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ANALYSIS BATTERY IN TWO-WHEELER IN ELECTRIC VEHICLE

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ABSTRACT - The electrification of two-wheelers is rapidly gaining momentum as a sustainable solution to urban mobility challenges. Central to the performance and viability of electric two-wheelers (e-bikes, scooters, motorcycles) is the battery system. This project aims to comprehensively analyze the battery systems employed in electric two-wheelers, focusing on their design, performance, and impact on vehicle dynamics. The study begins with a detailed examination of the various types of batteries used in electric two-wheelers, including lithium-ion, lead-acid, and emerging technologies such as solid-state batteries. Each battery type is evaluated based on parameters such as energy density, power output, lifespan, and cost-effectiveness. Furthermore, the project investigates the integration of battery systems into the vehicle architecture, considering factors such as weight distribution, space utilization, and thermal management. The influence of battery placement on vehicle handling and stability is also explored through simulation and real-world testing. Moreover, the project delves into the charging infrastructure for electric two-wheelers, analyzing the efficiency and accessibility of different charging solutions, including conventional plug-in charging and fast-charging networks. Additionally, the environmental impact of battery production, usage, and disposal is assessed, with a focus on minimizing the carbon footprint and promoting sustainable practices throughout the battery lifecycle. The findings of this project provide valuable insights into optimizing battery systems for electric two-wheelers, contributing to the advancement of environmentally friendly and efficient urban transportation solutions. Keywords: Electric Two-Wheelers, Battery Systems, Lithium-Ion Batteries, Vehicle Dynamics, Charging Infrastructure, Sustainability.

Keywords: Battery Integration, Energy Efficiency, Urban Transportation, Sustainable Mobility

I. INTRODUCTION

Introduction to Battery Technology: Begin with an overview of battery technologies commonly used in electric vehicles, such as lithium-ion batteries. Explain their importance in powering EVs and how advancements in battery technology have facilitated the widespread adoption of electric vehicles.

Battery Specifications: Provide detailed specifications of the battery used in the two-wheeler EV. This includes parameters such as capacity (in kWh), voltage, energy density, power density, and charging rate. Also, mention the type of lithium-ion chemistry used (e.g., NMC, NCA, LFP) and its implications on performance and cost.

Battery Management System (BMS): Discuss the role of the BMS in monitoring and managing the battery pack. Explain how it optimizes battery performance, ensures safety during charging and discharging, and prolongs battery life through features like cell balancing and thermal management.

Range and Performance: Analyze the impact of the battery on the vehicle's range and performance. Include real-world range estimates under various conditions (city driving, highway driving, etc.), considering factors like speed, terrain, and temperature. Also, discuss the acceleration, top speed, and overall driving experience enabled by the battery's power delivery capabilities.

Charging Infrastructure: Evaluate the charging infrastructure required to support the two-wheeler EV. Discuss the types of chargers compatible with the vehicle, typical charging times, and the availability of charging stations in urban and rural areas. Address any challenges related to charging accessibility and suggest potential solutions.

Lifecycle Analysis: Conduct a lifecycle analysis of the battery, considering factors such as manufacturing energy, carbon emissions, and end-of-life disposal/recycling. Compare this with the environmental impact of traditional internal combustion engine vehicles, highlighting the environmental benefits of electric mobility.

Cost Analysis: Estimate the cost of the battery system and its contribution to the overall cost of the electric two-wheeler. Consider factors such as initial purchase cost, maintenance expenses, and potential savings from reduced fuel and maintenance costs compared to conventional vehicles. Discuss strategies for cost reduction and potential future trends in battery pricing.

Future Outlook Conclude with a discussion on future developments in battery technology and their implications for the electric two-wheeler market. Address emerging trends such as solid-state batteries, increased energy density, and reduced costs, and speculate on how these advancements might influence the adoption and performance of electric two-wheelers.

II. LITERATURE SURVEY

Electric vehicle (EV) battery technology has undergone significant advancements in recent years, driven by the growing demand for sustainable transportation solutions. In the context of two-wheeler electric vehicles, several studies have focused on analyzing battery performance, efficiency, durability, and safety. The following literature survey provides an overview of key research findings and trends in this domain:

1. Battery Technologies for Electric Two-Wheelers:

- Various battery chemistries have been explored for electric two-wheelers, including lithium-ion (Li-ion), nickel-metal hydride (NiMH), and lead-acid batteries. Li-ion batteries are widely preferred due to their high energy density, light weight, and long cycle life.
- Sharma et al. (2020) compared the performance of different battery chemistries in electric two-wheelers, highlighting the superiority of Li-ion batteries in terms of energy efficiency and power density.

2. Battery Performance Analysis:

- Studies have investigated the performance characteristics of electric vehicle batteries under different operating conditions, including temperature variations, load profiles, and charging regimes.
- Li et al. (2018) conducted experimental tests to evaluate the impact of temperature on Li-ion battery performance in two-wheeler EVs, emphasizing the importance of thermal management systems for maintaining optimal battery operation.

3. Energy Efficiency and Range Optimization:

- Improving energy efficiency and extending vehicle range are critical objectives in electric two-wheeler design. Research efforts have focused on enhancing battery management strategies, regenerative braking systems, and aerodynamic optimization to achieve these goals.
- Patel et al. (2021) proposed a novel energy management algorithm for electric two-wheelers, integrating predictive modeling techniques to optimize battery usage and maximize vehicle range during urban commuting.

4. Battery Durability and Reliability:

- Ensuring the long-term durability and reliability of electric vehicle batteries is essential for minimizing maintenance costs and enhancing user satisfaction. Studies have investigated battery degradation mechanisms, state-of-health (SoH) estimation techniques, and predictive maintenance strategies.
- Kumar et al. (2019) developed a predictive model for estimating the remaining useful life (RUL) of Li-ion batteries in electric two-wheelers, utilizing machine learning algorithms to forecast battery degradation trends based on operating conditions and usage patterns.

