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Piezoelectric Power generation in E Scooter

[1] Dr. Nadeem Pasha K [2] Dr. Salim Sharieff
[3] M S Chethan Kumar,
[1] Associate Professor [2] Professor & Head
[3] Student
Department of Mechanical Engineering,
HKBKCE, Bangalore, India

Abstract: The increasing demand for eco-friendly transportation has led to the development of electric scooters (e-scooters) as an alternative to conventional fuel-powered vehicles. To enhance the efficiency and sustainability of e-scooters, researchers have explored various methods to harness energy from different sources. One promising approach is the utilization of piezoelectric materials for power generation in e-scooters. Piezoelectricity is the ability of certain materials to generate an electric charge when subjected to mechanical stress or deformation. By integrating piezoelectric elements into strategic locations of an e-scooter, such as the handlebars, footrests, or suspension system, the mechanical vibrations and deformations generated during riding can be effectively harvested and converted into electrical energy. This paper presents an overview of the application of piezoelectric power generation in e-scooters. It discusses the principles of piezoelectricity, the selection of suitable piezoelectric materials, and the design considerations for integrating piezoelectric elements into the e-scooter structure. Furthermore, the work highlights the potential benefits of piezoelectric power generation, including extended battery life, reduced dependence on external charging, and the ability to charge the e-scooter during operation. The abstract also presents some challenges associated with piezoelectric power generation in e-scooters, such as the limited power output of piezoelectric materials and the need for efficient energy conversion and storage systems. Additionally, potential solutions and future research directions are discussed to address these challenges and further improve the feasibility and effectiveness of piezoelectric power generation in e-scooters. In conclusion, piezoelectric power generation offers a promising avenue for enhancing the energy efficiency and sustainability of e-scooters. By harnessing the mechanical vibrations and deformations generated during riding, piezoelectric materials can convert them into usable electrical energy, potentially reducing the reliance on external charging and extending the range of e-scooters. Continued research and development in this field have the potential to make significant advancements in piezoelectric power generation and its integration into e-scooter technology.

Index Terms- **Micro Mobility, Regenerating module, reliability.**

I. INTRODUCTION

The adoption of electric scooters (e-scooters) in India has been gaining momentum due to the growing concerns over environmental pollution and the need for sustainable transportation solutions. As the demand for e-scooters increases, there is a need for innovative approaches to enhance their energy efficiency and reduce dependence on external charging infrastructure. One such approach is the utilization of piezoelectric power generation in e-scooters. Piezoelectricity, the phenomenon of generating electric charge in certain materials when subjected to mechanical stress or deformation, presents an opportunity to harness the mechanical energy generated during the operation of e-scooters and convert it into usable electrical energy. This approach has the potential to extend the range of e-scooters, reduce the frequency of battery charging, and make them more self-sufficient in terms of power supply. In the Indian context, where the adoption of e-scooters is rapidly increasing, incorporating piezoelectric power generation technology holds several advantages. First and foremost, India faces challenges related to inadequate charging infrastructure in many areas, especially in rural and remote regions. By integrating piezoelectric elements into e-scooters, they can generate electrical energy during regular usage, reducing the reliance on external charging stations and providing a more convenient and independent power source. Moreover, India has diverse road conditions, with numerous speed breakers, rough terrain, and vibrations during travel. These dynamic mechanical forces can be harnessed using piezoelectric materials strategically placed within the e-scooter's structure. This presents an opportunity to capture and convert these vibrations into electricity, further augmenting the e-scooter's power supply. Additionally, piezoelectric power generation aligns well with India's commitment to renewable energy and reducing carbon emissions. As a clean and sustainable energy conversion method, piezoelectricity can contribute to the country's renewable energy goals and reduce the overall environmental impact of transportation. However, there are challenges that need to be addressed for the widespread adoption of piezoelectric power generation in e-scooters in India. These challenges include optimizing the power output of piezoelectric materials, designing efficient energy conversion and storage systems, and ensuring the durability and reliability of the piezoelectric elements under varying road conditions. In conclusion, the integration of piezoelectric power generation in e-scooters has the potential to revolutionize the electric vehicle industry in India. By leveraging the mechanical vibrations and deformations experienced during e-scooter operation, piezoelectric materials can generate electrical energy and reduce the dependence on external charging infrastructure. With further research, development, and implementation, piezoelectric power generation technology can contribute significantly to the sustainable and energy-efficient transportation landscape in India.

