

A Power Seat that Helps the Elderly Get Up and Down the Stairs

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Abstract

This is a wheelchair that is convenient for the elderly. It differs from ordinary electric wheelchairs on the market in that it can help the elderly solve problems such as getting up, sitting up, going up and down stairs, traveling, etc., and can have a high degree of intelligence. Older people with less learning ability and inconvenient mobility can also operate easily. At the same time, they have high security and can meet the needs of the elderly, such as life, entertainment and fitness. The principle of helping the elderly get up and sit is to use the motor and mechanical structure to achieve a slow rise and fall of the seat. The whole process uses the motor intelligent drive to adjust the motor power and speed according to the load change, and automatically feedback and control. When the old man sits on the power assist chair, the sensing device installed on the chair will sensitively detect the load change, and then transmit signals to the control motor. According to the signal and intelligent control, the mechanism starts to respond accordingly, thereby implementing various Features.

Keywords

Elderly wheelchair, electric wheelchairs, signal and intelligent control.

1. Background

Nowadays, China's population is aging. Many adults are busy with work and it is difficult to accompany them with the elderly. As a result, the problem of "empty nesters" in Chinese society has become increasingly prominent. The elderly living alone, due to the decline of physiological functions, cause slow action and poor self-care ability. Facing the simple problems of going up and down stairs, traveling and even getting up often takes a lot of effort to complete, and even bears the risk of falling, seriously affecting the elderly. Quality of life and safety. The elevators are not popular in many old-fashioned apartments. Some of the old-fashioned machines on the market also have many problems such as complicated operation, low intelligence, and poor safety. They cannot help the elderly to solve problems in their lives.

2. Design Purpose

Based on this background, we designed a mobile wheelchair that uses a simple mechanical structure to meet the basic functions of the wheelchair. The overall structure of the chair is not only beautiful, but also fully considers the comfort of sitting, to achieve a comfortable look, sitting more It is the effect of enjoyment. The structure of the chair is very simple, but very practical. It makes full use of the rotating pair, and many of the connecting rods are flexibly

connected together to become such a multifunctional chair. At the same time facing the problem of up and down stairs, use the non-slip track, the tail is aligned with the stair when going up the stairs, use the connecting rod driven by the stepper motor to put the track structure down, use the bayonet on the track to continue the stairs, and face the front when going down the stairs. The action can be repeated to reach the purpose of going upstairs. This design is designed to help the elderly to go up and down the stairs and sit up, but also equipped with a variety of entertainment and leisure measures, broadcast, timing, blood pressure measurement can be satisfied. Helping the elderly is not only to satisfy their needs for the basic life of food, clothing, housing and transportation, but also to let them actively enjoy life and experience the convenience and spiritual enjoyment that technology brings to them.

3. Structure and Working Principle

(1) Slow lift seat design

Through the whole process, the motor is intelligently driven, that is, the speed-regulating motor can be used to adjust the motor power and speed according to the load change, and automatically feedback and control. When the old man sits on the power assist chair, the sensing device installed on the chair will sensitively detect the load change, and then transmit signals to the control motor. According to the signal and intelligent control, the mechanism starts to respond accordingly, thereby implementing various Features. The motor intelligent driving device also has the advantages of strong applicability, no influence of ambient temperature, wide output torque range, convenient control, etc. At the same time, it can flexibly adopt various signals such as direct current, alternating current, short wave and pulse, and can be flexibly adapted. In the work of enlargement, memory, logic judgment and calculation, it can realize ultra-small size, mechanical self-locking, easy installation, convenient maintenance and overhaul

In the case that the law of the original member is unchanged, the follower can obtain different motion laws by changing the relative length of each member. This feature enables flexible adjustment of the device, multi-angle, multi-directional adjustment of seat height and angle, with great flexibility, can also meet the requirements of different motion trajectories.

(2) Curved chain lifting device

The curved chain of the climbing building is equipped with a lifting device. When climbing the stairs, we put it down by controlling the direct-acting electric push rod device. When traveling on the flat ground, we put the bent chain to the bottom of the seat, so that the bent chain is not installed. Will affect the travel of the wheelchair on the ground. This allows the seat to be substantially aligned with the horizontal direction when the wheelchair is upstairs, increasing comfort.

