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Design and Development of Foldable Electric Bicycle

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Abstract: An electric foldable scooter is a compact and convenient mode of transportation that has gained popularity in recent years. This scooter is powered by an electric motor and can be easily folded and stored, making it ideal for commuters who need to travel short distances. The scooter is designed to be lightweight and portable, with a range of up to several miles on a single charge. Its compact size also makes it easy to manoeuvre in tight spaces and navigate through traffic. Electric foldable scooters offer a sustainable and eco-friendly alternative to traditional modes of transportation and are becoming increasingly popular as people seek to reduce their carbon footprint and save on transportation costs.

Keywords: Sustainable, Eco-friendly, Portable, Foldable, Lightweight.

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1. Introduction.

In India, two-wheeler plays an important role in fulfilling personal transportation, mostly in urban areas due to their affordability. Due to high fuel consumption and emission contribution of two-wheeler in urban areas needs to receive more attention and also need to improve the near-term sustainability of energy and urban air quality in the future.

Therefore, the implementation of this hybrid technology for two-wheeler will result in reduction of greenhouse gas emission and petroleum oil in-dependency to a large extent. It also decrease the emission of carbon dioxide gas and other harmful gases. The plug-in concept is implemented in certain concept car and two-wheeler in the market in a limited way. Our product, Foldable Electric scooter is space efficient and affordable. And, due to less weight, it is easily portable and transport. This E- vehicle is eco-friendly and do not use any type of fuels.

Park and Cho (2020) [1] discussed the design and development of a compact electric foldable scooter for urban transportation. The authors explain the need for sustainable and efficient transportation options in urban areas, and describe the design considerations and engineering challenges involved in creating a foldable scooter that is both compact and functional. The article outlines the design process, including the selection of appropriate materials, components, and manufacturing techniques. The authors also describe the testing and evaluation of the prototype scooter, including its performance and safety features.

The article concludes that the foldable electric scooter is a promising transportation solution for urban areas, with potential benefits such as reduced traffic congestion and air pollution. The authors suggest that further improvements in battery technology, motor efficiency, and overall design could lead to even greater adoption of electric foldable scooters as a sustainable transportation option.

Zhang et al. (2019) [2] focused on the design and analysis of a foldable electric scooter. The authors outline the motivation for designing a foldable scooter, which includes the need for efficient and convenient transportation options in urban areas. The article details the design considerations, including the selection of appropriate materials and components, the folding mechanism, and the overall layout of the scooter. The authors also describe the analysis of the scooter's performance, including its stability, maneuverability, and energy consumption. The article concludes that the foldable electric scooter is a promising transportation option for urban areas, with potential benefits such as reduced traffic congestion, air pollution, and increased convenience for users. The authors suggest that further improvements in battery technology, motor efficiency, and overall design could lead to even greater adoption of electric foldable scooters as a sustainable transportation option.

Zhang et al. (2020) [3] focused on the structural optimization design of a foldable electric scooter. The authors aim to improve the performance and usability of the scooter by optimizing its structure and reducing its weight. The article describes the design process, which includes the selection of appropriate materials and components, as well as the optimization of the scooter's structural design using finite element analysis (FEA). The authors also discuss the experimental testing of the optimized scooter design, which showed significant improvements in its performance and usability compared to the original design. The article concludes that structural optimization can improve the performance and usability of foldable electric scooters, making them more attractive for users and potentially increasing their adoption as a sustainable transportation option. The authors suggest that further research is needed to optimize other aspects of the scooter, such as its powertrain and battery system, to achieve even greater performance improvements. The article was published in the Journal of Advanced Transportation in 2020.

Tang et al. (2019) [4] provided an overview of the operational and environmental issues related to electric scooter sharing systems. The authors provide a comprehensive analysis of the current state of electric scooter sharing systems, including their history, current market trends, and future potential. The article highlights the environmental benefits of electric scooter sharing systems, including reduced greenhouse gas emissions and improved air quality. The authors also discuss the operational challenges associated with these systems, such as safety concerns, user behavior, and regulatory issues. The article concludes that electric scooter sharing systems have the potential to significantly impact urban transportation by providing a low-carbon, convenient, and affordable option for users. However, the authors note that further research is needed to address the operational and environmental challenges associated with these systems and ensure their sustainable development. The article was published in the Journal of Cleaner Production in 2019.

