

A New Intelligent Wheelchair Design Based on Pressure Power Generation and Photovoltaic Power Generation

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Abstract

On the basis of ordinary electric wheelchair, the work adopts the combination of pressure power generation and photovoltaic power generation to improve the endurance of the electric wheelchair. The device adopts the dual technology of pressure and photovoltaic power generation to transform mechanical energy and light energy into electric energy to realize the self-use of wheelchair power; design the solar umbrella to realize the function of efficient capacity and shelter from wind and rain; and use solar energy as driving energy and clean energy to improve environmental protection and low carbon. Use the structure of the wheelchair to optimize the energy management, and supply power to the wheelchair through the battery. By installing solar panels on the side and back of the wheel hub of the wheelchair, the solar controller is converted into electric energy into the battery, and the related functions of the wheelchair are supplied through the battery. The design of this work vigorously responds to the national call of low carbon environmental protection, facilitates the life of users, in line with the requirements of energy conservation and environmental protection in today's society, has a good application prospect, and has a high feasibility and economic benefits, more reflects the humanistic care.

Keywords

Electrical engineering; pressure power generation; photovoltaic power generation; self-production and self-use; low carbon environmental protection; humanistic care.

1. INTRODUCTION

According to the data of the seventh National Population Census and China Disabled Persons' Federation, the number of physically disabled persons in China is 24.72 million, accounting for about 29% of the total number of disabled persons in China; the number of elderly people over 65 in China is 190 million, among which the disabled and semi-disabled elderly population is up to 42 million, and the potential users of wheelchairs are about 19 million. As shown in Figure 3, with the increasing number of elderly people, the number of potential elderly wheelchair users is also expected to exceed 20 million. The demand and use of wheelchairs is also increasing year by year, and it is estimated that the number of wheelchair users is close to 40 million. However, according to the National Research Center, due to many pain points in the function and design of traditional wheelchairs, the actual adaptation proportion of wheelchairs in China is only about 10%.

Table 1. 2012-2017 Electric wheelchair adaptation requirements in China

	Years					
	2016	2017	2018	2019	2020	2021
Quantity demanded	5×10^4	7×10^4	1×10^5	3×10^5	5×10^5	1×10^6
Market quantity	3×10^4	5×10^4	7×10^4	1×10^5	2×10^5	5×10^5
Wheelchair weight	60	59	59	59	59	56

Design a new type of wheelchair energy storage system based on pressure power generation, solve the problems of traditional wheelchair power supply system, improve the use of wheelchair convenience and sustainability, economic benefits will be greatly improved. This system not only meets the needs of users, but also improves the convenience and comfort of users, improves the travel safety of the disabled and the elderly with inconvenient legs and feet, and no longer worries about the short battery life and insufficient charging. With the help of pressure ceramics and photovoltaic power generation to provide electricity not only reduces the dependence of wheelchairs on household electricity, saves energy, reduces the consumption of fossil fuels, and follows the pace of the national promotion of energy conservation and emission reduction. This system combines caring for the elderly with the call for energy conservation and emission reduction, which is of great significance to the development needs of new energy in today's society, and more reflects the humanistic care.

2. DESIGNSOLUTIONS

The system is mainly divided into design ideas, pressure power generation module, photovoltaic power generation module.

2.1. Train of Thought of Design

The system places the pressure generation ceramic sheet in the tire structure by independently designing decompression and damping concave cushion. As shown in Figure 4, when running through the wheelchair, the wheelchair will generate the pressure transformation on the tire to produce alternating current through the rectification module and store it into the battery through the BOOST module. Built from 6 solar collector panels into independently designed solar umbrella to efficiently collect solar energy, solar collector panels have the characteristics of long service life, high stability, strong sustainability, etc., the generated electric energy to the photosynthetic energy storage unit for wheelchair use, promoting the sustainable development of China's economy.

2.2. Pressure Power Generation Module

The system uses the reduced reduction damping concave cushion to solve the situation that the piezoelectric ceramic sheet is not easy to bend, and realizes the alternating compression of the pressure generator sheet through the connection of multiple groups of concave cushion tank. The high elasticity of rubber material can retain the pressure and the characteristics of inflatable rubber tire circular rotation, improve the power generation efficiency of pressure power generation. Improve the power supply system through the pressure ceramic sheet of the pressure inside of the rotating wheel to generate the electricity.

