Self-rechargeable electric cycle for rural cargo mobility

Chaitanya Ghegadmal[1], Om Hase[2], Sonal Gamane[3], Rohit Bibave[4], Vishal Ambre[5], Vaibhav Ghule[6]

[1,2,3,4,5,6] *(BE Student, Dept of Mechanical Engineering, Amrutvahini COE, Sangamner)*

Abstract - *This study introduces a self-rechargeable electric cycle designed to improve cargo mobility in rural areas. Addressing transportation challenges, the innovation integrates renewable energy sources, allowing continuous battery recharging during operation. This self-sustaining feature eliminates the need for external charging infrastructure, making it ideal for remote areas with limited access to electricity grids. The cycle's design prioritizes durability, efficiency, and ease of maintenance, tailored to the unique terrain and usage patterns of rural regions. Harnessing mechanical and recuperative energy from wheel rotation maximizes range and load capacity, while minimizing carbon emissions aligns with global sustainability goals. The research encompasses design, prototyping, and testing phases, demonstrating the feasibility and efficacy of the self-rechargeable electric cycle. Results highlight its potential to enhance rural cargo mobility, benefiting local businesses, agriculture, and last-mile delivery services. The integration of renewable energy and rural-specific design elements promotes equitable development and improves the quality of life in underserved rural communities.*

Key Words: Self-recharging, Cargo, Rural mobility, Electric vehicle, Tricycle.

1.Introduction

This study addresses the challenges hindering the development of electric vehicles (EVs) in India, focusing on issues such as pollution, inadequate charging infrastructure, high costs, and limited awareness, particularly in rural areas. Despite government initiatives promoting alternate fuels, EV progress faces obstacles like low battery range and dependency on foreign battery manufacturing. The study emphasizes the need for homegrown battery production to reduce costs. It explores the unique challenges faced by rural farmers and urban cargo transporters, proposing a solution in the form of a self-rechargeable electric cargo tricycle designed to carry a substantial load. The innovation aims to alleviate poverty, improve health, and contribute to India's development by addressing the specific needs of these populations. The research suggests using wheel rotation to recharge the tricycle's batteries, offering a potential solution to increase charging efficiency. The proposed electric cargo tricycle seeks to raise awareness about EVs in rural areas and provide a practical, sustainable transportation solution for both urban and rural communities.

2. Need and Necessity

2.1 Peoples facing difficulties while carrying load.

2.1.1 Farming


2.1.2 Cycle Rikshaw


2.1.3 Lorry Pullers


2.2 Hurdles in Development of Electric Vehicles

2.2.1 Limited Battery Range:

One of the primary challenges in the development of electric vehicles is the limited range offered by current battery technologies. While advancements have been made, the energy density of batteries is still a constraint, impacting the distance an EV can travel on a single charge.

Limited range can be a significant deterrent for potential EV buyers, especially for those who need to cover long distances regularly. This issue is particularly noticeable in regions with inadequate charging infrastructure.

2.2.2 Inadequate Charging Infrastructure:

For electric vehicles to be widely used, charging facilities must be readily available. In many areas, the charging infrastructure is insufficient, hindering the convenience and feasibility of owning an electric vehicle. Without a robust charging network, EV users may face challenges in finding charging stations, especially during long journeys. This limitation can discourage potential buyers and restrict the use of electric vehicles in certain regions.

2.2.3 Time-Consuming Charging Process:

Even with fast-charging technologies, the charging process for electric vehicles is generally longer than refuelling a traditional vehicle with gasoline. This longer duration can be inconvenient for users who are accustomed to quick refuelling. The time it takes to charge an electric vehicle can impact the user experience, affecting the acceptance of EVs for daily use, especially in situations where time is a critical factor.

2.2.4 Less Awareness in Rural Areas:

Awareness about electric vehicles is often lower in rural areas compared to urban centres. Limited access to information and education about the benefits of electric vehicles can hinder their adoption in these regions. Without sufficient awareness, potential buyers may not consider electric vehicles as a viable option. This lack of awareness can also affect the development of necessary support systems, such as charging infrastructure, in rural areas.

3. Literature Review

3.1 **Phapale Ishwar et.al.** developed a system to power bicycles using an alternator for battery recharging. Initially reliant on the battery, our electric vehicle model integrates a magnetic alternator to sustain continuous energy generation. This setup maintains a steady RPM of approximately 3000, ensuring consistent electricity production. Pedal torque initiates the alternator's rotation, which then generates power for battery replenishment. This innovative design allows for self-recharging capability during cycling, enhancing the bike's energy efficiency.