Chauhan and Patidar (2020) [5] provides a review of the performance evaluation of electric scooters. The authors aim to provide a comprehensive overview of the various performance factors that influence the operation of electric scooters, including their range, speed, acceleration, and efficiency. The article provides an overview of the different types of electric scooters, including those with hub motors, mid-drive motors, and direct-drive motors. The authors discuss the factors that affect the performance of these scooters, such as battery capacity, motor power, and vehicle weight. The article also provides a detailed analysis of the testing methods and performance metrics used to evaluate electric scooters, including range tests, acceleration tests, and efficiency tests. The authors compare the performance of electric scooters with that of conventional gasoline-powered scooters and discuss the potential benefits of electric scooters, such as reduced emissions and noise pollution. The article concludes that electric scooters have the potential to significantly impact urban transportation by providing a low-carbon, convenient, and affordable option for users. However, the authors note that further research is needed to improve the performance and reliability of electric scooters and ensure their widespread adoption. The article was published in Sustainable Cities and Society in 2020.

1.1 Problem Formulation

The problem formulation of an electric foldable scooter can be defined as the process of identifying and describing the key issues and challenges that need to be addressed in the design, development, and implementation of an electric foldable scooter. This includes considering various factors such as the performance, safety, reliability, cost, and sustainability of the scooter.

The problem formulation of an electric foldable scooter involves identifying the target user groups and their needs and preferences. This includes understanding the user's commuting patterns, the types of terrain the scooter will be used on, and the range and speed requirements of the users. The problem formulation also includes identifying the technical requirements and limitations of the scooter, such as battery capacity, motor power, and folding mechanism.

Additionally, the problem formulation of an electric foldable scooter involves considering the regulatory and legal requirements for the scooter, such as safety standards and environmental regulations. This includes ensuring that the scooter meets all safety requirements and is environmentally friendly.

Overall, the problem formulation of an electric foldable scooter involves a careful consideration of various factors that affect the design, development, and implementation of the scooter. It is an essential step in the product development process and plays a critical role in ensuring that the final product meets the needs and expectations of its users.

1.2 Objective

The objectives of an electric foldable scooter can vary depending on the specific needs of the user, the market segment, and the manufacturer. However, some common objectives of electric foldable scooters can include:

Portability: The primary objective of an electric foldable scooter is to provide a convenient and portable mode of transportation. The foldable design allows the scooter to be easily stored and carried, making it an ideal option for commuting, traveling, or short-distance trips.

Environmentally friendly: Another objective of electric foldable scooters is to reduce carbon emissions and promote sustainable transportation. By using electric power instead of gasoline, electric foldable scooters can significantly reduce the carbon footprint of transportation.

Convenience: Electric foldable scooters provide a convenient mode of transportation that is faster than walking and more affordable than driving or taking public transit. The objective is to provide users with a quick, convenient, and affordable option for short-distance trips.

Safety: Electric foldable scooters are designed with safety in mind, with features such as brakes, lights, and shock absorbers. The objective is to provide users with a safe and reliable mode of transportation that minimizes the risk of accidents.

Cost-effective: Electric foldable scooters are typically more cost-effective than traditional gasoline-powered scooters or cars. The objective is to provide users with an affordable and economical mode of transportation that can save them money in the long run.

Overall, the objectives of electric foldable scooters are to provide users with a convenient, affordable, and sustainable mode of transportation that meets their needs and preferences

2. Methodology

2.1 Design of foldable e-scooter

Initially 2D sketches were prepared and a model is finalized which is shown in the fig.

