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DEVELOPMENT AND INTEGRATION OF A WIND ENERGY HARVESTING SYSTEM FOR ENHANCED RANGE AND SUSTAINABILITY IN ELECTRIC CYCLES

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ABSTRACT

This paper presents the development and implementation of a wind energy harvesting system designed to be integrated into an electric cycle, with the goal of extending the cycle's operational range and reducing its dependency on external power sources. The system employs a small wind turbine mounted on the front wheel, which captures wind energy generated by the cycle's motion. As the cycle progresses, the wind turbine turns the kinetic energy of the wind into mechanical energy. This mechanical energy is transmitted via a shaft and chain mechanism to a generator mounted on the cycle. The generator then converts the mechanical energy into electrical energy. This electrical energy is subsequently stored in the cycle's battery, providing an auxiliary power source that supplements the primary battery charge. Key considerations in the design include optimizing the efficiency of the wind turbine and generator to maximize energy conversion, minimizing the impact on the cycle's weight and aerodynamics to preserve ride quality, and ensuring the durability and reliability of the system through robust engineering and regular maintenance. The proposed system aims to make electric cycles more sustainable by harnessing renewable wind energy, reducing the frequency of manual recharging, and enhancing overall efficiency. This innovative approach contributes to the development of cleaner, more efficient transportation solutions, promoting the adoption of environmentally friendly technologies in personal mobility.

Keywords: Electric Cycle, Wind Turbine, Generator System, Energy Storage.

I. INTRODUCTION

The growing global need for sustainable mobility has resulted in the growing popularity of electric cycles (e-cycles) as an ecologically friendly alternative to traditional motor vehicles. While e-cycles minimize carbon emissions, they still require frequent recharging from external power sources, limiting their range and usability. This aims to address this issue by creating and implementing a wind energy collecting system onto e-cycles, therefore expanding their range and increasing overall energy efficiency. The setup includes a tiny wind turbine fitted on the front wheel of the e-cycle. As the cycle progresses, the turbine gathers wind energy and transforms it to mechanical energy via a shaft and chain system.

This mechanical energy is then converted into electrical energy via a generator, which is stored in the cycle's battery to provide an additional power source. By harnessing wind energy while the cycle is in motion, the system seeks to reduce dependence on manual recharging, making the e-cycle more self-sufficient and eco-friendlier. Key design factors include maximizing the efficiency of both the wind turbine and generator, minimizing the system's effect on the cycle's weight and aerodynamics, and ensuring durability and reliability through sound engineering. Ultimately, this paper aims to encourage the use of renewable energy in personal transport, fostering more sustainable and efficient urban mobility solutions.

II. LITERATURE REVIEW

Wind energy harvesting, which was formerly employed in fixed applications such as wind turbines, is gaining popularity in mobile and small-scale devices. Wind energy is a significant renewable resource, and micro wind turbines have been studied for a wide range of applications, including powering portable devices and low-power applications. The use of tiny wind turbines in off-grid energy generation, concluding that the challenge is to maximize turbine performance for changing wind speeds while minimizing drag in mobile scenarios. Wind turbines have been proposed for trucks and other vehicles to capture the wind generated by their movement. These systems, however, confront considerable difficulties in balancing energy production with the additional drag and weight they generate. Nonetheless, innovations in turbine design and lightweight materials provide hope for increasing the efficiency of wind energy harvesting in motion. The use of wind energy gathering in electric cycles involves issues as compared to bigger vehicles. The aerodynamic drag created by installing wind turbines, the effectiveness of energy conversion at low wind speeds (typical of cycles), and the integration of gathered energy into the existing power grid are all significant challenges. There is a need for novel turbine designs that reduce drag and increase energy capture in low-speed settings like those faced by bicycles.

III. OBJECTIVE AND SCOPE

The primary objective of this paper is to develop and integrate a wind energy harvesting system that can be installed on an electric cycle to extend its range and improve its overall energy efficiency. The system will employ a small wind turbine mounted on the cycle's front wheel, capturing wind energy generated by the motion of the cycle. This wind energy will then be converted into mechanical energy via a shaft and chain mechanism connected to a generator. The generator will convert the mechanical energy into electrical energy, which will be stored in the cycle's battery. The paper focuses on designing and optimizing the wind turbine and generator to maximize the conversion of wind energy into usable electrical power while ensuring that the system does not significantly affect the cycle's weight, aerodynamics, or ride quality. Furthermore, the system will be engineered for durability and reliability, ensuring that it can withstand various environmental conditions and operational stresses without requiring extensive maintenance. This paper seeks to provide a solution that can be easily integrated into existing electric cycle designs or incorporated into future models to improve the sustainability and practicality of electric personal transportation.

