M. A., & Kartini, E. (2023). *Design of battery pack for electric bike*. In *AIP Conference Proceedings* (Vol. 2517, Art. 020012). AIP Publishing. <https://doi.org/10.1063/5.0121542>
- [5] Dishu, Gupta, H., Saifi, H., & Khan, S. A. (2024). *Performance analysis of BLDC motor for electric two-wheeler*. In *IEEE Conference Proceedings, ICPEICES, 2024* (pp. 217–222). IEEE.
- [6] Arifin, Z., Adiyasa, I. W., & Rasid, M. A. H. (2022). *Design optimization analysis on the performance of BLDC motors on electric bicycles*. In *Journal of Physics: Conference Series* (Vol. 2406, Article 012016). IOP Publishing. <https://doi.org/10.1088/1742-6596/2406/1/012016>
- [7] Bansal, R., Sharma, A., Ali, M., Shrivastav, P., Yadav, V., Mandloi, S., & Dhanotia, R. (2020). *Design and fabrication of electric bicycle*. *Advances and Applications in Mathematical Sciences*, 20(1), 25–36. Mili Publications.
- [8] Mutyala, S. (2019). *Design and development of electric motorbike*. *International Research Journal of Engineering and Technology (IRJET)*, 6(12), 1–5.
- [9] adhav, S. S., Chaudhari, P., Kshirsagar, S., Ingale, A., Mhaske, S., Chatterjee, P., & Kathale, S. (2022). *Design and simulation of BLDC motor*. *International Research Journal of Modernization in Engineering Technology and Science (IRJMETS)*, 4(5), 1–7.
- [10] Babu, B. S., Meenatchi, N., Kamalakannan, J., S, K., Boopathi, S., & M, S. K. S. (2022, December 8). *Economic impacts and reliability evaluation of battery by adopting Electric Vehicle*. <https://doi.org/10.1109/icpects56089.2022.10046786>
- [11] Bahrami, M., Dindar, A., & Mokhtari, H. (2019). *Energy regeneration technique for electric vehicles driven by a brushless DC motor*. *IET Power Electronics*, 12(13), 3397–3402. <https://doi.org/10.1049/iet-pel.2019.0024>

