

Design and Manufacturing of Stair Climbing Wheelchair

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Abstract - Electric-powered wheelchairs with stair-climbing ability have attracted great attention in the past two decades. By using the developed electric-powered wheelchairs with stair-climbing, many patients with walking difficulties are able to descend the stairs conveniently to participate in outdoor activities, which are beneficial to both their physical rehabilitation and mental health.

The development history is reviewed and wheelchairs with stair-climbing are compared based on a control method, cost of manufacturing and adaption to different stairs.

There are many models available in market but the cost is major factor due to which it cannot be used commonly by hospitals and differently abled person. Thus, the aim is to reduce the cost of the wheelchair without compromising the quality. The main factor which will reduce the cost is partial automation of chair. Most of the wheelchair which are available in a market have automatic control while moving on ground as well as while climbing on staircase. We are using automated drive only during climbing the stairs and the operation of wheelchair on ground is manual.

Key Words: Wheelchair, Stairs, Battery, chain & Sprocket, Belt & Pulley.

1. INTRODUCTION

Common wheelchairs can easily access many places, but when the user face stairs which often poses as obstacles, people can only step back, even though with the assistance from others, it is still very difficult to overcome these obstacles, which is inconvenient for those people who use common four wheeled wheelchairs.

Currently, standard four-wheeled wheelchair designs have some limitations and cannot perform standard routine tasks, such as stair climbing, sit-to-stand and stand-to sit operations. Though it is a cost-effective model; it restricts the mobility of person. Thus, this design will allow the person to climb up and down the stairs independently. This designed stair climbing wheelchair uses chain sprocket drive for transmission of torque and with the help of belt and pulley mechanism along with tilting mechanism it rises and climb down the staircase. This kind of stair climbing wheelchair will overcome the mobility limitation of four wheeled chair and at the same time it optimises the cost factor.

2. Component selection and System layout

2.1 Components of System

The system mainly consists of following components:

2.1.1 Frame

It consists of a chassis that carries motor, belt and pulley mechanism, sprockets, tilting mechanism, landing wheel mechanism, battery, seat which can be pivoted about a specific point to maintain the C.G of chair while climbing the stairs. The frame can be divided into two parts lower frame and upper frame. The lower frame is used to hold the chair along with the tilting mechanism, drive shaft, sprockets, motor, battery, landing wheel mechanism. The upper frame consists of seat, backrest, hand rest etc. The material to be used for the frame is mild steel. As mild steel has a relatively low tensile strength, but it is cheap and malleable.

2.1.2 Motor

Geared motor is selected as prime mover and its output shaft is further connected to sprocket. The motor should have sufficiently large torque rating to drive the whole belt pulley along the stairs.

2.1.3 Belt

Selection of belt should be such that it possesses anti-slip mechanism which is required while on the stairs to ensure the device changes to and from the stair angle in a controlled manner at the top of stairs. The proposed mechanism is based on the use of a single track. This reduces the pressure exerted on stair edges at the top and bottom of stairs. In this regard the track forms are optimally designed to maximize contact area away from the stair edge.

It is important that the thread of belt should provide sufficiently large friction so that it is possible to lock the chair at position on stair. Another important factor during selection of belt is sharpness of thread. If threads are too sharp there are chances breaking of thread which in turn responsible for slip.

2.1.4 Pulleys

The track belt is guided by series of pulleys as per the mechanism pulley will going to receive and transmit the power to belt it should have sufficient strength. In addition, with driving pulleys number of idler pulleys are arranged at specified distance to avoid slipping of belt. The Pulley wheel 7cm Dia. x 4cm Width is specially designed for conveyor belts.

2.1.5 Battery

Lithium ion Battery Pack is used as Power Source for Geared Motor. The gear motor requires 24 V DC power source. To get this much amount of power the lithium ion battery pack can be used. The required nominal voltage can be achieved by connecting cells in series and the required nominal capacity can be achieved by connecting cells in parallel.

So, for getting 24V, 7 cells are to be connected in series and for getting 15.4Ah, 7 cells are too connected in parallel. So total 49 lithium ion cells are required for the battery pack. The final pack configuration is designated as "7s7p pack" with final specification of 24V, 15.4Ah.

