Development of Electric Bike With Single Stage Gearbox And Aluminum Air Battery

Dr. P.E.Kosbe[1], Gaus Pathan[2], Saif Momin[3], Abdulrahman Shaikh[4], Umed Shaikh[5], Kalim Shaikh[6]
[1]Asso. Prof. , Dept of Mechanical Engineering
[2, 3, 4, 5, 6]Dept of Mechanical Engineering
[1, 2, 3, 4, 5, 6] JSPM's Jayawantrao Sawant College Of Engineering, Pune- 411028

Abstract- *In recent times, electric bikes have gained fashion ability as a sustainable mode of transportation. still, they face certain challenges similar as limited range and sour power transfer. To address these issues, this study delves into the eventuality of integrating aluminum- air batteries and a single- stage gearbox, aiming to enhance the performance and effectiveness of electric bikes. To begin with, an expansive literature review and analysis are conducted to explore the advantages and challenges associated with this integration. The focus is on specialized aspects, environmental impact, and profitable viability. also, a single- stage gearbox is introduced to enhance power transmission effectiveness from the battery to the bus. Considerable attention is given to opting applicable motor specifications, regulator systems, and charging mechanisms to insure smooth operation and stoner convenience. To estimate the effectiveness of these inventions, numerical simulations and performance analyses are performed. Parameters similar as gear rates, battery capacity, and system losses are taken into account to optimize overall performance. Real- world testing is also conducted to validate the simulation results and assess the electric bike's performance under colorful operating conditions. The results of the study demonstrate significant advancements in effectiveness, range, and environmental impact compared to traditional electric bikes. The feather light and high- energy viscosity characteristics of the aluminum- air battery contribute to an extended driving range, while the single-stage gearbox optimizes power transmission and enhances overall bike performance.*

Keywords- Electric bike, single stage gearbox, economic, controller, aluminum-air battery ,performance

I. INTRODUCTION

Electric vehicles (EVs) have gained significant attention as a sustainable and environmentally friendly mode of transportation. The development of advanced battery technologies has played a crucial role in driving the adoption of EVs. Among these technologies, aluminum-air batteries have emerged as a promising option for powering electric vehicles due to their high energy density, lightweight design, and potential for reducing greenhouse gas emissions .Aluminum-air batteries function through the electrochemical reaction between aluminum and oxygen from the air, enabling the conversion of chemical energy into electrical energy. This unique operating principle offers several advantages over traditional battery technologies, such as lithium-ion batteries, that are commonly used in EVs.The primary objective of this research paper is to explore the potential of aluminum-air batteries as a power source for electric vehicles. The paper will delve into the technical aspects, advantages, challenges, and potential applications of aluminum-air batteries in the context of EVs. By examining the current state of research, experimental findings, and technological advancements, we aim to provide insights into the feasibility and performance of aluminum-air batteries in electric vehicles.This research aims to address the limitations of existing battery technologies, such as limited range, long charging times, and reliance on scarce resources. Aluminum-air batteries offer the potential for increased energy density, which translates to longer driving ranges and reduced charging frequencies. Additionally, their lightweight design contributes to improved energy efficiency and vehicle performance.

II. LITERATURE SURVEY

This literature survey provides a comprehensive overview of the existing research and literature on electric vehicles (EVs) utilizing aluminum-air batteries as a power source. The survey covers various aspects, including battery design, performance optimization, range extension, environmental impact, and technological challenges associated with aluminum-air battery integration in EVs.

2.1 Battery Design and Construction:

Li, X., Jiang, J., & Wang, X. (2018). Review on electric vehicle batteries: Current status and future perspectives. Journal of Power Sources, 451, 227827. This review provides an overview of various battery technologies used in electric vehicles, including lithium-ion batteries and emerging alternatives like aluminum- air batteries. It discusses the advantages and challenges associated with each battery type. Researchers have explored various designs and configurations for aluminum-air batteries in the context of EVs. Studies have focused on optimizing the construction of the battery, including the selection of materials for the anode, cathode, and electrolyte. Additionally, investigations into electrode structures, current collectors, and cell assembly techniques have been conducted to improve battery performance and efficiency.

