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Electrical Power Generation using Human Locomotive Energy and its analysis Alternative Renewable Energy Source

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Abstract: Due to the advancement in technology as well as exponential increase in population, the energy demand is increasing rapidly. This increasing energy demand is met by non-renewable energy resources which will soon deplete the fossilized vestige. Furthermore, burning of fossil fuels leads to the emission of harmful greenhouse gases causing global warming which is a matter of serious concern. This swings us to opt for alternative energy sources which would minimize the environmental hazards. The enormous human population is an increasing commodity which can be used to harness energy for the betterment of human race. One of the alternatives can be through footstep. The waste energy of footstep power with human locomotion can be harnessed and utilized in numerous applications. This paper sheds light on generation of electrical energy through footstep.

Keywords: Power generation; Piezo-Electric Sensors; Piezoelectricty; battery.

I. INTRODUCTION

Man has need and used energy at an increasing rate for his sustenance and well-being ever since he came on this earth, a few million years ago. Without energy, survival is next to impossible. To meet these energy demands, we have consumed renewable energy resources rigorously. Due to this a lot of energy resources have been exhausted and wasted. Energy can be defined as the capability to do work and as we all know energy is conserved in nature, it can neither be created nor be destroyed. It can only be converted from one form to another. Though natural resources are a source of enormous power, they are depleting at a very fast pace. If we continue to use these non-renewable resources, at this pace and do not switch to other renewable sources it will soon deplete the fossilized vestige. The vigorous burning of fossil fuels for energy generation has led the greenhouse gases to penetrate our eco-system causing environmental concerns like global warming and ozone layer depletion. Owing to these environmental issues we must find innovative ways to generate pollution less power. Hence, there is an urgent need to switch to non-conventional methods of energy generation which is necessary for humanitarian welfare. Among various preferable choices walking is the most common activity in human life. When a person walks, he loses energy to the road surface in the form of impact, vibration, sound etc. due to the transfer of his weight at every step onto the platform. This energy can be trapped and converted into usable form such as, electrical energy. India is the second largest nation in the world in terms of human population and also among the fastest developing countries. This millions of population can be used as an advantageous asset for the growth and development of our nation. India is curious to adopt new technological non-conventional methods of energy generation which does not cause any pollution and are sustainable in the long run. Human footstep power has been in existence since time immemorial in the form of walking, swimming and running. However, modern technology has led to the enhancement of use of human power in more efficient manner. But still the walking energy, which is available in abundance, has not found an appropriate path to be trapped and utilized for human benefits. This motivated us to design a prototype to trap this energy and use it for a wide range of applications. By using piezoelectric sensors in the prototype, we are converting the mechanical energy of footstep which is wasted in the form of vibration, noise or stress into electrical energy. This electrical energy can be stored and further used for desired applications like charging a laptop, or a mobile, etc.

II. PIEZOELECTRIC MATERIALS

There are certain materials which through physical interactions undergo transformation by sensing a change in its environment and adopting themselves to eliminate the change. Piezoelectric materials are one of its kinds. They belong to the family of Ferroelectric materials. Ferroelectric materials possess spontaneous electric polarization. It can be reversed when subjected to an external electrical field over a range of temperature. The material having a P-E loop is a

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ferroelectric material. Piezoelectric materials have the ability to generate electricity whenever any mechanical stress is applied on them. Also the converse effect occurs i.e., a strain is generated when an electric field is applied. These materials are both natural and synthetic. Some of the naturally occurring crystals are Quartz, Topaz, Sucrose, Dry Bone, Tendon and Dentin. Synthetic piezoelectric materials can be in the form of crystals as well as ceramics. Example of synthetic crystals are Langasite ($La_3Ga_5SiO_{14}$), Gallium Orthophosphate ($GaPO_4$), Lithium Niobate ($LiNbO_3$) and Lithium Tantalate ($LiTaO_3$). Barium Titanate ($BaTiO_3$), Lead Zirconate Titanate (PZT), Potassium Niobate ($KNbO_3$), Sodium Tungstate (Na_2WO_3) and Zinc Oxide (Wurtzite structure) are some of the synthetic ceramics. The most commonly and widely used piezoelectric material is PZT. They are perovskite structure based (XYO_3).

