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Development of Smart Self-Energizing Electric Vehicle for Sustainable Mobility

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Abstract: The rapid growth of electric vehicles (EVs) has created a need for more efficient and sustainable energy management systems. One of the major challenges faced by conventional EVs is their dependence on external charging infrastructure, which can lead to range limitations and increased downtime. This project presents the design and development of a Smart Self-Energizing Electric Vehicle that enhances energy efficiency by converting kinetic energy into electrical energy during vehicle motion. The system utilizes a flywheel-based mechanism connected to a DC generator to capture rotational energy from the wheels and generate power. This generated energy is regulated using a DC-DC boost converter to maintain a stable output voltage and is then stored in lithium-ion batteries. An Arduino-based control unit, integrated with voltage and current sensors, continuously monitors system performance and battery status. Real-time data is displayed on an LCD screen for user awareness. Additionally, the system supports both DC and AC loads through an inverter module and allows conventional charging. This approach improves energy utilization, reduces range anxiety, and contributes to environmentally sustainable transportation solutions.
Keywords: Self-Energizing Electric Vehicle, Flywheel Energy Recovery, DC Generator, Boost Converter, Sustainable Mobility etc.

I. INTRODUCTION

The increasing concerns over environmental pollution, depletion of fossil fuels, and the rising cost of conventional energy sources have led to a global shift toward sustainable and eco-friendly transportation systems. Electric vehicles (EVs) have emerged as a promising alternative to internal combustion engine (ICE) vehicles due to their zero tailpipe emissions, higher efficiency, and reduced environmental impact. Governments and industries worldwide are actively promoting the adoption of EVs to achieve carbon neutrality and reduce dependence on non-renewable energy resources. However, despite their numerous advantages, EVs still face certain limitations, particularly related to battery capacity, charging infrastructure, and range anxiety.

One of the major challenges in the widespread adoption of EVs is their reliance on external charging stations. Frequent charging requirements, long charging times, and the limited availability of charging infrastructure in certain regions make EV usage less convenient for users. This creates a need for innovative solutions that can enhance the energy efficiency of EVs and reduce their dependency on external power sources. In this context, the concept of energy recovery and self-charging systems has gained significant attention among researchers and engineers.

The Smart Self-Energizing Electric Vehicle proposed in this project aims to address these challenges by integrating a mechanism that can generate electrical energy from the vehicle's own motion. The system is based on the principle of energy conversion, where kinetic energy produced during vehicle movement is captured and converted into usable electrical energy. A flywheel mechanism is employed to store rotational energy, which is then used to drive a DC generator. This generator converts mechanical energy into electrical power, which can be utilized to recharge the vehicle's battery.

To ensure efficient energy management, the generated electrical power is passed through a DC-DC boost converter, which regulates and maintains a stable voltage level suitable for battery charging. The energy is stored in lithium-ion battery cells, which are widely used in EV applications due to their high energy density, long cycle life, and reliability. An Arduino-based control system is integrated into the vehicle to monitor key electrical parameters such as voltage, current, and battery status. Sensors continuously collect real-time data, which is displayed on an LCD screen, providing users with important information about the system's performance.

In addition to self-charging capability, the system also supports conventional external charging, ensuring flexibility and reliability in different operating conditions.

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The stored electrical energy can be used to power DC loads directly, and with the help of an inverter module, it can also be converted into AC power for external applications. This dual functionality enhances the practicality and usability of the system.

Overall, the proposed Smart Self-Energizing Electric Vehicle represents an innovative step toward improving energy efficiency and sustainability in transportation. By utilizing regenerative concepts and intelligent monitoring systems, the project contributes to reducing energy wastage, minimizing dependence on charging infrastructure, and promoting the development of greener mobility solutions for the future.

II. PROBLEM IDENTIFICATION

- Conventional electric vehicles rely heavily on external charging infrastructure, which may not always be easily available in many areas.
- Frequent charging requirements increase dependency on charging stations and reduce overall convenience for EV users.
- Limited driving range of electric vehicles leads to range anxiety among users, restricting long-distance travel.
- A large amount of kinetic energy produced during vehicle motion is wasted and not effectively utilized for power generation.
- Existing regenerative braking systems recover energy only during braking, leaving unused energy during normal vehicle movement.
- Inefficient energy utilization reduces the overall efficiency and performance of electric vehicle systems.
- Lack of integrated mechanisms for continuous onboard energy generation limits the potential for self-sustaining EV operation.
- Absence of real-time monitoring and smart control systems reduces system transparency and energy management efficiency in small-scale EV prototypes.