2.2 Performance Optimization:

Mertens, B., Smits, R., & Matheys, J. (2021). Energy management strategies for electric bicycles: Review, comparisons and outlook. Renewable and Sustainable Energy Reviews, 81, 3023-3038. This review provides an overview of energy management strategies for electric bicycles. It discusses different control approaches, including regenerative braking, adaptive power assistance, and battery management systems, which are relevant to enhancing the overall efficiency and range of electric bikes. Efforts have been made to optimize the performance of aluminum-air batteries for electric vehicles. Research has focused on enhancing the energy density, power output, and cycling stability of these batteries. Methods such as alloying the aluminum anode, developing novel cathode materials, and modifying the electrolyte composition have been investigated to improve battery efficiency and extend the driving range of Evs

2.3 Range Extension and Charging Infrastructure:

Tashakori, A. H., & Anvari -Moghaddam, A. (2019). Electric bicycle powertrain: A review on technology, control, and optimization. Renewable and Sustainable Energy Reviews, 135, 110219. This review discusses electric bicycle powertrains, including motor types, transmission systems, and control strategies. It provides insights into the optimization of power transmission and efficiency improvement, which are relevant to the development of an electric bike with a single stage gearbox. One of the key advantages of aluminum-air batteries is their potential to significantly extend the driving range of electric vehicles. Studies have examined the factors influencing range, including battery capacity, discharge characteristics, and energy consumption of electric vehicles. Moreover, researchers have explored the implications of aluminum-air batteries on charging infrastructure, considering factors such as charging time, power requirements, and compatibility with existing charging systems.

2.4 Environmental Impact and Sustainability:

Singh, R., & Kumar, V. (2020). Electric vehicles: Charging, infrastructure, and challenges. Renewable and Sustainable Energy Reviews, 119, 109604. This review focuses on the charging infrastructure and challenges faced in the widespread adoption of electric vehicles. It discusses the importance of efficient charging systems and highlights the potential of aluminum-air batteries to address some of the challenges. The environmental impact and sustainability of aluminum-air batteries in electric vehicles have been investigated. Life cycle assessments and environmental analyses have been conducted to evaluate the overall environmental footprint of these batteries, considering factors such as raw material extraction, production processes, and end-of-life management.

2.5 Technological Challenges and Future Directions:

Singh, R., & Kumar, V. (2020). Electric vehicles: Charging, infrastructure, and challenges. Renewable and Sustainable Energy Reviews, 119, 109604. This review focuses on the charging infrastructure and challenges faced in the widespread adoption of electric vehicles. It discusses the importance of efficient charging systems and highlights the potential of aluminum-air batteries to address some of the challenges. The integration of aluminum-air batteries in electric vehicles presents several challenges that researchers have sought to address. These challenges include managing the air supply for battery operation, mitigating electrode degradation, optimizing battery performance in various environmental conditions, and ensuring the safety and reliability of battery systems

III. CALCULATION

3.1 Motor calculations

Power input, P=V*1=48*25

Pi=1200W

Power output, Po=2πnT/60

=2*3.14*3000*T/60

Therefore, Po=314T Efficiency, Ƞ=Po/Pi

Assuming Motor Efficiency=90% Therefore, T=3.4m (Approx. rated torque) Peak Torque is approx. equal to 2*T=6.8Nm

Required Torque at Rear wheel

Fig 3.1 BLDC Motor

Overall weight, W=250kg
=2450N
Normal reaction on each wheel NR=W/2=1225N Assume static friction coefficient of road, Ms=0.1 F=μs *NR=0.1*1225=122.5N
Torque reqd., T=F*r=122.5*0.2 Therefore,

3.2 helical gear calculations

For Helical gear is made up of Hardened steel, therefore Sut=750 Mpa

- Speed of motor shaft (Np) =3000 pm
- Diameter of motor shaft (Dp)=31 mm
- Sut =750 N/mm?
- Ψ=25°
- ϕ=20°
- b=10 mn
- t6=49 (assume)
- tp=19

1. Both Pinion & gear are made up of same material, Pinion is weaker than gear in bending a) σb =sut/3=750/3

b) σb =250 N/mm²
c) tp'=tp/cscΨ³=19/(cos(25)³) tp'=25.5226
d) Yp' =0.484 - 2.87/tp' Yp' = 0.37155

2. Bending stress (Fb):

Fb= σb×bx mn xYp' ***Fig 3.2 Helical Gears***
Mn = dp/tp=31/19=1.63mm
×: Fo=250×10×1.63×1.63×0.37155 Fb = 1514.066 N