IV. METHODOLOGY

The block diagram represents a system designed to power a bicycle with multiple energy sources, including pedalling, a battery, and a wind energy. Fig 1. Shows the Block Diagram to design self-powered electric bicycle.

1. **Pedal -** Provides manual power to the **Back Wheel**, aiding in propelling the bicycle.
2. **Battery -** Supplies energy to the **Motor** through a **Controller**, which regulates power to maintain efficient operation.
3. **Controller -** Controls the power flow from the battery to the motor and the other auxiliary equipment's like Throttle, Break Lever, ABS material Switch Set, Head Light by optimizing their performance.
4. **Motor -** Uses power from the battery (via the controller) to assist in driving the **Back Wheel**, contributing to the overall speed of the cycle.
5. **DC-DC Converter -** Connects to the battery and can help to regulate or step up the voltage to suit the voltage of the battery
6. **Generator -** Connected to the battery to recharge it, possibly using wind energy.
7. **Wind Turbines -** Positioned to capture wind energy generated by moving the **Cycle**. This energy is directed by the generator through the **DC-DC Boost Converter**, potentially supplementing power to the battery.

The technology works by combining different energy sources to improve bicycle propulsion. The rider's pedalling generates mechanical force to rotate the back wheel, which contributes to the bicycle's mobility. Simultaneously, the battery powers the motor, which also drives the back wheel. As the bicycle rides forward, wind rushes toward the front wheel, where it is caught by wind turbines. These turbines turn wind energy into mechanical energy, which is subsequently converted by the generator into electrical energy. This electricity can replenish the battery, resulting in a feedback loop that provides power to the motor. Fig 2. Represents the design of self-powered electric bicycle. The combination of pedaling, motor assistance, and wind energy utilization enhances the bicycle's speed and efficiency, making it a sustainable transportation solution.

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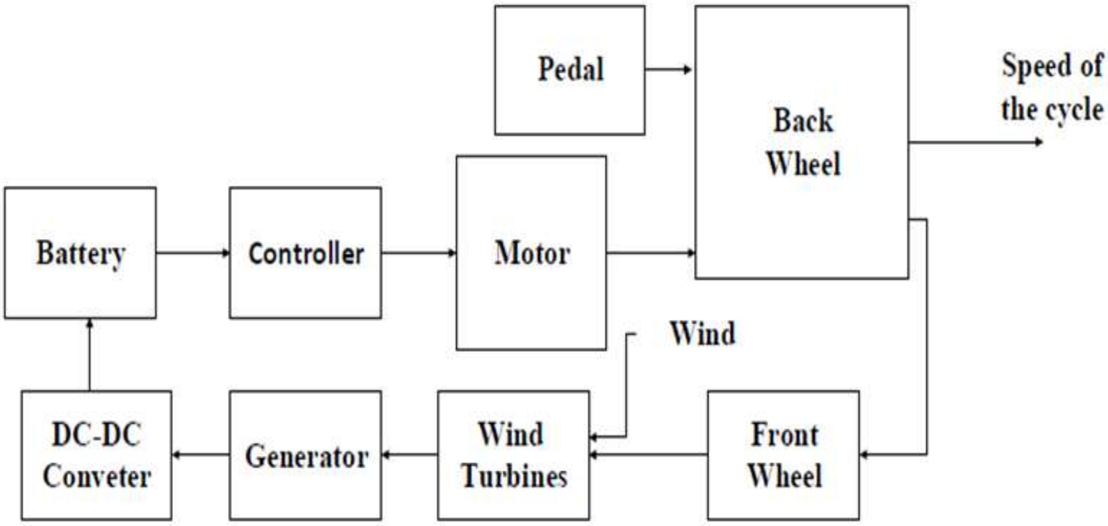