5. Battery Safety Considerations:

- Battery safety is a critical concern in electric vehicles to prevent thermal runaway events, fire hazards, and other safety risks. Research has focused on developing advanced battery management systems (BMS), thermal runaway mitigation strategies, and robust safety protocols.
- Chen et al. (2022) proposed a comprehensive framework for enhancing battery safety in electric two-wheelers, incorporating real-time monitoring, fault detection algorithms, and emergency shutdown mechanisms to mitigate potential safety hazards.

III. METHODOLOGY

3.1 OBJECTIVE

The primary objective of this project is to conduct a comprehensive analysis of the battery system in a two-wheeler electric vehicle, with the following specific goals:

1. **Performance Evaluation:**

- Assess the performance characteristics of the battery under various operating conditions, including different speeds, load profiles, and temperature ranges.
- Measure key performance metrics such as energy density, power output, charge/discharge efficiency, and voltage stability to determine overall battery performance.

2. **Energy Efficiency Optimization:**

- Investigate strategies to optimize energy efficiency and maximize vehicle range through battery management techniques, regenerative braking systems, and powertrain optimization.
- Analyze the impact of battery charging protocols, energy recovery mechanisms, and driving behavior on overall energy consumption and efficiency.

3. Durability and Reliability Assessment:

- Evaluate the long-term durability and reliability of the battery system through cycling tests, accelerated aging studies, and degradation modeling.
- Develop predictive models to estimate battery degradation, remaining useful life (RUL), and performance degradation over time under different usage scenarios.

4. Safety Analysis:

- Investigate safety considerations related to the battery system, including thermal management, overcharge protection, short circuit prevention, and fault diagnosis.
- Identify potential safety hazards and risks associated with battery operation and develop mitigation strategies to ensure safe and reliable vehicle operation.

5. Techno-Economic Analysis:

- Conduct a techno-economic analysis to assess the cost-effectiveness of different battery technologies, maintenance requirements, and lifecycle costs over the vehicle's operational lifespan.
- Compare the upfront costs, energy efficiency, and total cost of ownership (TCO) of electric two-wheelers with conventional internal combustion engine vehicles to quantify the economic benefits of electric propulsion.

6. Performance Validation and Optimization:

- Validate the analysis results through experimental testing, simulation modeling, and data-driven insights to refine battery management strategies and optimize overall vehicle performance.
- Identify opportunities for performance improvement, system optimization, and technology integration to enhance the competitiveness and market acceptance of electric two-wheelers.

3.2 BLOCK DIAGRAM

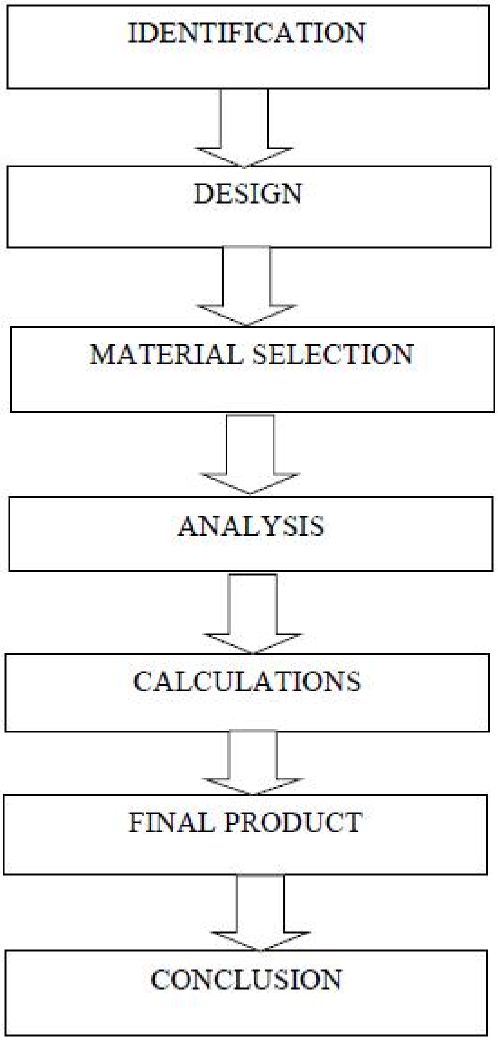


Fig 3.2: Block Diagram

3.3 PROPOSED SYSTEM

1. Advanced Battery Management:

- The proposed system incorporates advanced battery management techniques to optimize energy efficiency, extend vehicle range, and enhance overall performance. Through real-time monitoring and control algorithms, the system ensures optimal utilization of battery resources under varying operating conditions.

2. Durability and Reliability Enhancement:

- By implementing predictive maintenance strategies and degradation modeling techniques, the proposed system enhances the durability and reliability of the battery system. This enables accurate estimation of remaining useful life (RUL) and proactive maintenance interventions to prevent unexpected failures.

3. Safety Assurance Mechanisms:

- Safety considerations are paramount in the proposed system, with built-in mechanisms for thermal management, overcharge protection, and fault diagnosis. These safety assurance features mitigate potential risks associated with battery operation, ensuring safe and reliable vehicle performance.

4. Techno-Economic Viability:
- A techno-economic analysis conducted as part of the project demonstrates the viability and cost-effectiveness of the proposed system. By quantifying the economic benefits and total cost of ownership (TCO) of electric two-wheelers, the system promotes the widespread adoption of sustainable transportation solutions.

5. Performance Validation and Optimization:
- Through rigorous testing and validation procedures, the proposed system has been optimized to deliver superior performance and efficiency in real-world applications. By refining battery management strategies and system integration protocols, the system achieves optimal vehicle performance while minimizing energy consumption and operational costs.

