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Electricity through Train

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Abstract: *This paper aims at production of electricity by using the concept of the rotation of wind turbine due to the wind caused by the moving train and also by using an electrical power generation system. As anyone living near railway tracks will tell you, speeding trains generate quite a bit of wind as they whoosh past. The idea is to design a wind turbine that can be installed between the sleepers on a track, and as the train passes overhead, the wind drives a turbine to generate electricity. This device could be placed along railway or subway lines, and make good use of an otherwise wasted resource. An electrical power generation system comprises a variable capacitor and a power source. The power source is used in the form of a generator to prime the variable capacitor that effectively multiplies the priming energy of the power source by extracting energy from the passing vehicle. By alternately priming the variable capacitor using charge from the power source and discharging it at a later time in a cyclic manner to change the capacitance, a significantly large amount of electrical energy is produced due to change in capacitance.*

Keywords: *variable capacitor, turbine, railways, generation, wind.*

I. Introduction

In the future, civilization will be forced to research and develop alternative energy sources. Our current rate of fossil fuel usage will lead to an energy crisis this century. In order to survive the energy crisis many companies in the energy industry are inventing new ways to extract energy from renewable sources. While the rate of development is slow, mainstream awareness and government pressures are growing.

These challenges can be overcome by using renewable energy which are available to us every day. By utilising these huge amount of resources effectively we can overcome the deficiency of power.

1.1. Objective

The main objective is to build a power generation system such that it can contribute to the present power generation system as the need of energy is growing day by day. The generated power is eco friendly as well as inexhaustible means the power can be generated as long as the railways are in function.

This can be achieved by utilising the energy resources along the railway tracks i.e., by utilising the mechanical energy supplied by both wind gusts from train as well as mechanical energy supplied by the train when it is in motion.

The proposed technique relates generally to generating electricity and, more particularly, to a method and a system for generating electricity along a railroad track. Many known railroad systems employ a variety of wayside equipment alongside the railroad tracks. Within a network, railroad tracks often span rural and unpopulated areas, and as such, providing power to wayside equipment in remote locations may be a challenging and costly task. At least some known railroad systems run power lines into remote areas to power wayside equipment. However, depending on the location, such power systems may be expensive to install and to maintain.

Unfortunately, traditional automated devices generally obtain operating power from an external power source, which is not generally available in remote areas. That is, the automated device receives operating power that is generated at a remote location and that is delivered over a power grid, and coupling the grid to the device can be a costly proposition, especially in remote areas. In certain instance, local power sources, such as batteries, have been employed. In any event, even if a local or external power source is provided, these power sources may not provide a cost effective mechanism for producing sufficient levels of power for operation of the automated testing devices. Therefore, there is need for a system and method for improving electric power generation with respect to rail systems.

II. Generation System

A number of researches to overcome energy crisis against the exhaustion of fossil fuel, environmental pollution and global warming have been performed. Typically, a number of studies on renewable energy, such as wind, photovoltaic generation, etc., are actively in progress. These types of generation have advantages that they do not use fossil fuel as an energy source and emit greenhouse gas [1-4]. The other types of these researches against energy crisis are to reduce energy consumption or loss which deals mainly with how to improve energy efficiency.

As a means of efficiency improvement, various types of energy storage devices are being spotlighted and their application studies are making progress over the wide range of power systems [5,6]. Over the whole power system, researches about energy storage and its application scheme to retrench energy consumption and to enhance system efficiency are under progress. The electric railway system has a peculiar characteristic that the railway vehicles need huge electric power on acceleration and supply regenerative power on braking.[9]

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The electrical power generation system can be configured to generate electric power via movements of the rail. The technique provides an electric power co-generation system for use with a railroad network. The system includes a power source, such as a power generation device or an external power source. The power co-generation system includes first and second electrical capacitance portions that are electrically coupled to the power source and that are configured to carry positive and negative charges, respectively. The power co-generation system further includes a biasing device that is configured to separate the first and second capacitance portions with respect to one another. Thus, by varying the distance between the capacitance portions in response to a vehicle on the rail, the capacitance portions cooperate to act as a variable capacitor that facilitates the co-generation of power with respect to the system. That is to say, the mechanical energy of the biasing device is converted into electrical energy for the system.[7].

Nowadays, the energy-saving technology for urban rail transportation is mainly focused on how to carry out the regeneration braking energy recycling. A variety of methods have been proposed, such as the use of inverter technology and the use of various energy storage devices (batteries, super-capacitors[10-13], fly-wheel[8], hydraulic devices and so on). Considering the suburban application conditions (starts and braking have duration of several seconds and require high electrical power), super-capacitors are more suitable devices for the application on rail vehicles.

