Thermoplastic polymer track with gearing mechanism to harvest green energy for sustainable development

Sajid Hameed Siddiqui[1], *Ramesh* Chandra Nayak[2*,3], *Huzaifa* Fidvi[4], *N. H.* Khan[5], *Mahesh* Vasantrao Kulkarni[6], *Pratik* C. Ghutke[7] and *Manmatha* Ku. Roul[8]

[1]Department of Mechanical Engineering, Anjuman College of Engineering and Technology, Nagpur-440001, India.
[2]Department of Mechanical Engineering, Synergy Institute of Technology,Bhubaneswar-752101, Odisha, India.
[3] Post Doctoral Fellow, iHub Anubhuti-IIITD Foundation. New Delhi-110020, India.
[4]Department of Mechanical Engineering, Anjuman College of Engineering and Technology, Nagpur-440001, India.
[5]Department of Mechanical Engineering, Maulana Azad College of Engineering & Technology, Patna, Bihar, India
[6]Department of Mechanical Engineering, Dr. Vishwanath Karad MIT World Peace University, Pune-411038, India.
[7]Department of Electrical Engineering, Tulsiramji Gaikwad Patil College of Engineering and Technology, Nagpur-441108, MS, India.
[8]Department of Mechanical Engineering, GITA Autonomous College, Bhubaneswar, Odisha, India

Abstract. Consumption of energy and its demand is increasing constantly. There are various ways to generate energy. Non-renewable energy sources are in high demand, which causes harmful effects on the atmosphere. So environmentally friendly energy sources are very much required. Recently various researchers have been working towards green and environment friendly renewable energy causes. Energy generation from renewable sources, India is within top five position throughout the world. Support towards enhancement of energy generation by renewable sources has been declared by our Honourable Prime minister. The present work deals with a designed model to generate electricity by utilizing energy from footstep movement and vehicle motion. The designed model consists of a gearing mechanism, lever, and thermoplastic polymer track attachment. Thermoplastic tracks are easy to use because of their easier attachment and smooth surface. It is required to attach our designed system in places where maximum mobility of people and vehicle motions is possible. Generally, the places are national highways, temple roads, mall areas, etc. Due to movements on the track, the pressure energy of the foot and vehicle wheels transfers to rotational energy through the gearing attachments of our designed system. This rotational energy is utilized to rotate the armature of the generator to generate electricity and that electricity is stored in the battery for utilization on demand. The lever arm and thermoplastic track are placed with a 10 mm gap so that when load is applied on the track, the thermoplastic will deflect and the load will be

* Corresponding Author: rameshnayak23@gmail.com

transferred to the lever. Due to the provision of a gearing mechanism in our designed system, less input on the track will produce the required rotation of the generator shaft. Natural walking on the track to harvest energy without disturbing the body is very suitable for the stability of this designed system due to the provision of thermoplastic tracks.

