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Design And Development Of Electric Tricycle

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Abstract: This study explores e-trikes as pollution-free city transport, assessing their urban commuting performance. Petrol tricycles contribute to air and noise pollution due to the combustion of fossil fuels in their engines, emitting greenhouse gases and pollutants such as carbon dioxide, nitrogen oxides, and particulate matter, which can harm both the environment and human health. Petrol tricycles rely on gasoline as fuel, derived from non-renewable fossil fuels. We designed a tricycle with a 650W motor and 24V battery for eco-friendly short to medium city trips. Switching to electric drive maintains performance and ensures comfortable rides. With around a 16km range per charge, they meet urban mobility needs while championing sustainability. Besides eco-benefits, e-trikes prioritize passenger comfort and safety through smart design and stability. Extensive testing covers energy efficiency, range, and reliability, confirming e-trikes as a viable alternative to gas vehicles. Integrating e-trikes into city transit could dramatically cut pollution and boost air quality, fostering healthier urban environments. This study advocates for e-trikes to lead green mobility efforts and shape future urban transport. Key components include a PMDC motor, Battery, Charge controller, and Throttle.

1. Introduction

At present, many exciting developments in electric vehicle technology are taking place. Some of these have advanced sufficiently to be commercially available, while others remain for the future. The first demonstration electric vehicles were made in the 1830s, and commercial vehicles were available by the end of the 19th century. Today's concerns about the environment particularly noise and exhaust emissions, coupled with new developments in batteries, fuel cells, motors, and controllers, may swing the balance of electric vehicles.

There are many types of electric vehicles, such as railway trains, ships, aircraft, cars, bikes, bicycles, wheelchairs, and many more. But this project is focused on electrically powered tricycles, which are categorized under Low Speed Vehicles (LSVs) and are environmentally friendly modes of transport for short trips. The objective of the project is to design and develop a concept battery-powered tricycle for multipurpose use and to choose the best concept to reduce the cost and expensive batteries required. Besides that, to design a tricycle with high efficiency and greater flexibility to place components in a tricycle to optimize weight positioning and minimize aerodynamic drag.

2. Problem Definition

Problem 1: Battery Battery powered tricycles are normally expensive and require a lot of money.

Problem 2: The weight of an electric vehicle significantly impacts its performance, range, and overall cost.

Problem 1 Solution: Nowadays, the electric tricycles mainly make use of a brushless D.C. motor whose cost is very high. In our project, we will make use of PMDC motor which costs less and thus the cost of the electric tricycle is in turn reduced.

Problem 2 Solution: Typically, electric tricycles tend to be quite bulky. We are actively working to minimize the weight of the tricycle.

3. Project Objectives

The primary aim of this project is to create a battery-powered electric motor tricycle suitable for basic transportation and economic purposes.

The objectives include:

- To select the components for an electric tricycle.
- To design the components of the tricycle.
- To manufacture the components of an electric tricycle.
- To assemble the part of the electric tricycle.

4. Literature Review

The referenced papers contribute various perspectives to the domain of battery-powered tricycles:

M. Reddi Sankar et al. [1], this paper describes the development of a solar-assisted bicycle featuring a DC motor powered by solar radiation. The battery charges via solar panels mounted on the carriage. This system replaces traditional components like the gasoline engine and gear-shifting mechanism with environmentally friendly alternatives.

ArinzeDavidi et al. [2], the authors present an electric power train and control system integrated into a hand-powered tricycle, aiming to enhance mobility. The design prioritizes simplicity, affordability, reliability, and adaptability to existing tricycles with minimal modifications.