A. Drawbacks

- Heavy dependence on external charging stations increases charging time and reduces convenience.
- Limited driving range of EVs leads to range anxiety among users.
- Regenerative braking captures only a small portion of available kinetic energy.
- A large amount of energy produced during vehicle motion is wasted.
- Absence of continuous energy harvesting systems lowers overall efficiency.
- Poor energy management may affect battery life and performance.
- Lack of real-time monitoring systems reduces user awareness of power generation and usage.

B. Existing system

- The existing safety systems in electric vehicles (EVs) Conventional electric vehicles rely mainly on external charging stations to recharge their batteries.
- Energy is supplied only from stored battery power, which limits the vehicle’s driving range.
- Regenerative braking systems are used in some EVs to recover energy during braking.
- However, energy recovery occurs only during deceleration and not during normal vehicle motion.
- Limited charging infrastructure in many regions causes inconvenience to EV users.
- Lack of additional onboard energy generation systems reduces overall vehicle efficiency.

III. METHODOLOGY

A. Proposed System

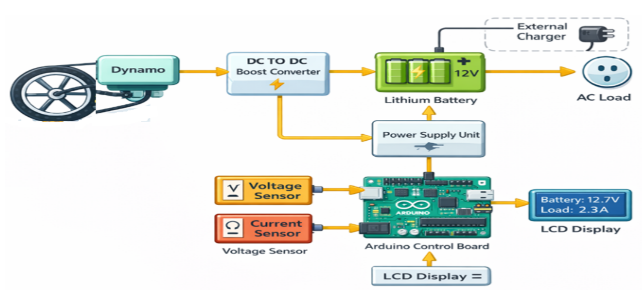

Figure 1. Proposed System

Working Principle:

- When the electric vehicle moves, the rotation of the rear wheel generates mechanical kinetic energy.
- The rotating wheel is connected to a flywheel mechanism through a belt drive system.
- As the wheel rotates, the belt transfers motion to the flywheel, allowing it to store rotational energy.
- The flywheel is mechanically coupled to a DC generator (dynamo).
- The rotation of the flywheel drives the DC generator, converting mechanical energy into electrical energy.
- The generated electrical power is initially low and may vary depending on wheel speed.
- Therefore, the generated voltage is passed through a DC–DC boost converter.
- The boost converter increases and stabilizes the voltage to a suitable level for battery charging.
- The regulated electrical energy is stored in a 12V lithium battery for later use.
- A power supply unit distributes power to different electronic components of the system.
- Voltage and current sensors continuously monitor battery voltage and charging current.
- The Arduino controller processes the sensor data and manages system monitoring.
- Real-time information such as voltage, current, and battery status is displayed on an LCD screen.
- The stored DC power can supply DC loads directly.
- An inverter module converts DC power into AC power for external AC loads.

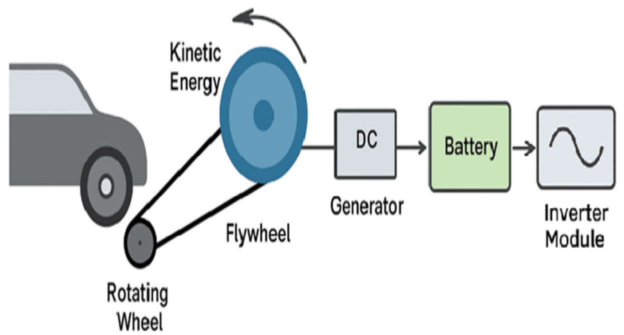

Figure 2. Functional Diagram

A. Hardware Used

- Flywheel Assembly: Stores rotational kinetic energy generated from the wheel motion and helps maintain continuous rotation for power generation.
- DC Generator (Dynamo): Converts mechanical energy from the rotating flywheel into electrical energy in the form of DC voltage.
- DC-DC Boost Converter: Increases the low voltage produced by the generator to a suitable level required for battery charging.
- Lithium Battery (12V, 2Ah): Stores the generated electrical energy and supplies power to different loads and system components.
- Arduino Controller: Acts as the main control unit for monitoring voltage, current, and system status.
- Voltage Sensor: Measures battery voltage and sends the data to the Arduino controller.
- Current Sensor: Monitors the charging and load current in the system.
- LCD Display: Displays real-time system parameters such as voltage, current, and battery status.
- Inverter Module: Converts stored DC power into AC power for AC loads.