III. PROCESS OF MAKING PIEZOELECTRIC CERAMIC

The process starts with the preparation of powder following the transformation into various shapes and sizes as per the requirement. It is followed by calcination in which the crystallization is done in the shape of perovskite structure. After the fabrication of shapes, they are placed in an oven for densification which is followed by sintering. Sintering is removing of any organic matter, water or other volatile particles that are present in the mixture. This gives better homogeneity. At times, binder is mixed into the mixture for better formation of simple or complex structure. Sometimes sintering allows the oxides to react for the formation of desired shapes. Volatility of PbO at high temperature is the main problem in the process of sintering of PZT. To eliminate this problem, a lead source such as $PbZrO_3$ is placed with PZT samples during sintering. This reduces the amount of lead loss from PZT samples. Still a 2%-3% loss occurs. A strong DC field is applied to orient the dipoles and then piezoelectricity is induced. According to the material and the composition, poling can be performed at room or higher temperatures.
The structure of unit cell of any material is a crucial parameter for determining the potentiality of piezoelectricity. Some of the material possess center of symmetry while some does not. The absence of center of symmetry results in the final movement of negative and positive ions which is caused due to the stress, resulting in the production of an electric dipole. Initially, the individual crystals have random orientation of electric dipole, which results in the cancellation of each other's dipole moments, resulting in no piezoelectricity. To overcome this, poling is performed to orient the dipole moments, commonly termed as domains. Through the process of polarization being done by the application of sufficient electric field, the domains orient themselves in the direction of electric field. Though, the result is never a cent percent orientation, it posses a large piezoelectric effect. The comparison among the various piezoelectric sensors has revealed that PZT is of superior characteristics as compared to other piezoelectric materials.

IV. PIEZOELECTRIC EFFECT

Microscopic structure of the crystals gives rise to a linear effect known as piezoelectricity. When subjected to strain, some ceramic materials get electrically polarized. This phenomenon is called as direct piezoelectric effect which is linear and reversible in nature. Whenever an electric field is applied, some ceramic materials become strained, resulting in converse piezoelectric effect. Movement of the ionic charges is the origin of piezoelectric effect in a crystal. When there is no external strain, there is symmetry in the charge distribution of the crystal resulting in the net dipole moment to be zero. The application of an external stress changes the charge distribution, resulting it to be no longer symmetric. Hence an internal electric field is developed due to net polarization.

V. WORKING OF MODEL

The footstep power generation works on the fundamentals of piezoelectric effect. Piezoelectric effect is the capability of certain materials to generate electric charge when subjected to mechanical stress. Electricity flows through crystals when they are squeezed. In piezoelectric crystals cells are not symmetrical. Piezoelectric crystals are electrically neutral under normal conditions. The structure gets deformed whenever squeezed or stressed, resulting in a net dipole moment which causes electric charges to appear. The net positive and negative charges get accumulated on the opposite faces of the crystal. Even though the charges in a crystal of piezoelectric material are not symmetrically arranged, they are perfectly balanced. Squeezing the crystal causes misbalancing of the charges resulting in the production of an electric field which generates voltage.

VI. HARDWARE IMPLEMENTATION

The schematic diagram of hardware setup is as shown in the figure. Main function of a piezoelectric crystal is to convert stress, pressure or strain into electrical energy. Stress can be produced by the weight of the person stepping on the piezoelectric tiles. Combination of a few piezoelectric sensors is use to overcome the low output voltage which would be generated by a single piezoelectric sensor. The connection can be either a parallel connection or a series

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connection or a combination of both the types. The generated output of the piezoelectric material is not controlled, which leads to the use of a voltage controller that converts variable voltage into linear voltage. AC ripples can be reduced using an AC ripple neutralizer which consists of a rectifier and a ripple filter.