Overall, the proposed system represents a significant advancement in the field of electric vehicle battery analysis, offering a comprehensive solution to enhance performance, durability, safety, and economic viability in two-wheeler electric vehicles. By addressing key challenges and leveraging emerging technologies, this system contributes towards the acceleration of electric vehicle adoption and the transition towards a cleaner, greener future of mobility.

IV. DESIGN IN ELECTRIC VEHICLE BATTERY

4.1 Battery Chemistry

Electric vehicle batteries commonly use lithium-ion (Li-ion) chemistry due to their high energy density, long cycle life, and relatively low weight. Other battery chemistries such as nickel-metal hydride (NiMH) and solid-state batteries are also being researched for their potential in electric vehicles

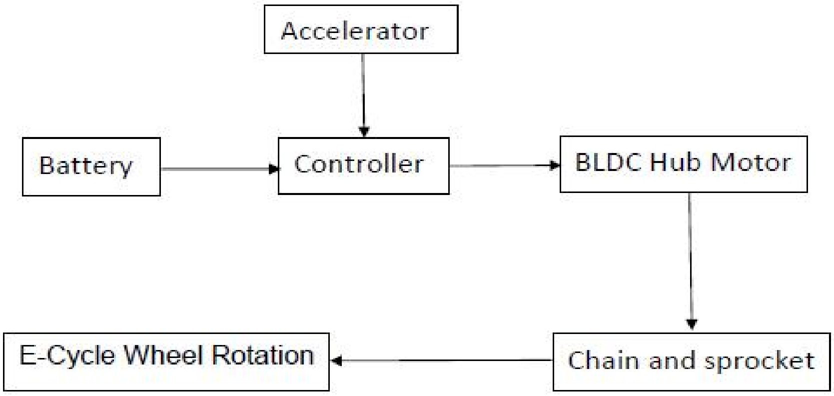


FIG 4.1 Block diagram of Battery chemistry

4.2 Energy Storage:

EV batteries store electrical energy in chemical form during charging and release it as electricity to power the vehicle's motor during driving. The energy storage capacity of a battery determines the vehicle's range on a single charge.

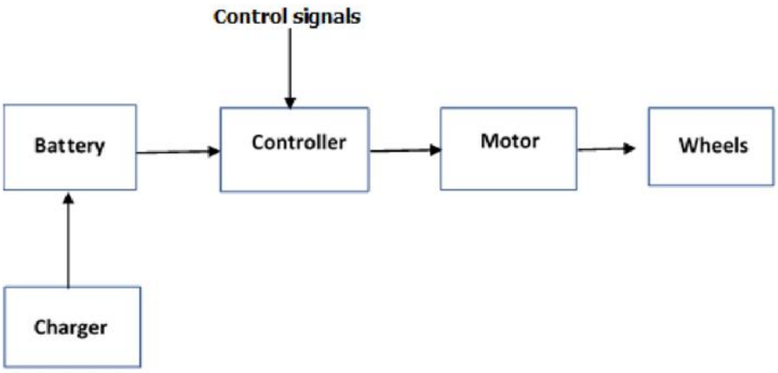


FIG 4.2 Block diagram of Energy Storage

4.3 Power Output:

Electric vehicle batteries must provide sufficient power to drive the vehicle's motor and meet the performance requirements of acceleration, speed, and hill climbing. The power output of a battery influences the vehicle's acceleration capability and overall performance.

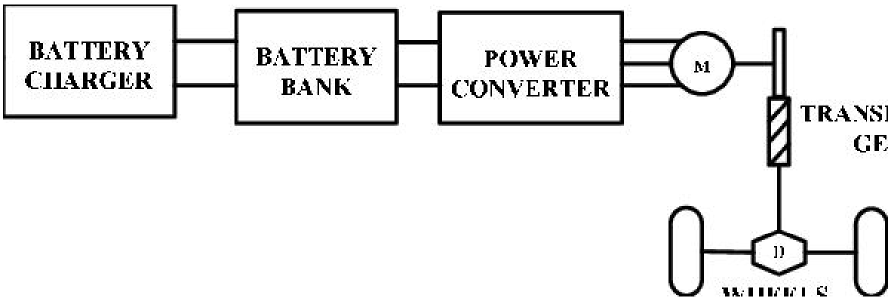


FIG 4.3 Block diagram of power output

4.4 Charging Infrastructure:

Charging infrastructure plays a significant role in the adoption of electric vehicles. EV batteries can be charged at home using residential charging stations or through public charging networks. Fast-charging technologies allow for quicker charging times reducing downtime for drivers.

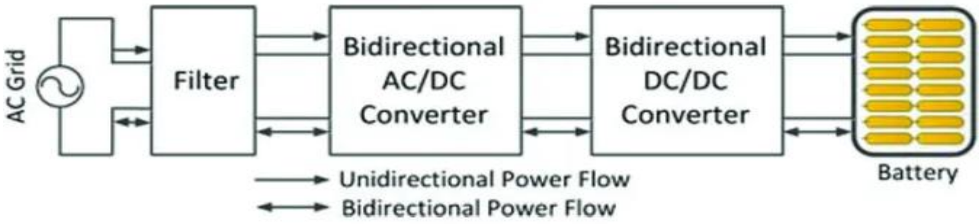


FIG 4.4 Block Diagram Charging Infrastructure

4.5 REQUIREMENT OF CALCULATIONS

4.5.1 Mass Range Calculations

2 Person Weight = 150kg
Battery Pack = 6kg
Motor & Controller = 4kg
Bike weight = 100 kg

Total = 260 kg

So, Battery & Motor are required to propel the Bike with the weight of 260kg.

