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Design and Development of EV Tricycle Cart

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Abstract: *This project aims to revolutionize the working conditions of street vendors by introducing an innovative electric tricycle cart solution. Our electric tricycle cart, designed with the vendor's comfort and efficiency in mind, significantly reduces physical strain and improves overall productivity. By integrating a powerful electric motor and a long-lasting battery our tricycle cart effortlessly tackles challenging terrains and heavy loads, allowing vendors to cover greater distances and transport larger quantities of goods. The ergonomic design of the tricycle cart ensures optimal comfort during extended use, minimizing fatigue and maximizing efficiency. Additionally, the quiet operation of the electric motor creates a more pleasant working environment, reducing noise pollution and enhancing customer interaction. By adopting this sustainable and user-friendly technology, street vendors can enhance their livelihoods, increase their earnings, and contribute to a more vibrant and inclusive urban economy. Our electric tricycle cart empowers vendors to work with greater ease, dignity, and success, ultimately improving their quality of life.*

Keywords: street vendors

I. INTRODUCTION

1.1 Introduction

In today's world, where sustainability and efficiency are paramount, the need for innovative transportation solutions is more pressing than ever. While a reliable tool, the traditional handcart often falls short in terms of ergonomic design, environmental impact, and overall performance. Recognizing this gap, we introduce the EV Tricycle Cart, a revolutionary solution that seamlessly combines the convenience of a tricycle cart with the power and sustainability of electric technology. Meticulously designed to be compact, lightweight, and effortlessly maneuverable, the EV Tricycle Cart’s sleek and ergonomic design ensures easy tricycle loading and transportation, making it perfect for a wide range of applications, from bustling urban environments to spacious warehouses. Whether navigating through narrow aisles or traversing uneven terrains, the EV Tricycle Cart effortlessly adapts to diverse settings. Embracing the power of renewable energy, the EV Tricycle Cart incorporates high-efficiency solar panels into its design. These panels harness the sun's energy to generate and store electricity, significantly reducing reliance on traditional power sources. This innovative integration not only minimizes environmental impact but also extends the operational range of the EV Tricycle Cart, enabling continuous use without frequent charging. Equipped with a robust electric motor, the EV Tricycle Cart delivers exceptional hauling capacity and effortless performance. This powerful motor effortlessly tackles various loads, from light packages to heavy materials, ensuring efficient and reliable transportation. With its impressive power and torque, the EV Tricycle Cart significantly reduces physical strain and enhances overall productivity. Powered by a rechargeable battery, the EV Tricycle Cart offers a sustainable and environmentally friendly alternative to traditional gas-powered carts. By eliminating harmful emissions and reducing energy consumption, the EV Tricycle Cart contributes to a cleaner and greener future. The long-lasting battery ensures extended operation time, minimizing downtime and maximizing productivity. The EV Tricycle Cart prioritizes user comfort and efficiency through its intuitive design and ergonomic features. The user-friendly interface, intuitive controls, and comfortable tricycle ensure a seamless and enjoyable user experience. The ergonomic design minimizes physical strain, allowing for extended periods of use without fatigue.

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1.2 Objective

- To create and engineer an electric handcart or pushcart that is ergonomically appropriate for the user.
- Offer an electric vehicle-powered solution for the pushing or pulling of a handcart or pushcart.
- To minimize the human efforts needed for operating the handcart.
- To prevent health complications associated with the manual operation of the hand/push cart.

II. LITERATURE SURVEY

Santhanakrishnan Narayanan [2] has authored a research document that provides a comprehensive review of electric cargo cycles (E-cargo cycles) and their potential in urban transportation. The focus of the review is primarily on commercial transport, while also addressing private use. It covers various aspects such as typology, market penetration, impacts, operational requirements, and policy considerations. The document outlines essential considerations for the implementation of E-cargo cycles in logistics operations, which include the necessity for adequate infrastructure, the potential use of intermediate shifting points, and financial factors. Policy recommendations presented in the document advocate for the enhancement of cycling infrastructure, the implementation of regulatory measures to facilitate E-cargo cycle usage, the provision of incentives, and the creation of awareness through campaigns and trial schemes. A significant insight from this document is the potential of E-cargo cycles to not only minimize environmental impacts but also to transform urban logistics and enhance the livability of cities. The review emphasizes the intricate interplay of factors that influence the adoption of E-cargo cycles, ranging from operational considerations to societal perceptions.