(3) Transmission

The transmission is an intermediate device that transmits the motion and power of the prime mover to the working mechanism. We use the rear structure of the engine to make the front axle not easy to overload, and to make full use of the car area, effectively reduce the height of the car floor, and help to reduce the impact of high temperature and noise on the elderly. The disadvantage is that the engine has poor heat dissipation conditions, and some faults during driving are not easily detected by the elderly. Long-distance manipulation also complicates the steering mechanism and makes maintenance adjustment inconvenient.

We adopt chain drive mode, the chain transmission efficiency is high, the service life is long; the instantaneous transmission ratio is constant, the work is stable and the shoulder height is high; the structure is compact, the space is reduced; the transmission power and the peripheral speed range are wide. The curved plate chain drive has large driving force, small connecting pressure and large climbing ability; small radius during turning, good flexibility; easy maintenance and

high comprehensive utilization performance. Through the combination of the two, the internal structure of the wheelchair is relatively simple.

(4) Use of non-slip bending chain

The bent plate has a large pressure, and there are many thorns on the bent chain, which has strong grip ability, thus greatly enhancing the stability of the up and down stairs, and the passability is excellent. Moreover, the grounding length of the bent chain is large, the position of the induction wheel is high, the climbing ability is large, and the stair layer can be effectively passed. Compared with the wheeled chassis, the anti-slip bending chain structure can be maneuvered in various complicated environments, with strong passing ability, wide application range, and good safety and reliability. At the same time, it has strong load-bearing capacity and driving ability, good flexibility and high stability. Can meet the needs of the elderly up and down the stairs, travel.

4. Design Principle Calculation

A single frame group weighs 15kg at no load, assuming that the weight of a bicycle is about 13kg, one frame group can park five bicycles, when fully loaded, the total weight is 80kg, the diameter of the optical axis is $d=3\text{cm}$, the thickness of the card $t = 10\text{ cm}$. The force of the frame group can be simplified as shown in the figure below.



Figure 1: Bracket force simplified diagram

(1) Body load structure size design calculation

The shear and squeezing forces of the optical axis are:

$$F_s = 0.5F = 0.5 \times 80 \times 10 / 2 = 200\text{N}$$

$$F_{bs} = F = 80 \times 10 / 2 = 400\text{N}$$

The shearing area and pressing area of the optical axis are:

$$A_s = \frac{\pi d^2}{4} = \frac{3.14 \times 3^2}{4} = 7.065\text{cm}^2$$

$$A_{bs} = t \cdot d = 3 \times 10 = 30\text{cm}^2$$

$$\tau = \frac{F_s}{A_s} = \frac{200 \times 10}{7.065} = 283.085\text{Mpa}$$

$$\delta_{bs} = \frac{F_{bs}}{A_{bs}} = \frac{400 \times 10}{30} = 133.33\text{Mpa}$$

(2) Motor link mechanism size design calculation

Since the four branches of the cable tie rod group have the same structure and the force is the same, the force analysis is performed by taking one of the branches as an example, as shown in the following figure.

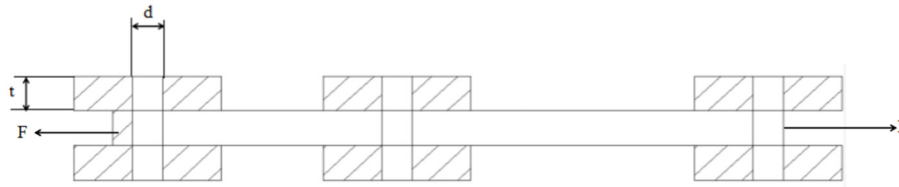


Figure 2: Stress analysis

One side frame group weighs 40kg, shaft pin diameter $d=1.5\text{cm}$, steel plate thickness $t=1.5\text{cm}$. The shear and squeezing forces of the axle pin are:

$$F_s = F/6 = 0.5 \times 40 \times 10 / 6 = 33.3\text{N}$$

$$F_{bs} = F/3 = 0.5 \times 40 \times 10 / 3 = 66.7\text{N}$$

The shearing area and pressing area of the optical axis are:

$$A_s = \frac{\pi d^2}{4} = \frac{3.14 \times 1.5^2}{4} = 1.766\text{cm}^2$$

$$A_{bs} = t \cdot d = 1.5 \times 10 = 15\text{cm}^2$$

$$\tau = \frac{F_s}{A_s} = \frac{33.3 \times 10}{1.766} = 188.54\text{Mpa}$$

$$\delta_{bs} = \frac{F_{bs}}{A_{bs}} = \frac{66.7 \times 10}{15} = 44.4\text{Mpa}$$

