



PIEZOELECTRIC ROADS

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ABSTRACT

This project aims to generate electricity and decrease the consumption of fossil fuels and conserve the electricity for further use.

In modern world, the technique needs amount of power for its various operations. These operations require a lot of fossil fuels, to overcome this consumption of power and fuels. In this paper we have presented method to produce pollution free electricity by the technique i.e. piezoelectric effect. This is kind of green solution for power generation.

Piezoelectric effect is the ability of a material to generate electric charge by applying mechanical stress. This report assess to commercial status of piezoelectric based techniques in roadway and railways. In this project we try to provide a sufficient energy as it can reduce the damage of pollution caused by power plants. Even when vehicle passing from the road, exerts pressure on the roadways and causes deformation. So to make the use of moving vehicle on road, we can generate power by our project and helps environment and our structures to be last long. This paper present about the piezoelectric sensor that can be implemented beneath the road bed to harvest the electricity from the vibration produced due to the vehicle moving on the road.

The main principle behind this project is the piezoelectric effect. The energy is produced from the consumer participation and it does not require any separate source of input energy.

Keywords: *Piezoelectric effects, piezoelectric material, smart roads, capacitor, energy harvesting, renewable energy, heavy traffic correlation.*

I. I N T R O D U C T I O N

Electricity has become a lifeline of present day civilization and thus its demand is enormous and is growing steadily. There seems no end to the different ways one can generate pollution free electricity. At one hand, rising concern about the gap between demand and supply of electricity for masses has highlighted the exploration of alternate sources of energy and its sustainable use. On the other hand, traffic on the road all over the world is increasing day by day thus; congestion on road is becoming inevitable with the fancy of masses towards personal transportation system for their growing mobility. Energy demand and heavy traffic correlation motivate to dream about the road that would harvest energy from the vehicles driving over it. For this, piezoelectric material embedded beneath a road, the piezo-smart road, can provide the magic of converting pressure exerted by the moving vehicles into electric current.



The system is based on piezoelectricity, which uses pads of metallic crystals buried beneath road to generate electricity when put under the pressure of quickly moving traffic. With the technology, now, engineers are poised to harvest some of the spare energy of the world's moving vehicles. When a vehicle drives over the road it takes the vertical force and compress the piezoelectric material, thereby generating electricity.

II. SCOPE OF THE PAPER-

The utilization of energy is an indication of the growth of a nation. For example, the per capita energy consumption in USA is 9000 KWh per year, whereas the consumption in India is 1200 KWh. One might conclude that to be materially rich and prosperous, a human being needs to consume more and more energy. A survey on the energy consumption in India had published a pathetic report that 85,000 villages in India do not still have electricity. Supply of power in most part of the country is poor. Hence more research and development and commercialization of technologies are needed in this field. India, unlike the top developed countries has very poor roads. Talking about a particular road itself includes a number of speed breakers. By just placing a unit like the "Power Generation Unit from Speed Breakers", so much of energy can be tapped. This energy can be used for the lights on the either sides of the roads and thus much power that is consumed by these lights can be utilized to send power to these villages.

III. PIEZOELECTRICITY AND PIEZOELECTRIC EFFECT-

The word piezoelectricity means electricity resulting from pressure. It is derived from Greek piezo or piezein, which means to squeeze or press, an electric or electron, which stands for amber, an ancient source of electric charge. Piezoelectricity was discovered in 1880 by French physicist Jacques and Pierre Curie.

The piezoelectric effect is understood as the linear electro-mechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry (notably crystals, certain ceramics, and biological matter such as bone, DNA and various proteins). The piezoelectric effect is the reversible process in that materials exhibiting the direct reverse piezoelectric effect (the internal generation of the electrical charge resulting from an applied mechanical force) also exhibits the reverse piezoelectric effect (the internal generation of the mechanical strain resulting from an applied electrical field).

IV. PIEZOELECTRIC ROADS-

The roads which produce electricity by application of mechanical energy when vehicle moves over the road, those roads are called as piezoelectric roads.

These roads are having a piezoelectric sensor within them to produce electricity.

This kind of construction is built in Israel, California and we are trying to construct it here in India.

V. CONSTRUCTION OF PIEZOELECTRIC ROADS-

1. The first layer is laid with fine gravel and sand content.
2. Then a thin layer of asphalt is laid which acts like a strong base for the generators.
3. Piezoelectric generators are placed in quick drying concrete as per design and left for 30 min.

4. Then all the generators are wired in series to get collective output.
5. A bitumen sheet is used to cover all the generators to provide better adhesion of concrete to asphalt.
6. Finally a thick layer of asphalt is laid which finishes the construction.