Julio A Sanguesa, Vicente Torres-Sanz, Piedad Garrido, Francisco J J Martinez, Johann M Marquez-Barja [3] have studied electric vehicles (EVs), emphasizing their technologies and associated challenges. The research begins by outlining the benefits of EVs compared to conventional combustion engine vehicles, including zero emissions, operational simplicity, reliability, reduced maintenance costs, and enhanced efficiency. The paper further categorizes EVs into distinct types: Battery Electric Vehicles (BEVs), Plug-In Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), Fuel Cell Electric Vehicles (FCEVs), and Extended-range Electric Vehicles (ER-EVs). A particularly noteworthy aspect of this study is its exploration of potential advancements in EV technology. It discusses innovative battery technologies, such as magnesium-ion and sodium-air batteries, which have the potential to significantly extend the range of EVs and decrease charging durations. Additionally, the importance of incorporating artificial intelligence and communication technologies into EVs is highlighted, as these can optimize charging processes and enhance overall efficiency. The document also poses critical questions regarding the comprehensive environmental impact of EVs, taking into account their entire lifecycle from production to disposal. This thorough examination offers a nuanced perspective on the challenges and opportunities within the EV sector, serving as a valuable resource for understanding the current landscape and future developments in electric mobility.

Sathish Kumar N and Vignesh A [4] present a comprehensive study on the design and analysis of an electric motor-driven kart to minimize reliance on fossil fuel-powered vehicles and enhance efficiency within the electric vehicle industry. The authors elaborate on the design of several subsystems, including the chassis frame, steering mechanism, electrical powertrain, and braking system. A primary emphasis of the frame design was placed on stability and driver safety, leading to the selection of Aluminum alloy 6063 for its advantageous lightweight and strength characteristics. The frame was developed using CREO 2.0 and subjected to analysis with ANSYS 14.5 to ensure its integrity under maximum impact load conditions. Notably, the design strikes a careful balance among performance, safety, and environmental sustainability. The authors have made informed choices regarding material selection and component design to enhance the kart's efficiency and overall performance. The application of finite element analysis to assess the frame's safety across various impact scenarios reflects a thorough approach to design validation. Additionally, the incorporation of modern features such as an LED display on the steering wheel and proximity sensors for collision avoidance indicates a progressive perspective on user interface and safety. The extensive calculations and analyses provided for each subsystem offer valuable insights into the engineering processes involved in electric vehicle design, rendering this paper a significant resource for both students and professionals in automotive engineering, especially within the expanding electric vehicle market.

Vignesh M.*, Dr. Arumugam, Vinoth, & Hariharan [5] . This study investigates the design and analysis of an electric bike frame. The research aims to develop a lightweight yet robust frame for commercial e-bikes, with the goal of enhancing their efficiency and environmental sustainability. The authors selected AISI 4130 Alloy Steel for the frame due to its accessibility, affordability, and superior mechanical properties. A notable finding from this research is the opportunity for further refinement of the frame design. The authors propose that examining various frame configurations, such as monocoque designs, could yield even more effective and dependable structures. Furthermore, incorporating alternative materials like carbon fiber or titanium may improve the frame's strength and performance, although this would come at a higher expense. The study also emphasizes the necessity of considering additional factors beyond mere structural integrity, including material availability, machinability, and cost-effectiveness, during the e-bike frame design process.