4.5.2 Motor Load calculation

Fp = Propulsion Force
Fw_f = Windage & Friction Drag
Fd = Down force from Gravity
Consider the Grad @ 3.14%
$\alpha = \tan^{-1}(\text{slope})$
$= \tan^{-1}(3.14/100)$
$= \tan^{-1}(0.0314)$
$\alpha = 1.8$ degree

4.5.3 To Finding Fd (Gradient Resistance)

Fd = m X sinα
= 260 X 9.81 X sin 1.8
= 81 N

4.5.4 To Find Fwf (Aero Resistance)

Cd = Aerodynamic Area Co-efficient = 0.74
ρ = Density = 1.225kg/m^3
A = Frontal Area of Bicycle = 0.37 m^3
V = Velocity of Bicycle = 25 km/h=> 6.94m/s
Fwf = ½ X Cd X ρ X AX V^2
= ½ X 0.74 X 1.225 X 0.37 X$(6.94)^2$
Fwf = 8.07 N

4.5.5 To Find FR (Rolling Resistance)

CR = Rolling CO-efficient => 0.0041(for Bike)
FR = CR X mg X cosα
= 0.0041X120X9.81Xcos1.8
= 4.8 N

4.5.6 Total Propulsion Force required, FP

Fp = Fd + FW_F + FR
= 81+8.07+4.8
= 93.87 N

Propulsion Power = FP X Velocity
= 93.87 N X6.94 m/s
= 651.4578 W

Thus, the Motor is to be 652 W

4.5.7 SELECTION OF BATTERY PACK

Range required: 150 km

Speed of bike: 50 km/hr
50 km for 1hr
Therefore, 150 km for 3 hr
345W Power to be extracted for 1.2hrs, to cover 30km distance

Therefore,
652 X 3h = 1954 W- h
1954 W-h battery Pack is required

Charge Rating (C) = 37.5 (7.5X5) /12.5
= 3C for Discharge

Charging allowed is 0.5C = 05X12.5
= 6.25 Amps

Safe current is 0.2C = 0.2X12.5
= 12.5AMPS

So, 42 V 2.5A Charger needed

4.5.8 CONTROLLER SPECIFICATIONS

36V X x A = 350W
x =9.7Ama
9.7< 37.5 Therefore Battery is safe

9.7<13 Therefore controller is safe

V. SELECTION OF COMPONENTS

5.1 Motorcycle Chassis

Fig 5.1 Motorcycle Chassis

The primary function of the motorcycle frame (also known as Motorcycle Chassis) is to hold the different parts together in one rigid structure and prevent it from falling apart. In other words, a motorcycle frame is its core structure or skeleton made to support the suspension, seats, handlebars, fuel tank, and engine. It also houses the steering equipment in the front with the help of a steering head tube.

Earlier, frames were commonly made from steel; however, manufacturers now also use long-lasting materials such as Titanium, Magnesium, Carbon Fiber, etc., depending upon requirements and production costs. There are various types of motorcycle chassis. In this post, we have listed a few of those.

5.2 Battery 2D&3D DIAGRAM

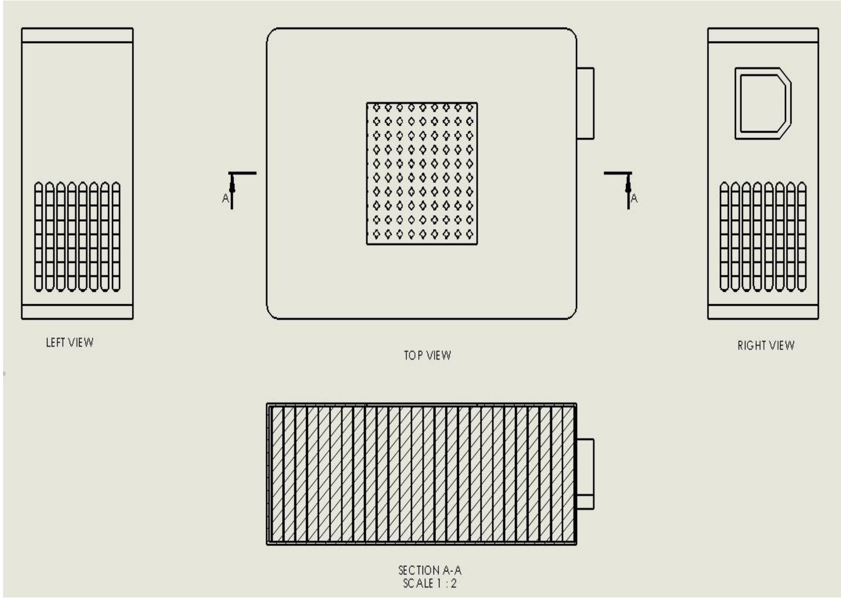


Fig 5.2 Battery 2D DIAGRAM

Analyzing a battery in a two-wheeler electric vehicle involves assessing various factors related to its performance, capacity, and efficiency. Here's a breakdown of what such an analysis might entail in a 2D format:

(c) Battery Capacity: Plotting the battery capacity over time to understand its degradation rate and overall lifespan. This involves analyzing how the capacity decreases with each charging cycle or over extended periods of use.

(d) Charging Time vs. Voltage: Creating a graph that illustrates how the charging time varies with the battery's voltage. This helps in understanding the charging efficiency and the relationship between voltage and charging speed.

(e) Temperature vs. Performance: Charting the battery's performance at different temperatures. This can reveal how temperature impacts the battery's efficiency, capacity, and overall performance.

(f) Voltage vs. Range: Mapping the voltage of the battery against the vehicle's range. This provides insights into how the battery's voltage affects the distance the vehicle can travel on a single charge.

(g) State of Charge (SoC) vs. Distance Traveled: Analyzing how the state of charge of the battery changes as the vehicle covers distance. This helps in understanding the battery's discharge characteristics and how efficiently it utilizes its stored energy.

(h) Efficiency Mapping: Creating a contour plot that illustrates the battery's efficiency under different operating conditions, such as varying speeds and terrain types. This helps in optimizing the vehicle's performance and energy consumption.