(3) Engine power calculation

To obtain the functional relationship between the motor drive torque and the total weight of the wheelchair and the inclination angle of the stairs when climbing the building:

θ : stair angle of the stairs,

G : total gravity; F : total traction of the track,

M : motor drive torque,

V : speed of the wheelchair relative to the slope of the stairs,

V_1 : linear speed of the driven wheel on the track wheel shaft,

V_2 : linear speed of the motor rim,

ω : track wheel angular velocity;

Track wheel diameter: $\phi 161$, $R_1 = 0.085\text{m}$,

The driven gear diameter: $\phi 126$, $R_2 = 0.063\text{m}$,

Drive gear diameter: $\phi 147$, $R_3 = 0.0735\text{m}$,

$$F = G \cdot \sin \theta$$

$$F_1 \cdot R_1 = F_2 \cdot R_2 = F_3 \cdot R_3 = M,$$

$$G = 1200\text{N}, \theta = 32.6^\circ,$$

$$M = G \cdot \sin \theta \cdot R_1,$$

$$\omega = \frac{V}{R_1},$$

$$V_1 = \omega \cdot R_2 = V_2.$$

Time takes $t=1s$:

$$\varphi = \frac{V_2 \cdot t}{2\pi R_3} \cdot 2^\pi,$$

$$M = f(G, \theta) M = f(G, \theta),$$

$$W = \int_0^\varphi M d\varphi = 277J,$$

$P = 277W$ (for the choice of motor).

(4) Curved chain movement

When going up the stairs, the tail is aligned with the stair steps. The track structure is driven down by the connecting rod driven by the stepping motor. The stairway on the bent chain is used to continuously climb the stairs. When going down the stairs, it faces forward, and the action is the same as before. The lower part is equipped with a crank rocker mechanism, which can realize the mutual cooperation between the structures, thereby achieving the driving purpose. At the same time, the card slot of the bent chain is stuck on the stairs to achieve the anti-slip function.

5. Innovation

Automation control mechanism

The power system is installed to realize the automatic control of the wheelchair, which makes the climbing process more labor-saving, and improves the safety factor of the wheelchair and the service life of the transmission gear.

Seat back adjustment mechanism

The design of the seat back adjustment mechanism enables the user to adjust the seat back of the wheelchair at any angle according to his own needs, thereby increasing the comfort of the wheelchair.

Assisting the elderly to stand up

The crank plate mechanism is used to lift the seat panel. This function brings great convenience to the elderly with weak legs.

Chain drive mechanism

In order to prevent the wheelchair from slipping during operation, a chain mechanism is used to drive each part of the power mechanism.

6. Application Prospects

This is a fully automatic smart booster chair that can help the elderly solve problems such as difficulty in getting up and down stairs, traveling, and getting up and getting down. This product adopts intelligent motor drive system, which can only feel the pressure changes around and make intelligent judgments. It has high intelligence, so that the elderly with weak learning ability and inconvenient movement can easily operate. At the same time, the anti-slip track is used. The structure makes the booster chair have high safety when going up and down the stairs and when traveling.

“A power seat that can help the elderly to go up and down the stairs” plays an important role in solving the independent life of the elderly in the process of urban development in China. It has realistic social significance and good development prospects for promoting sustainable urban development.

References

- [1] L. M. Wu, L. Hui. Mechanical principle? [J]. 2018 (01): 20.
- [2] W. Cong, B. F. Shan. Descriptive geometry and mechanical drawing [D]. Aviation Industry Press, 2018.
- [3] Y. F. Zhang. Engineering Mechanics [D]. Beijing University of Aeronautics and Astronautics Press 2017.
- [4] Z. H. Qin. Electrical Engineering [D]. Harbin Institute of Technology, 2017.