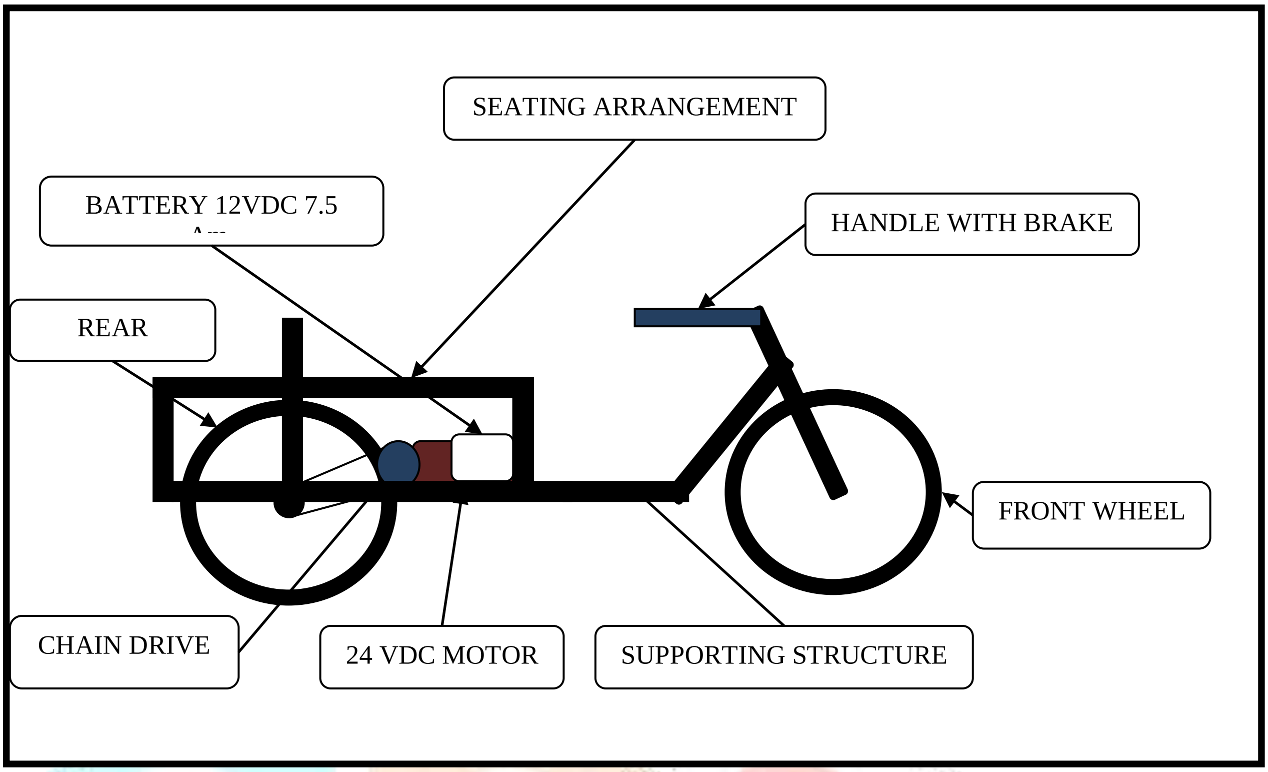
N. Sasikumar et al. [3], this paper discusses the increasing importance of solar energy in India as a clean and sustainable alternative to conventional power sources. It highlights the declining costs of solar energy, particularly Solar Thermal Electricity (STE) and Solar Photovoltaic Electricity (SPV), emphasizing their potential to mitigate environmental issues like global warming.

Md. FahimBhuiyan et al. [4], the authors focus on designing and developing a more efficient and lightweight BLDC motor controller for electric bikes/tricycles. The controller exhibits superior performance in power consumption and noise reduction compared to existing models, attributed to optimized component selection and high-frequency switching.

Yogesh Sunil Wamborikar et al. [5], this paper propose a solar-powered vehicle solution to address the depletion of nonrenewable energy sources. It outlines the basic principles of a solar car, utilizing energy stored in batteries charged by solar panels. The motor, powered by these batteries, drives the vehicle, with motor speed regulated by an electrical tapping rheostat to conserve energy.