II. PROBLEMSTATEMENT

The problem addressed in this project is the limited battery life of electric scooters, which can restrict their range and usefulness, particularly in urban areas where they are most commonly used. Despite advancements in battery technology, the limited capacity and high cost of batteries remain significant barriers to the widespread adoption of electric scooters. To address this challenge, we aimed to explore the potential of integrating piezoelectric technology into electric scooters to enhance their energy efficiency and extend their battery life. The objective was to develop a prototype piezoelectric energy harvesting system that could capture the mechanical energy generated by the rider's motion and convert it into usable electricity to power the electric scooter.

1. Limited Range and Battery Life: Electric scooters (e-scooters) currently face limitations in terms of their range and battery life. Users often need to recharge their e-scooters frequently, leading to inconvenience and dependency on external charging infrastructure.

2. Insufficient Charging Infrastructure: In many regions, including rural and remote areas, there is a lack of adequate charging infrastructure for e-scooters. This poses challenges for users who may not have easy access to charging stations.

3. Sustainable Power Generation: As the demand for sustainable transportation solutions increases, there is a need for innovative approaches to enhance the energy efficiency of e-scooters. Traditional methods of charging, such as grid electricity, may not align with the goal of reducing carbon emissions.

4. Utilization of Mechanical Vibrations: E-scooters experience mechanical vibrations and deformations during operation, such as those caused by road conditions, speed breakers, and rider movements. There is a lack of effective utilization of these mechanical forces to generate electrical energy and reduce reliance on external charging.

5. Optimization of Power Output: Piezoelectric materials have the potential to convert mechanical energy into electrical energy. However, the power output of piezoelectric materials is limited, and there is a need to optimize their performance for efficient power generation in e-scooters.

6. Design Considerations: Integrating piezoelectric elements into the structure of e-scooters requires careful design considerations to ensure durability, reliability, and compatibility with various road conditions and usage scenarios.

7. Energy Conversion and Storage Systems: Efficient energy conversion and storage systems need to be developed to convert the electrical energy generated by piezoelectric materials into a usable form for charging e-scooter batteries or powering auxiliary components.

8. Cost and Feasibility: The cost-effectiveness and feasibility of integrating piezoelectric power generation technology into e-scooters need to be evaluated. The project should explore the economic viability and scalability of the proposed solution.

9. By addressing these problem statements, the project aims to overcome the limitations of traditional charging methods, enhance the energy efficiency and sustainability of e-scooters, and provide a more convenient and independent power source for users in India.

III. Literature Survey

Minazara et.al [2008] The authors of this paper had researched the development and testing of a piezoelectric generator that could harvest energy from the vibrations of a bicycle and convert it into electrical energy to power portable devices. They designed and constructed the generator, consisting of a cantilever beam with a piezoelectric element attached to it, which was attached to the frame of a bicycle concluded that for an optimal load of 100 generates 3.5 mW power that is sufficient to charge a battery or to power low consumption devices Through experimental testing, the authors demonstrated the effectiveness of the piezoelectric generator in harvesting energy from the vibrations of the bicycle, and discussed its potential applications, such as powering portable electronic devices and sensors, and the advantages of using such a sustainable and environmentally-friendly energy source. In general, the authors provide a comprehensive overview of the design and testing of a piezoelectric generator for harvesting energy from bicycle vibrations, and highlight its potential applications and benefits. [1]

Kumar et.al [2014] The authors and their team had researched , designed and constructed a piezoelectric energy harvesting system that utilized a piezoelectric cantilever beam and a load resistance to convert the mechanical energy from the vibrations and strain into electrical energy for this they conducted experiments to evaluate the performance of the piezoelectric energy harvesting system, measuring the voltage and current output under different conditions of vibration and strain. They found that the system was able to successfully generate electrical energy from both ambient vibrations and direct strain and that the voltage and current output were dependent on the frequency and amplitude of the vibrations and the magnitude of the strain applied. The authors concluded that piezoelectric energy generation has potential applications in low-power electronic devices, such as sensors, and that their experimental results showed the feasibility and effectiveness of this technology. They also discussed the limitations and challenges of piezoelectric energy harvesting, such as the need for optimal design and the low power output of the system. [2]

