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Development of Sustainable Energy Generation from Train Wheels

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Abstract-
Energy is essential for the economic development of our country. Energy exists in various forms in nature but the most important form of energy is electricity. Today's society is so dependent on the use of electricity that it has become a part of our lives. In this project, electrical power is generated by running the train on the railway track. Drive mechanism such as the wheel is rotated on the track; it will generate the electrical power from the power generating wheel. The principle of conversion of the rotational energy into electrical energy is used for generation of Electrical energy. The control mechanism carries the D.C generator, battery, Arduino Controller ,LCD Display and inverter Module. So, this technique is implemented to railways where the power generation is very high. Our project focuses on generating electricity in a new and simple way. In this project electrical power is generated by forward motion of train, here rotating energy is converted into electrical energy.

Key Words: Energy Harvesting, Non-conventional Method, Train wheels , Arduino etc.

1. Introduction

In order to generate more electricity we need to develop new strategies for producing electricity more efficiently and economically. This project introduces a way to generate electricity by train.

Normally, (Indian railway line) when entering a train station, train speed (regardless of type of service) is limited to FOUL MARK. (It is a point, located 1200 meters from the station - Indian railway rules). The train will therefore only travel during its inertia period. Power stored on the train cannot be fully recovered by re-braking. So converting it into wasting energy will be a tab.

While undergoing survey on Indian railways the outcome of survey was “Indian railways” are called as lifeline of our country in which around 2.3 crore of passengers travels daily. We have seen that Indian railways. We have also seen that Indian railways is also improving their services, official website, modification in coaches, gaining in speed and other several criteria with their hundred percent effort day by day. We came to the research that there are several villages facing lack of electricity even though railway tracks passes through them. So by knowing such condition, we decide to build a type project which will provide electricity by use of those railway tracks with less cost which is named as “free energy from railway track”.

These projects include simple gear and pulley mechanism so there is no kind of complexity in it and once it’s been installed it may long till many years but it will require slight maintenance.

Main reason beside this project was to provide such electricity facilities to those argotic people which will help them to run all the agricultural equipment’s due to which net income of the farmer will increase. Besides agricultural purpose, such electricity generated can also be used of several purposes.

In this process we also applied this basic principle of generating electricity. To convert the kinetic energy produced by the train's progress into electrical energy, the only difference being that we use the engine to convert kinetic energy into electrical energy.

In simple terms the rotating power generated by the front of a train engine is converted into electrical energy with the help of an engine. Today there is a need for a unique power system in our nation. The power available on the railway is one of the most common sources of energy production as there is no need for fuel as input to generate electricity and this is done using a gear drive. Dynamo takes the power to install a clay shaft that is capable of generating rotating power through the train's proportions and converting it into electricity.

2. Field of Invention

For the development of our country the availability of energy in vast range is very important. Energy is present in many form like heat, wind & more on. The most important form of energy is electrical energy because our modern society is so much depends upon the use of electrical energy. Due to this production of electricity in large scale is become necessity. For the large production of electricity we need to developed new techniques by which we produce electricity efficiently and economically. This paper introduced a new technique of production of electricity by train. This paper aims at production of electricity by using the concept of the rotation of motor due to the forward motion of train. In simple word we convert rotating energy which is produce by the forward motion of train engine into the electrical energy with the help of motor.

3. Need of System

In the working period of train most of energy is wasted which is form by motion of train. The interesting fact about India railway is there is a point away from the station which know foul mark, which is situated 1200 m away from the station. From this point rail engine driver cut off the speed of the train (which is also depend on the type of train) to stop a train exactly on the station. So train only move by it's inertia from the foul mark to station. So we can think how many

amount of power is generated by moving train, which is we are not used. The main aim of this invention is to convert this waste energy into the electrical energy. This converted electrical energy is used for other application. If we are able to produced energy which is equal to the energy used by railway engine then efficiency of this invention is 100%. But this is ideal condition, we produced energy which is near to this ideal condition. We convert this wasteful energy into rotating energy and then electrical energy with the help of motors.

