APPLICATION OF ALBER'S PRINCIPLE TO DEVELOP A DEVICE SUPPORTING WHEELCHAIR IN STAIR CLIMBING

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*(Manuscript Received on April 5th, 2012, Manuscript Revised March 8th, 2013)*no

ABSTRACT: *This paper presents developing Alber principle for machine supporting wheelchair in climbing stairs. The designed machine can support wheelchair and disabled people with total weight 80 kg climb up and down most of stairs and with speed 10-15 stairs per minute. Moving wheelchair and disabled people need assistant person who will hold handle and control the machine. The machine is designed with a simple structure, manufactured with low cost and simple controlling. Therefore the machine can be upgraded and manufactured in future.*

Keywords: *Alber, vertical plane, horizontal plane…*

1. INTRODUCTION

Our country experienced many wars, so quantity of disabled people have high rate in population. These disabled people do not have a lot of money to heal disease. Therefore, according to survey in 2005, number of disabled people of our country is up to 5.3 millions, this number account for 6.34% population in which the disabled people by movement account for more than 29.41%.[2]

Helping these disabled people joined community activities now become necessary and significant. To do that, climbing stair of disabled people at home and public place should be especially considered.

Because of that desire, this machine was researched, designed, manufactured so that it can help disable people and their wheelchair climb most of stairs at home and public place in Viet Nam.

2. MECHANICAL DESIGN AND CALCULATION

2.1. Introduction to Alber principle

According to figure 1, double chain sprocket 1.1 drive to two chain sprockets 1.2 and 1.3 by chain with the same transmission ratio, so two big wheels will revolve around center I_1 and I_2 with same angular velocity.

Two small chain sprockets 1.4 and 1.6 are fixed to I_1 I_2 I_3 frame, two small chain prockets 1.5 and 1.7 are connected with two safe wheel. Because two chain sprockets 1.5 and 1.7 are driven two chain sprocket 1.4 and 1.6 by chains C and D, when big wheels revolve around center I_1 and I_2 the safe wheel fit will also move but those direction are constant with I_1 I_2 I_3 frame.

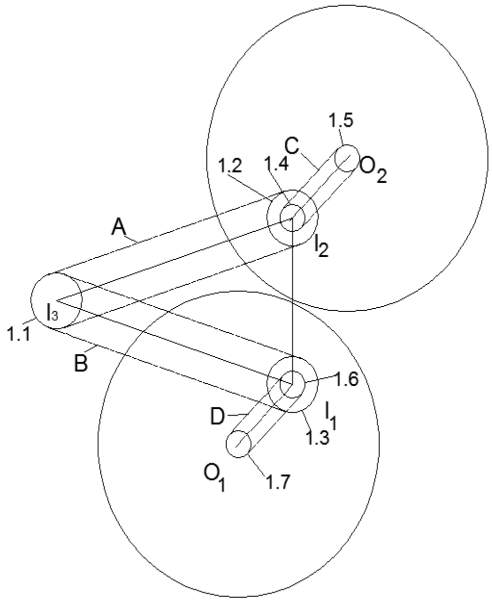

Figure 1. Alber principle.[1]

2.2. Structure of wheel unit

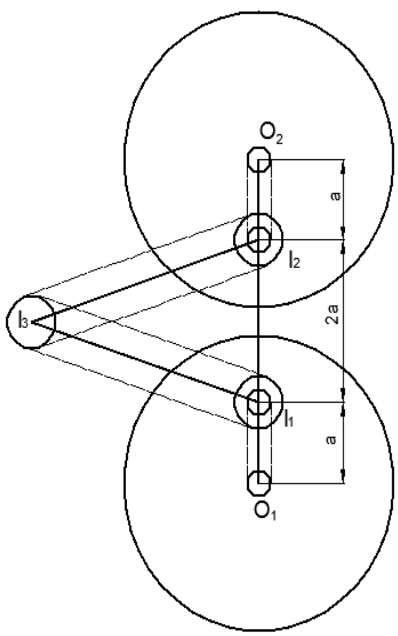

Figure 2. The positions of centers in a revolving circle [1]

Two big wheels are designed in order that they are not only able to revolve around center I_1 and I_2 but also they can revolve around their center. Therefore revolving around center I_1 and I_2 help machine can climb stair, and revolving around their center help machine ride on flat terrain.

