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A Novel Approach of Generating Electricity using Staircase featuring Piezoelectric Patches and DC Alternator

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Abstract— As we all currently use non-renewable energy sources like coal and petroleum as well as renewable sources like solar, wind, hydro, geothermal, etc. for electricity generation but still, we couldn't overcome our power requirements. In recent times, the necessity for electricity is growing rapidly and the state has arrived when we have to think of generating electricity in each and every possible way. Also, an increased environmental awareness is growing and there is a great demand for efficient and productive designs to involve in our daily routine. The world has embraced this concept by incorporating solar panels, wind turbines, and promoting this limited type of energy source via zip cars. We looking for new ways to generate energy, we will be focusing on harvesting energy from everyday activities which are also eco-friendly and good for nature.

This paper shows a novel approach for harvesting electricity from a commonly used staircase by utilising the energy which is being wasted while climbing the stairs using Piezoelectric crystals and DC alternator with a special gear assembly arrangement.

Keywords— Electricity Generation, Harvesting Energy, Piezoelectric Crystals, DC Alternator.

This paper tries to illustrate how energy can be produced from a regularly used stair step. As the construction of new buildings are increasing to allocate the growing population so does the usages of the steps. Even a small structure these days has more than one floor. While climbing upstairs, we found that a lot of human energy gets wasted in the form of heat and friction but instead of simply letting it go we can harvest that energy. There is a huge prospect of collecting this very energy and generating power out of it by replacing the conventional stairs with Electric stairs [1] [2]. The proper utilization of waste energy which is produced by of human foot is very much pertinent and crucial for crowded nations like ours (India). This paper focuses on the same. By the means of our project we are trying to harvest the energy in two ways, one is the gear and motor arrangement mechanism that takes the staircase power and converts the power to an electrical source, and the other one is a piezoelectric generator placed on the stair which when given a mechanical stress generates a voltage so we can harvest that energy too [3] [4]. The generated power then can be stored in batteries or we can use an inverter circuitry and use it as convention electricity at our household plugs which has an output of 220 volts. The generated electricity will be totally free of cost and it will be used as per our own needs and purposes. It's free of cost eco-friendly energy which is easily useable and as far as we know this is a non-conventional power generation system when we compared it with the prevailing systems.

I. INTRODUCTION

II. MOTIVATION

Authors are trying to harvest the energy from the motion of individuals who are using staircase to travel from one floor to next and then turn it into electricity [5] [6]. Our methodology generates electric power without any adverse impact on environment and is very efficient for use in urban areas. The energy which is wasted by humans while using staircase is utilized in

III. WORKING METHODOLOGY

In this part of the paper we will discuss about how our system works and what is its methodology of working. We are using here two merged methods for harvesting the waste human power.

i) Piezoelectric crystal patches/ plates.

ii) Alternator with gear mechanism assembly.

i) Piezo electric crystals are said to give an output of about 13 volts on an average but after performing experiment practically we found that each piezoelectric plate was providing around 1.3-1.5 volts after the entire processing with sufficient amount of current. so as our project is having 24 individual piezo electric plates so we divided them into pair of 2 where each pair will be interconnected in parallel combination resulting in 12 pairs yielding about 15 - 18 volts as output. We rectify it and pass it through a ripple neutralizer because piezoelectric plates produce AC outputs. Then we pass this voltage through a voltage regulator and filtration circuit which regulates the output voltage to 12 volts and soothes the output preventing it from voltage spikes or fluctuations.

ii) An alternator will act as a second source of produced electricity and it produces directly in DC form. On an average, a dc alternator produces DC output of about 13-15v but with high current, much higher than piezoelectric plates. Our special gear mechanism assembly pays a very vital role here. It's working mechanism is such that irrespective of a push or a pull, it always turns the rotor of the alternation in one direction only. Resulting in continuous dc output. (images to explain the working of mechanism are shown in Fig. 1)

our system and is delivered as output. The energy source is continuous in nature and is renewable. Moreover, we are sanguine that this way of electric energy generation will be used for remote electrification and to fulfil the growing power demand of the world as well. Also, this set-up is very sustainable from an environmental aspect. Our primary motive is to collect as much energy as we can, unrelenting the reliability and safety of conventional stairs.