Shuh Jing Ying, Stephen Sundarrao, et al. [6], introduce a hand tricycle originally designed for individuals with lower extremity weakness but possessing power in their hands and arms. This tricycle is adapted by incorporating an electric motor and battery to provide assistance. The fundamental functions of the original design remain unchanged. The battery, motor, speed reducer, and clutch are meticulously arranged, with an additional sprocket affixed to the drive wheel. The motor controller offers five speed settings, enabling forward and backward movement. The researchers retrieved a lightweight tricycle, weighing approximately thirty pounds, from storage, albeit non-operational. The wheel configuration includes one fixed-direction drive wheel at the front and two pivoting wheels for steering at the rear. Two handles beside the seat facilitate hand-controlled steering. Positioned in front of the driver is a large 25.4 cm diameter sprocket connected to two crank handles, allowing Shuh Jing Ying and Stephen Sundarrao, along with their co-authors, to power the vehicle with their hands.

5. Methodology



The design of the electric tricycle is adaptable to current hand-powered tricycles with minimal modification. It encompasses an electric motor, a drive system, a battery, an accelerator, a battery charger, and a power supply. A PMDC motor was chosen due to prohibitive fuel costs, rendering a combustion engine impractical. An intelligent battery charger handles battery charging. The first aspect addressed was the drive system, ensuring efficient power transmission from the motor to the front wheel. Secondly, a method of motor control was determined, incorporating speed and braking controls into a simple electrical accelerator. Thirdly, power is supplied to the motor via a battery pack. All components (motor, transmission, controls, and batteries) are designed for easy installation on existing hand-powered tricycles. The conversion to an Electric Tricycle is straightforward and reversible.

6. Design of Project

The ratings of the motor are calculated in a theoretical way, and based on its result, the ratings are determined. The weight of the tricycle is determined to be 33 kg, and the average weight of two people is taken as 100 kg, and the total mass is 133 kg. The top speed is considered 40km/hr, and the gradient is 70%.

$F_{(rolling)} = Cr \times Weight$

$= 0.004 \times 133\text{ kg} \quad [Cr = 0.004 \text{ Asphalt road}]$

$= 0.532N$

Calculate the force required to overcome air resistance:

$F_{(air)} = 0.7 \times 0.5 \times 1.225 \times 11.11\text{^}2 \times (\text{Frontal area}) \times Ca$

Coefficient of rolling resistance $(Cr) = 0.004$

Adjusting value (constant) $= 0.7$

Coefficient of air resistance $(Ca) = 0.88$

Width $= 32$ inches, Height $= 29$ inches

Frontal area $(A) = (\text{Width} \times \text{Height}) = (32 \times 29)$ square inches

Convert the frontal area from square inches to square meters:

Frontal area $(A) = (32 \times 29)/(1000 \times 1000)$ square meters

Frontal area $(A) = 0.000928$ square meters

$F_{(air)} = 0.7 \times 0.5 \times 1.225 \times 11.11\text{^}2 \times 0.000928 \times 0.88$

$F_{(air)} = 39.14N$

$F_{(total)} = F_{(rolling)} + F_{(air)}$

$F_{(total)} = 0.532N + 39.14N$

$F_{(total)} = 39.672N$

let's convert this force into power (wattage). Power (P) is defined as force (F) times velocity (v):

$P = F_{(total)} \times v$

$P = 40.54N \times 11.11m/s$

$P = 441.41\ W$

Calculation of Torque

$T = F \times r$

$T = 39.672 \times 20$

$T = 10.088\ Nm$

The minimum wattage of the motor required to carry a 133 kg load at 40 km/h velocity is approximately 441.58 watts. Therefore, we chose 650 Watt motor which available in the market.

Calculation of Range of Tricycle at full load:

To calculate the range of the tricycle for two 12V 7.5Ah batteries, we need to convert the battery capacity from ampere-hours (Ah) to watt-hours (Wh) because power consumption is typically measured in watts.