As anyone living near railway tracks will tell you, speeding trains generate quite a bit of wind as they whoosh past. Industrial designers Qian Jiang and Alessandro Leonetti Luparini have come up with a device that's installed between the sleepers on a track, and as the train passes overhead, the wind drives a turbine to generate electricity. The wind Turbine devices could be placed along railway or subway lines, and make good use of an otherwise wasted resource. Energy resources in our modern fast paced techno-world is fast depleting. Hence a renewable energy source is much required at the moment. Thus researching new and innovative systems in renewable energy sector is an indispensable prerequisite.

This power generation system utilizes The kinetic energy[16] thus created by the wind flow induced by the train can be effectively utilized to generate power on a larger scale [15] [17] and also the mechanical energy exerted during the train movement which is utilized by the variable capacitor to generate electrical energy[7]

III. Wind Turbine

When you think of wind power, you think of giant turbines harnessing big breezes. We have designed a device that can capture the wind created by trains as they whoosh down the track. This wind turbine generator device is installed between railroad ties and buried half-underground so as to not interfere with normal train operation. As the train passes overhead, the whooshing wind spins a turbine inside the T-Box to generate electricity.

This wind turbine generator is a power generator that harnesses wind-energy when a train moves across the tracks. The box kind of merges with the sleepers on the tracks and houses all the components necessary to harness, store and supply converted power. What makes this project really cool is that it doesn’t rely on nature to be a source, instead it optimizes a human activity

A train travelling approximately 125 mph would produce a wind speed equivalent to almost 50 feet/second. These wind turbine generators would capture this wind, it's turbines producing about 3,500 Watts of power. If the train was about 656 feet long, travelling around 187 mph and passing over that 1 km (.062 miles) stretch, this wind turbine generator could produce about 2.6 kilowatts of power.

The device could potentially provide electricity to remote and underserved areas or to facilities along the railway.

These turbines are installed in the railway tracks as shown in the figure whenever a train passes through these railway tracks they bring huge amount wind power. As they are installed in the track these winds make the turbine rotate and produces electrical

IV. Capacitor

A variable capacitor is a capacitor whose capacitance may be intentionally and repeatedly changed mechanically or electronically. Variable capacitors are often used in L/C circuits to set the resonance frequency, e.g. to tune a radio.

4.1. Concept

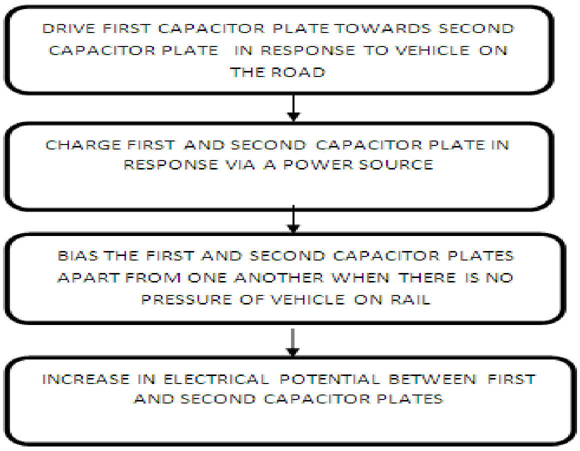
Power generation is achieved in this device by pulling apart the base plate and the movable plate and then extracting energy stored in the electric field. During the input phase, the mass is forced against the contact studs(power supply) on the base plate, connecting it to a charging circuit, which brings it to a starting potential. In response to motion of the frame, which is attached to the host, the mass is accelerated sufficiently in the opposite direction and moved to the top plate where it will be stopped by the contact studs on the top plate. The energy stored in the capacitor is then extracted by an output circuit.

How this system works with rails?

An electrical power generation system comprises a variable capacitor and a power source. The electrical power generation system is configured to generate electric power via movements of the rail. The power source is used in the form of a generator to prime the variable capacitor that effectively multiplies the priming energy of the power source by extracting energy from the passing vehicle. By alternately priming the variable capacitor using charge from the power source and discharging it at a later time in a cyclic manner to change the capacitance, a significantly large amount of electrical energy is produced due to change in capacitance than from the power source itself.

The system includes a power source, such as a power generation device or an external power source. The power train power generation system includes first and second electrical capacitance portions that are electrically coupled to the power source and that are configured to carry positive and negative charges, respectively. This system further includes a biasing device that is configured to separate the first and second capacitance portions with respect to one another. Thus, by varying the distance between the capacitance portions in response to a vehicle on the rail, the capacitance portions cooperate to act as a variable capacitor that facilitates the co-generation of power with respect to the system. That is to say, the mechanical energy of the biasing device is converted into electrical energy for the system.

