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A Self-climbing wheelchair

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Abstract: The device is equipped with a control unit on the right side of the handle and is equipped with an automated control system that enables automated up and down stairs and travel on flat ground. Through the control device, the elderly can easily drive the wheelchair, changing the human-powered mode of the traditional wheelchair, and improving the speed of the wheelchair on the flat ground while greatly ensuring the safety of the elderly, which greatly facilitates the travel of the elderly. So that the elderly can travel farther.

Keywords: Self-climbing, wheelchair.

1. Background

China's population is aging, and with the sharp increase in the elderly population, the proportion of disabled people has also increased significantly. Among the disabled, the proportion of patients with physical disabilities is the largest. Wheelchairs play an important role in this group of people. Although many barrier-free facilities in today's society have been established on a large scale, ordinary wheelchairs have been able to enter and exit on many occasions, but they can often encounter stairs, roads, overpasses, etc. The obstacles can only be discouraged, so designing a wheelchair-safe wheelchair that is safe, reliable, convenient and suitable for the needs of the elderly and disabled patients has attracted more and more attention from the people.

2. Overall design

Control device

The product control unit is mounted on the right handle and is equipped with an automated control system that enables automated up and down stairs and travel on flat ground. Through the control device, the elderly can easily drive the wheelchair, changing the human-powered mode of the traditional wheelchair, and improving the speed of the wheelchair on the flat ground while greatly ensuring the safety of the elderly, which greatly facilitates the travel of the elderly. So that the elderly can travel farther.

Powerplant

The engine is installed under the seat, which is the red part of the figure. The gear connected to the red part is the driving gear. The driving gear drives the rotation of the upper and lower gears, and drives the rear wheel and the lower gear of the wheelchair to drive the track to complete the wheelchair climbing. Floor movements as well as forward and backward.

The main consideration when installing the engine: whether the selected engine meets the needs of the wheelchair.

After theoretical calculations, we calculated the required engine power to be about 277W, so we chose the engine of the household battery car (power is 350W-500W).

Transmission

Adopting the transmission mode combining gear transmission and crawler transmission, the gear transmission has high transmission efficiency and long service life; 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 crawler 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, the most complicated structure is realized with the simplest structure, and the simple structure is advantageous for the maintenance and repair of the wheelchair.

Hydraulic device

A hydraulic device is mounted under the wheelchair seat, which is the blue part of the illustration, making the back and seat of the wheelchair an adjustable mechanism. The installation of the hydraulic device can ensure the safety of the elderly when climbing the building, and at the same time, the elderly can maintain the level of the body when going upstairs, thereby improving the comfort of the elderly.

The main problem we considered when installing the hydraulic unit: whether the material of the selected hydraulic rod can withstand the weight of the wheelchair and the elderly.

In response to this problem, we also carried out theoretical calculations and calculated that the stress of the hydraulic rod is about 9.8 MPa. Therefore, we choose the hydraulic rod with aluminum alloy material (the allowable stress is about 20 MPa) to bear the weight of the elderly and the wheelchair.

Track lifting device

The crawler's crawler is equipped with a lifting device. When climbing the stairs, we put the crawler down through the control device. When we are on the flat ground, we take the crawler under the seat so that the installed track does not affect the wheelchair's travel on the flat ground.

3. Theoretical design calculation

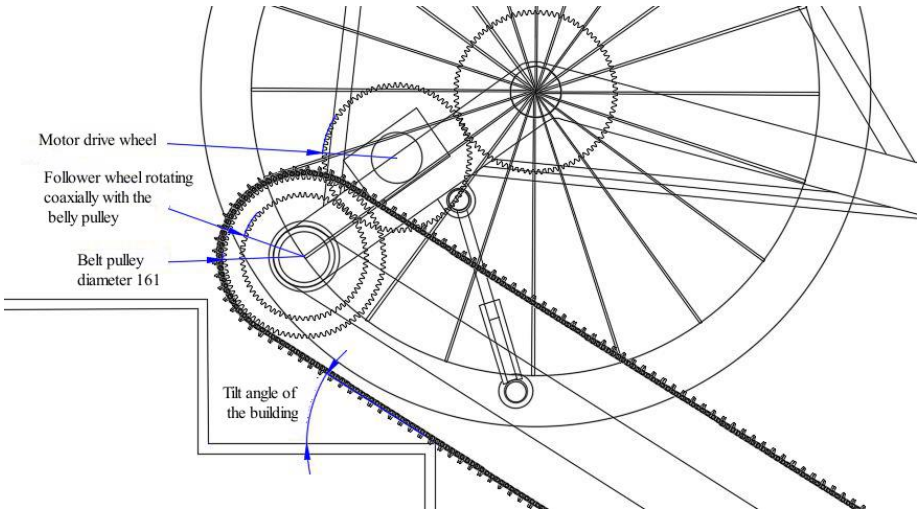

Figure 1. Internal structure diagram

Determine the selection of the engine

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 : $\varphi 161, \mathrm{R}_1 = 0.085\mathrm{m}$,

The driven gear diameter: $\varphi 126, \mathrm{R}_2 = 0.063\mathrm{m}$,

Drive gear diameter: $\varphi 147$, $\mathrm{R}_3 = 0.0735\mathrm{m}$,

$$\mathrm{F} = \mathrm{G} \cdot \sin\theta \mathrm{F} = \mathrm{G} \cdot \sin\theta,$$

$$\mathrm{F}_1 \cdot \mathrm{R}_1 = \mathrm{F}_2 \cdot \mathrm{R}_2 = \mathrm{F}_3 \cdot \mathrm{R}_3 = \mathrm{M},$$