3.2 **Avesh Khan et.al.** created a bicycle trolley with a hitch system and wheels for carrying bicycle cargo instead of a motor. It can significantly raise the cargo capacity of a bicycle. The trolley could be needed as a general-purpose goods carrier or for a specific purpose, like the transportation of passengers or a certain kind of merchandise. Since it has been around for a very long time, trolleys have made it easier for people to transport items rather than having to do it themselves.

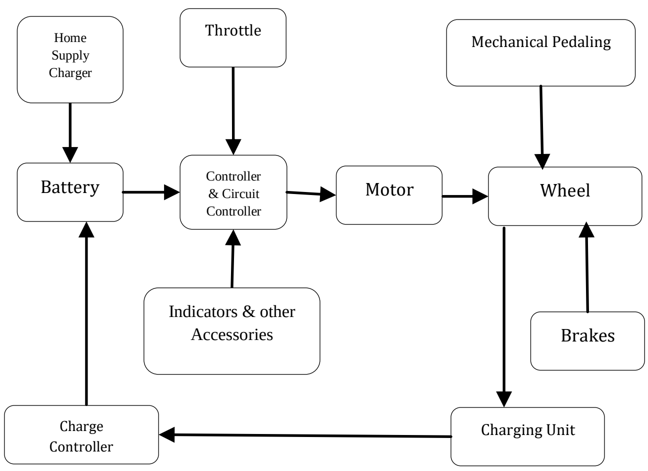
3.3 **Shubham U. Tayde et.al.** created an electric vehicle in response to fuel restrictions and environmental concerns—two issues that are critical to the modern economy and fast-paced lifestyle. Due to their role in pollution and global warming, traditional vehicles must give way to more environmentally friendly options, such as e-bikes. These do have certain restrictions, though. In order to overcome them, we have created an electronic bike that generates power on its own without the need for external fuel or charging sources. Because of its creative design, which produces all of its own electricity, it operates continuously and has no negative environmental effects.

3.4 **GIRISH B KALLIHAL et.al.** traction system for an autonomous Electric Vehicle combines batteries and a dynamo. It efficiently integrates two energy storage systems for enhanced performance. By analysing vehicle characteristics and routing profiles, energy consumption is determined. The system components, including batteries, dynamo, power converters, and control strategy, are detailed. A control strategy is devised to optimize energy management and increase autonomy.

3.5 **Mazlan, Rozdman et.al.** based on alternator speed, an energy audit was done on alternator output and battery voltage. Alternators have been changed to accommodate the growing need for power in cars. This study employs a Proton Preve 1.6 Manual automobile to examine how alternator speed affects the charging system. Three engine speeds were put to the test: 1500 RPM for the idle, 3000 RPM for the cruise. The findings show that improved power generation and quicker battery charging rates are caused by faster alternator speeds.

4. Methodology

4.1 Electrical System



4.1.1 Essential System Components

4.1.1.1 Motor –

As per the requirement that motor must be able to carry the 170 kg load with the full speed of 25 km/hr the motor must be powerful. By Design calculations mention in the next section the motor we are going to use will be the 1000 W Brushless DC motor. It will be the hub motor (Assembled within the tire assembly) mounted to the front wheel of the cycle. We have chosen front wheel to assemble the motor to get higher starting torque and higher speed.

Fig 2 . BLDC Hub Motor

4.1.1.2 Battery –

As per the motor specification the battery should be capable to provide enough amount of voltage. So, by the calculation we decide to use Lithium-ion battery because of its advantages like High energy density, Low maintenance, Performance and longevity, Versatility, Improvement of safety performance. The Power output of the battery will be 48v voltage and 24ah current. As per the calculation battery is capable to drive the motor.

4.1.1.3 Controller –

In this case, the motor generates a back emf directly proportional to its speed and is normally powered by a voltage from the controller. Due to the difference between the controller's output voltage and the motor's back emf, the motor's back emf grows and the current reduces as it moves faster. The current ceases when the motor speed reaches a very high level because the back emf matches the output of the controller. If the motor runs even faster than the current, it must go negative (feeding back into the controller) since the back emf is now greater than the output voltage of the controller. And so the braking begins. The controller has to manage this current.

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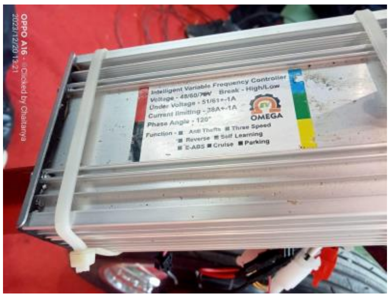

Fig 3. Charge Controller Connections.

4.1.1.4 Charging Unit – The Alternator

An alternator is a key component in the generation of electrical power in various applications, most notably in automobiles. Its fundamental purpose is to convert mechanical energy, often derived from an engine's rotation, into electrical energy. As per the requirements we are going to use alternator used in car.