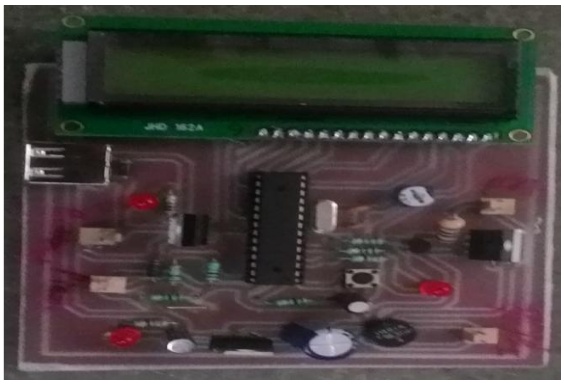

FIG. 1 PCB Connections

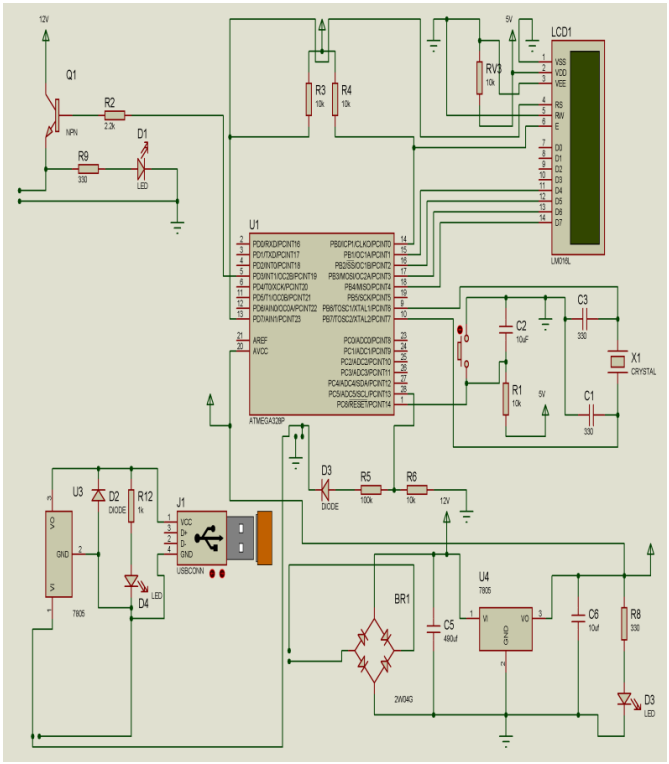

FIG. 2 Circuit Diagram

A. Piezoelectric sensors

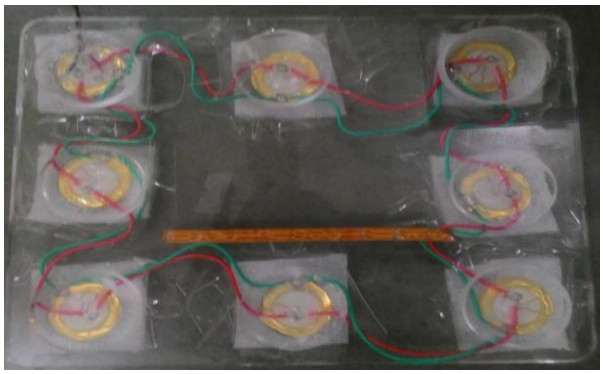

FIG. 3 Piezoelectric Sensors

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A piezoelectric sensor is a transducer that uses the piezoelectric effect to convert the measured pressure, strain, acceleration or force into an electrical signal. When a mechanical stress or pressure is applied, an electric field is induced on the material causing a voltage appearance resulting in the subsequent current flow.

B. ATmega328

ATmega is a 32k microcontroller having an AVR advanced RISC architecture. It's a 28 pin package. ATmega 328 has various advantages over other microcontrollers like high performance, low power consumption design and 131 instructions and executed in a single clock cycle with two cycle multiplier. Memory of this microcontroller includes 1kb of EEPROM, 32kb of programmable FLASH, 2kb of SRAM, 10,000 right and erase cycles for FLASH and 100,000 for EEPROM. It provides programming lock for software security. Its peripheral features consist of two 8 bit Timers/ Counters which includes separate Prescaler and Compare mode. Also it has one 16 bit Timer/Counter with a capture, compare and separate prescaler mode. It has separate oscillator for real time counter and 6 PWM channels.

VII. WORKING

Through a step down transformer, power is supplied to the bridge rectifier to convert AC supply into unidirectional DC. With the help of a capacitor, the ripples or distortions are removed giving a 12V DC supply to a voltage regulator. The purpose of using a voltage regulator is to convert 12V DC into 5V DC which is required for the further working of the circuit. With the help of a 16Hz crystal, required frequency is generated due to the oscillators present inside the crystal. The ripples and distortions are reduced by the capacitors across the crystal. A push button is connected in the circuit to reset the microcontroller. The piezoelectric sensors sense the mechanical input which can be in the form of stress, acceleration, pressure, force, etc. and convert them into an electrical signal. The generated electrical signals are transferred to the microcontroller which converts the signals in the form of a voltage value which is then displayed on a 16*2 LCD along with the step count with the help of an assembly language program. Reset button is used to start the programming from the beginning. A lead acid battery is connected in the circuit which is charged due to the generated voltage and stores the power for future use. A USB connector is presented for charging of mobile phone.