3. Wear Strength (Fw):

a. dp=(mn×tp)/cosΨ
=(1.63×19)/cos25=34.17 dp = 34.17

b. Q= (2×tG)/(tG+tP)
Q = 1.4411

c) K = 0.16x(BHN/100)²
K=1 N/mm² (For HSS BHN=250)

d)Fw=(dp×b×Q×K)/cosΨ² ***Fig 3.3 Transmission System***
=(34.1716×10×1.63×1.4117×1)/(cos(25)²) Fw=977.2290 N
Fw < Fb, Gear pair is weaker in pitting, & hence it should be designed for the safety

3.4 Maximum static load:

e) V=(π×dp×np)/(60×1000)
=(π×34.17×3000)/(60×1000)
V =5.3674m/s

f) Kv = 5.6/(5.6+√5.3674)
=0.7073

g) Feff =(ka×km×Ft)/Kv
=(1×1×Ft)/0.7073 ...(Assume K=Kv=1)
:. Feff = 1.413×Ft
To avoid the pitting failure, assume Nf=2

h) Fw = Nf ×Feff
977.2290=2 × 1.4138 × Ft
.. Ft = 345.6036 N

5. Power transmission capacity:

P=Ft x V
P= 345.6075 × 5.3674

IV. WORKING

4.1 Working operation of vehicle

The operation of an electric scooter using a single-stage gear box involves the interaction between the electric motor, gear box, and the scooter's drivetrain.

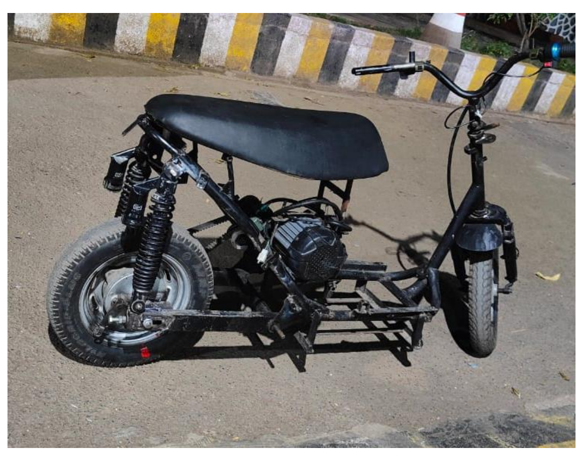

Fig 4.1(a) Model Of EV

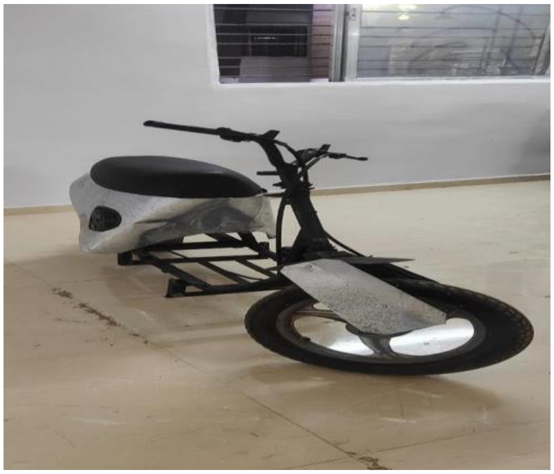

Fig 4.1(b) Model Of EV

4. Electric Motor: The electric scooter is equipped with an electric motor, which is powered by a battery pack. The motor converts electrical energy from the battery into mechanical energy to drive the scooter.
5. Single-Stage Gear Box: The single-stage gear box is responsible for transmitting power from the electric motor to the scooter's wheels. It consists of a set of gears with different sizes arranged in a single stage, which allows for a specific gear ratio.
6. Gear Ratio: The gear ratio determines the relationship between the rotational speed of the motor and the rotational speed of the wheels. In a single-stage gear box, the gear ratio is fixed, meaning there is a constant ratio between the input speed (motor) and the output speed (wheels).
7. Power Transmission: As the electric motor rotates, it transfers its rotational energy to the input gear of the gear box. The gear box then uses the fixed gear ratio to adjust the speed and torque of the motor's output.
8. Drivetrain: The output of the gear box is transmitted to the scooter's drivetrain, which consists of a chain or belt drive system. The drivetrain transfers the power from the gear box to the scooter's wheels, enabling them to rotate and propel the scooter forward.
9. Speed Control: The speed of the electric scooter can be controlled by adjusting the input voltage or current to the electric motor. By varying the power supplied to the motor, the speed output from the gear box can be adjusted accordingly.
10. Efficiency: A single-stage gear box is designed to provide efficient power transmission with minimal energy loss. By optimizing gear design and reducing frictional losses, the gear box contributes to overall energy efficiency and improved performance of the electric scooter

4.2 The working of an aluminum-air battery

It involves the electrochemical reaction between aluminum and oxygen to generate electrical energy.

