Team: Subway Solutions

Harvesting the Kinetic Energy of Subways

Utilizing motion from traffic in subways as an alternative source of energy

Renewable energy is an increasingly used avenue for energy production that will only continue to rise in popularity as fossil fuels dwindle. Society's dependence on nonrenewable resources including oil, natural gas, and coal has proved to be extremely harmful to the environment and resulted in severe damage to the environment. It is essential for people to develop new innovative methods of generating renewable energy to replace these conventional dissipating power sources. The implementation of piezoelectric systems in roads and sidewalks has become a trending area of speculation for the generation of a clean source of renewable energy and both the private sector and governments have taken interest in further developing this idea. Our method of implementing this system in a subway station and enhancing its efficiency by combining it with a mechanical flywheel generator improves upon this traditional method concept and offers a consistent source of renewable energy. Subway stations are a hub of human activity around the world, ferrying passengers everywhere day in and day out. These stations contain vast amounts of energy from the combination of people and trains constantly in motion, yet it is going to waste, while the stations themselves receive energy from external, generally nonrenewable sources. Our proposed method will utilize this energy to power the station itself through the addition of piezoelectric beams on subway rails that can harvest kinetic energy from the motion of speeding subway cars.

The piezoelectric effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. Crystals which acquire a charge when compressed, twisted or distorted are said to be piezoelectric. Rochelle salt produces a comparatively large voltage upon compression, as well as barium titanate, lead zirconate, and lead titanate, which are used in ultrasonic transducers.

The traditional approach to the usage of a piezoelectric system has been to place a layer of piezoelectric material underneath a road or sidewalk and using the motion of passersby to generate energy. However, this program is not very cost-effective as it requires installation of piezoelectric material underneath a very large surface area to generate significant energy production. This is both extremely expensive and time consuming. Furthermore, implementing piezoelectric systems on roads remains inefficient as vehicles traveling on roads are often unable to fully squeeze the piezoelectric tiles due to inconsistencies of road travel (changes in traffic, pressure on tires, etc.), ultimately wasting significant amounts of energy that could have been potentially generated by the system. Our method of combining a pressure plate flywheel design with a piezoelectric system in a subway station is able to mitigate many of the drawbacks of the traditional approach. Since pressure exerted by subways is concentrated onto the two side rails, the piezoelectric material which only needs to be placed under a small strip of track is consistently squeezed each time the train passes by and thus minimum amounts of the kinetic energy is wasted. Thus, our method will be able to generate higher energy outputs for cheaper, easier and quicker implementation.

Our designed piezoelectric system constitutes two parts: a transducer to convert potential energy into electrical energy and an electrical interface to manage the energy. Usually, a rectifier and voltage regulator are two main components in the electrical interface. It will use two synchronized switches for doubled efficiency of the rectifier, resulting in 93% energy conversion. We will implement the piezoelectric system with a naturally occurring commonly found piezoelectric material such as Rochelle salts, encased in carbon fiber beams in order to withstand the pressure of the constant stream of subway trains travelling across them, while also remaining convenient in implementation. The carbon fiber beams are shaped as pressure plate that the piezoelectric system is stored in. The pressure plate will also be connected to a series of gears and flywheels to generate additional electricity. When pressure is applied, the beams turn gears that will rotate the flywheels, spinning a generator that creates electrical energy, similar to a squeeze flashlight. This energy, combined with the energy generated from the piezoelectric material will then be used to power the lights of the underground subway stations while the trains are running. Any excess energy will be stored in the generator of the station for later use.

This proposed system will help reduce the high amounts of energy expended in generating electricity for subway stations. For example, the NYC subway stations use around 500,000 kilowatts during its peak hours, and our design will reduce the amount of this energy that needs to be supplied by power plants. The existing infrastructure of the railroad systems could be kept intact as the beams would only have to be placed under the existing metal railings of the track. This would allow either the private sector or the government to avoid the time-exhaustive and expensive method of tearing apart the highways and inserting the piezoelectric material. Additionally, our method is extremely efficient in comparison to the traditional proposed piezoelectric systems as the force of the subway trains are concentrated on a very small surface area resulting in high pressure outputs. Subway trains run in a closed, predictable system, which increases the reliability of our proposed method in producing enough energy to power the lights of the station.

Trials run with a piezoelectric system laid under one kilometer of a single-lane highway yielded nearly 200KWh or 720MJ. Assuming that this experiment was a best case scenario and that a consistent amount of pressure was applied throughout the length of highway tested, the maximum weight of the cars on the highway is approximately 347,753 kg. Further calculations show that a similar mechanism implemented in a subway system would produce 222KWh (799.2 MJ), an 11% increase on the data provided. This is a significantly greater amount of energy production based on just one aspect of our method. Taking into account the increased pressure in the subway system, as well as the increase in the uniformity of the subway system, our entire method could be anywhere from 25-35% more efficient.

The proposed mechanism generates an alternate source of power which can limit the amount of harmful pollutants that are emitted when conventional sources of nonrenewable resources are used to generate electricity, helping mitigate the rapid effects of climate change. It utilizes the unused kinetic energy already present in subway systems to produce energy that will power the infrastructural systems including lights and signs within the station. The mechanism has a convenient implementation, as no new construction will be required and installation of the beams can be done after operating hours. It has significant potential to be more efficient than the current tested methods of implementation on a highway. It is a convenient, relatively inexpensive solution that will reduce dependency on fossil fuels.

Works Cited

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