Block Diagram



The technique provides an electric power co-generation system for use with a railroad network. The system includes a power source, such as a power generation device or an external power source. The power co-generation system includes first and second electrical capacitance portions that are electrically coupled to the power source and that are configured to carry positive and negative charges, respectively. The power co-generation system further includes a biasing device that is configured to separate the first and second capacitance portions with respect to one another. Thus, by varying the distance between the capacitance portions in response to a vehicle on the rail, the capacitance portions cooperate to act as a variable capacitor that facilitates the co-generation of power with respect to the system. That is to say, the mechanical energy of the biasing device is converted into electrical energy for the system.

In accordance with above technique, a method of co-generating power via a vehicle travelling on a rail is provided. The method includes the act of driving first and second capacitor plates with respect to one another in response to the vehicle that is travelling on the rail. The method also includes the act of charging the first and second capacitor plates via a power source, such as a power generation device or an external power source. The method further includes biasing the first and second plates apart from one another, thereby displacing the plates with respect to one another. This displacement changes the electrical capacitance between the first and second plates and, resultantly, increases the electric potential between the first and second plates. In turn, this displacement of the first and second plates facilitates the co-generation of electrical energy from the kinetic and potential energy of the vehicle on the rail.

4.2. Variable Capacitor

The power co-generation device includes a variable capacitor. The variable capacitor has two capacitance portions, such as conductive plates that are each coated with a thin film of dielectric material. The two electrically conductive plates are held mutually apart in an open position via a biasing member, such as a compression spring. The plates are electrically coupled to the power source, such as the illustrated power generation device, and each plate carries opposite charges with respect to one another. The variable capacitor facilitates changes in the distance between the two plates causing electrical power generation from this changing distance.

To facilitate electrical isolation of the two capacitance plates a dielectric film is provided on one plate or on both of the plates. The dielectric film acts as an insulator between the conductive plates and impedes the flow of current between the capacitor plates. In one exemplary embodiment, the dielectric film includes polyimide material, such as a kapton having functionally linked polymers. The dielectric film includes aluminum oxide having polar metal oxide bonds possessing large permanent dipole moment. The dielectric film may include polymers, ceramics, or the like

4.3. Power Source

The power source is coupled to the conductive plate. The power source may be located locally within the power tie or external to the power tie. The power source is coupled to the conductive plate via the power conditioning circuitry and a power isolation device. The power isolation device is a switch or a diode

4.4. Operation

When DC voltage is applied across the two plates of the variable capacitor, a concentrated field flux is created between the plates and electrons are liberated from the positive conducting plate and deposited on the negative conducting plate. Thus, one of the plates develops a positive charge, while the other plate develops a negative charge. The greater the difference of electrons on opposing plates of a capacitor, more flux is generated and the capacitor is able to store more electrical energy. Specifically, the voltage across the capacitor (i.e. between the plates) is increased. The capacitance of the capacitor is dependent on the area of the plates, distance between the plates, and ability of dielectric material to support electrostatic forces, as discussed further below. Because, each plate stores equal but mutually opposite charge, the total charge in the capacitor is zero. In the illustrated embodiment, an analog signal line between the co-generation device and the sensing device carries an analog signal indicative of the load on the rails. The operation of the variable capacitor is discussed in two levels as discussed below:

4.4.1. Open position

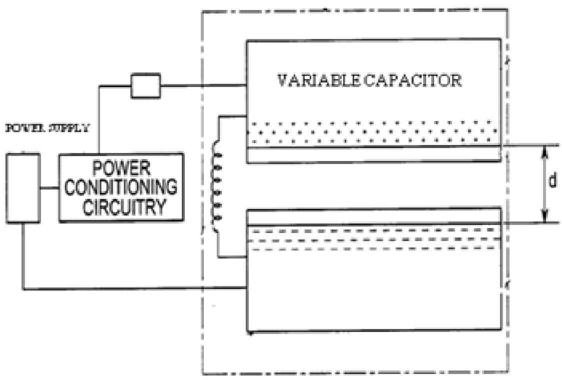


Fig4.4.1. Open Position

The above figure illustrates variable capacitor in an open position. The plates are biased apart and held in this open position by a biasing member, such as a compression spring. The plates are separated by a larger gap "d" in the open position, and the open position corresponds to a situation when there is no vehicle above the rails. The capacitance of the capacitor is directly proportional to the electrostatic force field between the plates, and the capacitance of the capacitor is calculated in accordance with the following relationship:

$$C = \frac{\varepsilon A}{d}$$

Where C is the capacitance in farads, ε is the permittivity of the dielectric, A is the area of the plate in square meters, and "d" is the distance between the plates in meters. From the above mentioned relationship, it can be seen that the capacitance of the capacitor is reduced in the open position, because the capacitance is inversely proportional to the distance or gap "d" between the capacitor plates.

