New Treadmill Design for Energy Harvesting

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ABSTRACT: Recently, increasing pollution around the world as a result of the increased demand for energy is an essential and critical issue that people face nowadays. As a result of this, there was an increase and an urgent need to produce electricity from its clean sources. The process of producing clean energy is one of the necessary steps to reduce pollution around the world in addition to the possibility of maximizing the resources of institutions by reducing the depletion of different resources to produce the energy that humans need in various directions. This paper aims to convert the kinetic energy generated from walking and running people into electrical power. It can carry out with a brilliant output by the implementation of a new treadmill system with gears. The idea of this system summarizes by the conversion of human walking force using gears and duplicate the overall rotational speed which connected with a generator to produce electricity. Experiments of the clean energy production carried out using the treadmill system with gears and the electric power generated as a result of walking and running. Also, a comparison between the production of clean energy calculated once using the regular treadmill and once using the proposed system (treadmill system with gears). With applying of the new design of the treadmill system with gears in Sport and Health center with ten machines a 500 kw yearly would obtain from one center which can increase the energy production and reduced the percentage of pollution.

KEYWORDS: treadmill, kinetic energy, electrical power, generator, produce electricity, energy

INTRODUCTION

The renewable energy development beginning in the world traced back to the global warming problems as well as the global oil crisis over the world [1]. Since some studies stated that with according to the result of forecasting, the oil would be in a stable period, and its annual production peak will be around 2040. Also, the natural gas will enter the heyday period, and its annual production peak will be around 2060, which will play a pivotal role in the future energy sustainable development. Furthermore, the coal has entered a high-to-low-carbon transition period, and its direct use and the discharged pollutants would be significantly reduced [2]. Despite these statistics, different countries intend to investigate in the sector of renewable energy production to reduce the percentage of pollution resulting from energy production in its various sources [3]. The definition of energy considered renewable if it comes from natural resource, these renewable sources are either driven by the (sun, wind, hydropower, ocean waves, biomass, direct solar energy) or kinetic energy [4]. Nowadays, and with the development of societies, there is a considerable amount of modern condominiums which spread through the developed cities. These condominiums have different facilities, and one of these facilities is the gym centers. The application of treadmill exercise is more and more extensive and widely used for several purposes [5-7]. Such as utilizing Treadmill to do fitness sports, applying rehabilitative robot basing on Treadmill to rehabilitation medical engineering and the simulation training using Treadmill as the carrier in the process of astronaut training [8-10].

Moreover, treadmills used in addition to fitness purposes, it has been used for energy production [11]. As a result of increasing the electric demand, a significant amount of work made to find a new way to generate electricity [12]. Electricity considered as a significant fundamental indicator for the development of any nation, in the region of South Asia especially in India and with reference of the World Bank IRDA-IDA analysis, there are 21.3% of the people of
India which approximately 298.6 million of people have no electricity [13]. Also, the output power of electricity from the non-conventional source reached for 34.25% of the total electricity production from 2010-2014, as stated in [11]. In Iraq, the production of electricity through the conventional source is 60% of the people demands [14]. Due to the increase in fuel price and the problem of increasing global warming, which affects negatively as a result of the rising number of electrical panels. Production of Electricity from the non-conventional sources increased, and the demand for using green energy have raised. Statistics obtained from Renewable Energy Directorate / Ministry of Science and Technology Iraq gained around 2.6 MW of his electricity production based on non-conventional sources as shown in figure 1.

![Pie Chart](image)

**Figure 1.** Percentage of non-conventional source production in the Ministry Of Science and Technology-Iraq

Some researchers addressed parts of the process of kinetic energy conversion into electric power, as stated in [15, 16]. The authors used the treadmill to produce power by the treadmill design with the existing of the washing machine with a unique design coupled with the treadmill system. The treadmill system provides torque for the washing machine through a connected gearbox. Other researchers [17] have utilized the two-wheel of vehicles for electricity generation. While the others have used the kinetic energy of walking and ruining using footstep [18]. The hypothesis of the proposed project is based on the utilization of the kinetic energy of moving object and convert it into electric power as a green source. This energy produced when people exercise and use the treadmill for walking. To fulfil energy demands, a new model of the treadmill system introduced for more energy harvesting with the same moving speed rate of walkers.