4. Literature Review

• P Purna Prasad et al. 2017, Their availability is also limited. Therefore, we need to find other sources that can meet the growing need for solar, wind, geothermal, tidal, and nuclear. Energy is essential for the economic development of our country. Energy exists in various forms in nature but the most important form of energy is electricity. Today's society is so dependent on the use of electricity that it has become a part of our lives. Energy is needed such as heat, light, dynamic etc. Modern advances in science and technology have made it possible for us to turn electricity into whatever form of demand. This has given electricity a place of pride in today's world. We cannot imagine a world without electricity. The survival of the industrial sector and our social structures depends largely on low costs and uninterrupted supply of electricity. Our paper focuses on generating electricity in a fictional and simple way.

• Saurabh D. Bhusate et al. 2017, In this paper, we are generating energy through a power harvesting system that operates only on the railway line for electricity applications. Today there is a need for a unique power system in our nation. The power available on the railway is one of the most common sources of energy production as there is no need for fuel as an input to generate electricity and this is done using an easy-to-use gear system. These systems carry flap, rack and pinion, gears, freewheel, flywheel, DC generator, battery. The main focus of this arrangement is to harvest a large amount of energy from the railway line that can be used to power infrastructure along the track with a capacity of 8 to 10 watts or more.

• Y. Lethwala et al. 2018, In this research paper I have encountered a problem facing many Indian districts namely power shortages. India has a major railway that connects almost every town and town in every province, and with the help of railway tracks we have developed a system to generate electricity from a moving train over tracks. This system can be installed underground under a railway line where there is a decrease in electricity. In India many villages are still without electricity. So to power those villages with electricity our system could be a single solution that could be installed under a nearby railway line, and the system would generate electricity. The built-in system can also store electricity for later use. The program developed by us is highly commended for solving the problem facing Indian villages.

• Qi. L. et al. 2022, This paper reviews and analyzes previous studies on vibration energy harvesting technologies in the railway environment. It introduces the basic aspects of vibration energy acquisition, including vibration frequency, train speed, and energy flow, and compares different energy harvesting strategies. The application of vibration energy harvesters for powering monitoring sensors on both line-side and vehicle-side is discussed. The paper also addresses challenges such as system stability, durability, and economic viability, providing recommendations for future research.

• Lin. T. et al. 2023, This study proposes methods to harvest mechanical energy present in railcar suspensions and railroad tracks using electromagnetic generators. A compact electromagnetic energy harvester, integrating a mechanical motion rectifier (MMR), was designed, fabricated, and tested. The harvester demonstrated up to 71% mechanical efficiency and a power output of 50W, illustrating its potential to power track-side accessories and reduce reliance on the national grid.

• Duarte F. et al. 2022, This paper reviews the development of energy harvesting technologies for railways, identifying and analyzing various technologies being studied and developed. It examines how these technologies can be categorized and provides a technical analysis and comparison using prototype results. The study highlights the potential of railways, continuously exposed to train loads, as a source for energy harvesting to be transformed into electrical energy.

• Zhang R. et al. 2022, This research presents a track vibration energy harvester designed for applications in freight trains. Utilizing a ball screw to convert bidirectional motion into unidirectional rotations and a bevel gear to increase speed, the harvester achieved a maximum output power of 28.0416W and a mechanical efficiency of 75.92%. The high performance of this mechanical motion rectifier (MVR) indicates its potential to meet the power demands of wireless sensor networks, ensuring the normal operation of freight trains.

• Wang. Y. et al. 2023, This study assesses the energy harvesting potential on American, German, and Chinese track spectrums, along with field-measured freight lines. It provides a systematic design approach for energy harvesting devices in railway applications, considering factors such as track conditions and train dynamics. The research aims to optimize the design of energy harvesters to maximize efficiency and reliability in real-world railway environments.

5. Research Gap

Despite significant advancements in railway energy harvesting technologies, several research gaps remain unaddressed. Many studies focus on theoretical frameworks or small-scale experimental setups, but large-scale implementation remains limited due to practical challenges such as system stability, durability, and cost-effectiveness. While previous research explores kinetic, vibration, and electromagnetic energy harvesting, there is a lack of comparative analysis to determine the most efficient approach for different railway conditions. Additionally, existing studies often neglect the long-term impact of wear and tear on railway infrastructure caused by energy harvesting systems. Furthermore, energy storage and distribution mechanisms

require further optimization to ensure uninterrupted power supply. Future research should focus on integrating smart monitoring systems, improving conversion efficiency, and conducting real-world pilot studies to validate scalability.

