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CRAFTING AND EVALUATING AN ELECTRIC HYBRID VEHICLE'S DESIGN AND ANALYSIS

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Abstract - Electric hybrid scooters combine the flexibility of recharging from any external power source with the option to run on a petrol engine. These scooters utilize a rechargeable battery to store electricity, providing power to one or more electric motors for movement. Distinguished by their absence of a step-through frame, these scooters can accelerate using electricity from an external source, with a speed limit of 45 km/h. The battery stores electricity, and the vehicle is propelled by an electric hub motor. As pollution-free road transport, this project involves converting a petrol vehicle into a hybrid electric vehicle, emphasizing the reduction of battery charging time. The eco-friendly approach minimizes human effort. The project details the design and manufacturing processes involved in creating an electric scooter, adhering to the aesthetic principle of the golden section proportion. The final product, constructed using traditional modeling and engineering techniques, features outer housings made from carbon fiber.

Key Words: **Electric vehicle**, **Hub motor**, **Chain motor**, **Lithium-ion Battery**, **key result indicators**, **etc**

1.INTRODUCTION

The escalating concerns regarding global warming and urban air pollution have led to a concentrated effort in transport policy decision-making to develop environmentally friendly vehicles. Research has been directed towards addressing the significantly lower air quality in cities, directly linked to vehicle emissions, particularly from private cars. Episodes of haze in Southeast Asia in various years heightened environmental awareness. Urban transport policies aiming to reduce private car usage have increased the adoption of non-polluting vehicles like electric scooters. Despite the rising number of electric scooter users, challenges related to safety and comfort persist, hindering further adoption for meaningful environmental impact. Our study employs computer simulation to model the aerodynamic effects of existing safety and comfort features, presenting a new design that optimally integrates these elements. As fifth-year mechanical engineering students, we were tasked with developing a single-seated electric scooter, emphasizing the design, fabrication, and learning processes involved. This semester focuses on information gathering, concept generation, and initial drawing stages, paving the way for fabrication in the next semester. This hands-on process enables students to comprehend the intricacies of building a product from inception to completion, with each step serving as a self-learning opportunity. The design of the electric scooter involves three phases of the engineering design process: conceptual design, embodiment design, and detail design.

1.1 TYPES OF ELECTRIC VEHICLE BASED ON MOTOR

Electric scooters can be broadly categorized into two main types of motors: hub motor and chain motor systems. Hub motors are housed inside the hub of either the front or rear wheel, creating an all-wheel drive. They are commonly used in electric bikes as well. Unlike electric bikes, electric scooters use a throttle for speed control instead of pedals. The hub motor system in electric scooters is easy to install or remove from the scooter wheel, providing a balanced weight distribution, especially when the battery is mounted in the middle or back of the scooter. This design eliminates the need for a chain and offers versatility in scooter weight management.

The other type of electric scooter utilizes a chain motor, which is connected with a chain, sprocket, and gear to propel the scooter. Unlike the gearless hub motor, the chain motor employs gears, influencing the scooter's torque and speed. Typically, the chain motor is installed at the rear tire of the scooter, while the hub motor can be positioned at either the front or rear. Electric vehicles, including scooters, offer advantages such as cost savings, reduced pollution, and tax incentives. They ensure a safer driving experience with controlled speeds and lower tire wear, universally relying on Direct Current (DC) electric motors for propulsion. The critical force for setting the vehicle in motion and determining desirable characteristics is torque, a common requirement across these motors.

(a) Hub motor

(b) Chain motor

1.2. MORPHOLOGICAL CHART

The morphological chart, derived from functional decomposition, served as a design tool to address each design criterion. The selected choices in the design process, highlighted in the chart, were thoroughly evaluated for optimal performance and maximum adherence to requirements

Task	Soluti on				
Frame	Portable	Portable	Fixed	Semi portable	
Type of joint	Soldering	Welding	Mechanical fastener	Adhesive glue	Rivet
Type of seat	Double seat (fixed)	Single seat (fixed)	Bucket seat	Single seat (adjustable)	Small Cafe RacerSeat
Type of electric motor	**12V 350W Electrical Hub Motor**	**24V 250W** belt drive	**24V 250W** chain drive	**24V 400W** chain drive	

Task	Solution				
Socket plug/ cord (Battery charger)	Two pin plug	Three pin plug	Adapter	Adapter	USB
Power source	Gasoline Engine	Turbo Engine	Electric Motors	Stirling engines	Human powered
Mechanism	Gears	Belts	Chains	Linkages	Hybrids
Front light	Double round	Single round	Rectangular	Eclipse	
Type of battery (rechargeable)	Lead Acid	Lithium Ion (Li-ion)	Nickel cadmium (NiCd)	Lithium Ion Polymer	Lithium Ion
Type of spring/ absorber	Leaf Springs	Torsion bar	Coil spring	Shock Absober	front fork shock absorbe
Type of swing arm	Regular swingarm, twin shock	Regular swingarm, monoshock	Regular swing arm, mono-shock		

Task	Solution				
Type of Fork	Telescopic fork	trailing link fork	Earles fork	Girder fork	
Design of Girder forks	A	B	C	D	
Steering	All three fixed tires	Two front rotate Two rear fixed	One front rotate Two rear fixed	One front rotate One rear fixed	
Transmission of power to wheel	Direct transmission	Belting	Chain	Differential	Electric hub motor
Material selection for the main body frame (swing arm, body frame& fork)	Aluminium	Mild steel	Carbon Fiber	Composite material	

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2. DESIGN CALCULATION

Electric vehicles offer key advantages, including fuel cost savings, reduced pollution, and appealing tax incentives. They also ensure a safer driving experience with controlled speeds and minimized tire wear. Despite variations in speed, size, and operation methods among electric vehicles, they commonly utilize Direct Current (DC) electric motors for wheel propulsion. The critical factor unifying these motors is the requirement for torque, a force that initiates motion and determines essential characteristics.