(i) Cycle Life Analysis: Plotting the number of charging cycles against the battery's capacity retention. This provides insights into the battery's longevity and helps in estimating its lifespan under different usage scenarios.

(j) Voltage Drop Under Load: Graphing the battery's voltage drop when subjected to different loads. This helps in understanding the battery's ability to maintain stable voltage levels during operation, which is crucial for consistent performance.

(k) Internal Resistance Analysis: Analyzing how the battery's internal resistance changes with temperature and state of charge. This information is essential for assessing the battery's overall health and performance.

(l) Regenerative Braking Efficiency: Evaluating the efficiency of regenerative braking by plotting the energy recovered during braking against the vehicle's speed and deceleration rate.

(m) These 2D analyses provide valuable insights into the performance, efficiency, and health of the battery in a two-wheeler electric vehicle, aiding in optimization and future improvements. has come into widespread use where other power supplies are absent, such as in remote location sand in space.

5.3 3D Battery Arrangement DIAGRAM

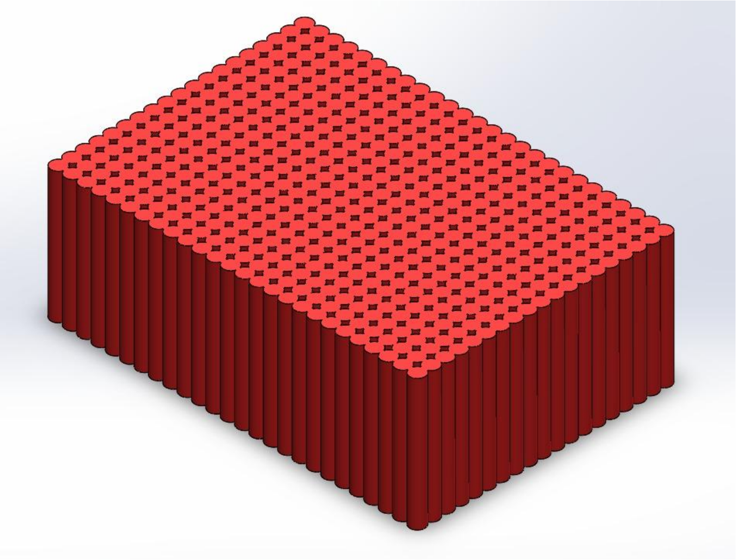


Fig 5.3 Battery 3D DIAGRAM

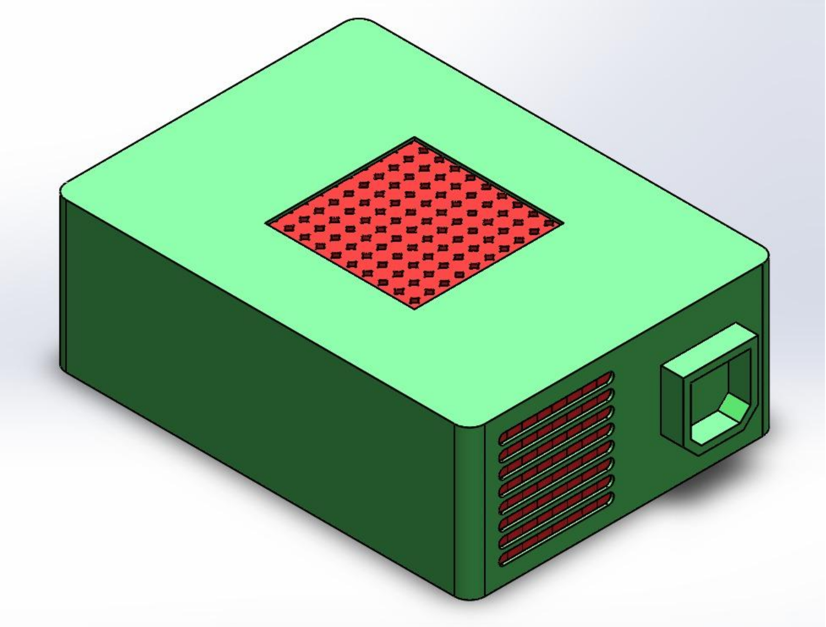


Fig 5.4 Battery Out Side 3D DIAGRAM

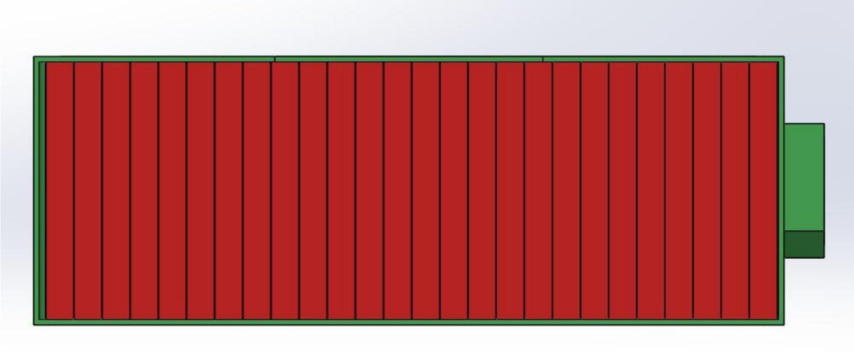


Fig 5.5 Battery 3D DIAGRAM

5.4 Battery Arrangement

- Lithium-ion batteries are rated as 3.7 V DC and about 2300 mAh ,
- If you want 48 V DC, you need 16 batteries to be connected in series.
- Now 16 batteries in series connection will give you 48 V, 2300 mAh (ie, 2.3 Ah).
- If you want 30 Ah (30000 mAh) you will again need 15 sets of batteries each set consist of 16 batteries, all 15 sets will be connected in parallel.
- In this way you have to buy 16*15 = 240 lithium batteries in order to make 48 V 30 Ah scooter battery.