The distance between two centers of two big wheels will change when machine climb stairs. The distances are designed as below.

The distances between revolving centers I_1, I_2 and centers of big wheels are equal: $I_1O_1 = I_2O_2 = a$.

The distance between two rovolving centers is 2a: $I_1I_2 = 2a$.

Thank to above design, in one revolving circle around revolving ceters, the ceters of big wheels will be on a horizontal line in one time as figure 3. This means machine wheel can ride on flat terrain when the ceters of big wheels are on a horizontal line.

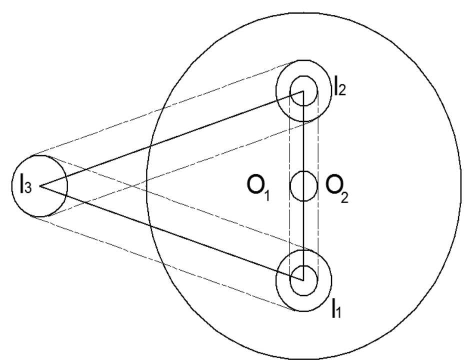

Figure 3. The positons of big wheel's centers are on on horizontal line[1]

2.3. Process of climbing up stairs

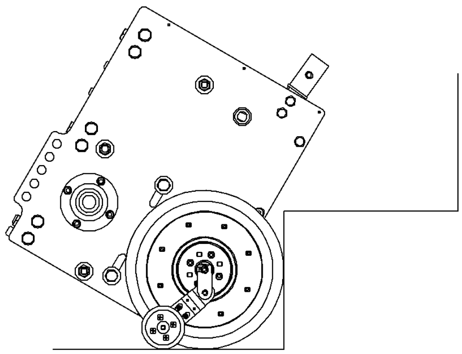

Figure 4. Machine makes ready for climbing up a stair

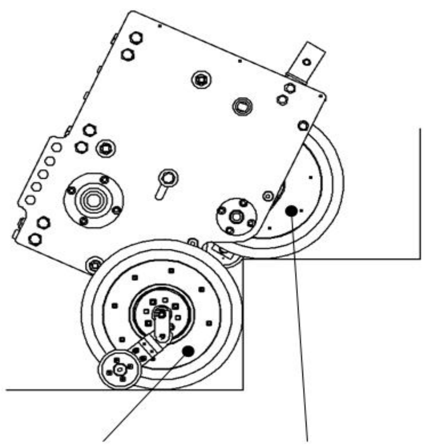

Figure 5. Machine is climbing up a stair

5.1: Two external big wheels 5.2: Two internal big wheels

Before climbing up stair, assistant person will pull machine to touch the vertical plane of stair like figure 4. Then assistant person push button and machine start climbing the first stair like figure 5.

The revolving centers of two external big wheels are lower than revolving centers of two internal big wheels. So when machine climbs up a stair the two external big wheels will lift two internal big wheels up to horizontal plane of next stair first. After being lifted, the two internal big wheels will lift two external big wheels up to horizontal plane of next stair. At this time the machine has already climbed up a stair and centers of big wheels are on a horizontal line. And process of climbing up a different stair repeats.