2.3. Photovoltaic Power Generation Module

Photovoltaic power generation is a technology that directly converts light energy into electric energy by using the photovoltaic effect of semiconductor interface. Photovoltaic power generation system is composed of solar heat collector plate, solar energy controller, support structure plate, photosynthetic energy storage unit equipment. The solar collector panels are

installed on the wheelchair shed through a solar umbrella. During the daytime, the wheelchair generates electricity through the solar umbrella heat collector. The outside of the umbrella is covered with flexible amorphous silicon thin film solar module, and the inside of the umbrella is covered with electric heating film with good heat insulation, which can quickly dry the rain on the umbrella.

3. THEORETICAL DESIGN CALCULATION

The piezoelectric ceramic element is embedded in the wheelchair tire, when the wheelchair moves, the pressure of the piezoelectric ceramic element changes, and the electric polarization phenomenon will be generated inside the crystal, and the corresponding two surfaces will have opposite charges with the symbol, generating voltage. Using the "photovoltaic" effect: when sunlight shines on the solar umbrella, six solar panels have an efficient capacity to convert solar energy into electricity, which is stored through the solar controller.

3.1. Design Principle of Power Supply System of Pressure

Pressure power generation technology is a process of converting mechanical energy into electrical energy by using the physical deformation or friction process under pressure. At present, pressure power generation technology has been widely used in self-charging devices

Due to the continuously changing direction of external forces, the excitation force $F = F \sin(t)$ is a function of time t . In the piezoelectric crystal model with dimensions of length a , width d , and height h , the strain S_1 , stress T_1 , displacement D_3 , and electric field strength E_3 are all converted into functions of time t . By conducting a surface integral of the stress $T_1(t)$ in the direction of the electrode plane, the formula for electric charge, the output current $i_0(t)$ and voltage $u(t)$ of the piezoelectric oscillator, the relationship between the optimal load resistance R_{opt} and the output power P , and the energy E can be obtained.

$$Q = \iint D_3(T) dx dz = \frac{d_{31} l F_{max} \sin(\omega t)}{h} + a l \varepsilon_{33}^T E(t) \quad (1)$$

$$i_0(t) = \frac{d_{31} l F_{max} \omega}{\sqrt{h^2 + 2a^2 l^2 \omega^2 (\varepsilon_{33}^T)^2 R^2}} \sin(\omega t + \varphi) \quad (2)$$

$$u_0(t) = i_0(t) R = \frac{d_{31} l F_{max} \omega R}{\sqrt{h^2 + 2a^2 l^2 \omega^2 (\varepsilon_{33}^T)^2 R^2}} \sin(\omega t + \varphi) \quad (3)$$

$$R_{opt} = \frac{h}{\sqrt{2} a l \omega \varepsilon_{33}} \quad (4)$$

$$P = \frac{1}{2} i_0^2(t) R = \frac{d_{31}^2 l^2 F_{max}^2 \omega^2 R}{2(h^2 + 2a^2 l^2 \omega^2 (\varepsilon_{33}^T)^2 R^2)} \quad (5)$$

3.2. Booster Module Design

The Boost module realizes the voltage regulation function through the superposition principle of the self-inductance electromotive force and the power supply, so that the voltage generated by the piezoelectric ceramic sheet can meet the requirements of battery charging. The simulation circuit is shown in Figure 1.

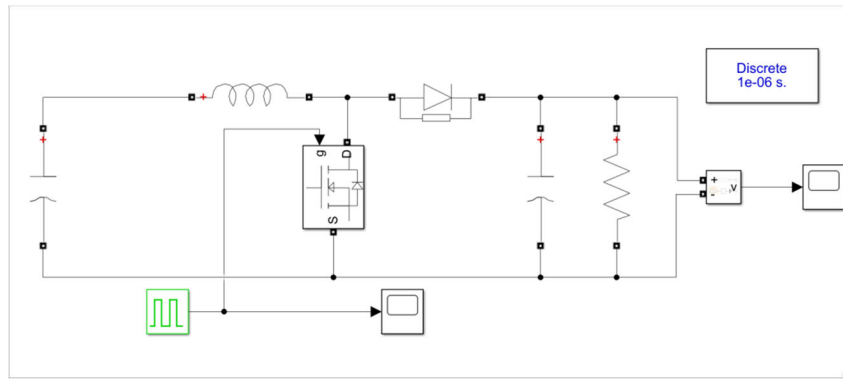


Figure 1. Booster module simulation circuit

3.3. Photovoltaic power generation

I is the output current of solar cell; I_{ph} is the light current; I_{mp} is the maximum power point voltage; V is the output voltage of solar cell; V_{mp} is the maximum power point voltage; q is the charge contained by individual electron; k is the Boltzmann constant; T is the temperature on the surface of solar cell; I_0 is the reverse saturation current; V is the output voltage of solar cell; P is the output power of solar cell.