6. Methodology

A. Block Diagram

Fig. 1. Block Diagram

B. Working

The idea of the Proposed work is to make the entire operation to be automatic , without having the need for any manual/manpower contributions .The requirement is to generate energy or power ,not from any external source but internally.

Power can be generated internally from wheel rotation which contributes mechanical power. The Principle of a DC power Generator is to convert mechanical energy to electrical energy. Hence the output of DC generator is Electrical energy. (DC power), which is stored in a 12 volt DC battery. The stored electricity has the output above the ground, so that whenever there is need of the electricity, the stored power can be directly transferred to any place in very short period of time.

Dynamo generates electricity it sends to dc boost converter. Boost converter is used to regulate the dc power. Electricity is stored in Battery. Inverter Module is used convert 12v dc to 220v AC. AC power is used to glow AC load. Voltage regulator is used to convert 12v dc to 5v dc. Arduino is used to process the all function. LCD display attached to arduino to display voltage status of power generation.

C. Components Used

- Wheels
- Dynamo
- DC TO DC boost Converter
- Battery
- Arduino Uno Controller
- 7805 IC Module
- LCD Display
- Inverter Module
- AC Load
- Resistor
- Capacitor
- Others.

7. Circuit Diagram

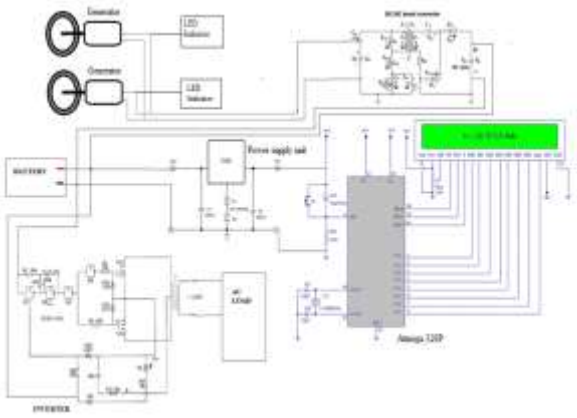

Fig. 2. Circuit Diagram

8. Calculation

Voltage (V): 12V
Power (P): 10W

Conversion Efficiency: Assume 80% (for converting mechanical energy to electrical energy, if applicable)

Time (t): 1 hour for energy calculation

- Calculate Current

Using the formula for power:

$$P = V \times I$$

$$I = \frac{10W}{12V} \approx 0.833\,A$$

- Energy Generated

The energy generated over time can be calculated using,

$$\text{Energy (Wh)} = P \times t$$

For 1 hour:

$$\text{Energy} = 10W \times 1h = 10Wh$$

- Energy to Kilowatt-Hours (kWh)

1 kWh = 1000 Wh

$$\text{Energy (kWh)} = \frac{10Wh}{1000} = 0.01kWh$$

- Assess Energy Generation from Train Wheels:

Assumed RPM of Train Wheel: Let's say the train wheel rotates at 300 RPM.

Circumference of Wheel: Assume a wheel diameter of 0.5 meters (typical for trains).

$$\text{Circumference} = \pi \times d \approx 3.14 \times 0.5 \approx 1.57\,m$$

- Distance Travelled per Minute:

$$\text{Distance} = \text{Circumference} \times \text{RPM} = 1.57m \times 300 = 471m/min$$

- Speed of Train:

$$\text{Speed} = 471m/min \times \frac{60min}{1h} \approx 28.26km/h$$

If a train is traveling at a speed of 28.26 km/h, and assuming an efficient dynamo (12V, 10W), it can continuously generate 10Wh of energy per hour. This illustrates the feasibility of using train wheel motion to generate electrical energy effectively.

9. Results and Discussion

Project Image :