III. METHODOLOGY

The design and development of the EV tricycle cart followed a systematic approach, starting with the identification of the project's purpose and functional requirements. Initial research involved studying existing electric tricycles and similar low-speed electric vehicles to understand their performance, limitations, and market demand. Based on the intended use-case—such as goods delivery or passenger transport—key specifications were defined, including payload capacity, range, speed, and structural dimensions. The design phase was carried out using CAD software like SolidWorks to create detailed 3D models of the chassis, body, and component placements. Material selection focused on lightweight yet durable options, such as mild steel for the frame and composite materials for the body. The powertrain system was designed around a BLDC hub motor paired with a lithium-ion battery pack and an intelligent motor controller to ensure efficient energy use and safety. A Battery Management System (BMS) was integrated to monitor battery health and prevent overcharging or overheating. The prototype was fabricated based on the CAD designs, followed by integration of electrical and mechanical systems. Extensive testing was conducted to evaluate performance parameters such as speed, stability, braking efficiency, and range under various load conditions. Feedback from these tests informed iterative improvements, ensuring the final design met safety standards, user convenience, and sustainability goals.

3.1 Flow Chart

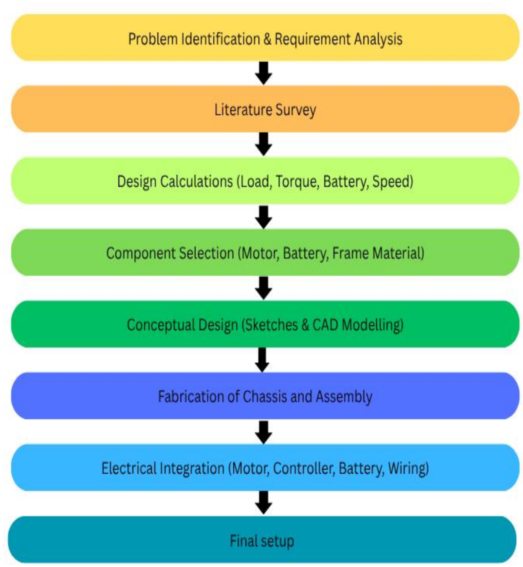

Fig.Flow Chart

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3.2 Concept Design Overview

The project titled 'Design and Development of EV Tricycle Cart' introduces an innovative and effective solution aimed at alleviating the physical challenges encountered by street vendors and small-scale goods transporters. The proposed design features a three-wheeled, electric-powered tricycle cart equipped with a spacious cargo area and a robust frame. In contrast to conventional pushcarts that demand considerable manual effort, this EV tricycle cart is engineered to be motor-assisted, thereby significantly minimizing the physical exertion required from users. The integration of an electric drive system facilitates smoother and more efficient movement, particularly in urban and semi-urban environments where street vendors frequently navigate congested roads and uneven terrain. With two rear wheels ensuring stability and a front wheel for steering, the tricycle provides balanced weight distribution and ease of maneuverability. This design not only advocates for sustainable transportation through zero-emission electric power but also empowers local vendors by improving their mobility, productivity, and overall working conditions.

3.3 Working System

The working system of the EV tricycle cart is based on the integration of electric propulsion, mechanical support, and electronic control components to enable smooth and efficient operation. The system is powered by a rechargeable battery pack, typically lithium-ion, which stores electrical energy and supplies it to a Brushless DC (BLDC) motor through an electronic motor controller. When the rider operates the throttle—usually a twist grip or thumb lever mounted on the handlebar—it sends a signal to the controller to adjust the power delivered to the motor, thereby controlling the speed of the vehicle. The motor, which can be either hub-mounted on the rear axle or centrally positioned with a chain drive, converts electrical energy into mechanical motion, propelling the tricycle forward. A battery management system (BMS) is included to monitor and regulate the battery's voltage, temperature, and state of charge, ensuring safe and efficient operation. The tricycle's mechanical framework, including the chassis, wheels, and suspension system, supports the vehicle structure and absorbs road shocks, enhancing ride comfort. Braking is achieved through mechanical or hydraulic brakes, and in some advanced models, regenerative braking is used to convert kinetic energy back into electrical energy during deceleration. An onboard dashboard provides real-time feedback on battery status, speed, and system diagnostics, enabling the user to monitor and control the vehicle effectively.