The battery current and output power equation, the maximum power point voltage and current equation are as follows:

$$I = I_{ph} - I_D = I_{ph} - I_0 \left[\exp\left(\frac{qV}{nkT}\right) - 1 \right] \tag{6}$$

$$P = VI = V \left\{ I_{ph} - I_0 \left[\exp\left(\frac{qV}{nkT}\right) - 1 \right] \right\} \tag{7}$$

$$V_{mp} = V_{oc} - \frac{nkT}{q} \cdot \ln\left(\frac{qV_{mp}}{nkT} + 1\right) \tag{8}$$

$$I_{mp} = I_{ph} - I_0 \left[\exp\left(\frac{qV_{mp}}{nkT}\right) - 1 \right] \tag{9}$$

4. PERFORMANCE ANALYSIS

4.1. Device parameters

According to the different gravity pressure of the wheelchair, from the above formula, the pressure generator can be connected in parallel with 14 pieces of the wheelchair. According to the influence of solar panels by light time and power generation efficiency, six 12V2.5W, one 18V10W solar panels are used to generate power related device parameters. The wheelchair generates electricity through piezoelectric ceramics and photovoltaic panels during driving. In the process of driving, the total weight of the wheelchair is 750N, the daily use of eight electric wheelchairs is 4h, the total capacity of pressure ceramic tablets and solar panels is about 20Wh, and the average daily capacity is 160Wh. The wheelchair generates electricity through piezoelectric ceramics and photovoltaic panels during driving. In the process of driving, the total weight of the wheelchair is 750N, the daily use of eight electric wheelchairs is 4h, the total capacity of pressure ceramic tablets and solar panels is about 20Wh, and the average daily capacity is 160Wh.

4.2. Social benefits

Assuming in Beijing the city proper district market this brand wheelchair, the market total capacity of 566000 people, target customer groups mainly for the disabled and the elderly, set for 15% of the total capacity, the target customer capacity of 84900 people, can facilitate 84900 old man travel with the disabled, avoid the shortage of power, improve the customer comfort and convenience, more reflect the humanistic care.

4.3. Environmental benefits

Still in the the city proper district of Beijing, for example, if the 84900 people hold the electric wheelchair designed in this paper, run 4h, each tire into 14 pressure power, wheelchair back and wheel shell into solar cells, total seven pieces, if the enough sunshine, under the condition of running 4h a day, can power about 20Wh a day. A pressure-generating intelligent wheelchair runs at a speed of 14 km/h for 4h every day. After optimizing the electric energy, it is stored and utilized and reasonably calculated, and can generate 20Wh of electricity. If the assumed conditions are established, it can save 30.72 tons of standard coal and 90.27 tons of CO₂ gas can be reduced every year, which has good environmental benefits of reducing carbon emissions.

5. INNOVATION POINT

5.1. Save Electricity and Produce it for Self-use

This work combines the concept of energy saving and emission reduction with humanistic care, and realizes the "self-use" of wheelchair electric energy by special groups using wheelchair. Avoid frequent charging can achieve energy saving and environmental protection, greatly reduce the cost of electricity and reduce carbon emissions.

5.2. Low-carbon and Environmental Protection

Through the pressure of the tire through the wheelchair mechanical movement, the independent design of pressure reduction and vibration reduction grooves, the electric energy generated by piezoelectric ceramics is collected through the supplied to the battery, the energy is high conversion efficiency, small energy loss, and realizes the characteristics of fast charging and discharging, durability and high power.

5.3. Humanistic Care Fast and Innovation

Independent design of solar umbrella architecture, using solar energy as a driving energy, the use of clean energy, improve environmental protection, low carbon. USB convenient interface —— for electronic equipment power use. The LED lighting system —— provides the light for the night road driving. Solar umbrella device —— for the user to shade and shelter from the rain.V

6. CONCLUSION

The target group of this work is clear, mainly including the elderly, the disabled with poor legs and feet and medical treatment, which solves the disadvantages of single charging of traditional wheelchair, improves the defects of convenience and comfort of traditional wheelchair, and has a broad application prospect. According to the statistics of the National Bureau of Statistics, by the end of 2022, China's aging degree will be further deepened, with the population over 60 increasing by 21.9 million, up 1.6 percentage points. The demand and utilization rate of wheelchairs will further increase, providing new opportunities for the smart wheelchair market based on pressure power generation. This system takes solar energy and mechanical movement as the power source, which can not only relieve the practical pressure of traditional energy, but also meet the development needs of the current low carbon environmental protection, and

provides a new idea for the design and development of daily supplies in the future. Photovoltaic sunshade can not only provide convenience for people's life, but also achieve the purpose of energy saving and emission reduction, which has a high promotion value in the era of energy saving and environmental protection.

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