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Design and Fabrication of Step Climbing Commode Type Wheel Chair

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***Abstract*: The main problem faced by the spinal cord injury patient is, they cannot walk and climb the staircase as normal person climb or walk. They also find difficulties to go to restroom. Simple mechanical devices play a major role in household purposes. Wheel chair play a major role in this area and they are very useful in these kinds of situations. The wheel chair is designed in a way which will be helpful for the patients to climb the stair case. This type of wheel chair is also useful for the patients to go to restroom because it is designed in Commode type. So, it plays a major role for those who find difficulties in this case. The process of climbing the wheel chair in staircase is achieved with the help of Tri wheel mechanism. This will make the patients move independently with the help of joystick/remote control.**

***Keywords*: Joystick, Stair climbing, Tri wheel mechanism, Wheel chair.**

1. Introduction

A wheel chair is used for the purpose of moving the patients who are affected from severe injuries such as leg fracture, spinal cord injury and some severe affects. The wheel chair is used to move from one place to another but the disadvantage of this, is that the patients who are affected cannot climb the staircase where there is no elevator/lift. So, this wheel chair helps to climb the staircase even without the usage of lift. This can be achieved with the help of joystick which is even simpler and can be controlled easily. The tri wheel mechanism is used in which the wheel chair can climb the stair case.

The objective here is to design and manufacture a stair climbing wheel chair that serves different purposes which includes moving on the floor and climbing the stairs. In the early designs, a single wheel or a set of wheels set on each side is merely capable of moving the vehicle on flat surfaces. Here the modelling is done in such a way that it has tri wheels for shifting the load over stairs. It comprises of two sets of three wheels attached to a frame at 120degrees, positioned at the bottom of the trolley which works as a single unit. Handles are provided to give support to the frame and apply the human effort either to push or pull the wheel chair. The size, shape, selection of the frame, position of the trolley changes as per the working load and requirement. With bearing support, the wheels are mounted on the shaft. Material selection is also a main consideration. In general, Stainless steel is used to carry heavy loads and mild steel is preferred for moderate loads.

2. Literature Review

Kilari, Snehita Praneetha, et al., (2019). In this journal the trolley is designed to climb staircase with the help of tri wheel mechanism and this type of mechanism is used to climb the staircase easily with heavy load which cannot be carried away simply or by just lifting it. This concept of tri wheel mechanism is shifted to wheel chair. The primary objective of bearing heavy load like 120-150 kg is achieved during testing. The performance is slightly complicated when the straight frame was tested for varying step sizes. But when tested with Quasi-static frame, the vehicle exhibited greater performance even for stairs with different dimensions. Static structural analysis demonstrates that it is capable of moving heavy loads with less deformation and without any fracture.

Hinderer, et al., (2017). From this journal it is observed that the wheel chair is capable to move with the help of joystick and in some case the more elderly people are dependent on care. Due to this care is not taken regularly to patients and there are shortages of nursing homes. In this type of wheel chair the patient can move independently with the help of joystick movement. This is the purpose of autonomous stair climbing wheel chair. This paper introduces a new technology with which wheel chairs or robots can overcome stairs independent and safe. This mechanism based on legs is described in detail and demonstrated with the help of a function model. The technology introduced here with which the wheel chair overcomes autonomous which will help the patients move on their own and they can move independently.

Petzäll, Jan. (1996), The forces needed when traversing step obstacles with a wheel chair were calculated according to the principles of mechanics and processed by a computer for the different principal traversing situations. This journal refers to overcome the obstacles in the pathway of wheel chair. Based in the trials the conclusions are that step obstacles with a height of 50mm can be easily be traversed with a manual wheelchair manoeuvred by an attendant. The occupant of the wheelchair can sit safely and comfort- ably during the traversing at this height. An obstacle height of 100 mm can be traversed with a rear wheel drive wheelchair and a front wheel drive wheelchair

backwards. This journal refers to overcome the obstacles in the pathway of wheel chair.

Quaglia, Giuseppe Franco, et al., (2017). Wheelchair's, a concept for a stairclimbing wheelchair capable of moving in structured and unstructured environments, climbing over obstacles and going up and down stairs. A concept for a stair climbing wheelchair was presented. Thanks to its auto-adaptive locomotion units, it can move in structured and unstructured environments, climb over obstacles and go up and down stairs. The locomotion unit's mechanical design makes it possible to reduce the number of motors and thus the wheelchair's weight and size. In fact, only one motor is necessary for each locomotion unit. Control algorithm complexity also decreases: changes in locomotion mode, from rolling on wheels to walking on legs, are triggered entirely by local friction and dynamic conditions, with no need for a high-level control. By comparison with other solutions, stair climbing operations are safer and passenger posture can be arranged dynamically. With these features, the wheelchair presented could be very useful for disabled people.

Matteo, et al., (2020). The wheelchair is able to Climb single obstacles or Staircases with a triple-wheels Cluster architecture. From this journal, the path of the wheel is noted in which let us consider three wheel one wheel is rested in the floor while climbing the staircase and the other two wheels are moved with help of motor and then after climbing one step the consecutive wheel is balanced and the other two wheels are moved and they are all made to fix in an angle of 120 degrees each and this will be engaged in tri wheel frame to move the wheel chair upwards to the top of the staircase and the method is carried out again and again.

Ghani, N. M. A. Nasir, A.N.K. et al., (2013). This paper focuses on the control of the wheel chair with the help of joystick movement. The challenges are to control the front and rear motors as well as the tilt angle and ensure the sustainability and stability of the wheel chair to climb the staircase. This type of wheel chair uses control such as the fuzzy control which is useful for the patient or the operator to drive or to run the wheel chair to without any 2nd person. The patient itself can run the wheel chair with the help of blue tooth control. The controller consists of Adreno board, motor drive relay which is used to control the wheel chair.