Mishra et.al [2015] In the paper, the author provides an introduction to piezoelectricity and discussed the different types of piezoelectric materials, their properties, and applications. He then delved into the potential use of piezoelectric materials zirconate titanate or multiwalled carbon tubes as a source of electricity generation and their applications in various devices such as sensors, actuators, and energy harvesting systems and explored the possibility of using piezoelectric materials to develop devices for daily use by army personnel, such as shoe inserts that could generate electricity from walking or running pressure. He explained the potential benefits of such devices, including reducing the weight of batteries carried by soldiers and providing a reliable source of electricity in remote locations. The author also highlighted the challenges and limitations of using piezoelectric materials for energy harvesting, including the need for optimal design and the variability of vibrations and pressure generated by different activities. He emphasized the importance of further research and development to improve the efficiency and reliability of piezoelectric energy harvesting devices. paper provided a comprehensive review of the potential of piezoelectric materials for generating electricity and their use in daily life, especially for army personnel. His analysis highlighted the need for further research and development in this field and provided valuable insights into the challenges and limitations of piezoelectric energy harvesting. [3]

Mr. Garimella et.al [2015] In the paper, the authors researched for generating electricity from vibrations using a piezoelectric transducer. They described the experimental setup and methodology used to test their approach and presented the results of their tests, which demonstrated the successful generation of electricity from vibrations. The authors also discussed the potential applications of their approach, including powering wireless sensor networks, remote monitoring systems, and other low-power electronic devices. They highlighted the advantages of using their approach, such as its simplicity, reliability, and cost-effectiveness. the authors also compared their approach with other existing methods for generating electricity from vibrations and discussed the limitations and challenges of each method. They concluded that their approach was a promising alternative for generating electricity from vibrations, especially for low-power applications. Their research contributed to the growing field of energy harvesting and provided a basis for further development of vibration-based energy harvesting technologies. [4]

Sun et al [2015] In this paper, the authors proposed a piezoelectric energy harvesting system for tire pressure monitoring in vehicles. They designed a harvester that could be integrated into the tire valve stem and used the deformation of the tire to generate electrical energy. They investigated the effects of different design parameters, such as the shape and size of the harvester, on the performance of the system. They also evaluated the potential of the proposed system for powering wireless sensor networks in tire pressure monitoring applications. [5]

Tang et al [2017] The authors researched about a piezoelectric energy harvester for automotive suspensions that incorporates a nonlinear electromagnetic vibration energy generator. They designed a harvester that could convert the kinetic energy of the suspension into electrical energy using piezoelectric and electromagnetic mechanisms as well as They demonstrated that the nonlinear generator could improve the efficiency of the system by increasing the output power of the harvester and also discussed the design considerations and performance characteristics of the proposed harvester. [6]

Zhang et al [2019] the authors researched about a piezoelectric energy harvesting system for recovering waste heat from automotive exhaust systems. They designed a harvester that could convert the thermal energy of the exhaust gas into electrical energy using piezoelectric materials. They evaluated the performance of the harvester under different operating conditions, such as exhaust gas temperature and flow rate, and demonstrated that the proposed system could produce a significant amount of electrical energy. [7]

Jin et al [2019] In this paper, the authors began by highlighting the importance of energy harvesting in automobiles to reduce reliance on traditional fuel sources and improve sustainability. The authors had analysed various methods of piezoelectric energy harvesting, such as cantilever beams, bimorphs, and multi-layered structures. They evaluated the advantages and limitations of each method, and discussed the impact of factors such as vibration frequency, temperature, and humidity on the performance of piezoelectric materials in automotive applications. They discussed that use piezoelectric materials to harvest energy from the suspension system of a vehicle and found that it could generate up to 20 watts of power. piezoelectric materials in the tires of a vehicle to generate electricity, which could be used to power sensors or other low-power devices. the potential of piezoelectric energy harvesting in automobiles and suggested future research directions to enhance the efficiency of this technology. They emphasized the need for further research to optimize the design and placement of piezoelectric materials in automobiles, as well as to develop new materials with improved performance characteristics. [8]

liu et al [2019] The authors had reviewed the current state-of-the-art in piezoelectric energy harvesting for intelligent vehicle systems. They discussed the potential applications of piezoelectric materials in various systems, including suspension, braking, and tire pressure monitoring. They discuss various aspects of the technology, including the types of piezoelectric materials used, the design of the energy harvesting system, and the applications of the technology in intelligent vehicle systems. The authors also analyse the challenges and opportunities for the future development of piezoelectric energy harvesting for intelligent vehicle systems. They conclude that this technology has great potential to enhance the energy efficiency of intelligent vehicle systems and reduce their environmental impact. They also analysed the different types of harvesters that can be used and the design considerations and performance characteristics of these systems. [9]