**Design of the Proposed Model**

A device utilized by humans for walking, jogging, and running named as a treadmill system Two types of treadmills available which are: Motorized treadmill machine and Manual treadmill machine, as shown in figure 2.
For the motorized Treadmill, it has a rotating belt driven by an electric motor, the speed of walking belt treadmills controlled as shown in figure 2 B. In this case, the energy consumed from an external source that is the electric energy converted into kinetic energy. Whereas in manual treadmill speed of the belt is governed by the running speed of the human. It does not have electrical connections as the speed rate does not control by the motor as shown in figure 2 A. The manual treadmill machine used with the proposed model in which the speed rate of belt treadmills increased and doubled with the handling of gears. In this paper, a manual treadmill system has been used and re-designed with the addition of gears to increase and double the speed of Pulley with the same speed rate of walkers’ see figure 3.
The structure design of the new Treadmill

The new treadmill design consists of two wheels over which walking belt connected. The rim of wheels combined with a shaft. In which the shaft coupled to the gears and at the end of gears, a D.C. generator is. Six gears with different diameter (100 mm for the small gear and 200 mm for the big gear) which joined as shown in figure 4 which is mounted on generator support to provide mechanical stability.

![Image](image_url)

**Figure 4.** Two-Dimension of New Treadmill Machine

Gear design and calculations

Gears work on the principle of conservation of energy used in speed variation, force variation, change in direction [20]. With the new design of the Treadmill, the gear system is used to increase the speed with the assist of spur gear. Figure 5 shows the diagram of the gears used in this design.
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Figure 5. Structure Diagram of Used Gear System

The main idea summarized in the utilizing of the different multi-size of spur gears (number of teeth) and mounted together to duplicate the rotational speed of the final gear which connected to a generator. Table A shows the treadmill parameters

Table 1. Treadmill Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>W1</th>
<th>W2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (mm)</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>No of Teeth</td>
<td>24</td>
<td>12</td>
<td>24</td>
<td>12</td>
<td>24</td>
<td>12</td>
<td>24</td>
<td>12</td>
</tr>
</tbody>
</table>

To calculate the rotational speed over the new design is explained as below:

- The average walking speed of a human is 5 km/h which is equal to 27.75 rad/sec for wheel 1 and gear 1 using equation 1

  \[ v = w \cdot r \]  \hspace{1cm} (1)

  \textit{where} : v = \text{linear velocity}; w = \text{angular velocity} ; r = \text{radius};

  Number of turns equals to 265 rpm by applying equation 2

  \[ W = \frac{2\pi N}{60} \]  \hspace{1cm} (2)

- Based on gear principle and applying equation (1), (2) the final rpm at gear 6 equals to 2120
Angular speed has duplicated by controlling the gear which connected. The overall angular speed for the gear which connected to the generator calculated with the applying of equation (2), and the result of total angular speed is (222) rad/sec;

Table (2) shows the overall speed Rad/sec and RPM for different walking and running speed

Table 2. Overall Speed

<table>
<thead>
<tr>
<th>Speed Of Walking [21,22]</th>
<th>Overall Speed (Rad/Sec)</th>
<th>Overall Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Km/Hour</td>
<td>222</td>
<td>2120</td>
</tr>
<tr>
<td>14 Km/Hour</td>
<td>624</td>
<td>5960</td>
</tr>
</tbody>
</table>

Generating system Utilization in the new design of the Treadmill machine

In general, generators classified into two types which are (D.C. generators and A.C. generators). D.C. generator is used for the production of D.C. voltage by rotation of its shaft through the axis of a treadmill belt coupled through a gearbox system [23]. A 250 w, 12-volt D.C. generator and 3.17 mm diameter coupled to a gearbox with a property of constant torque with variable speed and it has no frequency issues governed by NdFeB permanent magnet with Nylon fibre blades [24] as shown in figure 6.