IV. DESIGN AND ANALYSIS

4.1 Design

4.1.1 CAD Model

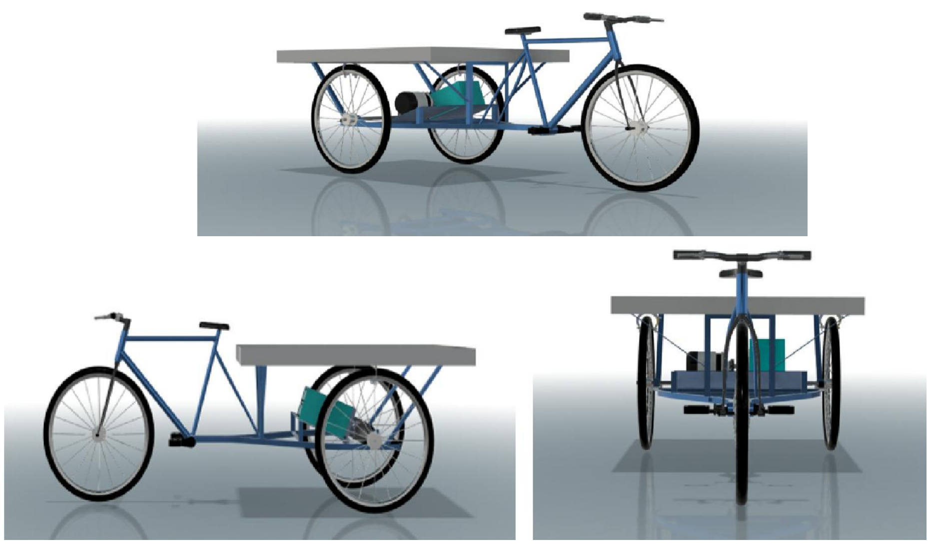

Fig. Cad Model

4.1.2 Drafting

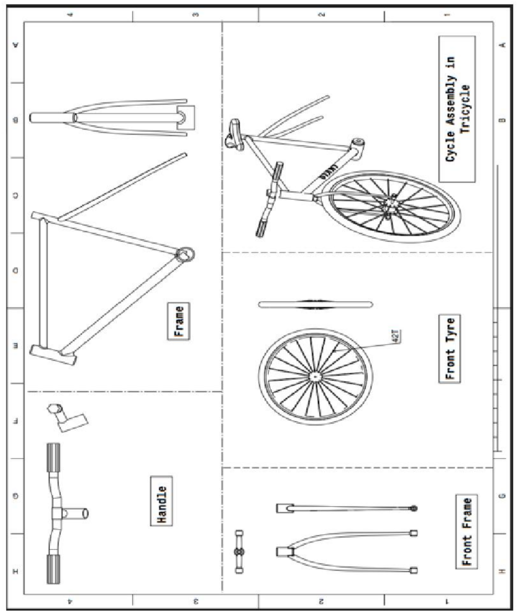

Fig. Cycle Drafting

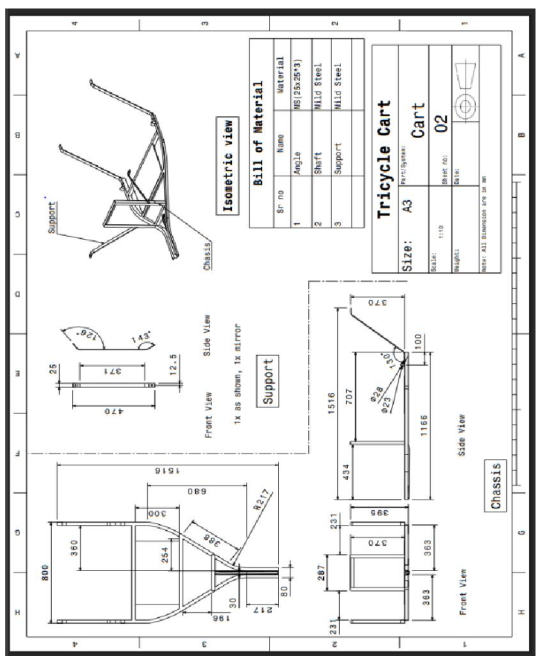

Fig. Chasis Drafting

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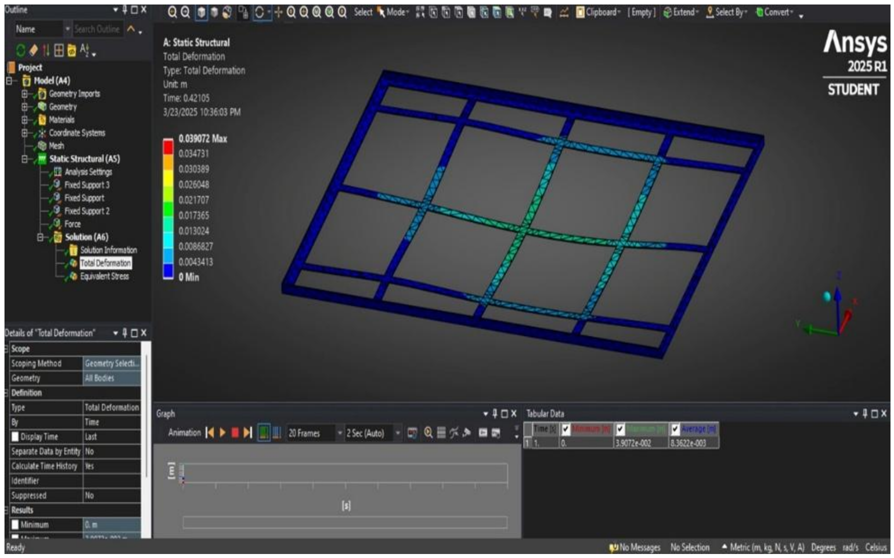