2.4. Process of climbing down stairs

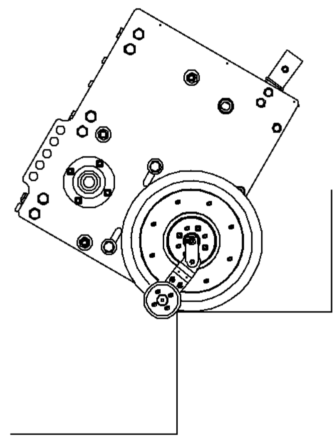

Figure 6. Machine makes ready for climbing down a stair

Before climbing down a stair, the assistant person will push machine to reach vertical plane of stair like figure 6. When machine is reaching vertical plane of stair, four safe wheels will reach vertical plane first. After passing vertical plane, the four safe wheels will drop down like figure 6. Having four coils that connecting four connecting rods 1 and four connecting rods 2. These coils will pull four connecting rods 1 in order to direction of four connecting rods 1 reach direction of four connecting rods 2. At that time, the four rubber brakes which attached with four connecting rods 1 will have friction with four big wheels. Therefore four big wheels will stop at vertical plane of stair.

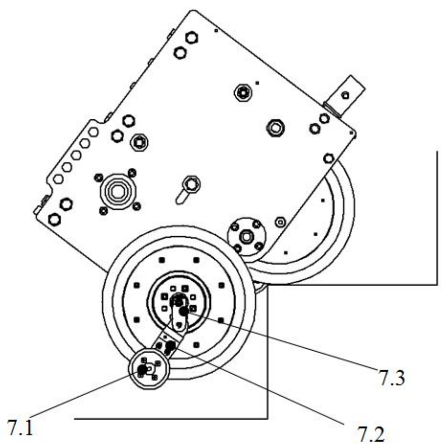

Figure 7. Machine is climbing down a stair

7.1: Four safe wheels; 7.2: Four connecting rods 1; 7.3: Four connecting rods 2

The revolving centers of two external big wheel are lower than revolving centers of two internal big wheels. So when machine climb down a stair the two internal big wheels will lift two external big wheels up to horizontal plane of next stair first. After being lifted the two external big wheels will lift two internal big wheels up to horizontal plane of next stair. At this time the machine has already climbing down a stair and centers of big wheels are on a horizontal line. And process of climbing down a different stair repeats.

2.5. Diagram of machine principle

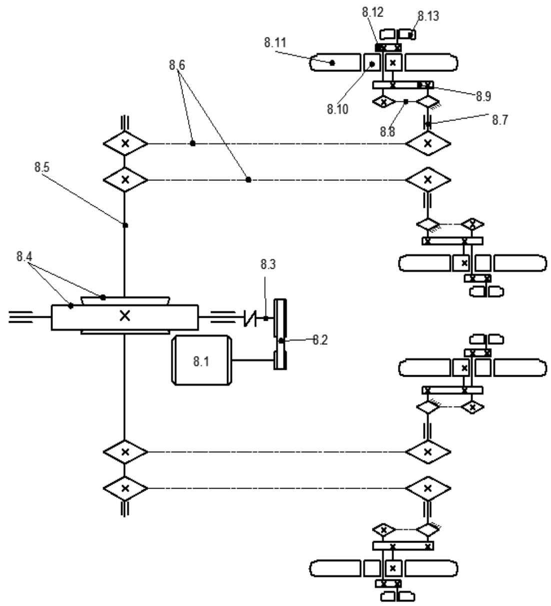

Figure 8. Diagram of machine principle

8.1: Motor; 8.2: Timing belt drive; 8.3: Shaft I; 8.4: Worm gear drive; 8.5: Shaft II.; 8.6: Chain drive; 8.7: Shaft III; 8.8: Chain drive; 8.9: Connecting rods of big wheels; 8.10: Shaft part; 8.11: Big wheels; 8.12: Connecting rods of safe wheels; 8.13: Small wheel.