Li et al [2019] The authors proposed a piezoelectric energy harvesting system for automotive suspensions that could convert the vibration energy of the suspension into electrical energy using piezoelectric materials. They designed a harvester that could be mounted directly on the suspension and evaluated the performance of the system under different driving conditions. They demonstrated that the proposed system could produce a significant amount of electrical energy that could be used to power various electronic systems in the vehicle. [10]

IV. OBJECTIVES

The objectives of piezoelectric integration:.

1. Explore the potential applications of piezoelectric technology in other areas of transportation and energy generation: The final objective is to explore the potential applications of piezoelectric technology in other areas of transportation and energy generation. This will involve researching and identifying other potential applications of piezoelectric technology, and evaluating its feasibility and effectiveness in these contexts. The findings of this objective will provide insight into the broader implications of piezoelectric technology for sustainable energy generation and transportation.

2. To conduct a comprehensive literature review on piezoelectric power generation, specifically focusing on its application in e-scooters, to gain a thorough understanding of the current state of research, advancements, and challenges in the field.

3. To analyze the energy requirements and limitations of conventional e-scooters, including their range, battery life, and dependence on external charging infrastructure, in order to identify the potential benefits and opportunities offered by piezoelectric power generation.

4. To investigate the principles of piezoelectricity, including the behavior of piezoelectric materials and their ability to convert mechanical vibrations and deformations into electrical energy, to establish a foundation for the design and implementation of the piezoelectric power generation system in e-scooters.

5. To evaluate and compare various piezoelectric materials, such as lead zirconate titanate (PZT), polyvinylidene fluoride (PVDF), and other emerging piezoelectric materials, based on their power generation capabilities, efficiency, durability, and compatibility with the operating conditions and requirements of e-scooters.

6. To identify the optimal locations and integration strategies for incorporating piezoelectric elements into the structure of e-scooters, considering factors such as mechanical stress distribution, vibration characteristics, and user comfort, with the aim of maximizing the energy harvesting potential.

7. To design and develop a prototype or simulation model of an e-scooter with integrated piezoelectric power generation system, considering the overall system architecture, component selection, and electrical circuitry required for efficient energy conversion and storage.

8. To characterize and measure the power output, conversion efficiency, and reliability of the piezoelectric power generation system under various operating conditions, including different road surfaces, speeds, and rider behaviors, to assess its performance and feasibility in real-world scenarios.

9. To investigate the challenges associated with power optimization, energy storage, and system integration, and propose suitable solutions and strategies to improve the efficiency, reliability, and overall effectiveness of the piezoelectric power generation system in e-scooters.

10. To evaluate the economic feasibility and cost-effectiveness of integrating piezoelectric power generation technology into e-scooters, considering factors such as material costs, manufacturing processes, potential energy savings, and the return on investment for the end-users and manufacturers.

11. To provide recommendations and guidelines for the practical implementation and scalability of piezoelectric power generation in e-scooters, addressing considerations such as regulatory compliance, standards, safety requirements, and potential future research directions.

12. By accomplishing these detailed objectives, the project report aims to contribute to the existing knowledge and understanding of piezoelectric power generation in e-scooters, offering insights into its technical feasibility, performance optimization, economic viability, and potential for sustainable transportation solutions.

V. COMPONENTS USED

1. Booster Module - The booster module is an electronic circuit that is designed to amplify the voltage output of the piezoelectric energy harvesting system to a level that is suitable for charging the electric scooter's battery. Since the voltage output of a piezoelectric energy harvesting system is typically low, the booster module is necessary to ensure that the harvested energy is efficiently and effectively transferred to the electric scooter's battery. The booster module uses a step-up converter circuit to increase the voltage output of the piezoelectric system to a level that is sufficient for charging the battery.