4.4.2. Closed position

The BELOW figure illustrates variable capacitor held in a closed position. When a vehicle is above the rails, the plates are biased towards each other, thus reducing the gap "d". This reduction in the gap "d" changes the distance between the plates and also changes the capacitance characteristics of the variable capacitor. From the above mentioned relationship, it can be seen that the capacitance of the capacitor in the closed position is increased due to the

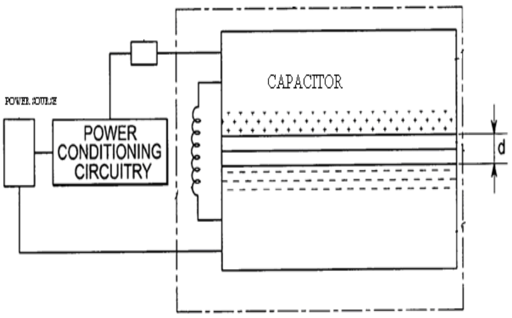


Fig4.4.2. Closed Position

reduced gap "d" between the capacitor plates. Indeed, in the closed position, the value of "d" is effectively the thickness of the dielectric film, and this thickness is significantly smaller than the value of "d" in the open position. Thus, decreasing the capacitance of the capacitor

4.4.3. Analysis

(i) The capacitance of the capacitor is calculated in accordance with the relationship:

$$C = \frac{\varepsilon A}{d} \tag{1}$$

(ii) Voltage across the plates in open position is calculated as:

$$V_o = \frac{C_c}{C_o} V_c \tag{2}$$

Where C_c is the capacitance in the closed position in farads, C_o is the capacitance in open position in farads, V_c is the voltage across the plates in closed position, and V_o is the voltage across the plates in the open position.

Consider, let dielectric permittivity k=2.5, $\varepsilon_{0=8.55}$ picofarads/m, $\varepsilon=k\varepsilon_{0=2.2\times10}^{-11}$ farads/m, A=0.1 m^2, t=1 micron (10^{-6} m) is the thickness of the dielectric layer, d=1 mm (10^{-3} m) is the space between the plates.

$$C_c = \frac{\varepsilon}{t}A = \frac{2.2\times10^{-11}\text{farads/m}}{10^{-6}\text{ m}} \times 0.1\text{ m}^2 = 2.2\times10^{-6}\text{farads} = 2.2\ \mu f;$$

Thus, when the exemplary variable capacitor is in the closed position, the capacitor has a capacitance value of 2.2 microfarads, and the distance between the plates is defined by the thickness of the dielectric material. When the distance between the plates is increased, the capacitance of the variable capacitor is changed to:

$$Co = \frac{\varepsilon_0}{d} A = \frac{8.55 \times 10^{-12}}{10^{-3}} \times 0.1 \cong 0.0009\ \mu f;$$

Where d>>t. In this system, the electrical potential across the plates is inversely proportional to the capacitance of the device and is:

$$v_o = \frac{C_c}{C_o} \times V_c \cong 2400$$

where Vo is the voltage or electric potential across the plates when the plates are in the open position and Vc is the electric potential across the plates when the plates are in the closed position.

V. Conclusion

Increasing the electrical potential of the variable capacitor also increases the electrical energy of the system, as the mechanical energy of separating the plates is converted into electrical energy. Thus, in the above example, the electrical energy of the capacitor is increased by 2400 times. The power generation device effectively primes the variable capacitor, and the energy of this priming is multiplied by varying the distance between the capacitor plates. By alternately priming the variable capacitor using power from the power source and discharging it at a later time in a cyclic manner to change the capacitance, a significantly large amount of electrical energy is produced due to change in capacitance in comparison to the electrical energy and power from the power source itself. A number of such systems are connected together for greater energy delivery.

Advantageously, communication between the power ties facilitates sharing of resources and also facilitates the development of certain data types, such as block occupancy detection, distance to train, detection of broken rail, or the like

Additionally, by monitoring various properties of the variable capacitor, certain properties regarding the vehicle passing on the rail can be determined. For example, determining the time, the capacitor is in the closed position or the open position provides an indication of the speed of the vehicle.

Thus the property of variable capacitance and also utilizing the winds during the movement of train is used to trap energy (kinetic and potential) of the vehicle movement in the rail. By alternately priming the variable capacitor using the charge from the power source and discharging it at a later time in a cyclic manner to change the capacitance, a significantly large amount of electrical energy is produced due to change in capacitance. Though the theory appears to be neat and clean, the system is only proposed and is yet to be designed experimentally

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