5.5 Battery Bar Graph;

A bar graph can be a straightforward way to visualize certain aspects of battery analysis in a two-wheeler electric vehicle. Here are a few potential analyses represented using bar graphs:

5.5.1; Battery Charging ;

- 0% to 25% = 52.28 min/sec
- 25% to 50% = 58.47 min/sec
- 50% to 75% = 60.25 min/sec
- 75% to 100% = 61.22 min/sec

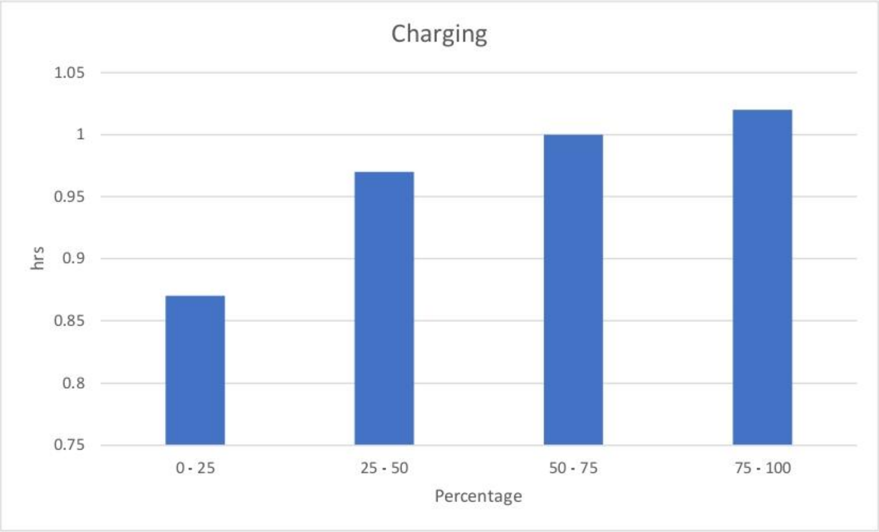


Fig 5.6 Battery Charging

5.5.2; Battery Discharging ;

- 100% to 75% = 45.58 min/sec
- 75% to 50% = 65.22 min/sec
- 50% to 25% = 98.42 min/sec
- 25% to 0% = 124.28 min/sec

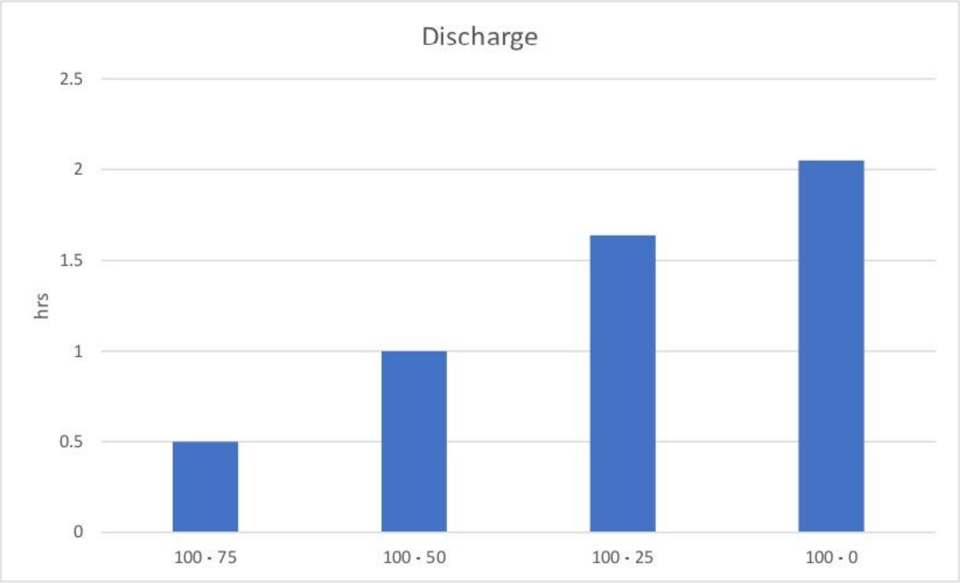
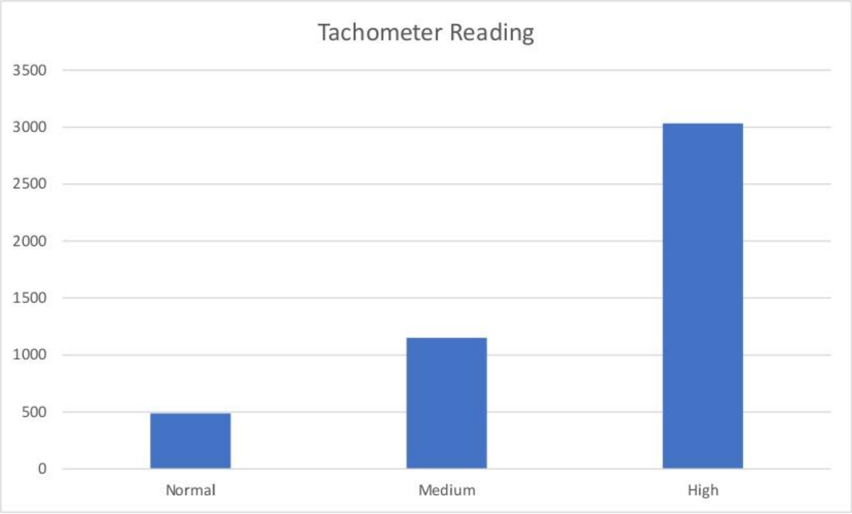


Fig 5.7 Battery Discharging

5.5.3; Tachometer Reading ;