4.2 Analysis



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Save Project Before Solution	No
Save Project After Solution	No

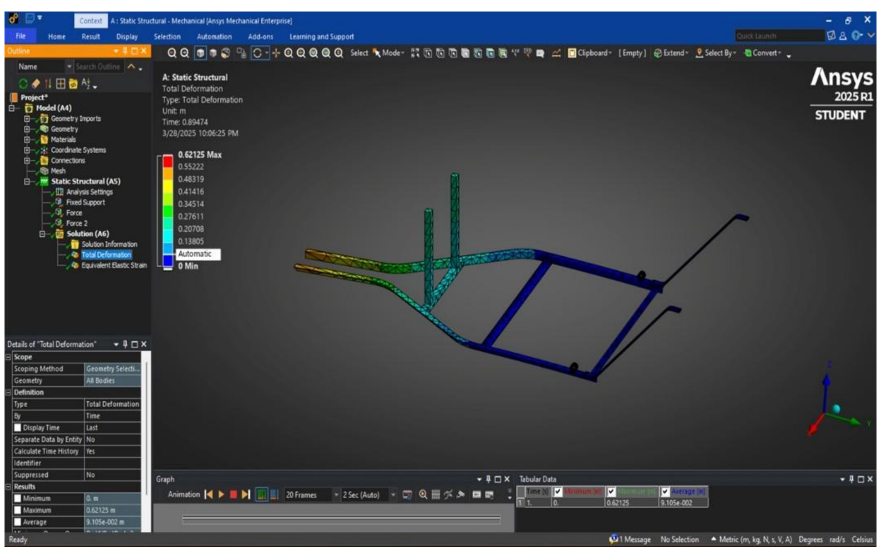

Fig. Chassis Analysis

Parameter	Value	Unit/Details
Payload	165	kg
Vehicle Weight	35	kg
Total Mass	200	kg
Rolling Resistance Coefficient	0.01	Typical for bike tires

