Design and Fabrication of Power Generating Treadmill

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Abstract

This paper aims to take advantage of treadmill's wasted electrical energy during a person's workout and utilize the energy for charging electrical appliances. The energy expended on a treadmill during the exercise is all wasted. In order to take advantage of the wasted energy, it could be harnessed by a power generator and stored in a battery bank. The electrical energy generated during the exercise on the treadmill could be utilized to power electronic devices and appliances. The attached power generation machine will not interrupt a person's workout flow and it can be attached to any treadmill due to its friendly design. Wasted energy is harnessed in this research by a non-traditional manner of using shaft and wheel method. A multi-meter is used to measure the voltage and current and power is then calculated from the readings recorded. Tests have shown that the prototype machine is able to fully charge a 3096 mAh smartphone in 135 minutes and the phone could be fully charged for 2 charging cycles. This power generating machine is showing a good implementation for the Sustainable development Goals (SDG's).

Keywords: Energy harvesting; Power generator; Treadmill; Using wasted energy

1. Introduction

The Every day, there is a noticeable rise in energy demand. Traditional energy sources, such as fossil fuels, are having long harmful influence on the environment. A theoretical model of an Energy Generating Gymnasiums System (EGGS) that can reuse and transform wasted energy has been presented [1]. The purpose of this power generating treadmill is to utilize an energy harvesting system that moves in response to the motion of a treadmill in order to convert the treadmill's kinetic energy into electrical power [2].

Energy harvesting works by capturing little amounts of energy that would otherwise be lost or squandered as heat, vibration, or light. Renewable energy production is becoming one of the best strategies for energy production. Renewable energy production accounts for an estimated two-thirds of total worldwide power generation and is predicted to more than double by 2040. This increase is

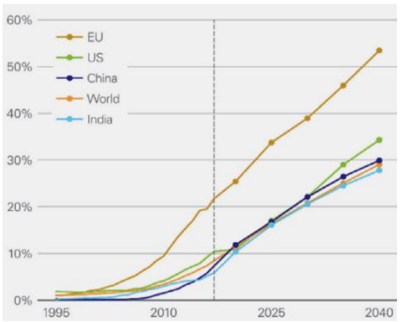

Fig. 1 Glimpse of energy future [3]

regarded seriously as a target to cover at least 30% of total utilized energy [3]. Figure 1 is showing the glimpse of energy future.

Three types of harvesting system are considered for this paper.

Piezo electricity is the charge that builds in certain solid materials (such as crystals, ceramics, and biological matter like as bone, DNA, and different proteins) when mechanical stress is applied [4].

The effect occurs when a ferro-electric material is subjected to a direct application of any kind of mechanical force or when a mechanical force is generated in response to the application of an electric field. Ferro-electric materials' molecular structure displays a local charge separation known as an electric dipole. When an electric potential is applied, the lead zirconate titanate crystal vibrates, producing an indirect effect. PZT is composed of two types of materials: soft and hard [5]. The piezoelectric effect takes place whenever a ferro-electric material is subjected to a direct application of any kind of mechanical force. Piezoelectric materials are a subset of the larger family of ferro-electric materials.

Mechanical energy conversion devices, such as electromagnetic harvesters, are gradually replacing battery-powered electronic devices [6]. The conversion of the mechanical energy that is being harvested into electrical energy is accomplished by a method known as electromagnetic energy harvesting. According to Faraday's law, the amount of electromotive force that is produced by a circuit is directly proportional to the time that passes before there is a change in the magnetic flux linkage that is contained inside the circuit.

Electrostatic converters are capacitive devices that transmit energy when the plates of a variable capacitor separate or the area of the plate changes in response to external mechanical energy [7]. The variable capacitor is the heart of the electrostatic energy harvester; it exploits a change in capacitance to generate a voltage or charge rise in the harvesting device. They are classified into two general categories: continuous charge and constant voltage [8].

Electrostatic harvesting has been found to offer the least amount of complexity, lowest energy density, and smallest integrated current size compared to other energy harvesting techniques [9]. Because of this, it is the most applicable to real-world situations and offers the best potential for long-term power production.

2. Methodology and Experimental Setup

Electromagnetic energy harvesting has been chosen as the energy collecting principle. The treadmill machine generates power by translating the horizontal motion generated by gym exercise to rotational motion [10]. A technical drawing of a redesigned conceptual design for a power generating treadmill machine is proposed in this paper. The final modified design is more comprehensive and feasible in terms of achieving all the objective goals. SOLIDWORKS software has been used to create the detail drawings for the final design in Figure 2.