2. Charging Module - A charging module is an electronic device that is used to charge rechargeable batteries or other energy storage devices. The specific working of a charging module will depend on its design and intended application A charging module requires a power source to charge the battery or energy storage device. This may be a wall outlet, USB port, or other power source, depending on the design of the module. The charging module typically includes a voltage regulator that ensures that the battery or energy storage device is charged at the correct voltage. This helps to prevent overcharging, which can damage the battery, and undercharging, which can result in reduced battery capacity.

3. Lead Acid battery : A lead-acid battery is a type of rechargeable battery that uses a chemical reaction to store and release electrical energy. Lead-acid batteries are commonly used in automotive applications, as well as in backup power systems and other industrial applications. The specific battery you mentioned has a voltage of 14 volts and a charging or discharging current of 0.39 amps. This information is important to know when selecting a charging or discharging device for the battery.

4. Customized Lithium Ion Battery: A lithium-ion battery is a type of rechargeable battery that uses lithium ions as the primary component of its electrolyte. Lithium-ion batteries are widely used in portable electronics, electric vehicles, and other applications where lightweight, high-energy density storage is required. The specific battery you mentioned has a voltage of 53 volts and a capacity of 1000 watt-hours. This information is important to know when selecting a charger or discharge device for the battery.

5. Foot Rest – Piezoelectric materials are integrated to harness the mechanical stress generated when a person places their foot on the footrest. The piezoelectric materials installed in the footrest can convert this mechanical stress into electrical energy. With each step taken or each time the leg is placed on the footrest, the piezoelectric materials generate electricity, effectively capturing and utilizing the mechanical energy produced by the movement. This integration allows for the harvesting of electricity from the natural movements of individuals, offering a potential source of sustainable power generation.

6. Suspensions: Suspension systems are an important component of electric scooters, as they help to absorb shocks and vibrations from uneven surfaces, providing a smoother and more comfortable ride, where piezoelectric can be installed in suspensions in future.

VI. Methodology

The following procedure were processed for creating the project model, which is as shown in the figure 1 as such in flow chart below:

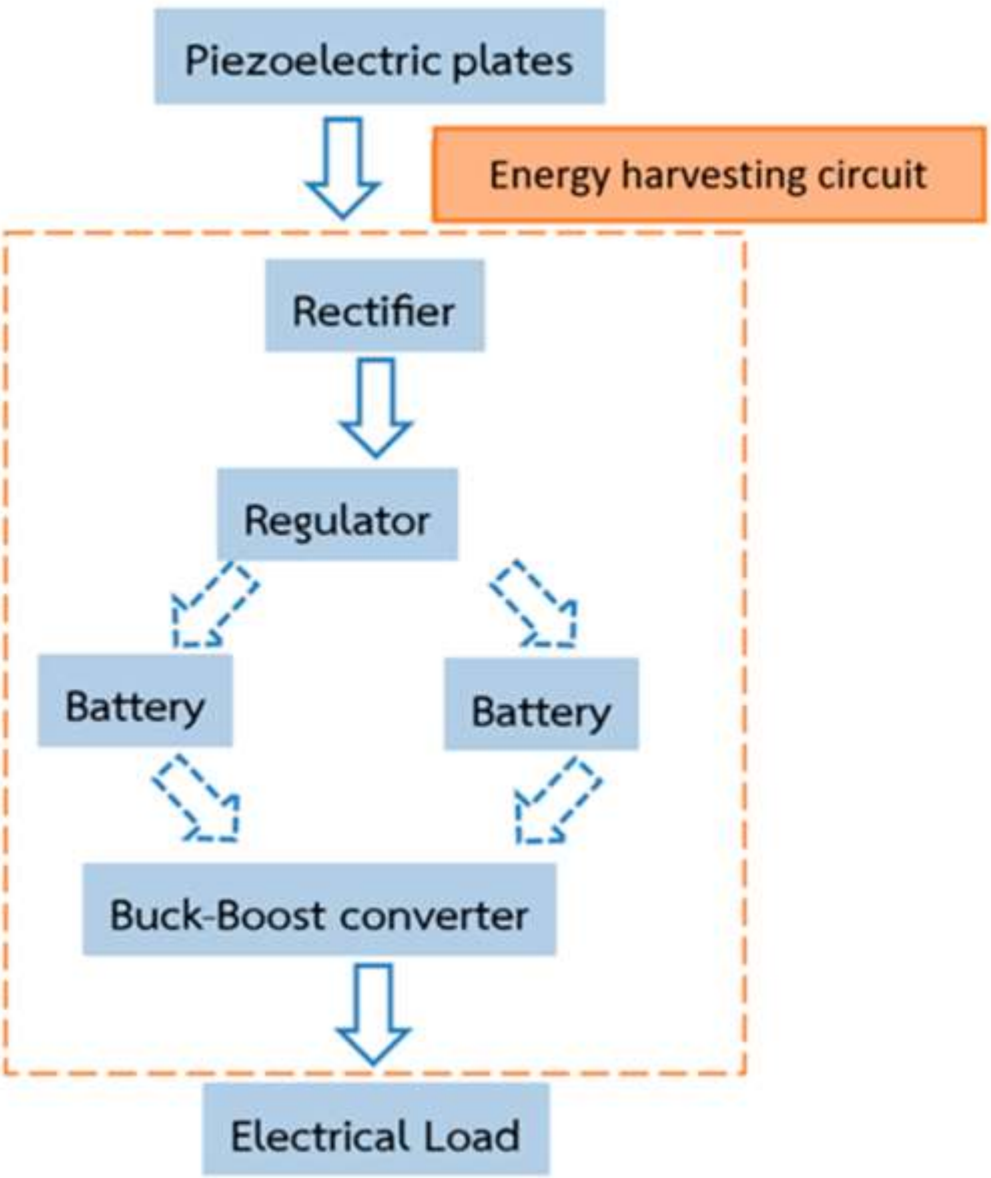

Figure 1: Flow Chart of Methodologies

VII. Result and Discussions

Basic Sketch

2D CAD model: Solid edge version 2022 was used to construct thebasic 2D Sketch of the design of the E-Scooter with Piezoelectric material ,it is described as shown in the figure 2 below:

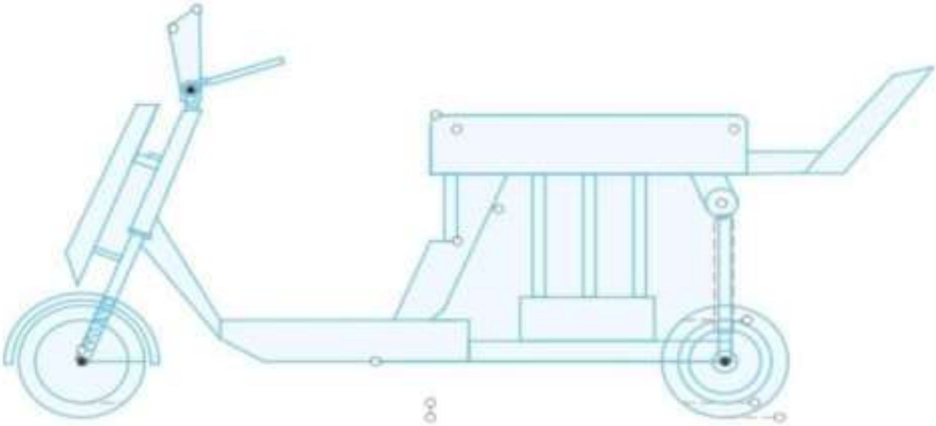

Figure 2 : 2D Sketch of the Model

3D Model

Based on the 2D Model of the bike the whole model was designed into 3D using Fusion 360 Software. The figure 3 below shows the 3D Model of Piezoelectric setup in E-Scooter.

Fig 3: 3D Model of Scooter using Fusion 360

Customization of Lithium-Ion Battery

The Lithium Ion Battery was customized according to the need of motor, 52V Lithium ion battery was created and attached with the motor. The below shown figure 4 shows the Customized lithium ion battery.