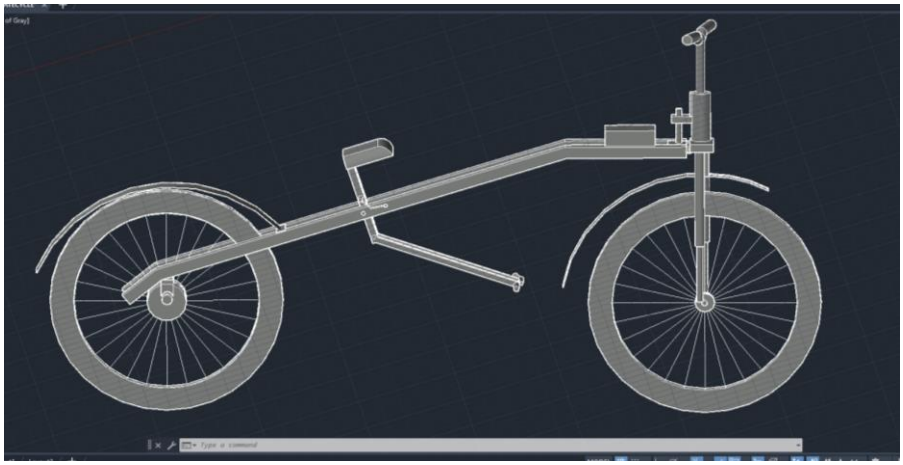

Figure 1. Design of model

2.2 *Dimensions*

Height: 90 cm

Width: 40 cm

Length: 95 cm

Wheel diameter: 40.64 cm

2.3 *Suspension*

Front: Leading link with coil springs.

Rear: None (we can uses, if required)

Table 1. Specification and Performance

Battery capacity	Motor(watt)	Carry Weight (kg)	Running Range (km)
36v & 10Amp	250 watt	40 kg	30 km
36v & 10Amp	250 watt	50 kg	25-28 km
36v & 10Amp	250 watt	55 kg	25 km
36v & 10Amp	250 watt	60+ kg	20 km
36v & 15Amp	250 watt	40 kg	40 km
36v & 15Amp	250 watt	50 kg	30+ km
36v & 15Amp	250 watt	60+ kg	30 m

2.4 Used Components

The project consists of various mechanical and electrical elements.

1. BLDC Hub Motor: A Brushless DC (BLDC) hub motor is a type of electric motor that is commonly used in electric vehicles, including electric bikes, scooters, and cars. Unlike traditional brushed motors, which use mechanical commutators to switch the direction of the current in the motor, BLDC motors use electronic controllers to switch the direction of the current.

   The hub motor design means that the motor is integrated into the wheel hub, which can provide a number of advantages for electric vehicles. For example, the compact design of the motor allows for more space for batteries, which can increase the range of the vehicle. Additionally, the hub motor design eliminates the need for a chain or belt drive, which can reduce maintenance requirements and increase the efficiency of the vehicle.

2. Motor Controller: The electric scooter controller is a critical component of the scooter's electrical system, responsible for regulating the flow of electrical power from the battery to the motor. The controller receives signals from the scooter's throttle and other inputs, and uses this information to adjust the power output of the motor to match the rider's desired speed.

3. Throttle: In an electric scooter, the throttle is a device located on the handlebar that regulates the flow of electrical power from the battery to the motor, controlling the speed of the scooter. It is operated by the rider's hand and comes in various forms, such as twist grips, thumb throttles, and trigger throttles. Throttles can also have additional features like cruise control and electronic braking for a smoother and more responsive riding experience.

4. Lithium-ion Battery (36v & 12Amp): Lithium-ion batteries are rechargeable batteries that have become increasingly popular in various electronic devices, including electric scooters. Basically They are know for their more energy density, long life, and low self-discharge rate. Lithium-ion batteries use lithium ions to move between the anode and cathode during charging and discharging cycles, producing electrical energy. Compared to other battery types, lithium-ion batteries offer several advantages, including lighter weight, higher energy efficiency, and longer lifespan. Due to these advantages, lithium-ion batteries have become a preferred power source for many electric scooters.

5. Battery Charger: A battery charger is a device that is used to recharge batteries, including those used in electric scooters. It provides electrical energy to the battery cells to restore their charge, allowing the battery to power the electric scooter again.

6. Iron Rod: Basically, we are creating a frame design of Electric foldable scooter by the help of iron rods and other iron materials.

7. Disc Brake: A disc brake is a type of braking system that is commonly used on electric scooters. It consists of a rotor or disc that is mounted on the wheel, and a calliper that contains brake pads which squeeze the rotor to slow down or stop the wheel. When the brake lever is pulled, the calliper applies pressure on the rotor, generating friction that slows down the wheel.

8. Circuit Diagram : A Circuit diagram of Electric Folding Scooter , that show the connection of all electronic devices with Motor Controller .