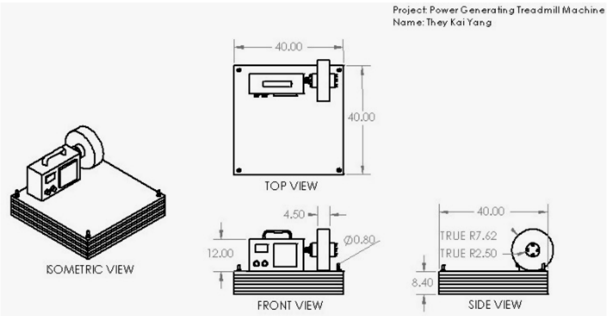

Fig. 2 Isometric and orthographic of the prototype

A functional prototype of the power generating treadmill machine has been fabricated. The generator will be mounted on a base, with a wheel coupled to it through a shaft. The coupling is transferring the rotational motion from the wheel to the generator shaft, which will generate the electrical energy. wooden planks have been chosen to fit the weight requirement and height of the power generator.

Fig. 3 Completed prototype of power generating treadmill machine

Figure 3 shows the completed prototype of the power generating treadmill machine. The experiments have conducted at three different speeds (5km/h, 7km/h, 9km/h) that an average human is comfortable for walking, jogging and running on.

3. Result and Discussion

Tests are conducted on the designed treadmill generator at three different speeds that an average human is comfortable running on. No load is used in the first set of experiments, and the three comfortable speeds used are shown in Table 1.

SPEED 1	SPEED 2	SPEED 3
5km/h	7km/h	9km/h
Slow pace	Medium pace	Fast pace

Table 1 Experimental Criteria

The result of the experiments from speed 1 to speed 3 has been recorded and presented in Figure 4.

3.1 Result of Voltage Generated for Three Speeds

Figure 4 is showing the voltage generated. The readings of the multi-meter have been taken after the treadmill was ran for 5 minutes to ensure stability. The voltage readings for 5km/h, 7km/h and 9km/h have been repeated three times and averaged out to reduce inaccuracy in the final value of voltage.

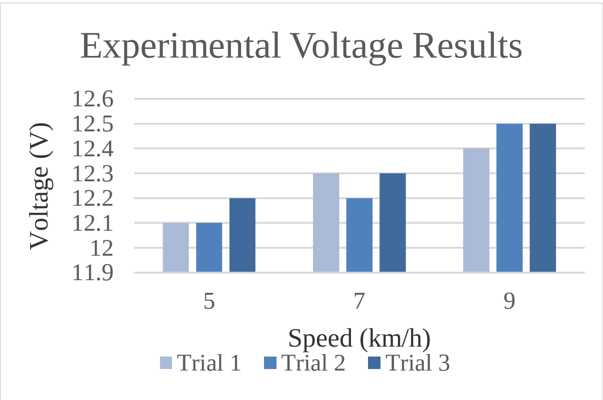

Fig. 4 Graph of experimental voltage results

3.2 Results of Current Generated for There Speeds

Figure 5 shows the experimental current generated by the power generator. The current readings for 5km/h, 7km/h and 9km/h are repeated three times and the results were averaged out to reduce inaccuracy in the final value of current. Figure 5 is showing the overall results of the experimental current generated.

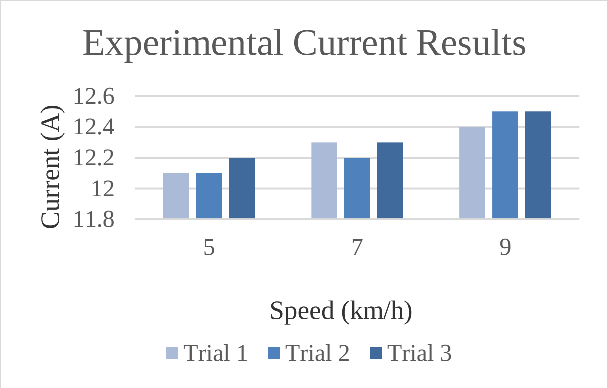

Fig.5 Graph of experimental current results

3.3 Results of Power Generated for Three Speeds

To obtain the value for power generated for the three speeds, the average value from the voltage and current output are used. The value of power in Watts are obtained by using the equation below.

$$P = I \times V$$

Figure 6, shows the results by calculating the average voltage, current and power generated at the three different speeds.

From Figure 6, it can be observed that the power generated from the power generating treadmill machine increases as the speed of the treadmill increases. From this observation, it can be concluded that power generation is directly proportional to the speed of the treadmill. Figure 6 shows the relation of power generation and speed of the treadmill.

