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Generation of electricity by running on a leg-powered treadmill

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ABSTRACT: In today's world global warming & other related environmental issues becomes an important matter of concern in the angle of environmental pollution. To tackle this problem we have to decrease our dependence on fossil fuel especially for generation of electricity and increase the use of green-energy or environment friendly method of electricity generation. This paper will discuss about a treadmill which can generate electricity when someone running on its track. Treadmill is generally used for walking or running while staying in the same place. If someone runs on the track of this machine for one hour then it will generate certain amount of electric energy which will be enough to lighting a LED bulb up to 10 to 12 hours.
KEYWORDS– DC generator, Diode, Inverter, LED bulb, Treadmill.

I. INTRODUCTION

A treadmill is a device generally used for walking orrunning while staying in the same place. Treadmillswere introduced before the development of poweredmachines, to harness the power of animals or humansto do work, often a type of mill that was operated by aperson or animal treading steps of a tread-wheel togrind grain.More recently, treadmills are not used to harness power, but used as an exercisemachines for running or walking while staying in one place. Rather than the userpowering the mill, the machine provides a moving platform with a wideconveyor belt (track), driven by an electric motor. The belt moves to the roller, requiring the user to walk or run at a speed matching that of thebelt. The rate at which the belt moves is the rate of walking or running.Thus, the speed of running may be controlled and measured. The moreexpensive, heavydutyversions are motor-driven(usually driven by an electricmotor). The simpler, lighter, and less expensive versions passively resist themotion, moving only when walkers push the belt with their feet. The latter types are known as manual treadmills. The picture of a normal treadmill is given below.

Fig.1 A man running on atreadmill

Here this paper will explain about a manual (leg-powered) treadmill which canmove only when walker push the belt with his feet. But the addition is that there is a certain number of small DC generators, whose moving parts are mechanically coupledor connected with the moving parts of the machine (rollers) which moves when belt of the treadmill is moving. When the rotor (moving part) of the DC generator starts moving or rotating it will produces emf across its output terminals. This generated emf can be used for charging of Battery or other purposes.

II. WORKING PRINCIPLE

All we know about bicycle generator, where a small dc generator is attached to one of the wheel (generally back wheel) of the bicycle. When the bicycle is running, the rotor of the generator which is attached to the wheel of the cycle, also rotates and due to this an emfis generated across the output terminals of the generator. This emf is then generally used for lighting the head-light of the bicycle. The diagram of a bicycle generator is shown below.

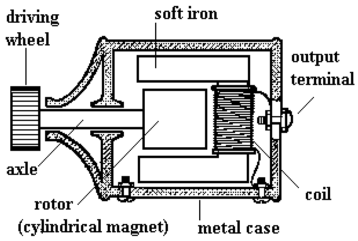

Fig.2 Diagram of a bicycle generator (12V, 6W)

The bicycle generator is relatively small and a small torque is required to make rotation of its rotor. Here, in the treadmill, instead of using one single large generator we use a number of small generators (bicycle generators),electricallyconnected in parallel and mechanically coupled with the rollers of the treadmill.