First, calculate the total battery capacity in watt-hours (Wh):

$\text{Battery capacity (Wh)} = 12\ V \times 7.5\ Ah \times 2 = 180\ Wh$

$\text{Battery capacity (Wh)} = 12V \times 7.5Ah \times 2 = 180Wh$

Now, use this to estimate the range:

$\text{Range} = 180\ Wh/441.41\ W$

$= 0.407\ \text{hours}$

Convert range from hours to kilometers:

$\text{Range in kilometers} = 0.407\text{hours} \times 40km/h$

$= 16.28km$

7. Electrical Components

1) D.C. Motor:

We're utilizing a 650W, 24V PMDC (brushed D.C. motor) with a speed of 480 rpm. This motor generates torque directly from the DC power supplied, employing internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

2) Motor Controller:

The motor drive circuit includes 20A short circuit protection. A 24V DC voltage is fed into the LM7812C voltage regulator IC, reducing it to 12V. This voltage is then applied to the input of the SG3526, a high-performance pulse width modulator IC. The PWM width, controlling the motor speed, is adjusted using a 10KΩ potentiometer. The output of the SG3526 is connected to a driver circuit comprising two MOSFETs, responsible for driving the motor.

3) Electrical Accelerator:

The accelerator employed is a potentiometer, varying the motor speed. Essentially, the PWM controller receives input when the accelerator is twisted, determining the amount of electricity to send to the motor. It converts DC from the battery to AC for the motor. Twisting the accelerator adjusts the electricity fed into the motor, affecting torque and speed.

4) Battery:

Lead-acid batteries with 24V and 7.2 amp-hour ratings are utilized. The battery selection depends on voltage, ampere, wattage rating, etc.

8. Advantages and Dis-Advantages

Advantages

1. Speed: Electric tricycles typically boast higher top speeds compared to standard tricycles with similar riders.
2. Environmental friendliness: By significantly reducing oil consumption and gasoline imports, widespread electric tricycle usage could have a profound positive impact on the environment. Electric power usage produces no pollution, making it eco-friendly and potentially reducing global warming, smog formation, and toxic pollution from conventional vehicles.
3. Lower greenhouse gas emissions: Electric tricycles contribute to relatively lower greenhouse gas emissions.
4. System efficiency: The overall system efficiency of electric tricycles, factoring in electric power production, transmission, distribution, local storage in batteries, and conversion to mechanical motion, is estimated to be approximately 50%. This stands in stark contrast to combustion engine vehicles, which typically range from only 15% to 25% efficiency.
5. Reduced energy consumption during idling: Unlike combustion engine vehicles, electric tricycles consume no energy during idling, saving power.
6. High torque: Electric motors in these vehicles can deliver exceptionally high torque over short periods, facilitating swift acceleration on highways.

Disadvantages:

1. Maintenance costs: Repairing or replacing components in electric tricycles can be expensive, leading to high maintenance costs.
2. Battery disposal: Proper disposal of failed batteries is essential to prevent environmental degradation.
3. High initial cost: The upfront cost of electric tricycles is typically higher compared to traditional tricycles.

9. Conclusion

The electric tricycle, successfully designed and developed, offers a solution to pollution. Our oil dependence poses environmental, security, and economic challenges. Oil vulnerability leads to price fluctuations and gas shocks, complicating foreign policy. Oil and petroleum products are major contributors to global warming pollution, surpassing coal. Transportation, heavily reliant on oil, accounts for over two-thirds of U.S. petroleum demand and is a significant source of air pollutants. Motor vehicles emit pollutants like carbon dioxide, exacerbating global climate change. The transportation sector is responsible for approximately 30% of all U.S. greenhouse gas emissions. Electric vehicles offer a solution, reducing pollution and providing an eco-friendly mode of transportation.

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