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

$$\mathrm{M} = \mathrm{G} \cdot \sin\theta \cdot \mathrm{R}_1,$$

$$\omega = \mathrm{V} / \mathrm{R}_1,$$

$$\mathrm{V}_1 = \omega \cdot \mathrm{R}_2 = \mathrm{V}_2.$$

Time takes t=1s:

$$\varphi = \mathrm{V}_2 \cdot \mathrm{t} / 2\pi \mathrm{R}_3 \cdot 2^{\pi},$$

$$\mathrm{M} = \mathrm{f}(\mathrm{G}, \theta) \mathrm{M} = \mathrm{f}(\mathrm{G}, \theta),$$

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

$\mathrm{P} = 277\mathrm{W}$ (for the choice of motor).

Determine the selection of hydraulic rods

The hydraulic rod is the most stressed place for the entire wheelchair. In order to ensure the reliability of the hydraulic rod, we use mathematical, theoretical mechanics, material mechanics knowledge to calculate the normal stress of the hydraulic rod. According to the theory, the force of the hydraulic rod depends on the total gravity of the wheelchair and the person and the angle of inclination of the stairs. So below we find the functional relationship between them.

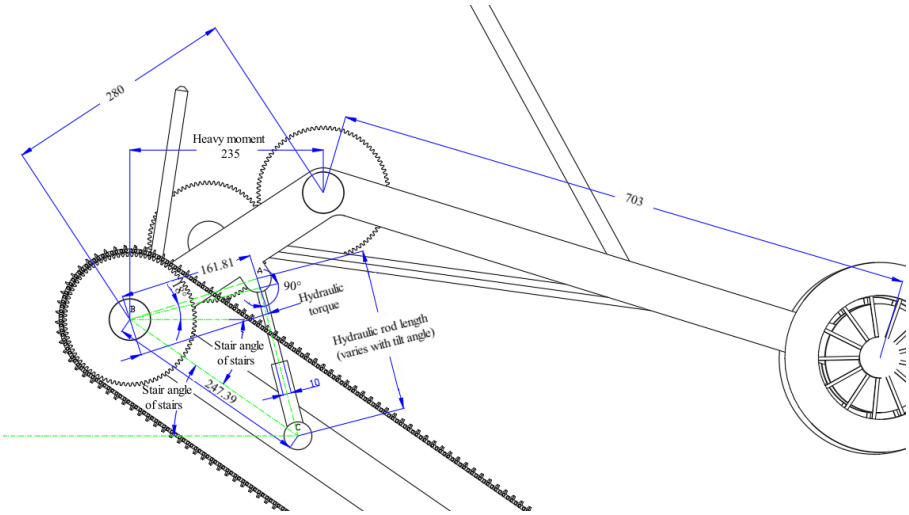

Figure 2. Dimension drawing diagram

Tips:

θ:Stair angle of stairs,

F: Hydraulic rod is stressed,

G: Total gravity of wheelchairs and people,

h: moment of hydraulic pressure to point B,

△L: the moment of total gravity versus point B,

$$AC^2 = AB^2 + BC^2 - 2AB \cdot BC \cdot \cos(18^\circ + \theta)$$
$$= 0.08738 - 2 \times 0.16181 \times 0.27739 \times \cos(18^\circ + \theta)$$
$$= 0.08738 - 0.08006 \times \cos(18^\circ + \theta)$$

$$AC = \sqrt{0.08738 - 0.08006 \times \cos(18^\circ + \theta)}$$

$$S_{\Delta ABC} = \frac{1}{2} AB \cdot BC \cdot \sin(18^\circ + \theta) = \frac{1}{2} AC \cdot h$$

$$0.04003 \times \sin(18^\circ + \theta) = AC \cdot h,$$

$$\therefore h = \frac{0.04003 \times \sin(18^\circ + \theta)}{\sqrt{0.08738 - 0.08006 \times \cos(18^\circ + \theta)}},$$

$$\sum M_{(B)} = 0, F \cdot h = G \cdot \Delta L,$$

$$\therefore \Delta L = 0.235m,$$

$$F = \frac{G \cdot \Delta L}{h} = \frac{0.235 \cdot G \cdot \sqrt{0.08738 - 0.08006 \times \cos(18^\circ + \theta)}}{0.04003 \times \sin(18^\circ + \theta)},$$

Single hydraulic rod:

$$\frac{F}{2} = f(G, \theta) = \frac{0.1175 \times G \times \sqrt{0.08738 - 0.08006 \times \cos(18^\circ + \theta)}}{0.04003 \times \sin(18^\circ + \theta)},$$

Assume the slope of the stairs:

The hydraulic rod has a cross section of 1 cm in diameter.

$\tan\theta = \frac{16cm}{15cm}$, $\theta \approx 32.6^\circ$, $G = 1000N$, $\frac{F}{2} = 770.29N$,

$$\sigma = \frac{F/2}{A} \approx 9.8MPa(\text{for hydraulic rod selection})$$

4. Innovation

Tooth clutch mechanism

The toothed clutch mechanism is optimized to improve the disadvantages of large fluctuations in the center of gravity of the star wheel and unstable movement, and realize the dual movement function of the wheelchair using the same transmission system to complete the climbing and walking.

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 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.

Application prospects

Older age groups with older people with disabilities.

Paraplegia, hemiplegia, leg weakness or mobility of people with disabilities.

Living in the elderly with no elevators.

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