Keywords: Energy, path, model, technology, environment, gear,

1 Introduction

Energy is one of the most important requirements for all. Energy to fulfil the demands of large-scale requirement and for small scale requirements. Large scale deals with Kilowatt (KW) and Mega watt (MW). Small scale deals with Watt (W) and mill watt (mw).Number of methods are there to harvest energy, but the method to harvest energy to fulfill the requirement without creating any problem towards environment is a great achievement. For this reason, researchers are attempting towards sustainability energy harvest. Oguntosin et al. [1] offered a piezoelectric based model to produce electricity, their model was suitable to store energy from the pressure generated due to movement, from their work it was found that the designed model is suitable for powering small devises in remote areas where there is no chance of electricity provision.Verma et al. [2] presented a model, that works with help of piezoelectric and turboelectric generator arrangements, their designed model is suitable for harvesting energy from body motion. Due to hybrid arrangement, it was found that their system is suitable for producing electricity with low cost and with wide range. Sobianin et al. [3] presented an experimental set up, that setup is along with energy harvester and analyser. From their study, it was found that analyser arrangements along with their designed system is providing the characteristics of harvested energy. Their study was also deals with theoretical validation. Linganiveth et al. [4] presented the possibility disadvantages of non-renewable resources. To solve these issues they have developed an energy harvester that works to produce electricity from piezoelectric effect. From their work it was found that their intended form is suitable to generate electricity from pressure energy. Yang et al. [5] presented a pneumatic operated piezoelectric model to generate electricity, from their work it was found that the pressure parameter is one of the most important parameters towards magnitude of energy harvest. Maximum pressure to the system results minimum voltage and minimum pressure results more voltage. Durgadevi et al. [6] presented a model to generate electricity by utilizing waste energy from foot step. They fixed their model to various places where there was maximum movement was occurred. From their work it was found that energy harvesting from these ways are towards green environment and sustainability. Ahmad et al. [7] studied on low frequency energy harvester to generate electricity from flexible piezoelectric energy harvester model, it was found that there designed model is suitable for generate electricity from frequency level 5 kHz to 7 kHz.Callanan et al. [8] presented a model that works with sound pressure generated from thermal system arrangement, it was found that their system was working with low level pumping input to produce high magnitude. Zhou et al. [9] presented a model that works by taking noise energy as input and electric energy as output, their model was consists of piezoelectric beams with magnet, from their work it was found that distance between sound source and the attachment is a most important factor for energy harvest.Ahmad et al. [10] presented a model for harvesting energy from human traffic. The harvested energy can be used to power cell phones and emergency lights, their designed model demonstrated the possibility of electric energy by applying low pressure on piezoelectric material. They also highlighted that their designed model is towards green

technology innovation. Palosaari et al. [11] presented a piezoelectric energy harvester along with circular diaphragm, from their study it was found that pre-processing techniques are an effective way to improve the efficiency and performance of this type of piezoelectric harvester, which could potentially power a variety of mobile devices and sensors in future applications.Jamil et al. [12] studied on green energy harvest method by designing a model to convert vibration energy to electric energy, their work was based on design analysis of capacitance, frequency, and electromechanical evaluation to determine the capacitance matrix, natural frequencies of the various modes, in their work the displacement was induced by the moving mass, load distribution, and pressure distribution. Linganiveth et al. [13] studied on generation of electrical energy by green waves depends on the charge applied to the sensor. It found that the load on the sensor depends on various factors, including the pressure exerted on the pad area by the pressure of the material on the beam. The advanced hybrid ground plane ensures cost-effective, green and sustainable power transmission and promotes sustainable development.Nayak et al. [14-24] studied on sustainability towards green environment. Donelan et al. [25] established that considerable electricity generation with little extra attempt invent this method which is very much compelling for prosthetic limbs power momentum as well as varied conveying scientific apparatus. Rome et al. [26] studied by experiments on a rucksack of suspend forces that convert material power. The identical is carried through straight operation of supporting strength (measuring 20 to 38 kgs) to electrical energy for the phase of standard on foot (produce till 7.4 W, else 300-fold raise over preceding shoe devices (20 mW)]. The author also expected and mentioned upon inherent metabolic reserve (against with elongated sturdy rucksack support) is important for the stage of electrical energy production.The present work deals with a intended model to produce electricity by utilizing energy from footstep movement and vehicle motion. The designed model consists of a gearing mechanism, lever, and thermoplastic polymer track attachment. Thermoplastic tracks are easy to use because of their easier attachment and smooth surface. It is required to attach our designed system in places where maximum mobility of people and vehicle motions is possible. The pressure energy developed on the track is transferred to rotational energy and that rotational energy is utilised to rotate the shaft of generator for producing electric energy. The best advantages of the designed track with provision of thermoplastic polymer that the track will not disturb the motion.

2 Experimental Set up and Procedure

In this work the designed and development of an energy harvester has been presented, The designed system will generate electricity with the pressure energy of the vehicle motion and movement on the track. The track is made up with thermoplastic polymer, so the displacement due to pressure energy on the track will not disturb to vehicle and human being. So, It is required to attach our designed system in places where maximum mobility of people and vehicle motions is possible.

The figure 1 confirms the total pact of the designed energy harvester; it deals with suspension unit, transmission unit and electric unit. The suspension unit consists of thermoplastic polymer track, ram, lever attached with eccentrically to the pulley. The transmission unit consists of meshed gears, flywheel, bearings and belt and electric unit consists of generator and battery.