Rolling Resistance Force (F_r)	19.62	Newtons (N)
Slope Angle	5°	Assumed
Gradient Resistance (F□)	170.8	Newtons (N)
Acceleration	0.278	m/s² (0–10 km/h in 10 s)
Acceleration Force (F_a)	55.6	Newtons (N)
Total Tractive Force (F□)	246.02	Newtons (N)
Wheel Radius	0.66	meters
Torque Required	73.8	Newton-meters (Nm)
Power Required (at 10 km/h)	683.9	Watts
Motor Rated Power	250	Watts (MY1016Z2)
Battery Capacity	24V, 20Ah = 480 Wh	$LiFePO_4$
Estimated Runtime	2.22	Hours (at constant 250W draw)
Estimated Speed (Actual)	32	km/h (based on RPM & wheel size)
Used Speed in Analysis	10	km/h (for realistic performance)

4.3 Motor Performance Analysis

Torque Calculation:- → The torque produced at the wheel is crucial for moving the loaded cart.
T = P / ω Where:
T = Torque (Nm)
P = Power (W)
ω = Angular speed (Rad/s)
Motor speed (RPM) after gear Reduction
N = 3300 / 9.78 = 337 RPM = 42.3 RPM
ω = (2π x 337) / 60 = 35.3 rad/s
P = 250 / 35.3 = 7.08 Nm
Output Torque = 0.73 Nm x 9.78 = 7.13 Nm
Power Consumption and Efficiency
Total Energy Consumption (Wh/km)
E consumption = P / V for 24V, 250W motor
E consumption = 250 / 24 = 10.4 Wh/km
Considering real-world inefficiencies!
Actual = 12-14 Wh/km

4.4 Load Calculation

Tricycle Speed and Torque Calculation (with Load)
Vehicle Specifications:
Rear and Front Wheel Diameter: 26 inches (0.6604 meters)
Wheel Circumference: π × D ≈ 2.074 meters
Driving Sprocket Teeth:9
Driven Sprocket Teeth: 16
Chain Type: #25 (ANSI 25)
Gear Reduction: 9.78:1
Motor: MY1016Z2 (24V, 3300 RPM, 22 Nm torque)
Pedal welded (non-functional)
Speed Calculation with Gear Reduction:
- Motor RPM = 3300
- Reduction Ratio = 9.78:1

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- Wheel RPM = 3300 / 9.78 ≈ 337.6 RPM
- Wheel Circumference = 2.074 meters
- Speed = 337.6 × 2.074 = 700.3 m/min
- Speed = 700.3 × 60 / 1000 ≈ 42.02 km/h (Theoretical under no load)

Load Impact Analysis:
- Payload: 165 kg
- Estimated Vehicle Weight: 35 kg
- Total Weight: 125 + 35 = 160 kg
- Rolling Resistance Coefficient (C_r): 0.01 (standard for bike tires)
- Rolling Resistance Force: F□ = 0.01 × 200 × 9.81 ≈ 19.6 N
- Wheel Radius: 0.3302 m
- Torque Required at Wheel = F□ × r ≈ 19.6 × 0.3302 ≈ 6.47 Nm
- Motor Torque = 22 Nm

V. CONCLUSION

The initiative effectively tackles the significant issues encountered by street vendors who have historically depended on manual handcarts, which require considerable physical exertion and present long-term health hazards. By implementing an electric tricycle cart, the team has offered a viable, ergonomic, and environmentally friendly mobility solution that greatly alleviates physical stress, boosts operational efficiency, and encourages sustainable urban transportation. The design incorporates a durable electric drive system and user-focused features, ultimately empowering vendors with enhanced mobility, increased range, and improved working conditions. This innovation not only elevates the quality of life for users but also has a positive impact on the environment and the local economy by promoting cleaner, more inclusive urban infrastructure.

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