![D.C. Generator 12 Volt](image.png)

Figure 6. D.C. Generator 12 Volt

The Electrical generation system consists of many parts which are used to convert the kinematic energy produced from the walking objects over the treadmill system. With the specification of D.C. generator which used in this prototype as explained above, an Automatic Voltage regulator is also used to enhance the output power and boost convert circuit used. Also, using a battery to charge from the 12-volt D.C. generator and then an inverter is connected to the overall system. In which, Inverter used to convert D.C. volt generators into A.C. volt electricity as shown in figure 7.
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Figure 7. Invertor circuit used in the proposed system consists of the following parameters:

IC CD 4047, Resistors (1, 8, 0.1 K ohm with 0.5 watt), 12-volt rechargeable battery, IRFZ 44 MOSFET and step down transformer 230 primary (12 volt-0-12 volt) 5 Ampere secondary. The invertor circuit built around IC CD4047 which wired as an astable multivibrator. The operating frequency has been set to be 50 H.Z. The power of MOSFET IRFZ44 directly driven by the q and q’ output of CD4047. The power MOSFET connected in PUSH Pull configuration (power amplifier). The MOSFET will switch according to the pulse from CD4047 a stable multivibrator. Thus, A.C. voltage transferred to the primary transformer; it is stepped up to 230 volts.

The inverter output is filtered using capacitor C2 and used a suitable heatsink of MOSFET. As shown in figure 8.

Figure 8. Inverting Circuit Output

Energy Harvesting

The process of energy harvesting with treadmill system summarizes as following:
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- Human walking and running on the treadmill system with spur gears generates a linear velocity which leads to rotate Wheel 2 (W2) and make it rotate with number of rotation (N2).

- Rotation of N2 moved to wheel 1 (W1) through the belt and make (W1) rotate with the number of rotation (N1).

- Wheel 1 connected with a spur gear system which is a compound of six gears mounted together makes the number of rotation at gear 1 has the same number of rotation N1 as below

\[ N_1 \text{ at Wheel 1} = N_1 \text{ at gear 1} \]

- Gear characteristics move the number of rotation through the six gears duplicates the number of rotation at gear 6.

- Generator is coupled through G6 with duplicated number of rotation.

- An automatic voltage regulator used for voltage regulation.

- D.C. voltage into A.C. voltage introduced with using of inventor.

- A.C. voltage generated after the inverting process is filtered, smoothened and transfer it for the use of home appliances when required.

\[ W = 2120 \text{ revolution per minute, as calculated in Table 2} \]

This speed is nearly equal to generate 250-WATT power across DC generator.

Result and Discussion

Energy Harvesting using the new system of Treadmill have conducted practically in the premises of the Applied Mechanic and Electronic Laboratories at the University of Baghdad, AL Khwarizmi College of Engineering, Automated Manufacturing engineering Department. As shown in Table 2 the produced power based on the normal and the new design of the treadmill machine in which the first column represents the different speed rate of the people while the 2nd and 3rd column represents the output power using the treadmill system with and without gears respectively.

**Table 3. Output power produced using Treadmill system with and without gears**

<table>
<thead>
<tr>
<th>Walking Speed (Km/h)</th>
<th>O/P from Treadmill without gears (WATT)</th>
<th>O/P from Treadmill with gears (WATT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8</td>
<td>118.23</td>
<td>180</td>
</tr>
<tr>
<td>3.2</td>
<td>136.27</td>
<td>195</td>
</tr>
<tr>
<td>3.8</td>
<td>162.18</td>
<td>210</td>
</tr>
<tr>
<td>4.2</td>
<td>170.42</td>
<td>250</td>
</tr>
</tbody>
</table>

Results compared to highlight the increase of the produced output power using the treadmill system with and without gears as shown in figure 9
Using the new treadmill system with gears the produced energy is 0.25 kw/h of Electricity per hour which will fulfill the demand of combination of one ceiling fan (60 WATT) and one LED tube light (9WATT) for two hours [25]. Extra energy can be used for charging trimming etc. purposes. Besides the practical calculation for energy harvesting, a simulation process is figured out using Mat lab software [26-28], see figure 10 which is used to test the mathematical calculations of converting the kinetic green energy of walkers into electrical energy.

With the new design of the treadmill machine and with one hour’s running, it can be used to fulfill the essential requirement of a single room up to two hours. So the new treadmill machine design considered as a new way of clean energy.

CONCLUSION
A technique has dwelled in this paper for Electricity Production. Brief outline consequences of renewable energy, a new design of treadmill system, and energy conversion system. As the increasing energy demands in society and due to an increase in the percentage of pollution, a crucial need is increased to implement green energy systems. Using the treadmill system with gears increase the energy harvesting by converting the kinetic energy produced from walking and running and convert it into power. For one sport and health center and utilizing ten treadmill system with gears a 500 kW monthly produced. It can increase the energy production and reduced the percentage of pollution as a result of using a new technique of clean energy production.

REFERENCES


New Treadmill Design for Energy Harvesting


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