Design of One Limb Movement Power Generation Device

Yanfang Li, Zhiyin Han, Chengmei Cui
Weifang Engineering Vocational College, Qingzhou 262500, Shandong, China

Abstract. Portable electronic products are playing an increasingly important role in people's lives, but the continuous power supply problem outdoors has increasingly become the bottleneck for its development, moreover, it also often makes people not get a good experience due to inadequate power. In allusion to the above problems, one kind of limb movement power generation device was designed. This device is composed of crank and connecting rod mechanism, speed-increasing gear set micro-generator and so on, and it converts the kinetic energy of human movement into electrical energy, stores electrical energy to storage battery or directly supplies for electronic products, in order to solve the continuous power supply problem outdoors for portable electronic products, active exploration has been made.

Keywords: limb movement, power generation device, design.

1. Introduction
With the advance of science and technology, portable electronic products are playing an increasingly important role in people's lives, especially when people go out or conduct outdoor activities; the use of electronic device becomes inevitable. However, due to large power consumption of electronic products and limited storage capacity of batteries, people often cannot get a good experience due to inadequate power. Although the mobile power bank can solve this problem to a certain extent, the mobile power bank is only a large-capacity battery, and its endurance capacity is still inadequate in some occasions. In order to better solve the continuous power supply problem of portable electronic products, this paper has designed one kind of limb movement power generation device, which is easy to wear and can quickly convert the human body's mechanical energy into electrical energy, this device can generate a lot of electricity and can be used at any time, it can continue to provide sufficient power for portable electronic products, moreover, it also reflects the new concept of low-carbon green travel and healthy life.

2. Research Status Analysis
The emergence and development of portable electronic products have enriched and facilitated the people's life, but the continuous supply of their power supply has become the bottleneck for their development. In order to solve the outdoor power supply problem for portable electronic products, more and more researchers have studied on using the mechanical energy of people's daily activities into electrical energy. Cheng Xiuliang and Meng Bo et al. proposes an electrode-free friction generator that obtains energy through friction between the sole and the ground[1], it makes a layer of multi-hole copolymer thin film attached to the sole as friction surface, which can generate about 700V electrostatic voltage. Gabriele Pellegrinelli et al. proposed a human movement energy collection scheme; it installed a small device on the top of the upper by sensing the acceleration of human motion[2], and temporarily
stored electrical energy in the capacitor, which can output 2.4V output voltage value. Li Qiang proposed the power generation by human body movement driving piezoelectric materials to vibrate, and it supply power for the wearable device after the voltage conversion[3]. In general, most of the existing research on wearable devices focuses on the use of special materials and trace electrical energy generated by human body movement, there is a lack of relative research by using mechanical structure and human body movement generate electrical energy, moreover, in addition to the use of mobile power bank at present, the continuous power supply problem of portable electronic products has not been well resolved. Therefore, it is of great practical significance to design one limb movement device that uses the human body's own movement to continuously generate electricity to supply portable electronic products, is convenient to wear, and does not affect people's normal movement.

3. Overall Design Ideas of Limb Movement Power Generation Device

3.1. Functional requirements of limb movement power generation device
In allusion to various problems of current portable electronic products, such as large power consumption, inadequate power supply and power generation products of wearable devices, this paper intends to design limb movement power generation device, it converts the movement energy when people's legs move into electrical energy through the mechanical mechanism. In order to achieve this conversion, the limb movement power generation device needs to meet the following three requirements: 1. it can convert the leg swing into rotary movement, and efficiently drive the micro motor to generate electricity; 2. It is easy to wear, and can adapt to people with different heights; 3. its output electric energy can be directly stored in the storage battery or directly used in portable electronic products.

3.2. Overall design plan of limb movement power generation device
In order to convert the kinetic energy of limb movement into electrical energy, the overall mechanism of limb movement power generation device intends to adopt crank and connecting rod mechanism, the schematic diagram of mechanism is shown in Fig.1. The limb movement power generation device is composed of waist fixing, leg fixing, crank and connecting rod mechanism, speed-increasing gear set, micro-generator and output mechanism. Its working principle: the upper end of limb movement power generation device is fixed to the waist through waist belt, and the lower end is fixed to the leg through strap; the crank and connecting rod mechanism is set between waist fixing and leg fixing, the function of crank and connecting rod mechanism is to convert the swing of leg movement into the rotation of crank, and it can achieve automatic adjustment in accordance with people' different heights and different sports states; the output rotation of crank and connecting rod mechanism drives the micro-generator to rotate to generate electricity through the speed-increasing gear set, the micro-generator is fixed on the waist and connected to the power storage device, and finally the output mechanism transmits the electric energy to the electric device.
4. Detailed Design Plan of Limb Movement Power Generation Device

According to the working principle of limb movement power generation device, this mechanism includes two movement mechanisms: a crank and connecting rod mechanism and a speed-increasing gear mechanism. The design of crank and connecting rod mechanism is mainly to convert the swing when the human body's legs walking and running into the rotation of mechanism, the design of speed-increasing gear set is mainly to further increase the rotational speed transmitted by the crank and connecting rod mechanism, thereby driving the micro-generator rotates to generate electricity.