VI. HARVESTING MECHANISM-

1. Generators harvest the mechanical energy of the vehicles and convert to electrical energy.
2. Electric energy is transferred and stored via harvesting module. Then it is charged into the battery on one side of the road.
3. From there it is distributed.
4. Yield: For 1 km of piezoelectric road of one lane we can generate 44000KWh per year

VI. PRACTICAL APPLICATION OF PIEZOELECTRIC ROADS-

The piezoelectric energy generating roads have been proposed in the car capital of the world, California. The design is based on piezoelectricity that is produced in response to mechanical stress applied on some solid materials like crystals and some ceramics. The design proposes the placement of piezoelectric sensor beneath the road surface which would produce electricity from the vibration of caused by movement of vehicles on road. When applied on road, the piezoelectric technology could produce up to 44 megawatts of electricity per year from one kilometre stretch of the road and meet the energy demand of about 30,800 households.

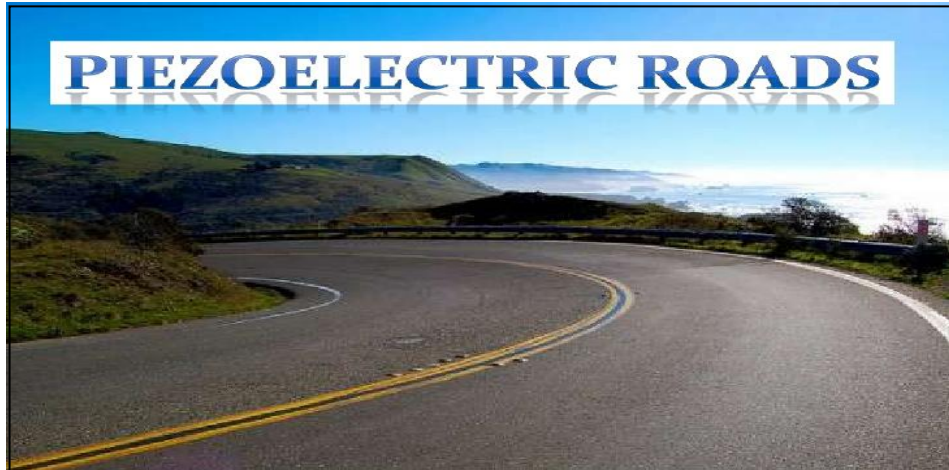


Fig 1: piezoelectric roads already built in California

VII. PIEZOELECTRIC MATERIALS-

Piezoelectric materials are the crystals that generate electricity when compressed or vibrated. They have the unique opposite property of generating a stress when voltage is applied to them.

Piezoelectric material falls within the class of multiple sold state materials that can generate with the help of some stimulus such as heat, stress, or light. Photovoltaic material generates electricity with the application of

light and thermoelectric material generates electricity with the application of heat. Piezoelectric material generates electricity by the application of stress.

These materials are all semiconductors, meaning they are much like conventional electronics, generally constructed of silicon or germanium with additional elements.

7.1 PIEZOELECTRIC SENSORS FOR ROADS-

The present inventions relates generally To the method of the electrically power generation and more particularly is a method and device to generate the electricity by using traffic on existing roadways to drive an electrical generators. The paper provides technically review about the production of electric power using PZT, MEMS, PMPG in piezoelectric roads- harvest traffic energy to generate electricity.

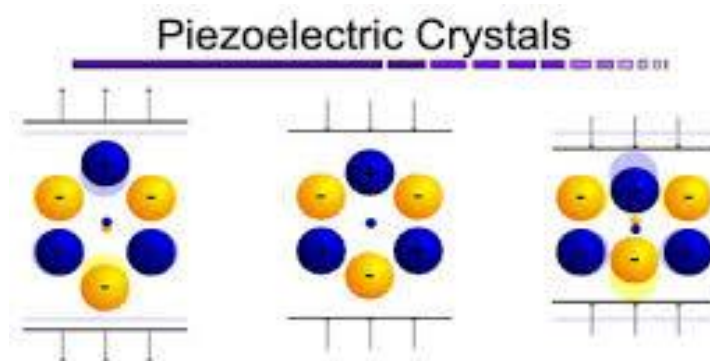


Fig: 2 Piezoelectric crystals

Since energy demand and traffic correlation motivates to dream about a device in the road would harvest the energy from the vehicles driving over it. For this, embed piezoelectric material beneath a road can provide the magic of converting pressure exerted by the moving vehicles into electric current. The method uses an electrical generation device installed beneath the roadbed. The electrical generating device includes a plate covered with 1 or more protection layer which lie beneath the surface of the road.

In this process material is embedded beneath the road with the electrical generating device. For a road with embedded piezoelectric generators, part of energy the vehicle expands on roads deformation is transformed into electric energy instead of being wasted as thermal energy.

This electrical generating device includes pressure plates that are covered with the protection layer or asphalt.