4.1.1.5 Charge Controller – The Voltage Regulator

A voltage regulator is a critical component in electrical systems, tasked with maintaining a stable and controlled output voltage within a specified range. It plays a crucial role in various applications, including power supplies, automotive systems, and generators. There are different types of voltage regulators, such as linear and switching regulators, each with its own characteristics. Linear regulators use a series pass element to regulate voltage, while switching regulators rapidly switch the input voltage on and off, providing higher efficiency. The primary functions of a voltage regulator include ensuring voltage stability, regulating the output despite changes in load or input voltage, and providing protection mechanisms against overvoltage and undervoltage. Some regulators also include features like current limiting and temperature compensation.

4.1.2 Working Principle –

In this electrical system, the tricycle is propelled by a motor powered by a battery. As the wheels rotate during movement, this mechanical motion is harnessed by an alternator connected to the wheel rotation. This mechanical energy is transformed into electrical energy by the alternator. A closed-loop system is created when the battery is charged using the electrical energy that was produced.

The battery initially provides electrical power to the motor for tricycle propulsion. The alternator is triggered simultaneously by the wheels turning, converting mechanical energy back into electrical energy. The second battery is recharged by rectifying this electrical energy to direct current. AS the first working battery get discharged the battery swapping will get placed and the vehicle will be driven by the second battery. Consequently, the system maintains a continuous cycle of converting between electrical and mechanical energy, ensuring a sustained power supply for the motor and other electrical components as the tricycle moves.

If somehow battery get discharged the tricycle can be driven and charged by means of mechanical pedalling, the chance of happening such incidence is about 1% only.

4.2 Mechanical Arrangement

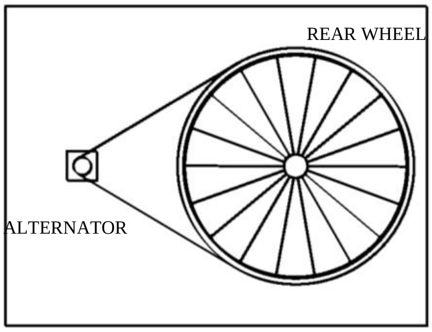

Fig 4. Alternator Arrangement

Here the tricycle will look like an ordinary tricycle with back trolley only the change we have made to increase the recharging efficiency is to be attached extra sprocket to rear wheels which will act as a large pulley. The chain on the sprocket will be attached to the alternator pulley (rotor). This system will make multiple rotations of alternator against one rotation of the wheel.