4.1. The design of crank and connecting rod mechanism

In order to convert the swing of legs when the human body walking or running into rotary movement, the crank and connecting rod mechanism was designed in the limb movement power generation device. The connecting rod in the crank and connecting rod mechanism is composed of upper rod of connecting rod, outer tube of connecting rod, and lower rod of connecting rod, its structural schematic diagram is shown in Fig.2. The upper rod of connecting rod is hinged with the large gear of the first-stage speed-increasing gear, and the large gear also as the crank in the crank and connecting rod mechanism. In order to make the limb movement device can face different heights and different movement states; the connecting rod is designed as retractable structure to achieve automatic expansion and contraction. The outer tube of connecting rod is designed to be hollow tube structure, its upper end is processed with internal threads to connect the upper rod of connecting rod, and the lower end is connected with the upper end of lower rod of connecting rod. The upper end of lower rod of connecting rod is set with boss, and a spring is set on the boss, the lower end of lower rod of connecting rod passes through the shield hinged fixed on the outer tub and fixed with legs. The retractable structural design of connecting rod effectively solves the problem when the connecting rod can automatically adapt to different fixed heights, moreover, it effectively avoids the phenomenon when the crank and connecting rod mechanism is stuck due to different fixed heights.
4.2. The design of speed-increasing gear set
In order to effectively drive the micro-generator to generate electricity and generate more electricity per unit time, the speed-increasing gear set is specially designed; its structural diagram is shown in Fig.4. The speed-increasing gear is divided into two stages; the first-stage gear set includes one large gear and two small gears with the same size, the large gear is an internal gear, the connecting rod swings to drive the large gear to rotate, the large gear drives two small gears set on different shafts to rotate, the small gears are engaged with the large gear; the second-stage gear set includes two same large gears and one small gear, the large gear is coaxial with the small gear of the first-stage gear set, and simultaneously drives the small gear of the second-stage gear set, the second-stage gear drives the micro-generator to rotate. After went through the two-stage speed-increasing gear set, the second-stage small gear output high speed to drive the micro generator work, thereby generating more electricity per unit time.
4.3. Design of electric energy output device

In order to make the electric energy of the micro-generator stored in the power storage device and used for mobile phones and mobile electronic products, the voltage stabilizing rectifier circuit and quick charging circuit are set between micro-generator and power storage device. The current emitted by the micro-generator of the voltage stabilizing rectifier circuit can be converted into the current stored in the power storage device or directly supply power for the electronic device, the quick charging circuit can increase the charging speed of the power storage device.

The power storage device is connected with the output mechanism, in order to adapt to different needs, the output mechanism uses the wired output module and wireless charging module two modules. The battery is set with breaking switch, it automatically cuts off the charging circuit when overcharging occurs after the battery is fully charged; prevents overcharging and overcurrent and reduce the battery life, in order to be easy to use, the breaking switch can also be manually cut off.

The waist fixing also includes one shell, the solar cell is set on the upper surface of the shell, and the solar cell is connected with the power storage device. On the one hand, the set of solar cells can assist limb movement power generation; on the other hand, it maintains a certain amount of electricity in the storage battery, avoids the situation where there is no electricity for use when movement cannot generate power.

5. Conclusion

One kind of limb movement power generation device is mainly introduced in this paper. Limb movement power generation device is mainly composed of waist fixing, leg fixing, crank and connecting rod mechanism, speed-increasing gear set, micro-generator and output mechanism. It uses the crank and connecting rod mechanism convert the leg swing when human body move into the rotational motion of the crank, and then drives the micro motor to generate electricity, then, the energy generated by the generator is stored in the storage battery or directly supplied to electronic products through the voltage stabilizing rectifier circuit and the quick charging circuit. On the one hand, limb movement power generation device solves the continuous power supply problem outdoors for portable electronic products; on the other hand, it also reflects the new life idea of low-carbon green travel and healthy living. Therefore, this design has important practical significance and practical value.
References

[1] Chen X L, Meng B, Zhang X S, et al. Wearable Electrode-free Triboelectric Generator for Harvesting Biomechanical Energy[J]. Nano Energy, 2015, 12(9): 19-25.

[2] Pellegrinelli G, Bau M, Cerini F, et, al. Portable Energy-logger Circuit for the Experimental Evaluation of Energy Harvesting Solutions from Motion for Wearable Autonomous Sensors [J]. Procedia Engineering, 2014, 5 (87): 1230 -1233.

[3] Li Qiang. Research on Wearable Device Power Supply System Based on the Power Generation by Human Body Movement[D]. Shandong University of Science and Technology, 2018.