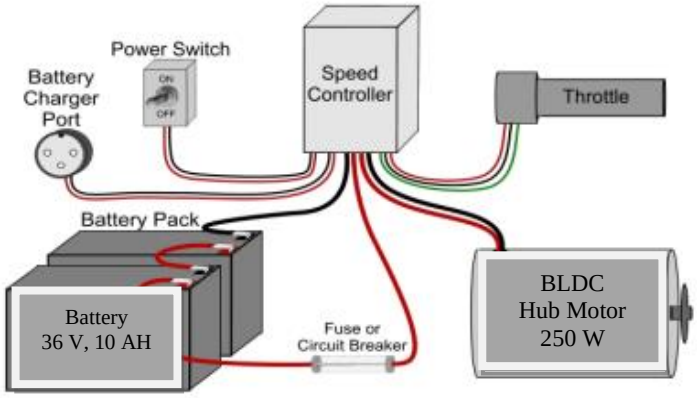

Figure 3. Circuit Diagram

3. Result

The electric foldable scooter is powered by a motor, which is connected to a battery that provides the energy required for movement. The capacity of a battery is typically measured in ampere-hours (Ah), which indicates the amount of charge that the battery can deliver over a certain period of time. The folded scooter can be parked in a compact space or carried with the integrated carrying handle. The loading weight capacity of an e-scooter with a 250watt motor can vary depending on various factors such as the design of the scooter, the quality of the motor and components used, and the terrain or conditions in which it is operated.

Figure 3. A fabricated model of Electric foldable scooter when it is folded

Figure 4. A fabricated model of Electric foldable scooter when it is on stand

3. Conclusions

An electric foldable scooters have gained popularity as a convenient and eco-friendly mode of transportation in urban areas. They offer advantages such as compact size, easy storage, and low operating costs, making them ideal for short distance travel. Design and engineering considerations, such as the use of high-performance BLDC hub motors, lithium-ion batteries, and disc brakes, have enabled electric foldable scooters to become more efficient, reliable, and safe. However, challenges still exist, such as ensuring sufficient range and battery life, improving overall durability and safety, and addressing issues related to infrastructure and regulations.

References

[1] Park, J. W., & Cho, J. R., "Development of a compact electric foldable scooter for urban transportation", Volume 7, Issue 5, 2020, pp.1105-1112. http://dx.doi.org/10.7236/IJASC.2019.8.1.58

[2] Zhang, Y., Li, Y., Li, J., Zhao, C., & Zhu, Y., "Design and analysis of a foldable electric scooter. International Journal of Advanced Manufacturing Technology", 102(9-12), 2019, 3207-3217.

[3] Zhang, Y., Li, Y., & Chen, X., Structural optimization design of a foldable electric scooter. Journal of Advanced Transportation, 2020, 1-8.

[4] Tang, T. H., Tan, C. K., & Yeo, H. S., "Electric scooter sharing systems: An overview of operational and environmental issues", Journal of Cleaner Production, 229, 2019, 1230-1240.

[5] Chauhan, A., & Patidar, V., "Performance evaluation of electric scooters: A review. Sustainable Cities and Society", 54, 101951, 2020.

[6] Justin, "Electric scooter controllers", Technical guide, 2018.

[7] Rider Guide. Available at - https://electric-scooter.guide/guides/definitive-guide-electric-scooters/. [Accessed: 31-may, 2022].

[8] Salisbury Restorers Society, Manuals 2017. Available at- http://www.salesburyscooters.com/manuals.html. [Accessed: 31-may, 2021].

[9] "Popular Mechanics ", Google Books,2017. https://books.google.com.my/books

[10] "Askoll", Askoll, 2017. https://mobility.askoll.com/site/en/news_events_approfondisci

[11] Manoj Kumbhalkar, Mhalsakant M. Sardeshmukh, Dattatraya V. Bhise, Sumant A. Choudhari, Kishor Rambhad, Pramod H. Sahare, Narendra K. Ade, "An insight into conversion of internal combustion engine (ICE) vehicle to electric vehicle for green transportation technology", Multidisciplinary Science Journal, volume 5, issue 4, 2023.

[12] Pranit A. Dhole, M. A. Kumbhalkar, Gajanan V. Jadhav, Akshay S. Dalwai, "Recent Trends in Transportation Technology as Hybrid-Electric Vehicle: A Review", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 7, pp 4-8, 2018