The piezoelectric effect converts the mechanical strain into the electrical energy (current or voltage) and the system is expected to scale up to 400kW from 1km stretch of dual carriage way.

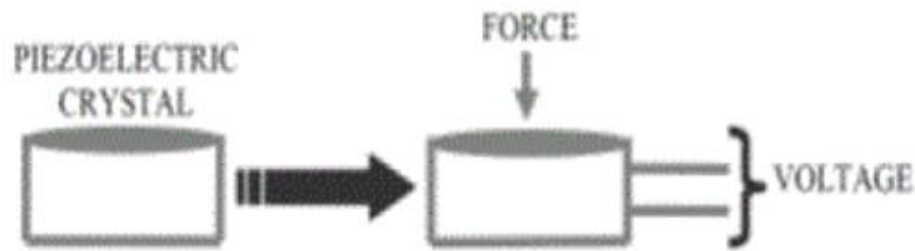


Fig:3 principle of piezoelectric crystals.

VIII. PRINCIPLE OF WORKING-

The basic principle which we use to generate electricity is the piezoelectric effect. A piezoelectric material is that one which converts mechanical energy or vibration energy that is experienced on it, to a charge which can be stored. When a force or pressure is exerted on the elastic piezoelectric crystal material, the crystal gets deformed and this causes it to develop charge between them and the crystal goes back to its original state.

This charge flow is converted to a voltage that can be stored in a battery. We explain about a disc shaped piezoelectric buffer plate in our paper. Since the power obtained from a few of them will be in a very small amount, we use voltage amplifying circuits here. As the size and number of piezoelectric crystals increase, the energy obtained from them also increases.

street light is controlled automatically by Light Dependent Resistors (LDRs). With the help of LDRs the street lights are automatically switched off during day time and switched off during night time. The automatic traffic light control is made possible by two pair of IR transceivers placed on each road of the four-way junction. Each transceiver pairs are kept face to face width-wise on each road.

When the IR signals between each of the transmitter and receiver pair gets cut proportionally according to the traffic density on each road, the traffic lights are controlled. This function with the help of a program stored in a microcontroller. Besides all these, the charging condition of the battery is sent and indicated every second to the nearest traffic control room.

IX. PROPOSED SYSTEM DESIGN AND OPERATION-

When a vehicle is running on specialised speed breaker, this will create pressure on pressure lever which is kept under the specialised speed breaker. As a result flywheel will create and the rotation of fly wheel will cause the DC generators to produce electricity. The electricity can be produced or recharged.

The process of this design is when a vehicle move over the road or at a place where we have kept the piezoelectric material, the vehicle exerts the force on that material. The pressure is generated dur to this force and hence the pressure converts it into the electrical energy.

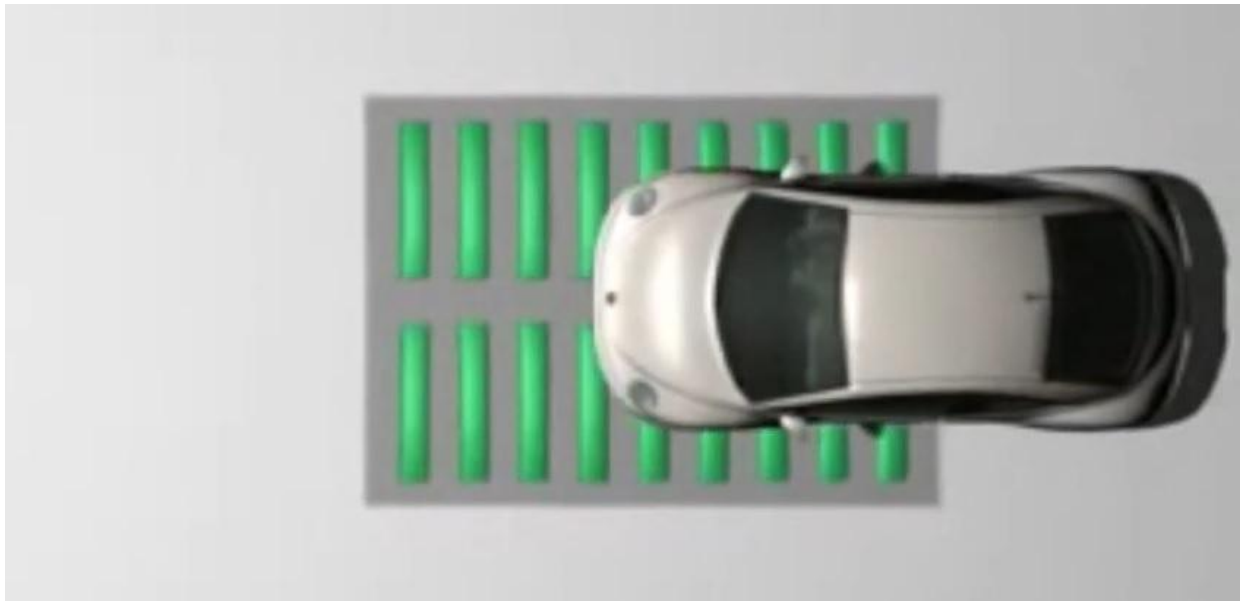


fig:4 working of piezoelectric roads.