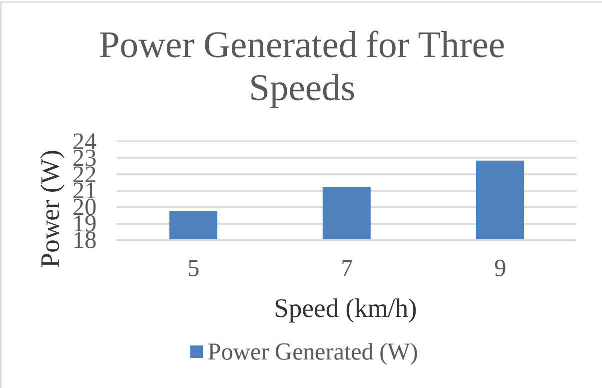

Fig. 6 Graph of power generated for the three speeds

3.4 Application of the power generating treadmill machine

Fig.7 Prototype charging a smart device

For the application of the power generating treadmill machine, the machine is charged fully by the treadmill. A smart device is then connected to the machine via a USB cable using the 5V USB port. Figure 7 shows the machine charging a smart device.

Time (minutes)	Battery Status of Smart Device (%)
0	0
15	15
30	31
45	43
60	55
75	68
90	80
105	90
120	95
135	100

Table 2 Table taken to fully charge a smartphone

According to the results of the conducted experiments, a smart device with a battery capacity of 3095mAh may be fully charged in 135 minutes using a 5V USB port in Table 2. When compared to a standard wall socket power point, the speed is regarded to be slower. The power generated by the prototype is a green energy that harvests wasted mechanical energy from the treadmill.

The lithium batteries utilized in the prototype have a capacity rating of 6600mAh. It is theoretically possible to charge a smart phone with a 3095mAh battery capacity to full battery capacity for 2.13 cycles.

4. Conclusion

A working prototype has been fabricated for the treadmill power generator to demonstrate the concept. Using wheel and shaft mechanism have reduced the intricacy of building the prototype. By incorporating the power generating treadmill machine into the gym, the user may charge their phone or power up any home appliances using waste energy conversion. Experiments at different speeds have shown that the proposed system can charge a smartphone of 3069mAh from 0% to 100% in 135 minutes, which is still within an acceptable time range. It delivers affordable and cost-effective energy to power electric appliances.. Aside from that, it does not affect the environment due to its zero-fuel input and zero greenhouse gas emissions which shows a good implementation of the SDG's.

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References

[1] Musharraf, M., Iqbal, F., & Saleem, I. (2018). Energy Generating Gymnasiums Machines for Renewable, Sustainable and Green Energy. International Research Journal of Engineering and Technology.
[2] Shingare, P. v, Somvanshi, V. B., Tore, T. P., & Sonawane, V. K. (n.d.). Gym Power Generation Mechanism (Vol. 4).
[3] Yahya, K., Salem, M., Iqteit, N., & Ahmad Khan, S. (2020). A Thermoelectric Energy Harvesting System. In

Renewable Energy - Resources, Challenges and Applications. Intech Open.
[4] Ravi Shekhar, & Prakash Kumar. (2019). Design and Analysis of Piezoelectric Energy Harvesting Systems.
[5] Adhithan, M. A., Vignesh, K., & Manikandan, M. (2015). Proposed Method of Foot Step Power Generation Using Piezo Electric Sensor. International Advanced Research Journal in Science, Engineering and Technology.
[6] Georgiev, N. P., & Raychev, R. P. (2020). Study of four-spring electromagnetic harvesters. IOP Conference Series: Materials Science and Engineering, 878(1).
[7] Aljadiri, R. T., Taha, L. Y., & Ivey, P. (2017). Electrostatic Energy Harvesting Systems: A Better Understanding of Their Sustainability Electrostatic Energy Harvesting Systems: A Better Understanding of Their Sustainability. Journal of Clean Energy Technologies, 5(5), 409–416.
[8] Elliott, A. D. T., Miller, L. M., Halvorsen, E., Wright, P. K., & Mitcheson, P. D. (2015). Which is better, electrostatic or piezoelectric energy harvesting systems? Journal of Physics: Conference Series, 660(1).
[9] Marzencki, M. (2005). Vibration energy scavenging. European Commission research Project VIBES (IST-1-507911) of the 6th STREP Framework Program.
[10] Kumar, M., & Mundada, G. S. (2007). Energy Harvesting from Gym Equipments. International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering ISO, 3297, 2321–5526.

Authors Introduction

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