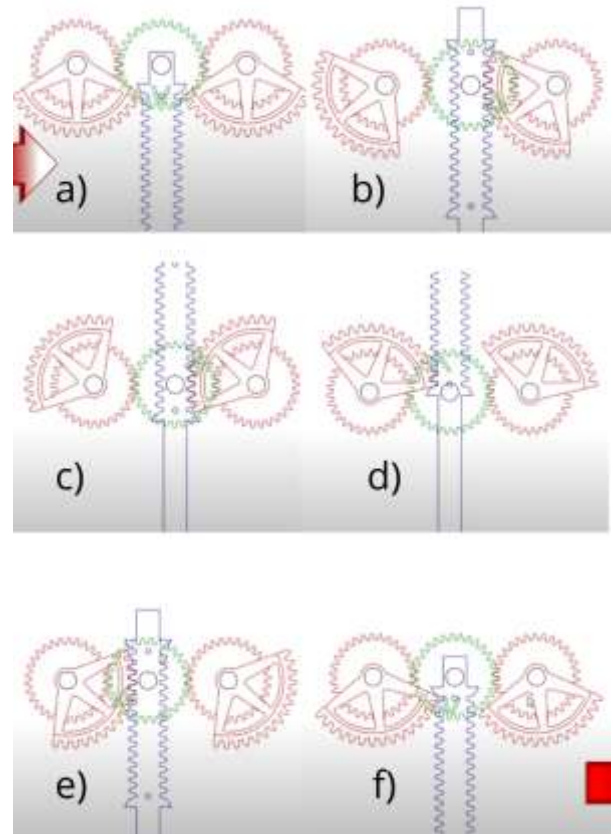


Figure 1. Showing unidirectional motion based rack and pinion gear mechanism assembly.

Then, we regulate the output voltage of Dc Alternator to 12v as we did earlier by using a voltage regulator and filtration circuit and hence now we get clean smooth 12 v output.

So now we have 12V output from 2 sources one from piezoelectric and the other from DC alternator then we merge both of these 12 volts from different sources together by using a merging circuit and hence as a result we get a clean output voltage of 12 volts with sufficient amount of current which can further be used in any form of electricity.

We are by default adding 2 options for the user to use the output from our project, one is 12V DC direct

which will be available in a DC jack and the other option is by having an inverter circuitry. This inverter circuit will convert from 12v volt DC to 220V AC, (same as our home invertors work) allowing the user to connect all 220 v electronics like laptop chargers,

IV. DESIGN IMPLEMENTATION

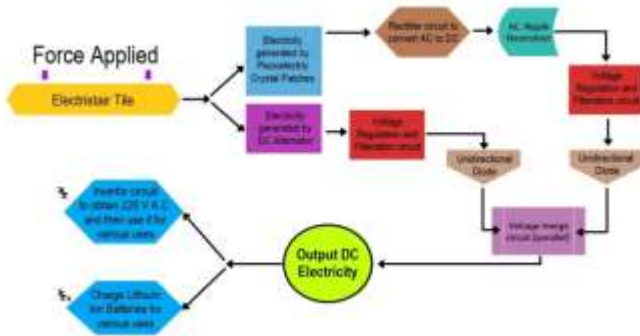


Figure 2. Shows the process of electricity generation using piezoelectric crystal and DC alternator.

V. SYSTEM ARCHITECTURE

Fig. 2 shows the process of electricity generation using piezoelectric crystal and DC alternator. Here we have our 3D modelled concept design in which we can see a part labelled as tile, this tile (where we give the load) is present on the top most portion of our hardware system, bellow that we have attached 24 piezoelectric crystal patches on another plate at the bottom, bellow this plate we have directly introduced the gear arrangement mechanism which is a unidirectional mechanism which means that no mater we push or pull

A. COMPONENTS REQUIRED

Figure 3. shows the 3D model concept design with all parts labelled. This can be explained as:

a) **GEAR ARRANGEMENT:** Here we are using spur gear with rack and pinion arrangement along with: springs, rods, alternator holder clamp, stair tile, and stair base. When stair will be pressed due to someone’s weight while climbing up the stairs then rack will be pushed down which will simultaneously press spring which is connected at its bottom and the teeth of rack will mesh together with those of pinion gears which have approx. half circumference of teeth, enabling the rotor of alternator to rotate in clockwise direction. Once the rack is fully pressed and reaches the bottom, now the real magic of this assembly happens. At present the spring is at it’s full compression, so when someone lifts up his foot from stair spring reverses the rack back to it’s original position but 2nd pinion gear

phone chargers, battery charger modules etc. to work without any cost of electricity.

In this part of the paper we will discuss about our system architecture disclosing all the necessary parts involved in our project that makes possible the harvesting of electricity from stairs.

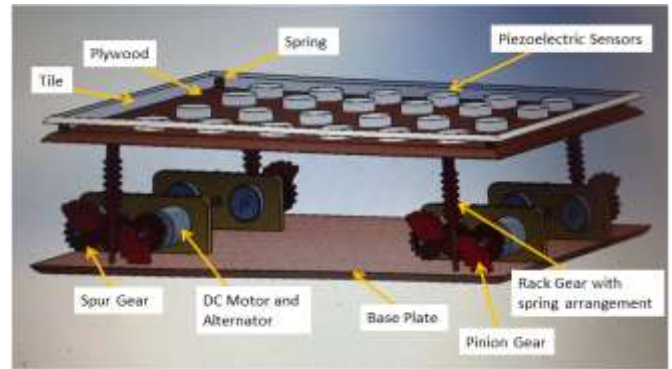


Figure 3. shows the 3D model concept design with all parts labelled.

the tile but in both cases the gears will always rotate in one direction only. In this gear arrangement mechanism, we have rack and pinion gear and spur gear. The lower end of the rack has the spring, and below the spring we have the base plate. With the gear arrangement, we have a DC alternator for collecting the electrical energy from the mechanical energy. You can refer the Figure 3. For going through all the parts which are labelled.

starts to mesh turning the rotor of alter again in clockwise direction rather than anticlockwise [7] [8].