Table 1.1. Machine specification

Machine weight	40 kg
Maximum disabled person weight	80 kg
Wheelchair weight	17,5 kg
Total weight	137,5 kg
Power input	2 x 12 VDC, 5 Ah
Motor	250W, 2500 revolutions per minute
Maximum height of stair	20 cm
Maximum speed of climbing stairs	15 steps per minute

2.6. Machine and component shape

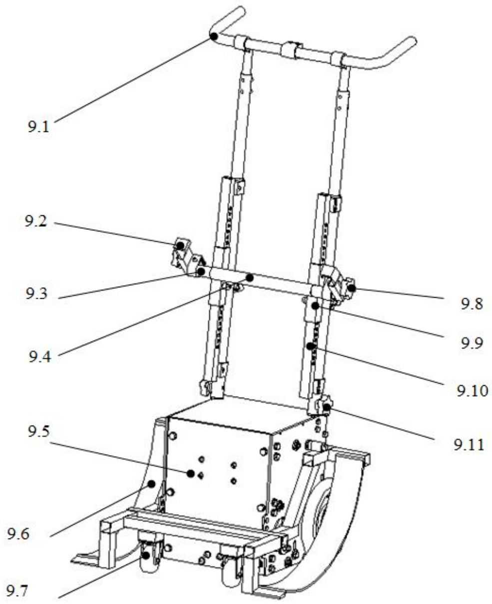

Figure 9. Machine shape from front view

9.1: Holding handle; 9.2: Wheelchair holder; 9.3: Cylindrical hollow rod; 9.4: Cylindrical hollow rod; 9.5: Machine frame ; 9.6:Wheelchair supporting part; 9.7: Supporting wheel ; 9.8: Turn-knob; 9.9: Slide hollow bar; 9.10: Hollow bar; 9.11: Turn-knob

Stair climbing starting button is push on holding handle (9.1). Cylindrical hollow rod (9.3) can slide in cylindrical hollow rod (9.4), holder (9.2) is used for holding wheelchair handle. Fame (9.5) is used for putting motor, drives and pins. Part (9.6) is used for supporting wheelchair. Two wheels (9.7) are used for supporting machine when attaching wheelchair, disabled person to machine. Two turn-knobs (9.8) are used for fixing holder (9.2). Two hollow bars (9.9) can slide along slide hollow bar (9.10). Two turn-knobs (9.11) are used for releasing and fixing handle parts and holder parts from machine frame.

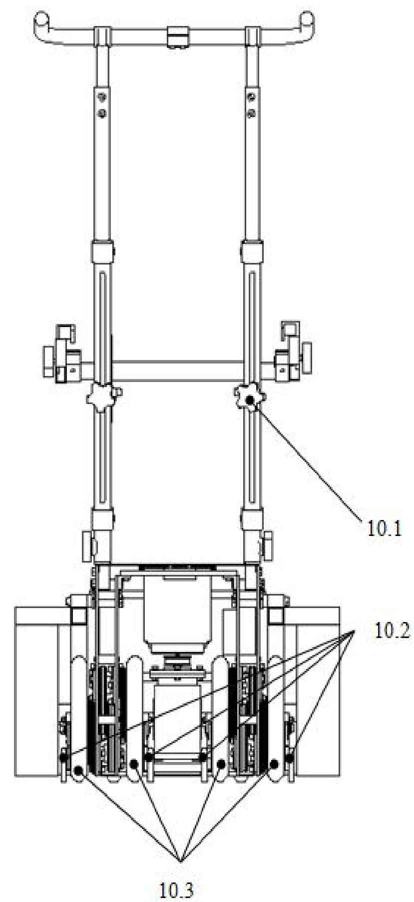

Figure 10. Machine shape from rear view

Two turn-knobs (10.1) are use for adjusting height of holding handle.

10.2: Four safe wheels.

10.3: Four big wheels.

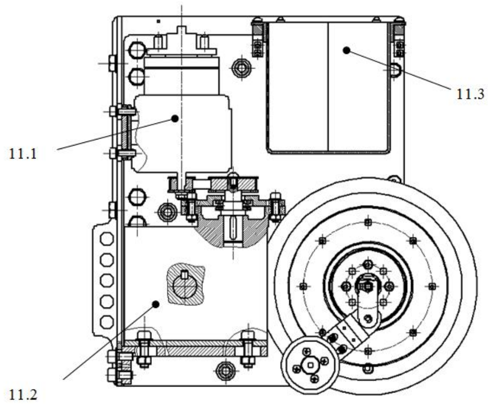

Figure 11. Position and shape of parts in machine frame

11.1: Motor; 11.2: Worm gear unit;