- Normal Reading - 487.9 RPM
- Medium Reading - 1150 RPM
- High Reading - 3034



RPM

Fig 5.8 Tachometer Reading

5.5.4 Speed Reading;

- Normal Speed = 14 RPM
- Medium Speed = 28 RPM
- High Speed = 48 RPM

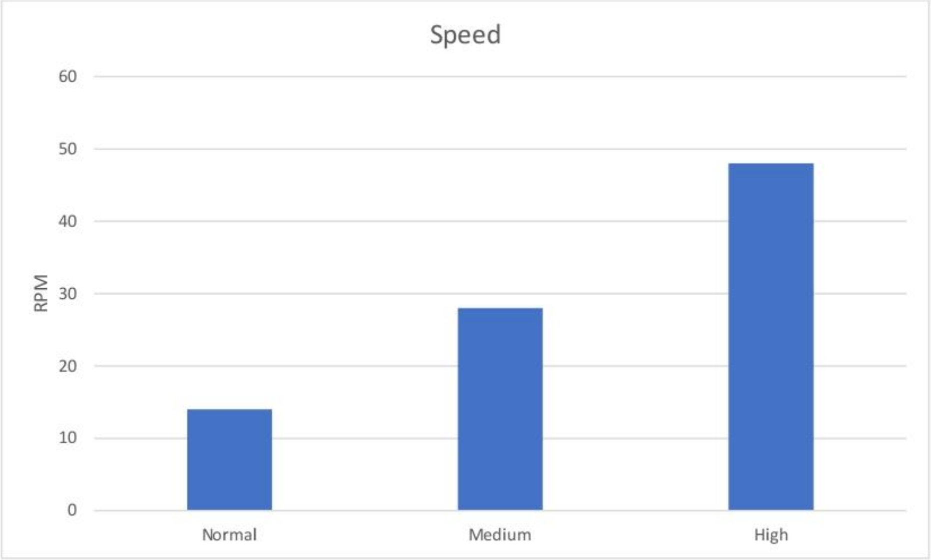


Fig 5.9 Speed Reading

5.6 Battery Pie Chart;

potential analyses of a battery in a two-wheeler electric vehicle represented using pie charts

5.6.1; Battery Charging ;

- 0% to 25% = 52.28 min/sec
- 25% to 50% = 58.47 min/sec
- 50% to 75% = 60.25 min/sec
- 75% to 100% = 61.22 min/sec

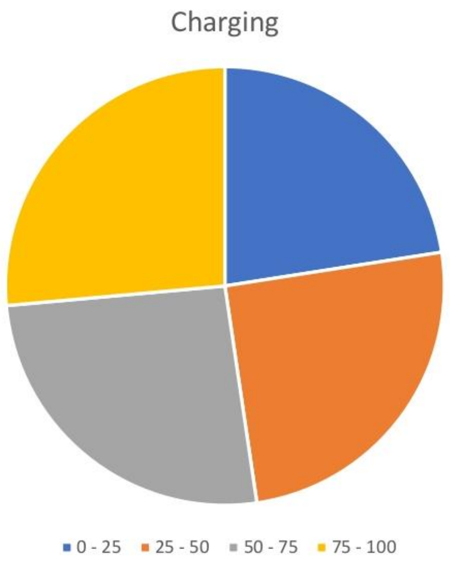


Fig 5.10 Battery Charging Pie Chart

5.6.2; Battery Discharging ;

- 100% to 75% = 45.58 min/sec
- 75% to 50% = 65.22 min/sec
- 50% to 25% = 98.42 min/sec
- 25% to 0% = 124.28 min/sec

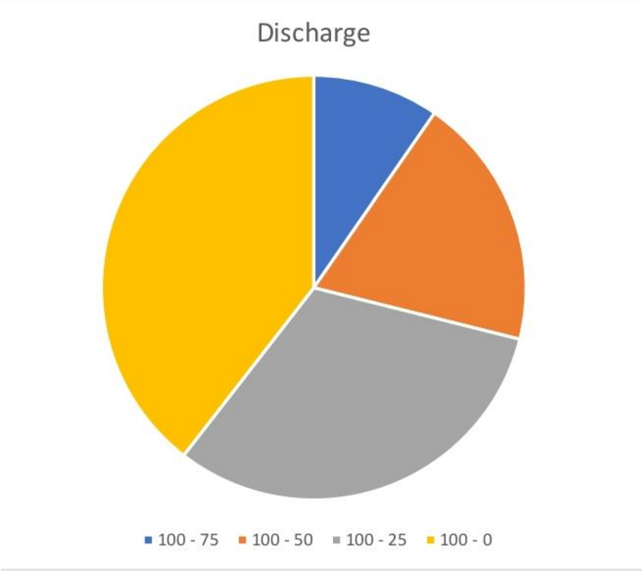


Fig 5.11 Battery Discharging Pie Chart

5.6.3; Tachometer Reading ;

- Normal Reading - 487.9 RPM
- Medium Reading - 1150 RPM
- High Reading - 3034 RPM

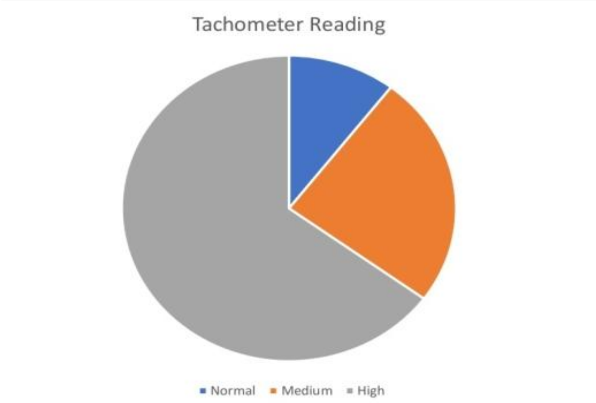


Fig 5.12 Tachometer Reading Pie Chart

5.6.4 Speed Reading;

- Normal Speed = 14 RPM
- Medium Speed = 28 RPM
- High Speed = 48 RPM

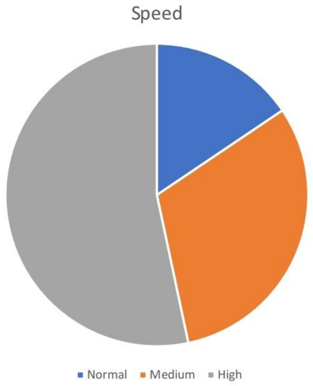


Fig 5.13 Speed Reading Pie Chart

5.7 Thermal Analysis

Modeling and simulation method saris sential to the thermal analysis of lithium- ion batteries (LIBs) in order to predict and optimize the thermal behavior of the battery system under various operating conditions. Numerous modeling and simulation techniques, from simple analytical models to complex numerical ones, have been employed to evaluate the thermal behavior of LIBs.