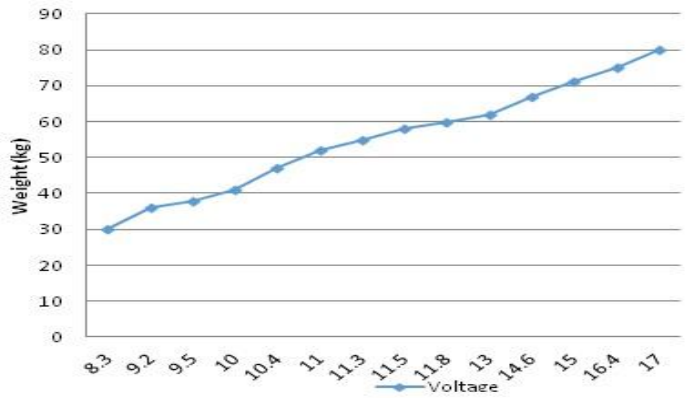

FIG. 4 Weight vs Voltage

VIII.RESULT

The power generated by a single piezoelectric sensor is quite less but connecting various piezoelectric sensors in different connections like parallel, series or the combination of both series and parallel leads to a sufficient power generation. Greater the pressure or the strain being applied on the piezoelectric sensors, greater is the power generated. This power is then stored in a rechargeable lead acid battery which can be used in the future as and when required. The relation between the generated voltage and the weight applied is judged which leads to a conclusion that they have a linear relationship.

IX. APPLICATIONS

A. Pedestrians energy harvesting

The mechanical energy of footstep of pedestrians producing pressure on the piezoelectric board during the day can be used to light the street lamps at night. An effective utilization of energy gives a possibility of achieving an ecofriendly energy source. The piezoelectric elements placed under the streets and roads convert the pressure exerted by the

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vehicles into electrical energy. Since the street lamps and traffic lights on a high way can run on a temporary source of energy, it is very useful. A little vibration can also be stored as power through this technology, since it uses vibrations to attain energy. Thus it creates a difference in energy harnessing as compared to a solar power plant or a wind power generator. Some slums in Brazil are lighted by a British Company named Pavegen. A special soccer field was built in Rio-De Janeiro, Brazil where the kinetic energy of the people running in the field was used to light up the slums. Solar panels and 200 tiles arranged on the field were used to collect energy during the day which were used to power LED lights at night. This example of harvesting the kinetic energy of people running in the soccer field is on a small scale but it can be very useful in the near future.

B. Artificial Basilar Membrane

Attempts are being made by Korea in the field of machinery which has recently developed an Artificial Basilar Membrane resembling the human's part without using any external source of power. It duplicates the cochlea in human ears and is the world's first device to materialize the hearing function. The stimulation of the auditory nerves by the artificial basilar membrane is done by piezoelectric sensors. The Nano piezoelectric element which is trapezoidal in shape is used to separate the frequency through basilar membrane. This generated signal is then used to produce an electrical signal to stimulate the auditory nerves enabling the user to hear the sound through it. This technology creates a new world for different disabled people who are suffering from external cochlea. As it can be implanted in the ear, thus it does not show their hearing disability. The battery can be used for a long duration as the device uses its own energy. In this way piezoelectricity has a valuable contribution in the field of medical science.

X. FUTURE SCOPE

It can been implemented at various stages like stairs of the bus, college, school, railway platforms, elevator entrance, ticket counters, escalators, cinema halls etc. It can be placed in shoes. Energy production in night clubs by the application of piezoelectric effect can be practiced. With the help of ARDINO, it can be used to detect the amount of traffic and switching of traffic lights accordingly.

XI. CONCLUSION

Dealing with the serious issue of energy crisis and use of renewable energy sources is a matter of utmost concern in the present scenario of rapid industrialization and modernization. Hence it is highly mandatory to look out for various alternate renewable energy sources to meet the growing energy demands. This paper contains one such distinguished power generation methodology. The vital aim of the project is to understand the importance of this method. The better understanding about the technique will help us to create awareness of the power generation method to bring a revolution in the world so that no person lives without sufficient electricity. There is a need to bring a change in the perception of energy. The footstep power generation technique is not only ecofriendly but is also reliable, durable and economical, making it suitable and accessible for lower income group people to meet their day to day power demands. The concept of piezoelectric effect gives a chance to use science and technology in daily life by giving an appropriate meaning to the business of energy. The piezoelectric materials has a great scope to expand itself in the field of energy generation when used in a suitable manner. The setup of piezoelectric sensors is especially suitable for areas where there is huge crowd. There is no requirement of long power transmission lines in street lighting if this method of production is used. Saving the energy today will help us to fabricate a better tomorrow.

REFERENCES

[1] T. L. Jordan, Z. Ounaies. "Piezoelectric Ceramics Characterization" – National Aeronautics and Space Administration Langley Research Centre Hampton, Virginia.

[2] Kiran Boby, Aleena Paul K, Anumol, C. V. Josnie Ann Thomas, Nimisha K.K. "Footstep Power Generation Using Piezoelectric Transducer" – Interntional Journal of Engineering and Innovative Technology, vol.3, Issue 10, April 2014.

[3] Miss Mathane Nitashree V., Miss Salunkhe Arati L., Miss Gaikwad Sayali S. "Footstep Power Generation Using Piezoelectric Material" – International Journal of Advanced Research in Electronics and Communication Engineering, vol.4, Issue 10, October 2015.