Fig 1: Block Diagram

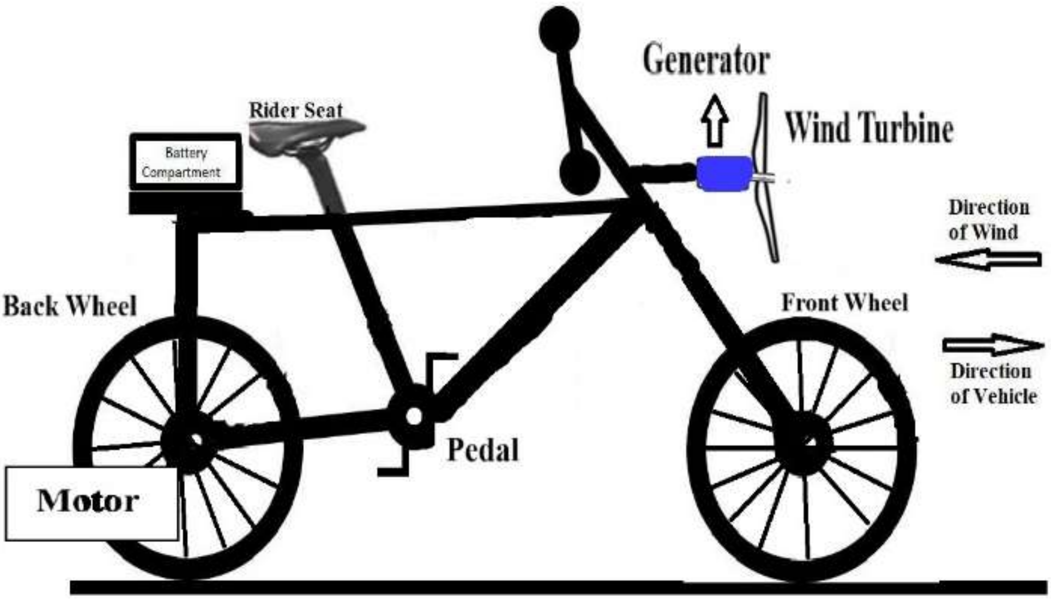

Fig 2: Design of Self Powered Electric Bicycle

V. MATHEMETICAL CALCULATION TO FIND THE RATING OF MOTOR AND BATTERY

5.1 Mass Range Calculation

Person Weight = 80kg

Controller = 4kg

Cycle weight = 10kg

Total = 100kg

5.2. Motor Load Calculation

F_{wf} = Windage & Friction Drag

F_d = Down force from Gravity

F_r= Rolling Resistance Force

F_p = Propulsion Force

Consider the Grad @ 3.14%

α = tan-1(slope)

= tan-1(3.14/100)

= tan-1(0.0314)

= 1.8 degree

To Finding F_d (Gradient Resistance)

F_d = m×sinα

= 100 × 9.81 × sin 1.8

= 30.81 N

To Find F_{wf} (Aero Resistance)

Cd = Aerodynamic Area Co-efficient = 0.74

ρ = Density = 1.225kg/m3

A = Frontal Area of Bicycle = 0.37 m3

V = Velocity of Bicycle = 20 km/h=5.5m/s

F_{wf} = ½ × Cd × ρ × A × V^2

= ½ × 0.74 × 1.225 × 0.37 × (5.5)2

= 5.07N

To Find F_r (Rolling Resistance)

C_R = Rolling Co-efficient = 0.0041(for cycle)

F_r = C_R × mg cosα

= 0.0041×160×9.81×cos1.8

= 4.02 N

Total Propulsion Force, F_p

Fp = F_d + F_{WF} + F_R

= 30.81+5.07+4.02

= 39.9 N

Propulsion Power = FP × Velocity

= 39.9 N × 5.5 m/s

= 219.45 W

Thus, The Motor is to be 250 W

Table 1: Ratings of motor and battery for different speeds.

	20 kmph			25kmph			30kmph		
F_d	30.81 N			30.81 N			30.81 N		
F_{wf}	5.07 N			8.08 N			11.64 N		
F_R	4.02 N			4.02 N			4.02 N		
F_p	39.9 N			42.91 N			46.47 N		
P_p	221.66 W			297.98 W			387.25 W		
w	250 W			350 W			400 W		
E	250 Wh			350 Wh			400 Wh		
V	24	36	48	24	36	48	24	36	48
A	10.4	6.94	5.20	14.5	9.7	7.2	16.6	11.1	8.3
Ah	12	8	7	16	11	9	18	13	10

5.3. Battery Pack Calculation

Battery rating is a crucial specification that defines the performance and capability of the battery used in electric vehicles (EVs). It encompasses several key parameters that indicate how the battery functions and its

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capacity. The battery rating depends on the desired range and power output. Table 1 represents the different ratings of motor and battery to be taken for different speeds.