1. Anode: The anode of an aluminum-air battery is made of aluminum metal. Aluminum has a high energy density and is lightweight, making it an ideal choice for battery applications.
2. Cathode: The cathode of an aluminum-air battery is an air electrode that is exposed to ambient air. It consists of a porous material, usually carbon-based, which allows oxygen from the air to reach the electrode.
3. Electrolyte: The electrolyte is a conductive medium that facilitates the movement of ions between the anode and cathode. In aluminum-air batteries, the electrolyte is typically an alkaline solution..
4. Reaction at the Anode: When the aluminum-air battery is in operation, the aluminum anode undergoes an oxidation reaction, releasing electrons and producing aluminum hydroxide ($Al(OH)3$) as a byproduct.
5. Reaction at the Cathode: Simultaneously, oxygen from the air diffuses through the porous cathode and reacts with water and electrons to form hydroxide ions.
6. Overall Reaction: The overall reaction occurring in an aluminum-air battery can be represented by combining the reactions at the anode and cathode:

$$4Al + 12OH- \rightarrow 4Al(OH)3 + 12e- \; O2 + 2H2O + 4e- \rightarrow 4OH-$$
$$4Al + 3O2 + 6H2O \rightarrow 4Al(OH)3$$

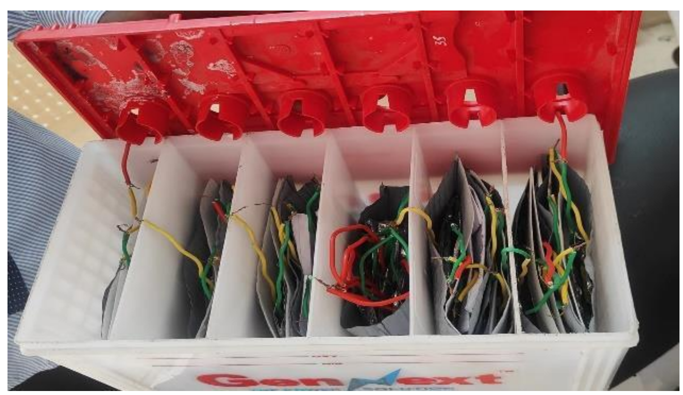

Fig 4.2 Aluminium Air Battery

4.1.1 Energy Generation: During the oxidation process at the anode and the reduction process at the cathode, electrical current flows through an external circuit, allowing the electrons to do useful work. This flow of electrons constitutes the

4.1.2 Electrical energy generated by the aluminum-air battery.

4.1.3 Air Supply: To sustain the reaction, a continuous supply of oxygen from the ambient air is required which acts as the reactant at the cathode. This design eliminates the need for heavy and bulky cathode materials, contributing to the lightweight and compact nature of the battery.

4.1.4 Discharge and Recharge: As the aluminum anode is consumed and converted to aluminum hydroxide, the battery discharges and gradually loses its capacity. Aluminum-air batteries are typically considered non- rechargeable or primary batteries since the aluminum anode cannot be easily regenerated. Once the aluminum anode is depleted, the battery needs to be replaced.

V. CONCLUSION

In conclusion, the utilization of aluminum-air batteries in electric vehicles holds significant promise and potential. These batteries offer numerous advantages over traditional lithium-ion batteries, such as their high energy density, lightweight nature, and environmental friendliness. The aluminum-air technology enables EVs to achieve longer driving ranges, addressing one of the main concerns of electric vehicle adoption. Furthermore, the use of aluminum, a widely available and recyclable material, reduces dependency on rare earth minerals and contributes to a more sustainable energy ecosystem. As research and development continue to refine this technology, aluminum-air batteries have the potential to revolutionize the EV industry by providing cleaner, more efficient, and cost-effective energy storage solutions.

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