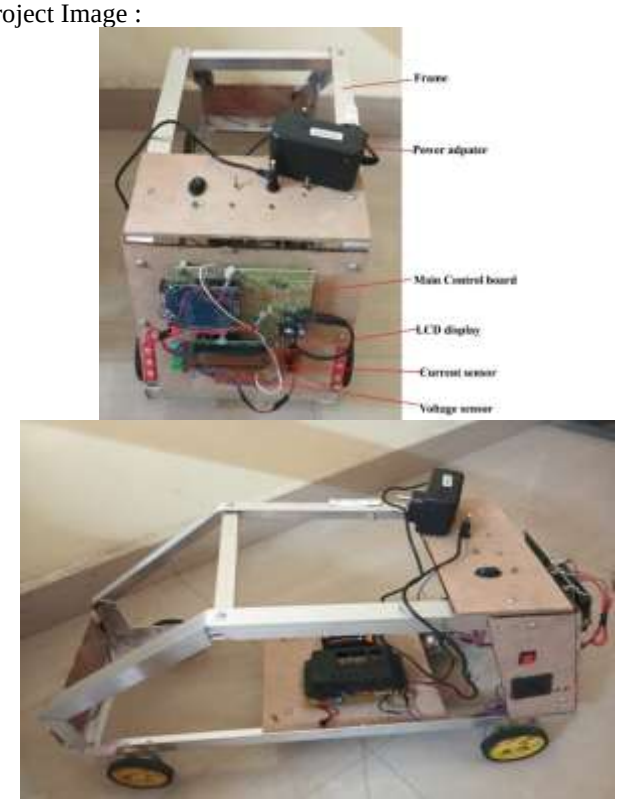

Fig. 3. Project Model

The power generation from train wheels project demonstrates an efficient method of harvesting kinetic energy from railway motion and converting it into usable electrical energy. Based on the experimental setup and calculations, the following observations and results were recorded:

1. Energy Extraction from Train Inertia:
   - A train slows down approximately 1200 meters before reaching the station, relying on inertia to reach the stop.
   - This kinetic energy, which would otherwise be wasted, is captured using a roller and gear drive mechanism to drive a dynamo for power generation.
2. Power Generation Efficiency:
   - If a train is traveling at a speed of 28.26 km/h, and assuming an efficient dynamo (12V, 10W), it can continuously generate 10Wh of energy per hour.
   - This illustrates the feasibility of using train wheel motion to generate electrical energy effectively.
3. Battery Storage and Power Utilization:
   - The generated DC power is stored in a 12V lithium-ion battery and monitored via an ammeter and voltmeter.
   - Power reserves can be discharged when required, ensuring a continuous energy supply for railway infrastructure needs.
4. Real-Time Power Monitoring:
   - The system integrates LED indicators to signal power generation, with toggle switches enabling energy transfer to applications such as irrigation pumps.
   - Initial tests generated 5V, successfully lighting up the LED. Further refinements increased the power output to 8V.
5. Application Potential:
   - The energy harvested can power railway signals, lighting systems, and nearby railway buildings.
   - The setup's compact and friction-reducing design enhances efficiency and reliability.

Discussion:

Energy Recovery from Train Inertia:

- Indian railway stations have designated braking zones, typically 1200 meters before the station.
- During this phase, trains move under inertia, wasting potential energy.

Concept of Energy Conversion:

- The goal is to convert this wasted kinetic energy into usable electricity.
- Efficiency aims to match the power used by the train engine, maximizing energy recovery.

Energy Generation Process:

- A dynamometer and motor are installed under the railway track.
- As the train moves, rotational motion is converted into electricity.
- The motor assists in power generation, enhancing efficiency.

Storage and Utilization of Power:

- Generated electricity is DC and stored in lithium-ion batteries.
- These batteries store large amounts of power and ensure availability when needed.
- Ammeter and voltmeter measure the generated power, ensuring real-time monitoring.

Power Distribution and Application:

- Stored power can be discharged above ground when required.
- Can be used for railway infrastructure, lighting, irrigation pumps, and nearby applications.
- Enhances sustainability by repurposing wasted energy into a useful resource.