11.3: Pins

Figure 12. Machine after manufacturing

2.7. Calculating necessary diameter of big wheels and distance between revolving centers and wheel centers

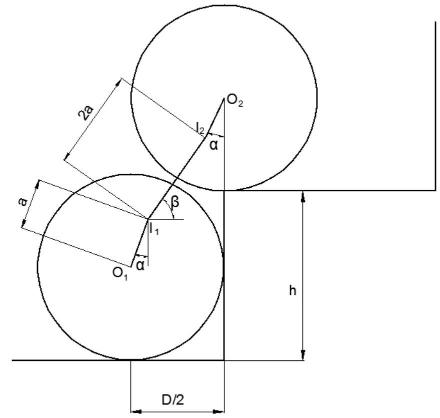

Figure 13. Dimentions of big wheels unit

Angle β is angle between machine and horizontal direction when machine climbing stairs, $\beta = 45^o - 65^o$.

Select:

Dimention of big wheels are D = 220 mm.

Distance between revolving centers and wheel centers is a = 60 mm.

To climb stairs, dimentions D and a have to satify two conditions

$h = 2a\cos(\alpha) + 2a\sin(\beta)$, $h \geq 200$ mm (4.1)

$2a\sin(\alpha) + 2a\cos(\beta) = D/2$ (4.2)

Or

$h = 2.60\cos(\alpha) + 2.60\sin(\beta)$ (2.1)

$2.60\sin(\alpha) + 2.60\cos(\beta) = 220/2$

With $\beta = 45^o - 65^o$ we have $\alpha = 12{,}6^o - 29{,}6^o$

Put $\alpha = 12{,}6^o - 29{,}6^o$, $\beta = 45^o - 65^o$ into (2.1). we have h = 202,2 – 213,1 mm.

3. EXPERIMENT AND RESULTS

3.1. Experiment

Machine was tested with 500 steps with height of step is 16 cm and with average weight of disabled person is 65kg.

3.2. Result

Machine opertated stably. Four safe wheels can safely stop machine at vertical planes of stair when machine climbing down stairs. Stair climbing speed of machine is proper with assistant person. Machine climbing smoothly,so disable person feel comfortable.

Controling machine is rather simple but it also need person have to spend a short time to from being familiar.

Figure 14. Machine climb up stairs

Figure 15. Machine climb down stair

4. CONCLUSIONS

Machine accomplished a important duty is moving diasbled person up and down stairs. Machine opertated stably and safely for user. Cost of manufacturing is low, controling way is simple.

However some of parts need to be changed by plastic materials. This mean machine will be lighter and power is used for machine is also lower.

From above result, we see that machine is potential to upgrade and manufacture. This is realy significant and helpful.

ỨNG DỤNG NGUYÊN LÝ ALBER ĐỂ THIẾT BỊ HỖ TRỢ XE LĂN VƯỢT CẦU THANG

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TÓM TẮT: *Bài báo trình bày việc phát triển nguyên lý Alber cho thiết bị hỗ trợ xe lăn vượt cầu thang. Thiết bị được thiết kế có thể di chuyển người tàn tật có trọng lượng tối đa 80 kg lên xuống hầu hết các loại cầu thang và tốc độ là 10-15 bậc/phút . Quá trình di chuyển người tàn tật cần có một người hỗ trợ, người ngày làm nhiệm vụ giữ các tay cầm và điều khiển thiết bị. Thiết bị được thiết kế với kết cấu đơn giản, được chế tạo với chi phí thấp và vận hành đơn giản nên có thể phát triển và sản xuất hàng loạt.*

Keywords: *Alber, vertical plane, horizontal plane…*

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[2]. http://www.sotuphapqnam.gov.vn/index.php/-cng-tuyen-truyn-pl/160--cng-gii-thiu-lut-ngan-hang-nha-nc-vit-nam-.