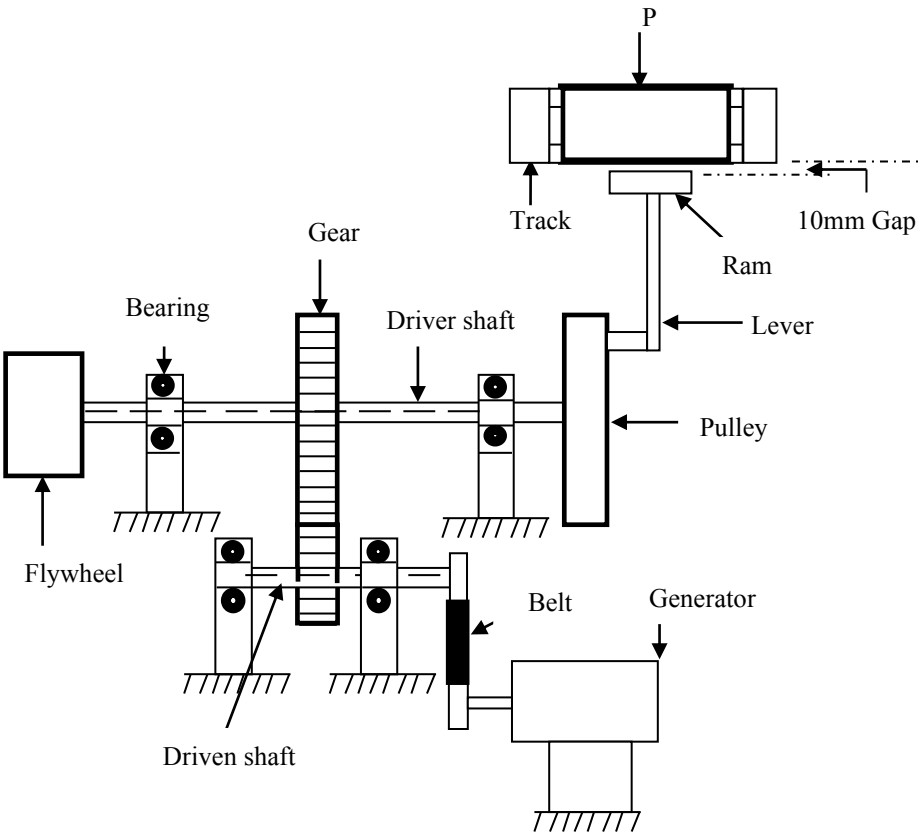

Fig. 1. Experimental arrangement

The thermoplastic polymer track is attached with the walk way. It consists of predominantly aliphatic carbon backbones in which flexible carbon chains which could be extended and rotated into many configurations, which provides flexible nature due to load applied on it. there is a small gap of 55 mm is placed in between the track and the ram, so due to deflection of the track it touches with the ram of the lever, the lever is eccentrically attached with the pulley, the deflection of the ram results to rotate the pulley, the pulley is connected with the end of the driver shaft. A bigger gear is attached at middle of this shaft, so the bigger gear will rotate due to rotation of the driver shaft, another small gear on the driven shaft is meshed with this bigger gear so power from driver shaft shifts to driven shsft through simple train arrangement, power from the driven shaft again transfers to the shaft of generator through belt drive. a heavy circular cross section metal is attached at end of the driver shaft to store energy and release as per requirement, Finally due to rotation of generator shaft emf is developed.
The figure 2 and 3 below demonstrate the mechanism of diffusion system The electric power generator unit contains a generator with specification 12 volt and 2 amperes current, a DC battery with 12-volt 7.2 ampere current and distribution lines.

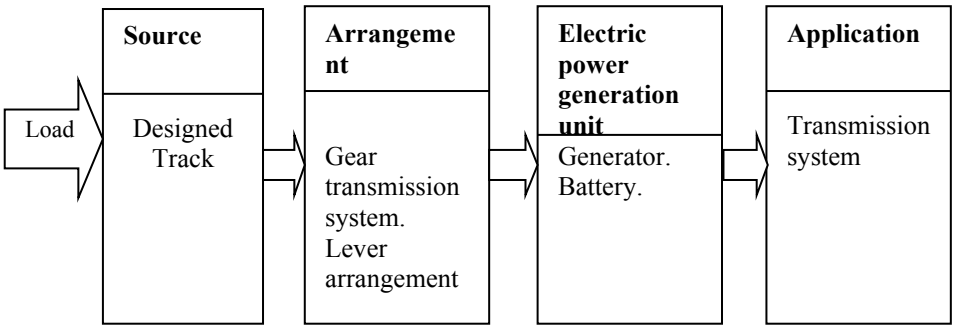

Fig. 2. Production of electricity mechanism

Table 1 below shows the parts dimensions of the designed system.