5. Model Views

5.1 Orthographic Views

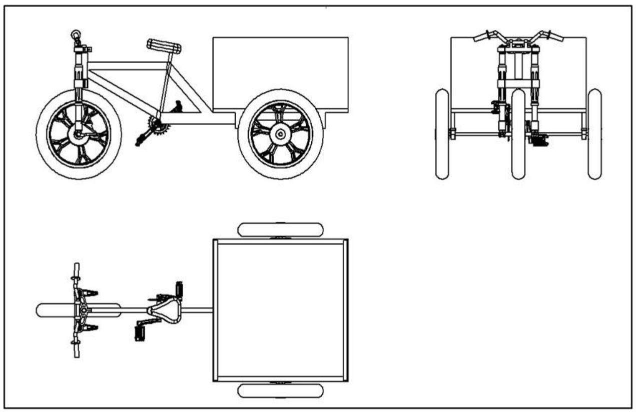

Fig 5. Orthographic Views

5.2 Isometric View in SOLIDWORK Software

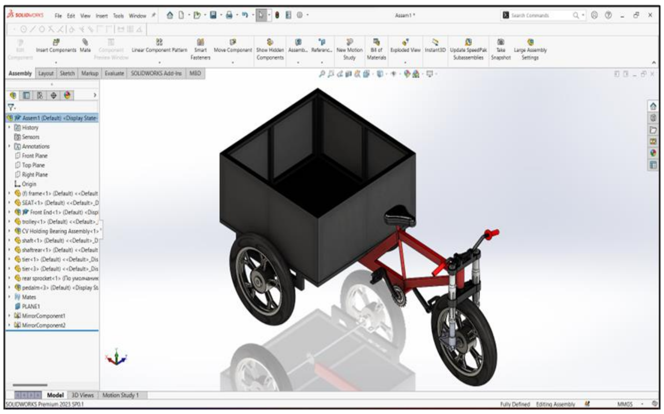

Fig 6. Isometric Views

5.3 Structural Analysis

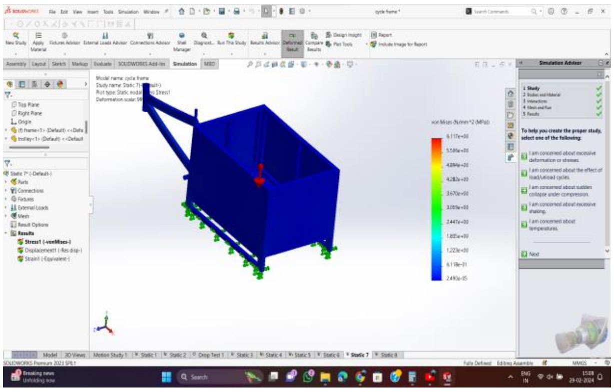

Fig 7. Structural Analysis

5.4 Actual Project View

Fig 8. Actual Project Views

6. Result

6.1 Power Transmission Efficiency Comparison

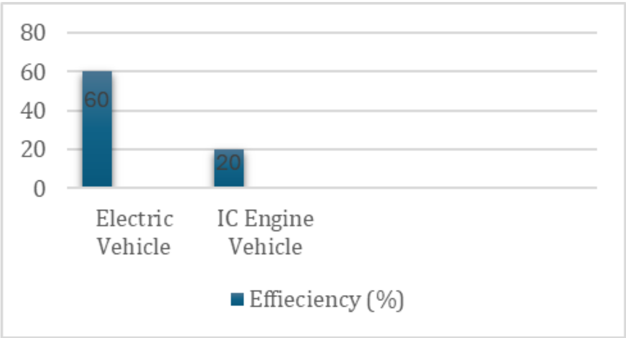

Fig 9. Power Transmission Efficiency Comparison

6.2 Comparison between conventional cargo vehicles and Electric cargo Vehicle w.r.t Initial cost, operating cost, and maintenance

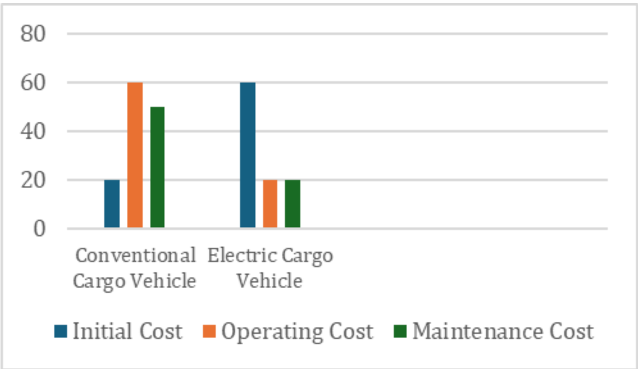

Fig 10. Cost Comparison

6.3 Recharging Efficiency Comparison

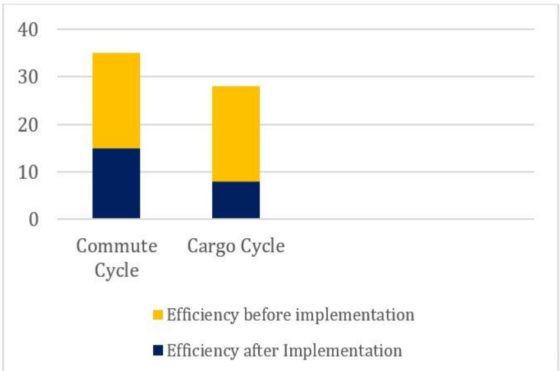

Fig 11. Recharging Efficiency comparison

6.4 Comparison with cargo cycles available in market

Parameters	Available Market Product	Proposed Product
Manufacturing Cost	Rs 150000	Rs 60000
Charging cost per unit	Rs 9.64	Rs 4.46
Self-rechargeable	Not Available	Available
Cargo Weight Capacity	100 kg	170 kg

Table 1. Comparison with cargo cycles available in market

3. CONCLUSIONS

The final product a cargo tricycle is capable to carry the 170 kg load at 40 kg/hr speed. The batteries of tricycle can be recharged around 35 % in the span of 50 km. The design of tricycle is very much simple, and it is manufactured at college campus by the project members with the scrap and in lower cost. As this is cost efficient than available products it will helpful for small scale load carrying operations.

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BIOGRAPHIES

Chaitanya Kishor Ghegadmal
(BE Mechanical, Hons. Electric Vehicle)

Om Santosh Hase
(BE Mechanical)

Sonal Balasaheb Gamane
(BE Mechanical)

Rohit Dilip Bibave
(BE Mechanical)

Vishal Dipak Ambre
(BE Mechanical)

Vaibhav Kailas Ghule
(BE Mechanical, Hons. Electric Vehicle)