Figure 4 : Customized LI-ION Battery

Finished Output of the E-Scooter

The Final outcome of the Fabrication of Light Weight Cost Effective E-Scooter with piezoelectric regenerative power is as shown in the figure 5 below:

Figure 5 : Final Output of the Model

Specifications & Performance

Weight of the E-Scooter- 45 Kg

Lithium Ion Battery - 52 voltages

BLDC Hub Motor - 1000 watts, 48 volts

Various test were performed to check the efficiency n performance of the E-Scooter and the results are listed below as follows:

Battery : Lead Acid Battery

Current : 1300mAh

Voltage : 12V

Watt : 15600 mAh

A = 0.01A

V = 10 - 15V

W = 0.01*15 0.15 WAH = **150 mWAh**

Piezo generating results

Each stress would generate : 10-20 Volts

Speed Range:

Basic Mode: 15- 20 km/hr

Economical Mode: 20-30 km/hr

Sports Mode: 28- 40 km/hr

The E-scooter had a very smooth run across the Streets of Bangalore and results were good considering the ride in urban areas.

Comparative Study Between Yulu Model and Our project model (With piezoelectric categorisation) in Table 1

Table 1 : Effect of Piezoelectric material on E-Vehicle

Specifications	Project Model	Advantages due to Piezoelectric material installedin E-scooter	Yulu Model
Range	42-46 KM	+ 5-7 KM	50 KM
Max Speed	40 km/hr	No Changes	25km/hr
Battery	1 unit charge required for full charge	+ 0.25 unit will charged though Piezoelectric power	Swappable Battery
Cost(Rupees)	27,000/-	Rs.300-500	55,000/-

VIII. Outcomes

1. A comprehensive understanding of the principles and applications of piezoelectric power generation, specifically in the context of e- scooters, providing a strong theoretical foundation for further research and development.

2. An in-depth analysis of the energy requirements and limitations of conventional e-scooters, highlighting the potential benefits and opportunities offered by piezoelectric power generation in terms of extending the range, reducing battery charging frequency, and enhancing the sustainability of e-scooters.

3. A detailed evaluation and comparison of different piezoelectric materials, including their power generation capabilities, efficiency, durability, and compatibility with the operating conditions and requirements of e-scooters, aiding in material selection for optimal performance.

4. Identification of suitable locations and integration strategies for incorporating piezoelectric elements into the structure of e-scooters, considering factors such as mechanical stress distribution, vibration characteristics, and user comfort, enabling effective energy harvesting without compromising the overall design and functionality of the e-scooter.

5. Development of a prototype or simulation model of an e-scooter with an integrated piezoelectric power generation system, demonstrating the practical implementation and performance of the technology in a real-world scenario.

6. Characterization and measurement of the power output, conversion efficiency, and reliability of the piezoelectric power generation system under various operating conditions, providing quantitative data and insights into its performance and feasibility in real-world usage.

7. Proposal of strategies and solutions for power optimization, energy storage, and system integration, addressing challenges such as power management, voltage regulation, and efficient energy utilization to enhance the overall efficiency and reliability of the piezoelectric power generation system in e-scooters.

8. Evaluation of the economic feasibility and cost-effectiveness of integrating piezoelectric power generation technology into e-scooters, including an assessment of material costs, manufacturing processes, potential energy savings, and the financial viability for end-users and manufacturers.

9. Provision of practical recommendations and guidelines for the implementation and scalability of piezoelectric power generation in e-scooters, considering aspects such as regulatory compliance, safety requirements, standardization, and potential avenues for future research and development.

10. Contribution to the knowledge and understanding of piezoelectric power generation in the field of sustainable transportation, offering valuable insights and findings that can inform further advancements in the technology and its integration into e-scooters, contributing to a cleaner and more energy-efficient transportation ecosystem.

11. By achieving these detailed outcomes, the project report aims to provide a comprehensive understanding of the benefits, challenges, and implementation strategies of piezoelectric power generation in e-scooters, serving as a valuable resource for researchers, industry professionals, policymakers, and stakeholders in the field of sustainable transportation.

Implementation:

1. Prototype development: The development of a working prototype of the piezoelectric energy harvesting system and the booster module will require the use of advanced materials and electronics, as well as specialized design and manufacturing techniques.

2. Performance testing: The performance of the prototype piezoelectric energy harvesting system and booster module will need to be tested in different operating conditions and environments to evaluate its efficiency and effectiveness.

3. Integration with electric scooters: The prototype piezoelectric energy harvesting system and booster module will need to be integrated with electric scooters to evaluate their impact on the overall performance and range of the scooter.