Table.1. Specification of Parts related with designed model.

Sl. No.	Parts Details	Specification	Extent
1	Balanced device	45 kg	one
2	Gear (Large diameter)	105 teeth	one
3	Pinion (Smaller diameter)	35 teeth	One
4	Strap with rectangular cross section	1520 mm length	One (Flat belt)
5	Carriage	Roller type	Six numbers
6	Generator (Direct current type)	12-volt, 2 amp	one
7	Pathway	2155X350X185mm	one
8	Winch	210 mm diameter	One
9	Battery	12-volt, 2 amp,	One

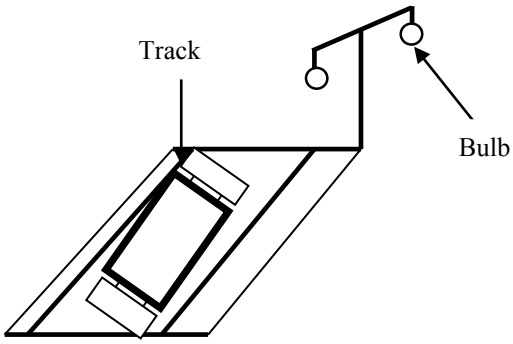

Fig. 3. Arrangement of the track in pathway

The figure 4 below demonstrate the exact designed system, the system consists of all units for harvest electrical energy from mechanical energy.

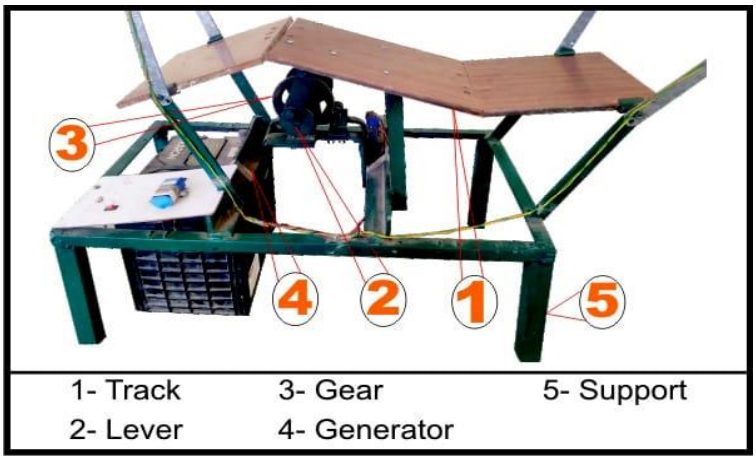

Fig. 4. Exact designed setup

Electricity from the designed model is available by utilizing energy from footstep movement and vehicle motion. An experimental data base has been presented to justify the requirement of output from the system with input. Due to presence of gearing mechanism, lever, and thermoplastic polymer track, the designed model is providing proper output.
Psupply = Input power supply to the designed model (watt)
m = Pathway content in kg = 65kg
S= Displacement of lever in meter = 0.055m
W= Weight = m x g
Work done on the track = Weight of body X Distance=m X g X Distance
= 65X9.81X0.055 Nm
= 35.07 J
Power on the track per step = work done/sec
= 37.76/60 Watts
= 0.629 Watts.

With one step on the track is producing 0.629-watt power, so for approximately 10000 hits 6290-watt power is available per day. The table 2 below shows some output available from the designed model.