B. Software Used

- Arduino IDE: Used to write, compile, and upload programs to the Arduino microcontroller for system control and monitoring.
- Embedded C Programming: The Arduino is programmed using Embedded C language to process sensor inputs and control system functions.
- Serial Communication: Used for communication between Arduino and connected modules such as sensors and LCD display.
- Sensor Data Processing: Software algorithms read voltage and current sensor signals and convert them into digital values.

- Display Programming: The Arduino program updates real-time system information on the LCD display.
- Power Monitoring Logic: The software continuously monitors battery charging conditions and system performance.
- Debugging and Testing Tools: Arduino IDE serial monitor is used to test sensor outputs and verify correct system operation.
- Control Algorithms: Basic control logic ensures accurate monitoring and efficient energy management in the system.

IV. RESULTS AND DISCUSSION

The proposed self-energizing electric vehicle system was tested to evaluate its capability to generate electrical energy from wheel rotation. The experimental setup consisted of an electric vehicle wheel connected to a DC generator (dynamo), a DC boost converter, a 12V battery for storage, and an Arduino-based monitoring system with voltage and current sensors. The generated electrical energy was used to power a load such as an LED, while the Arduino processed and displayed real-time voltage and current values on the LCD display.

During the testing phase, the wheel was rotated at different speeds to observe the corresponding electrical output from the dynamo. As the rotational speed of the wheel increased, the mechanical energy supplied to the generator also increased. This resulted in a higher electrical output voltage and current. The boost converter played a crucial role in stabilizing and regulating the generated voltage before storing it in the battery. This ensured that the energy produced from irregular wheel speeds could still be stored efficiently.

The results indicated that the system was capable of generating usable electrical energy from rotational motion. At low speeds, the generated voltage and current were relatively small, but as the speed increased, the power output improved significantly. This confirms that the system effectively converts rotational energy into electrical energy. The stored energy can then be used for low-power applications such as lighting systems, sensors, or auxiliary vehicle electronics.

Another important observation was the stability of the monitoring system. The voltage sensor and current sensor successfully transmitted real-time data to the Arduino controller. The LCD display continuously showed the voltage and current values, allowing users to monitor the charging condition of the battery. This real-time monitoring improves system reliability and helps prevent overcharging or excessive discharge of the battery.

The experiment also showed that the energy generation process is fully automatic. Once the wheel rotates, the dynamo immediately starts producing electrical energy without requiring any manual operation. This feature makes the system suitable for electric vehicles where additional energy can be recovered during motion. Although the generated power is relatively small compared to the main battery capacity, it can still contribute to auxiliary loads and improve overall energy efficiency.

Table 1: Sensor Reading vs. System Response

Wheel Speed (RPM)	Voltage (V)	Current (A)	Power (W)
20	1.8	0.12	0.216
40	3.2	0.18	0.576
60	5.0	0.26	1.30
80	7.4	0.34	2.52
100	9.8	0.42	4.12
120	11.6	0.48	5.57

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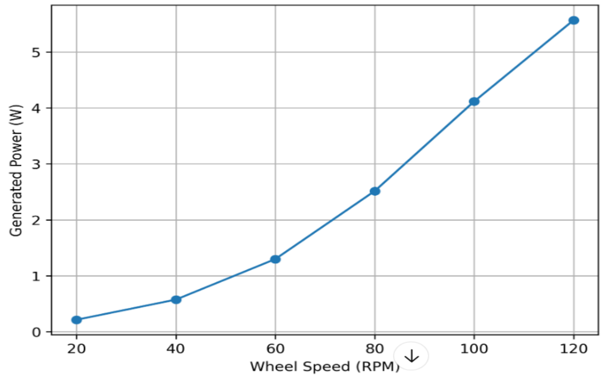

Figure 3. Power generated vs wheel speed

This graph clearly demonstrates that higher rotational speeds produce higher electrical power, validating the effectiveness of the proposed energy generation system.

However, some limitations were observed during the experiment. At very low speeds, the generated voltage was insufficient to charge the battery effectively. This means the system performs best when the vehicle is moving at moderate or high speeds. Additionally, mechanical losses due to friction between components slightly reduce the overall efficiency. Future improvements could include using high-efficiency generators, better gearing mechanisms, and optimized boost converters to increase the energy output.

Overall, the results demonstrate that the proposed system successfully converts wheel rotational energy into electrical energy and stores it in a battery while providing real-time monitoring. The concept proves to be a promising approach for improving energy utilization in electric vehicles and reducing dependency on external charging sources.