III. MECHANICAL ARRANGEMENT OF THE TREADMILL

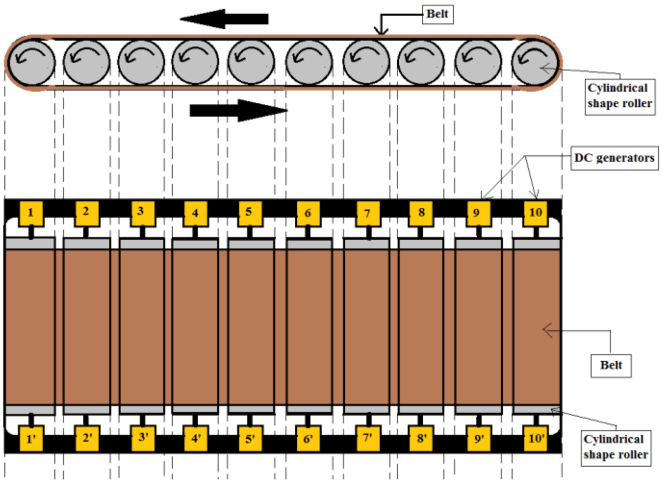

Fig.3 Basic diagram of mechanical arrangement of the treadmill

The full mechanical arrangement of the treadmill is shown in the Fig.3. In a treadmill the track which is generally a belt, is moving on some cylindrical shape of movable parts(or rollers) and those rollers are surrounded by the belt in both upper and lower sides. The each join side (left and right) of the roller is mechanically coupled with the rotor of a small DC generator in such a way that when the roller starts rotating the rotor of the DC generator also starts to rotate.

IV. ELECTRICAL CONNECTION OF THE DC GENERATORS IN THE TREADMILL

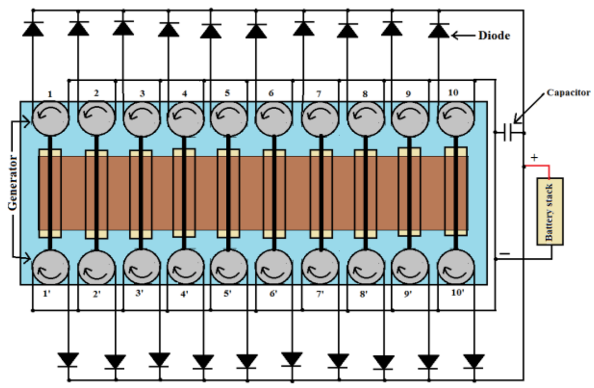

Fig.4 Electrical connection of the DC generators in the treadmill

The electrical connection of the treadmill is shown in the Fig.4. Electrically these generators are connected in parallel with each other but here one thing is that the rotor of each DC generator is rotating exactly in opposite direction with respect to the other DC generator which is connected in opposite side of the roller. For example in Fig.4 the DC generators 1, 2, 3……etc. are rotating in opposite direction with respect to the direction of the rotation of DC generators 1’, 2’, 3’…...etc. So, the emfs generated by them is also in 180^0 out of phase with respect to the other generator, situated in opposite side of the roller. To eliminate this problem we have to connect 1, 2, 3…... etc. in parallel with the opposite terminals of the parallel connection of 1’, 2’, 3’…..etc. Moreover, we have to connect a diode with the positive terminals of each DC generators. This will prevent them to work as a motor as they are mainly connected to the battery and their main work is to charge the battery not to take energy from it. If for any reason the belt of the treadmill is running in opposite direction then these diodes will prevent the current to circulate in opposite direction. There is also a capacitor connected across the output terminals (shown in Fig.4) to prevent the fluctuations of the DC output voltage and keep it steady-state or at a constant value.

V. CALCULATION

Fig.5 Direction of the forces acting on the treadmill

Here in the above figure (Fig.5),we saw that the force (**F_{total}**) is applied on the track (or belt) of treadmill by the runner, can be divided into two components, one is vertical component (**F_v**) and another is the horizontal component (**F_h**).

$$\vec{F}_{total} = \vec{F}_v + \vec{F}_h$$

Only the horizontal component of the applied force(**F_h**) is responsible for moving the treadmill’s belt.
Now, the average speed of jogging for a normal man is 10 km/h. So, if someone runs with that speed then the belt of the treadmill also runs with that speed. The dimension of a normal treadmill is shown as follows.