Table.2. Technical output from the developed model

Sl. No.	**Constraints**	**Particulars**
1	Unit price in INR	Rs.9500/-
2	Number of strikes on pathway in 24 hours	9000 to 11000 times
3	Induced voltage per step	6 volt
4	Power on the track in 24 hours	5840W/day
5	Consistent load in kg for single load	65kg
6	Regular current	1.3m-amp
7	Total Strike required to charge battery	8200 steps
8	Battery charging time	7 hours
9	Generator armature speed	520 revolution per minute

From experimental work, it was originate that the designed model is suitable to harvest energy from maximum possibility footstep movement and vehicle motion places. The designed system is performing best with less input on the track due to presence of gearing mechanism and lever attachments. From one designed track, it found that 60watt power is possible. This output energy can help to generate electricity to fulfill the demand.

3 Conclusion

- The presented model is suitable to charge a 12-volt battery within 6 to 7 hours. Due to presence of lever and gearing arrangement, the design system is working with less input and producing maximum rotor speed at generator.
- One unit of the designed module is found to be appropriate for supplying 60 watts of power, which aids to light a 5 watt LED bulb for 8 hours, the important aspect is the total significance of using clean and green means.
- Designed model is for electric generation by movement of human being and vehicles on the track, so movement of human being is psychological benefit.
- This level of technological readiness has allowed the development of commercially useful human energy harvesting systems based on various arrangements and storing this energy for various requirements.
- The requirement for manufacturing of this designed system is very easy, so such idea will help the young minds towards entrepreneur. .
- The model indicates the real force of each manual effort. A technocrat's summary view of the technological realm can be very open-ended and lead to the goal of a sustainable Earth.
- Our designed system provides high electromechanical conversion efficiency due to provision of gearing and lever mechanism.

4 Acknowledgments:

Support for this study was provided by iHub Anubhuti- IIITD Foundation", New Delhi and laboratory support for this work was by Synergy Institute of Technology, Bhubaneswar, Odisha.

References

1. Oguntosin, V., Ogbechie, P.T. Design and construction of a foam-based piezoelectric energy harvester (2023) e-Prime - Advances in Electrical Engineering, Electronics and Energy, 4, art. no. 100175,
2. Verma, P., Naval, S., Mallick, D., Jain, A. Hybrid Piezoelectric-Triboelectric Biomechanical Harvesting System for Wearable Applications (2023) IEEE Transactions on Circuits and Systems II: Express Briefs, pp. 1-1.
3. Sobianin, I., Psoma, S.D., Tourlidakis, A. A hybrid piezoelectric and electrostatic energy harvester for scavenging arterial pulsations (2023) Materials Today: Proceedings, 93, pp. 16-23.
4. Linganiveth, S.G., Amrudha Harshan, P.R., Shyam Sittharth, E., Abhilash, R., Umesh, M.V., Hariharan, J. Biomechanically Sourced Hybrid Energy Harvester - Towards a Sustainable Environment (2023) Proceedings of the International Conference on Intelligent and Innovative Technologies in Computing, Electrical and Electronics, ICIITCEE 2023, pp. 932-937.