Essentially, torque signifies the motor's turning power, playing a pivotal role in wheel propulsion. This paper introduces a torque calculation method tailored for electric vehicles. A. Factors Influencing Required Torque Several factors come into play when selecting a drive motor for an electric vehicle to determine the maximum torque required. These influencing factors include:

1. Rolling resistance
2. Gradient resistance
3. Acceleration force
4. Aerodynamic drag

Table -1: Component Specification

COMPONENT NAME	WEIGHT(KG)
Frame	15
Battery (4*11)	44
Motor	6
Auxiliary Components	5
Pinion (2*100)	200
Total	270

Rolling Resistance: Rolling Resistance is the force opposing a vehicle's motion, influenced by the interaction between wheels and the moving surface. Calculated as Fr (rolling) = m × a × Crr, it depends on tire material and surface roughness, resulting in 10.59 N in this case.

Drag Resistance: Drag Resistance, the air's opposing force on the bike, is determined by the formula $DR[N]=0.5\times Cd\times \zeta\times v^2 \times A$, resulting in 417.35 N. It becomes significant at speeds beyond a threshold.

Acceleration Force: Acceleration Force, influencing the vehicle's acceleration, is expressed as AF = [W ×v] ÷ t. For example, AF is calculated as 70.36 N for a specified velocity.

Gradient Resistance: Gradient Resistance is the gravitational force on an inclined surface, calculated as Fg[N] =m ×a ×Sin θ, where θ is the gradient angle. For a 0o gradient angle, Fg[N] is 0 N.

Torque: Torque, crucial for desired driving characteristics, is obtained as TTF [N] =RR [N] +DR [N] +GR [N] +AF [N], multiplied by the tire radius (R), resulting in 35.8 N-m.

Power Required: The motor's power requirement is expressed as P= 2πNT÷60, leading to a 10 KW requirement based on standard power ratings, considering gradient force. These results demonstrate the feasibility of determining motor torque for an electric vehicle with known parameters, allowing adjustments if the calculated torque exceeds motor specifications.

2.1 PLACEMENT OF MOTOR

The choice in Favor of the static motor was driven by several considerations. Unlike the mid-drive, it eliminates the need for a specialized frame design, providing flexibility for potential changes in motor suppliers in the future. Moreover, the static motor ensures an optimal riding experience without compromising the durability of drive train components, a concern with mid-drive motors. Additionally, the static motor offers a favorable weight balance, facilitating easy lifting and making it suitable for cross-country hill climbing, similar to the mid-drive configuration.

Benefits:

- Effortless removal of both the rear and front wheel due to the absence of extra cables.
- Optimal weight distribution, low and centralized, ensuring the best balance.
- Ideal for mountain bicycles, excelling in hill climbing capabilities.

Drawback:

- Potential wear on drive-train components, as power is transmitted through the drive-train.
- Requires a custom frame design and commits to a specific motor supplier from the outset, limiting flexibility for future changes.

Design of Drive-train:

1. Design calculation of chain sprocket diameter: n1=3000, n2=696.21, d1=50mm, therefore, d2=215.45 mm.
2. Length of chain: L=2C+π, c=420mm, L=1395mm.
3. Number of teeth: ratio=3000/696.21=3.8, z1=15, z2=52.
4. Pitch of sprocket/chain: a=420, standard pitch=12.7mm.
5. Power transmits capacity of chain: P=Pt+Pc+Ps, Pt=2.21m/s, Pt=904.97 N, Pc=91.31 N, Ps=448.5, total power=2311.64 N.

(a) Full kit of electric vehicle conversion

2.2 3D MODEL OF ELECTRIC HYBRID VEHICLE

(b) Frame design of electric hybrid scooter

(c) Connection design of electric hybrid scooter

3. CONCLUSIONS

This project focused on developing a hybrid scooter powered by both petrol and electricity, with a specific emphasis on Electric Bikes (e-bikes). E-bikes prove superior to traditional motorbikes, especially in urban areas, offering pollution reduction and cost-effective transportation. They provide convenient point-to-point travel and utilize Brushless DC (BLDC) motors for enhanced power efficiency.

To ensure optimal battery performance and lifespan, a Battery Management System (BMS) plays a crucial role. Monitoring the state of charge and state of health allows for efficient battery utilization. With the battery being the primary energy storage component in Electric Vehicles (EVs), a battery-assisted charging system prevents overcharging, ensuring battery health.

E-bikes serve as an affordable and accessible transportation mode for individuals of all ages, particularly for shorter distances. Their cost-effectiveness per kilometer, simplified design with fewer components, and ease of dismantling contribute to reduced maintenance requirements. A key highlight is their eco-friendly operation, as e-bikes eliminate reliance on fossil fuels, resulting in pollution-free and noiseless transportation. The overarching goal is to achieve a comfortable, compact, high-speed, and efficient electric two-wheeler.

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