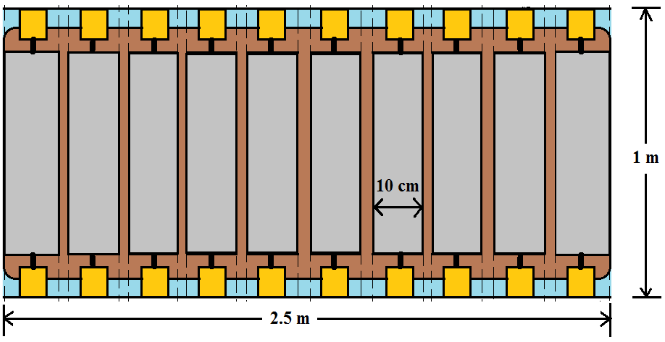

Fig.6 Dimension of a the treadmill

From the above diagram it is shown that the length of the belt is = (2 * 2.5 m) = 5 m (As the belt is surrounded the rollers in both upper and lower sides). So, for one full rotation of the belt a man has to run 5m. If a man running at a speed 10 km/h then in one hour the belt rotates = $(10 * 10^3) / 5$ =2000 times.
So, the speed of the belt rotation is 2000 r.p.h. (revolution per hour) or, (2000/60) = 33r.p.m. (revolution per minute).
Here, the diameter of each roller is = 10 cm.
So, for each rotation of the belt one roller completes = $(5 * 10^2) / (\pi * 10)$ = 16 full rotation. Here, the DC generator’s rotors are coupled with the rollers. So, each generator completes 16 full rotation with one full rotation of the belt. So, the speed of the each DC generator = (16 * 33) r.p.m. = 528 r.p.m.

This speed is enough to generate 6Watt electric power for each DC generator at 12V (output voltage).

Here, in the above arrangement of the treadmill we assume ten rollers which are surrounded by the belt. With each roller two DC generators are mechanically connected or coupled. So, the total number of DC generators is = (2 * 10) = 20.

Thus, the total power generating capacity of this system is = (20 * 6) = 120Watt.If one man run on this treadmill (with average speed of 10 km/h) for one hour then the total electrical energy produced by this system is = (120 * 1) = 120 Watt-hour.

Now, this energy can be stored in rechargeable DC batteries. Once the batteries are charged then we can use this energy for lighting or other purposes. The efficiency of the whole system is vary from 80% to 90%. Let, we see some of its applications.

Suppose we have a 10 Watt LED bulb, then we can lighting this bulb by directly connecting it with battery (or with chopper circuit if needed to adjust the DC voltage at rated value) for (120 / 10) * 0.85 = 10.2 hours (taking efficiency 85%).

We can also lighting a 40 Watt tube light (with suitable inverter circuit) for 3 to 4 hours. In one of my previous paper[1], I discussed about a special type of inverter circuit by which we can directly lighting 40 Watt tube-light without any choke and starter arrangement. Here we can use this inverter circuit for lighting tube-light.

VI. BLOCK DIAGRAM

The complete block diagram of working of this treadmill is shown below.

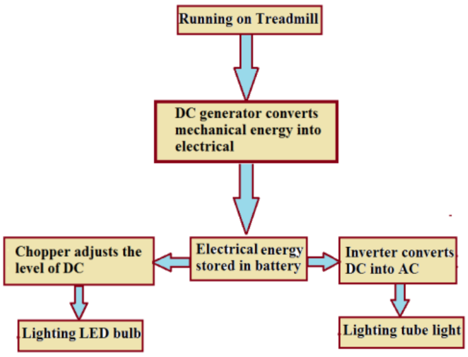

Fig.7 Block diagram of working of the treadmill

VII. CONCLUSION

So, here we saw that if someone runs on the treadmill for one hour then it can generate enough electrical energy by which we can lighting 10 Watt LED bulb for at least 10 to 12 hours. In this case, we store the generated energy in DC battery stack (array of parallel connection of DC batteries). This is one of the eco-friendly method of generating electricity. This method is very suitable for the remote areas where the electricity is beyond the reach of common people.This method can also be usable as a buck-up in load-shedding time.Here the running cost is almost zero and any special maintenance is not required. This treadmill can be easily operated by anyone (even a 10 years old children can run on it easily) as the connected DC generators are small and they require very small torque. The only drawback of this system is that the initial cost of installation is comparatively high. If every house install at least one treadmill of this type and lighting at least one LED bulb by this method then we can reduce a significant portion of our consumption of fossil fuel which is spent for generating electricity.

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Manish Debnath, received B-tech degree in Electrical Engineering from NIT, Agartala in the year 2014 (Enrollment no. **10UEE035**). His research interest includes Power System, Power electronics and Control System.