Analytical Model

Analytical models are based on mathematical equations that explain the basic physical processes, including as heat production, heat transmission, and temperature distribution, that influence the thermal behavior of LIBs. Analytical models are often simpler to (Greco,2014) develop and less computationally intensive than numerical models, and they may provide rapid and simple insights into the thermal behaviour of LIBs. Some of the most popular analytical models for thermal analysis of LIBs include distributed parameter models, which take the temperature distribution inside the battery into account, and lumped parameter models, which represent the battery as a single, homo genised thermal mass.

Analytical models, however, have a number of drawbacks, such as the need for simplifying assumptions, which (Abada,2016) may diminish the model's accuracy and restrict its application to intricate battery systems and operating scenarios. Additionally, since analytical models often depend on linearized or steady-state approximations, they may not be appropriate for analyzing highly nonlinear or transient thermal behavior.

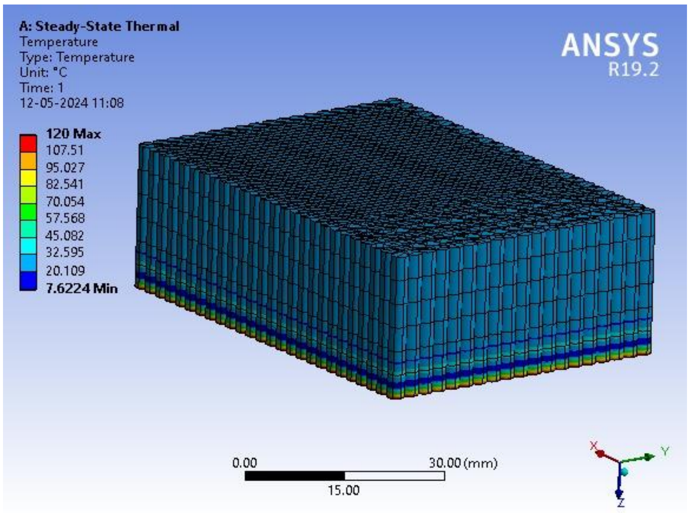


Fig 5.14 Steady State

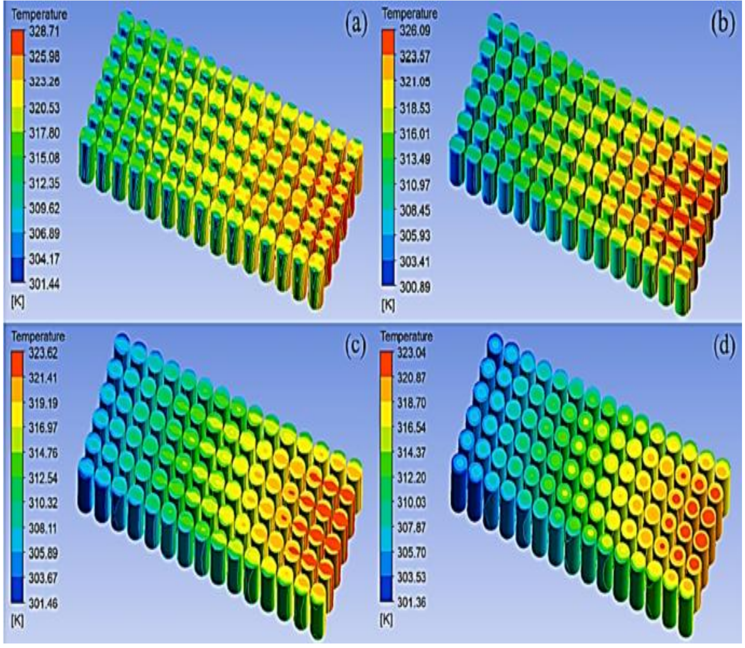


Fig 5.15 WideOutlet -Natural Convection

Wide Outlet -Natural Convection

The wide outlet with natural convection showed reasonable cooling effectiveness. The temperature distribution was fairly uniform across the battery pack, and but has reached peak temperatures. As from figure it is clear that, at the end of exit portion nearly middle, the battery temperature reaches a maximum temperature of 256 degree Celsius when under maximum capacity which is dangerous. And so natural convection for the proposed model may not be sufficient for adequate cooling during high-stress operations.

5.8 Final out put

Fig 5.16: Final output of battery

VII. CONCLUSION

The analysis of battery technology in two-wheeler electric vehicles underscores the transformative potential of electric mobility in mitigating climate change, reducing air pollution, and enhancing energy security. While significant progress has been made in battery performance, charging infrastructure, and environmental sustainability, several challenges remain on the path to widespread electric vehicle adoption.

Addressing these challenges requires collaborative efforts from policymakers, industry leaders, research institutions, and consumers to invest in innovation, infrastructure development, and regulatory frameworks conducive to electric mobility. By embracing electrification, sustainable urban planning, and renewable energy integration, we can accelerate the transition towards a cleaner, greener, and more equitable transportation system for future generations.

The analysis of battery technology in two-wheeler electric vehicles offers valuable insights into the opportunities and challenges of electric mobility. By harnessing the power of innovation, collaboration, and sustainable practices, we can pave the way for a brighter and more sustainable future of transportation.

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