5. Yang, C., Shi, W., Chen, C., Gao, Y., Wang, H. Design and Experimental Investigation of a Novel Piezoelectric Energy Harvester in Pneumatic System (2022) Energy Technology, 10 (6), art. no. 2200096, .
6. Durgadevi, S., Anbazhagan, R., Harini, R., Vimonisha, A. A Review of Performance Optimization of Footstep Energy Harvester (2022) 2022 International Conference on Communication, Computing and Internet of Things, IC3IoT 2022.
7. Ahmad, K.A., Sulaiman, S.N., Abdullah, N., Osman, M.K. A cavity structure based flexible piezoelectric for low-frequency vibration energy harvesting (2020) Advances in Science, Technology and Engineering Systems, 5 (5), pp. 1042-1049.
8. Callanan, J., Nouh, M. Standing-to-traveling wave transition in piezoelectric thermoacoustic energy harvesters (2019) Proceedings of SPIE - The International Society for Optical Engineering, 10967, art. no. 109671G, .
9. Zhou, Z., Qin, W., Zhu, P. Harvesting acoustic energy by coherence resonance of a bi-stable piezoelectric harvester (2017) Energy, 126, pp. 527-534.
10. Ahmad, N., Rafique, M.T., Jamshaid, R. Design of Piezoelectricity Harvester using Footwear (2019) ICETAS 2019 - 2019 6th IEEE International Conference on Engineering, Technologies and Applied Sciences, art. no. 9117314, .
11. Palosaari, J., Leinonen, M., Juuti, J., Hannu, J., Jantunen, H. Piezoelectric circular diaphragm with mechanically induced pre-stress for energy harvesting (2014) Smart Materials and Structures, 23 (8), art. no. 085025, .
12. Jamil, U., Sulaiman, M., Ghafoor, N., Malmir, M., Nawaz, F., Shakoor, R.I. Power Harvesting towards Sustainable Energy Technology through Ambient Vibrations and Capacitive Transducers (2023) 2023 International Conference on Emerging Power Technologies, ICEPT 2023, .
13. Linganiveth, S.G., Amrudha Harshan, P.R., Shyam Sittharth, E., Abhilash, R., Umesh, M.V., Hariharan, J. Biomechanically Sourced Hybrid Energy Harvester - Towards a Sustainable Environment (2023) Proceedings of the International Conference on Intelligent and Innovative Technologies in Computing, Electrical and Electronics, ICIITCEE 2023, pp. 932-937.
14. Technology to Develop a Smokeless Stove for Sustainable Future of Rural Women and also to Develop a Green Environment, Nayak, R.C., Roul, M.K. Journal of The Institution of Engineers (India): Series A, 2022, 103(1), pp. 97–104.
15. An attachment with the hand pump to lift water without any external source, Majhi, A., Das, A., panda, S.,Chandra Nayak, R., kumar Dash, S.Materials Today: Proceedings, 2022, 62(P12), pp. 6755–6758.
16. Design and development of smokeless stove for a sustainable growth, Nayak, R.C., Roul, M.K., Roul, P.D. Archives of Thermodynamics , 2022, 43(1), pp. 109–125.
17. Innovative Methods to Enhance Irrigation in Rural Areas for Cultivation Purpose, Nayak, R.C., Roul, M.K., Sarangi, S.K. Journal of The Institution of Engineers (India): Series A, 2021, 102(4), pp. 1045–1051.
18. Mechanical Concept on Design and Development of Irrigation System to Help Rural Farmers for Their Agriculture Purpose during Unavailability of External Power, Nayak, R.C., Roul, M.K., Sarangi, A., Sarangi, A., Sahoo, A. IOP Conference Series: Materials Science and Engineering, 2021, 1059(1), 012048.
19. Forced Draft and Superheated Steam for Design and Development of Community Smoke Less Chulha to Help Women in Rural Areas, Nayak, R.C., Roul, M.K., Sarangi, S.K., Sarangi, A., Sarangi, A. Lecture Notes in Mechanical Engineering, 2021, pp. 93–102.
20. Nayak, R.C., Samal, C., Roul, M.K., Padhi, P. A New Irrigation System Without Any External Sources (2023) Journal of The Institution of Engineers (India): Series A, 104 (2), pp. 281-289.

21. Fidvi, H., Ghutke, P.C., Gondane, S.M., Kulkarni, M.V., Nayak, R.C., Padhi, D. Advanced smokeless stove towards green environment and for sustainable development of rural women (2023) E3S Web of Conferences, 455, art. no. 02017,
22. Natural convection heat transfer in heated vertical tubes with internal rings, Nayak, R.C., Roul, M.K., Sarangi, S.K., Archives of Thermodynamics, 2018, 39(4), pp. 85–111.
23. Experimental investigation of natural convection heat transfer in heated vertical tubes with discrete rings, Nayak, R.C., Roul, M.K., Sarangi, S.K.Experimental Techniques, 2017, 41(6), pp. 585–603.
24. Design and development of smokeless stove for a sustainable growth, Nayak, R.C., Roul, M.K., Roul, P.D.Archives of Thermodynamics , 2022, 43(1), pp. 109–125.
25. Donelan, J.M., Li, Q., Naing, V., Hoffer, J.A., Weber, D.J., Kuo, A.D. Biomechanical energy harvesting: Generating electricity during walking with minimal user effort (2008) Science, 319 (5864), pp. 807-810
26. Rome, L.C., Flynn, L., Goldman, E.M., Yoo, T.D. Biophysics: Generating electricity while walking with loads (2005) Science, 309 (5741), pp. 1725-1728.