3. Design Calculation

Formula Used:

1. Calculation for Wheel frame:

$$R=\sqrt{(a^2 + b^2)}/ 3 \quad (1)$$

where,

a = Distance of height of the step.

b = Distance between the run of the step.

R = Distance between the centre of the wheel frame to the centre of the wheel.

Calculation:

$$R=\sqrt{(a^2 + b^2)} /3 \quad (2)$$

$$=\sqrt{(125^2 + 165^{2)}} / 3$$

$$=120\text{mm}.$$

2. Calculation for Wheel diameter:

$$r=6Rt + a[3b-\sqrt{3}a] / (3-\sqrt{3})\, a + (3+\sqrt{3})\, b \quad (3)$$

where,

t = thickness or width of the wheel frame.

r = radius of the wheel

Calculation:

let us consider, t=25mm

$$r = 6Rt + a[3b-\sqrt{3}a] / (3-\sqrt{3})\, a + (3+\sqrt{3})\, b \quad (4)$$

$$r = 6(20)(25) +125\, [(3(165)-\sqrt{3}(125)]/ (3-\sqrt{3})125+(3+3)165$$

$$= (18000+34812.5)/ (158.375+990)$$

$$= 50\text{mm}.$$

Minimum, radius of wheel is 50mm and diameter is 100mm (~4inches.)

The next size of the wheel 6 inches is chosen.

The wheel size which is taken accordingly is 6 inches (~150mm.)

4. Design of Wheel Frame and Wheel

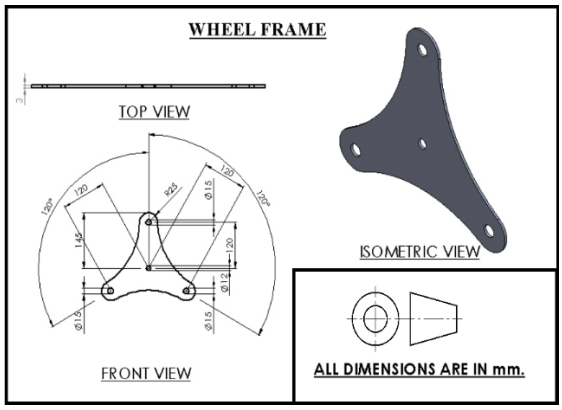

Fig. 1. Design of wheel frame

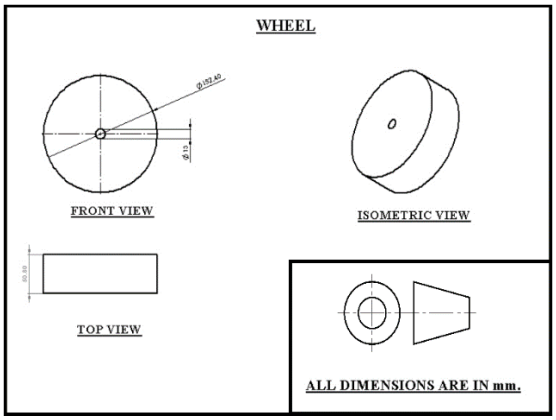

Fig. 2. Design of wheel

5. Load Calculation

Motor used: Wiper motor
Specifications of motor:
1. Voltage: 12v
2. Power rated: 14w
3. Rated current:1.1A

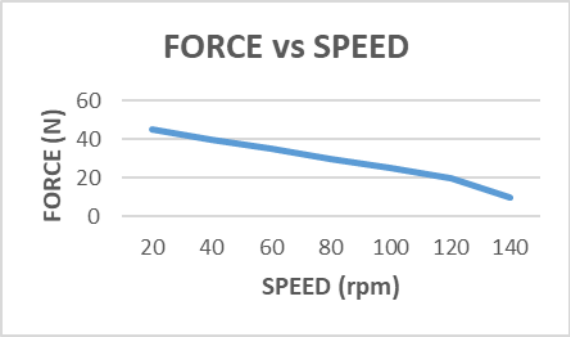

Fig. 3. Force vs. Speed

When the load acts the current increases and the voltage decreases. The current increases to the maximum of 5A. Life is 0.5 million cycle.

6. Bill of Materials

S. No.	Material	Quantity
1.	Castor wheel	12
2.	Wheel frame (Mild steel)	8
3.	Stainless Steel (body)	

7. Final Assembly

Fig. 4. Final assembly

A tri wheel frame is used in which the wheels are balanced with the help of other. The tri wheel attached to the shaft of the motor. Let us consider three wheels a,b,c and the wheels are attached in a single wheel frame when the shaft is rotated the wheel attached in the wheel frame is rotated and assume a,b moves upward in the step , and rotated by the support of a and b, c climbs towards the next step, thereafter c and a moves , with the support of c and a , wheel b climbs to the next step. By this way the wheel is moved step by step and it is possible to climb the staircase.

8. Conclusion

The step climbing Commode type wheel chair is fabricated to solve problems faced by the patients to climb staircase. The Bluetooth remote control system is used to operate the wheelchair easily. The Commode type structure is used for the patients to use toilets.

The primary objective of bearing heavy load like 12 kg is achieved during testing. The performance is slightly complicated when the straight frame was tested for varying step sizes. But when tested with Quasi-static frame, the vehicle exhibited greater performance even for stairs with different dimensions. Static structural analysis demonstrates that it is capable of moving heavy loads with less deformation and without any fracture.

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