V. ADVANTAGES

- Utilizes otherwise wasted kinetic energy generated during vehicle motion.
- Improves overall energy efficiency of the electric vehicle system.
- Reduces dependency on external charging stations.
- Provides real-time monitoring of voltage, current, and battery status.
- Supports both DC and AC loads through inverter integration.
- Promotes sustainable and eco-friendly transportation technology.

VI. APPLICATION

- Used in prototype electric vehicles for energy recovery demonstrations.
- Suitable for research on flywheel-based energy harvesting systems.
- Can be applied in hybrid electric vehicle energy management systems.
- Useful in educational laboratories for studying EV technologies.
- Can power small onboard electronic devices in vehicles.
- Supports development of sustainable and smart transportation systems.

VII. CONCLUSION

The proposed system demonstrates an effective method for generating electrical energy from the rotational motion of an electric vehicle wheel. The main objective of the project was to develop an automatic power generation system that can produce and store energy without relying on external power sources.

The experimental results confirm that rotational energy from the wheel can be successfully converted into electrical energy using a DC generator. The generated power is regulated through a DC boost converter and stored in a 12V battery for future use.

The integration of sensors and a microcontroller improves the efficiency and monitoring capability of the system. The voltage and current sensors continuously measure the electrical parameters of the battery, and the Arduino controller processes this information and displays it on the LCD screen. This allows real-time monitoring of the energy generation and storage process.

The system operates automatically as soon as the wheel starts rotating, which makes it suitable for electric vehicles and other rotating machinery. Although the generated power is relatively small, it can be used for low-power applications such as lighting and monitoring systems. Overall, the proposed system contributes toward improving energy efficiency and promoting sustainable power generation technologies.

REFERENCES

[1] Y. Zhang, H. Li, and X. Chen, "Flywheel energy storage systems for electric vehicles," Renewable and Sustainable Energy Reviews, vol. 135, pp. 110–118, 2022.
[2] A. Kumar, P. Singh, and R. Verma, "Energy recovery techniques in electric vehicles," IEEE Transactions on Transportation Electrification, vol. 7, no. 3, pp. 1452–1460, 2021.
[3] J. Li, T. Wang, and L. Zhao, "Design and analysis of DC–DC boost converters for electric vehicle applications," IEEE Access, vol. 8, pp. 203456–203468, 2020.
[4] R. Sharma, S. Gupta, and V. Mehta, "Smart monitoring systems for electric vehicles using IoT and Arduino," International Journal of Intelligent Transportation Systems Research, vol. 21, no. 2, pp. 145–153, 2023.
[5] D. Patel, M. Shah, and K. Joshi, "Kinetic energy recovery systems in electric vehicles," Journal of Cleaner Production, vol. 314, pp. 127–135, 2022.
[6] H. Wang, Q. Liu, and D. Chen, "Hybrid energy storage systems for electric vehicles," Applied Energy, vol. 292, pp. 116–124, 2021.
[7] N. Singh, P. Sharma, and R. Yadav, "Renewable energy integration in electric vehicle systems," Energy Reports, vol. 6, pp. 1023–1032, 2020.
[8] T. Brown, J. Smith, and K. Wilson, "Advances in electric vehicle energy management systems," Energy Conversion and Management, vol. 268, pp. 115–123, 2023.
[9] A. Gupta, R. Jain, and S. Bansal, "Design of smart electric vehicle charging and monitoring systems," International Journal of Energy Research, vol. 45, no. 9, pp. 13421–13430, 2021.
[10] S. Lee, J. Park, and H. Kim, "Mechanical energy harvesting in electric transportation systems," Sustainable Energy Technologies and Assessments, vol. 52, pp. 102–110, 2022
[11] A. Kumar, "Regenerative Braking Systems in Electric Vehicles: A Review," International Journal of Automotive Technology, vol. 23, no. 2, pp. 150–159, 2022.
[12] X. Li and Y. Chen, "Energy Harvesting Mechanisms for Electric Vehicles," Renewable and Sustainable Energy Reviews, vol. 145, p. 111081, 2021.
[13] P. Singh and S. Verma, "Design of Gear-Based Kinetic Energy Recovery System for EVs," Journal of Mechanical Engineering Research, vol. 12, no. 4, pp. 55–62, 2023.
[14] J. Wang and M. Zhang, "Smart Battery Management for Hybrid Electric Vehicles," IEEE Access, vol. 10, pp. 45678–45685, 2022.
[15] D. Patel and K. Joshi, "Integration of Boost Converters in EV Power Systems," Journal of Power Electronics and Drives, vol. 8, no. 1, pp. 22–29, 2023.