4. Cost analysis: The cost of implementing the piezoelectric energy harvesting system and booster module in electric scooters will need to be analyzed to determine the feasibility and potential cost savings of the technology.

5. Future research: Further research will be necessary to explore the full potential of piezoelectric technology in transportation and energy generation, and to identify other potential applications of the technology.

IX. CONCLUSIONS

Micro-mobility

The integration of piezoelectric technology into electric scooters can contribute to the growing trend of micro-mobility by improving the energy efficiency and sustainability of these vehicles. As urban areas become increasingly congested, micro-mobility solutions like electric scooters can provide a convenient, cost-effective, and environmentally-friendly alternative to traditional modes of transportation.

Regenerating module

The use of a regenerating module in conjunction with the piezoelectric energy harvesting system can further enhance the efficiency and sustainability of electric scooters by capturing and converting the energy lost during braking into usable electricity. This can help to extend the range of the scooter and reduce the frequency of battery recharging.

Reliability

The reliability of the piezoelectric energy harvesting system and the booster module will be a critical factor in determining the effectiveness and practicality of this technology for use in electric scooters. The system will need to be robust enough to withstand the rigors of daily use, as well as resistant to environmental factors like moisture, dust, and temperature changes.

X. CONCLUSION

In conclusion, the integration of piezoelectric technology into electric scooters has the potential to improve their energy efficiency, extend their battery life, and enhance their sustainability. The use of a regenerating module in conjunction with the piezoelectric energy harvesting system can further improve the efficiency of the electric scooter. However, the reliability of the system will be a critical factor in determining its practicality for use in electric scooters. With further research and development, the use of piezoelectric technology in transportation and energy generation has broad potential applications and can contribute to a more sustainable future.

XI. FUTURE SCOPE OF PROJECT

The integration of piezoelectric power in electric scooters presents a promising technology with significant future potential. Some of the potential future scopes of the project include the optimization of the piezoelectric material for improved efficiency and durability, the integration with other energy harvesting technologies to develop hybrid energy harvesting systems, the use of the technology in other micro-mobility vehicles, and the commercialization of the technology. Advancements in booster module technology can also lead to more efficient use of the energy harvested. Future research and development in these areas can lead to a more sustainable and efficient future for micro-mobility transportation.

XII. REFERENCES

[1]. Minazara, D. Vasic and F. Costa (2008) “Piezoelectric Generator Harvesting Bike Vibrations Energy to Supply Portable Devices”

[2]. Raghu Chandra Garimella, Dr. V R Shastry (2015) “An approach to generate electricity from vibrations”

[3]. Ritendra Mishra Shruti Jain C. Durga Prasad (2015)" A review on piezoelectric material as a source of generating electricity and its possibility to fabricate devices for daily uses of army personnel"

[4]. Ayan Bhattacharya (2018) “Piezoelectric energy harvesting in automobile Wheels”

[5]. Praveen Bajpai, Prateek Kr. Rai, Saptesh Kr. Mishra, Sumit Gupta (2019) "Piezoelectric Energy Generation from Vehicle Traffic” Volume: 06

[6]. Koustubh Soudarthi, Mohammed Kaleemullah, Dr. B.V.S. Rao (2020) “Impact of piezoelectric materials in electric vehicles” Volume 10, Issue 2

[7]. Alberto doria, Edoardo Macroni and Federico Moro (2021) "Energy harvesting from bicycle vibrations by means of tuned piezoelectric generators"

[8]. Jingting Sun, Jie Chen, Xiong Pan (2015) "Piezoelectric energy harvesting for vehicle tire pressure monitoring systems"

[9]. Qingguo Tang, Yuchen Guo, Xiao Hong Wang (2017) "A piezoelectric energy harvester for automobile suspensions with nonlinear electromagnetic vibration energy generator"

[10]. Mingdong Zhang, Xiaojian Yang, Kaiyan Wang (2019) "A piezoelectric energy harvesting system for automotive exhaust heat recovery"

[11]. Yuhui Jin, Huazhen Shen, Yaxiong Wang (2019) "Piezoelectric energy harvesting for automotive applications

[12]. Qi Li, Zhiyong Wang, Liqun Hou (2019) "A piezoelectric energy harvesting system for vehicle suspension vibration