X. DESIGN

The design consists of a thin box around the piezoelectric material, which is placed underneath the asphalt layer. As the truck pass over the plates embedded in asphalt layer, they compress a tank filled of hydraulic fluid under the road, which in turn creates a series of pumping action that turns a generator to produce electricity. When a car drives over the box, it takes the vertical force and compresses the piezoelectric material thereby generating electricity. The energy 80kWph kilometre of road for traffic-can be stored in nearby battery or super capacitor, depending upon the application or sent directly to street lights and other road side devices. The energy being converted into electricity through piezoelectric effect is coming from the motion of vehicles which will otherwise be wasted by heat when the roads deforms under the weight of the car. The layer of piezoelectric material is stiffer than the road material it replaces, so it even saves a tiny amount of energy.

Engineers have created new type of road which is capable of turning the vibrations caused by car into electricity. While the concept is not new, the application is novelty. The piezoelectric generators harvest the vibration energy and save it in roadside batteries that can be used by people.

Accordingly 1 truck can generate 2000 volts which could already be used to power the traffic lights or street lamps. This process is also known as parasitic energy harvesting. Under the upper asphalt there is the layer of piezoelectric crystals that produces electricity when suppressed. The same technology can be implemented to railways and runways.

It aims to capture energy when vehicles are slowing down in which cars or trucks would drive over a mat that would be installed on top of the road, on a highway off-ramp, or near a toll booth, saving wear and tear on the car brakes and transforming some of the slowing vehicle's motion into electricity. The mat uses mechanical or hydraulic cells to generate electricity and can be customized for cars or cargo truck traffic. These latest refinements maximize the amount of electricity generated without disrupting the driver or vehicle or



robbing a vehicle of the energy it needs to accelerate. This is because the system is designed to be installed in locations where vehicles are required to reduce speed, such as toll plazas, rest areas and drive-thrus, meaning the system only makes use of vehicle energy that would be required to slow down.

A kilometre of “electric road” could generate enough power for 40 houses, and progress in the technology could generate enough electricity to feed the national power grid. Private companies were competing in this sector but recently governments of developed countries are also taking notice to the developments in turning traffic rush into electricity and are funding many projects.

IX. OTHER FACTOR AFFECTING PIEZOELECTRIC ROAD EFFICIENCY-

Vehicle speed: it states that vehicles moving slowly appear to generate slightly more energy than faster-moving vehicle. In contrary energy efficiency always increases with more speed. Different types of vehicles such as bus, car, and motorcycle were tested at a speed of 45 mph and 65 mph. Power output is always greater with higher speed. Higher speed has a higher impact on frequency resulting in a higher decay.

Vehicle weight: Simply put, the higher the force exerted the more deformation of crystals and thus higher energy produced. The same principle applies for vehicles; a truck will generate more energy than light duty vehicles and motorcycle.

Traffic flow capacity: Upon implementing such technology, this parameter would be first considered. The overall technology performance will certainly provide less energy if power asphalts are designed in areas were less frequent vehicles cross over. It is suggested to apply power asphalts on busy roads were a reasonable number of vehicle capacity flow. Planning the location of power asphalt is an essential decision to meet energy needs.

XII. CONCLUSION

Having met the power metrics will make such invention a starting point to self-sustaining environment by being dependent on vehicle elements to curb down input energy and cost. This will be a revolution in the production of energy by meeting innovations and technologies to shape future energy. However, further concentration is required to quantify and result in a greater power outcome to become a reliable source of electricity.

At a time when governments are finding it hard to make land available for new power plants, extracting energy while using the vast spread of highways all over the world seems no less lucrative proposition. However, this idea has not yet gained enough ground among the policy makers even though researchers have shown that energy could be extracted from highways by fitting them with piezoelectric devices, solar panels, wind turbines and other energy generating tools. Future of the world would depend on our ability to create a self-sustaining environment where everything could be put to some use and dependent on each other. The energy generating road designs could become a starting point for a self sustaining future. We thus conclude that this thought will be a revolution in power production and curb down the energy costs thereby improving our country’s economy. This energy is produced by consumers’ participation without requiring any kind of input energy. Further concentration in the work would result in the better production of energy. We can see a better dimension of this piezoelectric concept in the futuristic world.



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