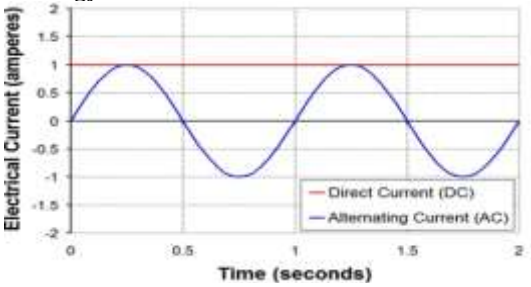

Fig. 4. Current Produce by dynamometer

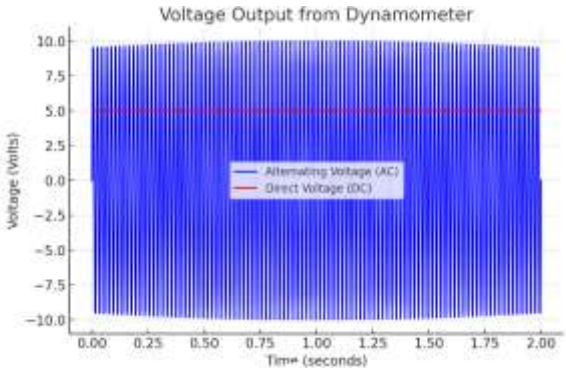

Fig. 5. Voltage Produce by dynamometer

During train operation, a significant amount of energy is wasted as kinetic energy. A unique feature of the Indian railway system is the presence of a designated braking zone, typically 1200 meters before a station. At this point, the train driver reduces speed based on train type, allowing it to reach the station using inertia alone. This movement results in wasted energy, which can be effectively harnessed and converted into electrical energy.

The primary objective of this innovation is to transform the unused kinetic energy of a moving train into usable electrical power. If the generated energy equals the train engine's power consumption, the efficiency of this system would be 100%. While achieving this ideal state is challenging, generating energy close to this efficiency is a significant step toward sustainable energy solutions.

Several techniques exist for harnessing electricity from train wheels and railway tracks. These methods aim to establish a free energy source system. One of the most efficient approaches is generating electricity through a rotational power conversion system. By utilizing a coherent input mechanism, energy can be harvested from the movement of train wheels and transferred via a chain drive to a generator. The wasted kinetic energy is thus converted into mechanical energy, which is further transformed into electrical energy with the help of motors

10. Advantages, Disadvantages and Applications

A. Advantages

1) Low initial cost.
2) We can generate electricity 24 hours a day on the train
3) There is no reduction in train speed.
4) The cost of repairs is low: - There is no need to look for regular meetings. So avoid additional costs.
5) This process does not harm the environment because there is no generation of something in the air, water or soil that harms the environment.

B. Disadvantages

• We cannot generate electricity when the train is stopped.

C. Applications

• Provides electricity for railway stations, signals, and lighting systems.
• Stores generated power in lithium-ion batteries for backup power needs.
• Can power streetlights and emergency lighting near railway tracks.
• Supports automated irrigation systems for nearby agricultural lands.
• Reduces railway energy dependence on external sources, promoting green energy.
• Can be used to supply electricity in areas with limited grid access.

11. Conclusion

The power generation from train wheels project presents an innovative and sustainable approach to harnessing kinetic energy from railway motion. By utilizing the inertia of a slowing train, the system effectively captures energy that would otherwise be wasted. The generated electricity can be stored in batteries and used for various applications such as railway signals, lighting, and irrigation systems. This method not only promotes energy efficiency but also reduces dependency on conventional power sources, contributing to a greener environment. Additionally, integrating a dynamo system with railway infrastructure offers a cost-effective solution for meeting electricity demands in high-traffic railway zones.

The project highlights the feasibility of using train motion for energy generation with promising results. With a train traveling at 28.26 km/h, an efficient 12V, 10W dynamo can continuously generate 10Wh of energy per hour. This small-scale demonstration proves the potential for large-scale implementation in busy railway networks. By refining the system for improved efficiency and integrating advanced technologies, this method can significantly enhance railway energy sustainability. This concept provides a reliable, low-maintenance, and eco-friendly solution for power generation. With further advancements, it can be a game-changer in the renewable energy sector for railway systems worldwide.

12. Scope of Project

From this redesign we generate electricity in the form of a moving train without making the train speed and not making any kind of rotation. The amount of electricity generation depends on the movement of the train and its speed. As speed increases the efficiency of power generation also increases.

• Increased Efficiency:
Enhancing dynamo and energy storage technology to improve power generation capacity.
• Integration with Smart Grids:
Connecting generated power to smart railway networks for efficient energy distribution.
• Expansion to High-Speed Rail:
Adapting the system for high-speed trains to generate larger amounts of electricity.
• Advanced Storage Solutions:
Using ultra-capacitors and high-capacity batteries for better energy storage.
• Multi-Application Use:
Supplying power for railway signals, station lighting, and electric vehicle charging stations.

- Hybrid Energy Systems:

Combining kinetic energy with solar or wind energy for enhanced sustainability.

- Widespread Implementation:

Deploying this technology across metro stations, high-traffic railways, and suburban areas.

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