Energy Consumption (E)=$P_{total} \times t$

P_{total} = Total power required in watts

t = Time for which the vehicle runs

E= $P_{total} \times t$

=250×1

= 250 Wh

Assuming a 24v battery,

Current drawn by a motor(I) = P_{total} / V

=250/24=10.4 A

Battery Capacity in Ah = E/V=250/24=10.4 Ah

For a range of 20 km at 20 kmph (~1 hour of operation), A 24V, 10.4 Ah to 15Ah battery would be typical, considering efficiency losses

VI. RESULTS AND DISCUSSIONS

Fig 3: Electric Cycle

Fig 4: PMDC Motor to drive the Cycle

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Fig 5: Wind Harvesting System

Fig 6: Integration of wind Harvesting System to Electric Cycle

The wind turbine is started rotating at about 10 kmph speed of the cycle. The maximum output voltage of the generator is 2v at a maximum speed of 20 kmph.

VII. CONCLUSION

In conclusion, successfully designed and integrated a wind energy harvesting system for electric cycles, aimed at extending range and enhancing sustainability. Our results demonstrated that the system could capture a portion of the energy from oncoming wind, converting it into electrical power to supplement the battery. This integration resulted in a modest but measurable extension of the cycle's range, providing an innovative way to increase energy efficiency for electric cycles. While the challenges of aerodynamics and efficiency constraints were addressed to some extent, future work could focus on refining turbine design, materials, and energy storage for even greater gains. Overall, this wind energy harvesting approach offers a promising pathway for more sustainable and self-sufficient electric transportation, contributing to the goal of reducing dependency on non-renewable energy sources and fostering greener mobility solutions.

VIII. REFERENCES

[1] Das HS, Rahman MM, Li S, Tan CW. “Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review.” Renewable and Sustainable Energy Reviews. 2020 Mar 1; 120:109618.

[2] Mastoi, Muhammad Shahid, Shenxian Zhuang, Hafiz Mudassir Munir, Malik Haris, Mannan Hassan, Muhammad Usman, Syed Sabir Hussain Bukhari, and Jong-Suk Ro. "An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends." Energy Reports 8 (2022): 11504-11529.

[3] Pareek, Surbhi, A. Sujil, Saurabh Ratra, and Rajesh Kumar. "Electric vehicle charging station challenges and opportunities: A future perspective." In 2020 International Conference on Emerging Trends in Communication, Control and Computing (ICONC3), pp. 1-6. IEEE, 2020.

[4] Rajendran, Gowthamraj, Chockalingam Aravind Vaithilingam, Norhisam Misron, Kanendra Naidu, and Md Rishad Ahmed. "A comprehensive review on system architecture and international standards for electric vehicle charging stations." Journal of Energy Storage 42 (2021): 103099.

[5] Singh, Praveen Prakash, Fushuan Wen, Ivo Palu, Sulabh Sachan, and Sanchari Deb. "Electric vehicles charging infrastructure demand and deployment: challenges and solutions." Energies 16, no.1 (2022): 7.

[6] Funke, Simon Árpád, Frances Sprei, Till Gnann, and Patrick Plötz. "How much charging infrastructure do electric vehicles need? A review of the evidence and international comparison." Transportation research part D: transport and environment 77 (2019): 224-242

[7] Ahmad, Fareed, Atif Iqbal, Imtiaz Ashraf, and Mousa Marzband. "Optimal location of electric vehicle charging station and its impact on distribution network: A review." Energy Reports 8 (2022): 2314-2333.

[8] Micari, Salvatore, Antonio Polimeni, Giuseppe Napoli, Laura Andaloro, and Vincenzo Antonucci. "Electric vehicle charging infrastructure planning in a road network." Renewable and Sustainable Energy Reviews 80 (2017): 98-108.

[9] Raphaela Paganya,b , Luis Ramirez Camargoa,c and Wolfgang Dornera. “A review of spatial localization methodologies for the electric vehicle charging infrastructure” International Journal of Sustainable Transportation 2019, vol. 13, no. 6, 433–449.

[10] Al-Hanahi, Bassam, Iftekhar Ahmad, Daryoush Habibi, and Mohammad AS Masoum. "Charging infrastructure for commercial electric vehicles: Challenges and future works." IEEE Access 9 (2021): 121476-121492.