Hence, in short, the gear mechanism allows the motor to rotate in one direction only irrespective of we push down or pull up the stair tile, which as a result produces enormous amount or electrical energy because there are 4 such gear assemblies and 8 DC Alternators [9].

b) **PIEZOELECTRIC CRYSTAL:** Piezoelectric crystal plates or patches are placed in the gap between the top plate and the intermediate tile and are used to convert the mechanical energy into electrical energy by the means of Piezo-electric effect. Piezoelectric Effect is the effect due to which some materials generate an electric charge in response to applied mechanical stress. They are mainly used as sensors of pressure or force for research and development in various industries. Examples of this sensor involve in

aerospace, medical, nuclear instrumentation, and as a pressure sensor it's used in the touch pad of mobiles. In basic terms, they are actually transducers, because they convert energy from one form to another (in this case from mechanical to electrical).

c) DC- ALTERNATOR: A DC Alternator is an electrical energy generator, that converts mechanical energy to electrical energy in the Direct Current form. the rotary motion of the shaft of the alternator produces electricity as an output, and in here we are converting linear to rotary motion to achieve the desired output electricity.

d) RECTIFIER: A Rectifier is an electronic circuit that converts Alternating Current (AC) to Direct Current (DC) at its output.

The process is known as rectification since it will "straighten" the direction of the current.

e) AC RIPPLE NEUTRALIZER: A Ripple Neutralizer is a device that is used to remove the ripples from the output of the rectifier and smoothens the output wave which is received from the filter, and it is constant up to the load and main voltage remains constant. Though, if any of the two is varied, then the received DC voltage at this point will change. For that, a regulator is applied to the output stage.

f) 7812 VOLTAGE REGULATORS: A Voltage Regulator is an electronic device which maintains a constant output voltage at a certain level. For example; a 12-volt voltage regulator will always deliver constant 12-volt as output if the input provided varies between 12 -20 volts. It uses a simple feed-forward design or a negative feedback loop system.

g) FILTRATION CIRCUITRY: The ripple in the signal denotes the existence of some AC component. This AC component will completely remove for to get pure DC output. So, we have to build a circuit that smoothens the rectified output into a pure DC signal. Most of the filtration circuits include capacitors and some basic electronic components.

h) UNIDIRECTIONAL DIODE: A Diode is a simple semiconductor electronics device that basically acts as a one-way switch for current. It allows current to flow easily in only one direction, but mortally oppose the current from flowing in the opposite direction.

i) MERGED CIRCUIT: As we are taking the voltage from the piezoelectric method as well as from gear mechanism, so we require to merged them in parallel combination. This is done by the merge circuit.

j) DC CONNECTOR PLUG: This plug will be at the last after the whole process gets completed. It is used so that user can directly use 12 volts DC if he wants to use it somewhere. For example: for charging batteries for other DC applications etc.

k) CONNECTING WIRES: Wires are necessary part of every system and they are used for electrical connection between various electronic devices.

VI. THEORETICAL CALCULATIONS

One Piezoelectric sensor given electric energy

= 1.3-1.5 volts

1 pair having 2 each connected in parallel give = 1.3 volts but with more current

12 such pairs as there are 24 in total will give us around 15 volts when connected in Series arrangement.

(Then we regulate the output to 12 volts by using a voltage regulator)

On the other hand, we have-

8 DC Alternators connected in parallel give us around 13 volts but with high current.

(Then we again regulate the output to 12 volts by using a voltage regulator)

So, now we got 12 volts each form 2 source. After getting this amount of voltage we marge it in parallel combination and hence we get a constant output of 12 volts with sufficient amount of current.

As per our calculations, one step will produce 12 volts which is able to light up a 3 x 4 matrix led panel for about 10 seconds because the capacitors in the filtration circuit will store some charge and release it gradually. So from here we can think about the amounts of steps on a single tile if it is placed in any building like an institute or a university full of thousands of children. Each day this system will encounter thousands of steps and we can generate enormous amounts of electricity just from staircases.

VII. CONCLUSION

In this paper, we discussed the novel approach of electricity generation from staircase using piezoelectric crystal and DC alternator. The objective of this research work is to generate clean and eco-friendly

electrical energy without compromising the reliability and safety of traditional stairs. The main motive is to trap the energy of people which is being wasted while using the stairs and after it's processing which we have shown in design implementation section, we get smooth 12 volts output which can be utilised as per any electric requirements. The energy source form each stair is in continuous and renewable form. Moreover, it ensures that this method of power generation will be beneficial for rural electrification and fulfil our power requirements of future cities. Now, we are looking forward to place our model at busy places such as university campuses, shopping malls, railway stations, bus stations, and the major substations where people make lots of crowds while they use to go up and down through the staircase. This approach will provide a lot of free generated electricity to consumers and full their daily requirements such as travelling on electric scooters, charging batteries, lighting up corridors etc.

VI. ACKNOWLEDGEMENT

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