2.1.6 Chain & Sprocket

Chain and sprocket drive is used to transmit power from prime mover to belt pulley mechanism. As speed reduction requirement from prime mover to belt mechanism is quite large, chain drive is more convenient than gear drive. Use of gearbox will increases the cost and weight of wheelchair system.

2.2 Transmission system

The transmission component of the wheelchair design is responsible for allowing the operator to climb and descend the staircase. The transmission system consists of the chain sprocket, pulleys, belt, and motor. The motor is mounted rigidly, so that all the torque produced is completely transferred to the sprocket.

Lithium ion Battery Pack generating 24 V is used as power source for gear motor which converts electric supply to motive power. Further this power is transmitted to sprocket. The required reduction of speed and increment of torque can be achieved through chain sprocket drive. With proper sequential arrangement of sprockets. The required torque is achieved then this torque is given to pulley belt mechanism. This pulley belt mechanism is similar to conveyor and is used during climbing and descending the stairs.

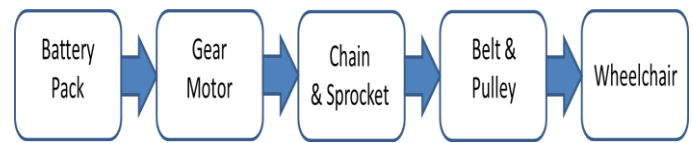


Fig -1: Flowchart of Transmission System

2.3 Tilting Mechanism

There is a tilting mechanism which connects the chair to the frame. There is need for the tilting mechanism because the person sitting on the wheelchair may feel like slipping from the seat because of the inclination of the stairs. More the inclination of the stairs, more he feels to slip from the chair. So, with help of the seat tilting mechanism the person sitting on the wheelchair can adjust the seat to the higher angle making the seat nearest to parallel to the ground so that he may sit comfortably on the wheelchair while it is climbing stairs. For tilting of seat two linear actuator are used one for forward stroke and another for return having sufficient load carrying capacity.

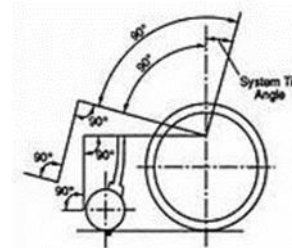


Fig -2: Seat Tilting Mechanism

3. WORKING

The project designed and built wheelchair capable of going up and down stairs. The moving unit implemented, provides an effective alternative to existing solutions that can improve physically challenged mobility. Working of wheelchair explained with help of three cases:

Case -1: Operation on ground

According the scope of project defined earlier working of wheelchair is manual on floor.



Fig -3: Manual Operation of Wheelchair

Case -2: Climbing up the stairs

Wheel chair when approach the stairs, this makes contact between belt and stair edge. The seat is tilted by tilting mechanism. This ensures that the CG of system remains in balanced position. This is necessary because the person sitting on the wheelchair may feel like slipping from the seat because of the inclination of the stairs. The more the inclination of the stairs the more he feels to slip from the chair. So, the person sitting on the wheelchair can adjust the seat to the higher angle making the seat nearest to parallel to the ground so that he may sit comfortably on the wheelchair while it is climbing stairs.

For climbing the chair, the angle of cross pulley aligns with the stairs and the teeth of the belt grips the stairs and elevates upwards. Once the cross pulley climbs the stairs, the main shafts approaches the stairs and climbs the stairs. When chair is about to reach last stair, the person may feel jerk due to sudden impact of chair on floor. To avoid this landing wheel is used which ensures gradual contact between chair and floor.

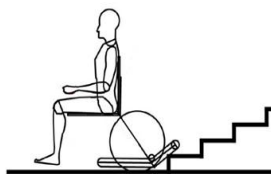


Fig -4: Stair Climbing Operation



Fig -5: Illustration of Landing Wheel

Case -3: Descending stairs operation

While descending stairs, with the help of landing wheel, gradual contact between chair and stairs is possible. The base module first descends the stairs followed by the cross pulley. At the end of stair, the angle of the module helps in descend.

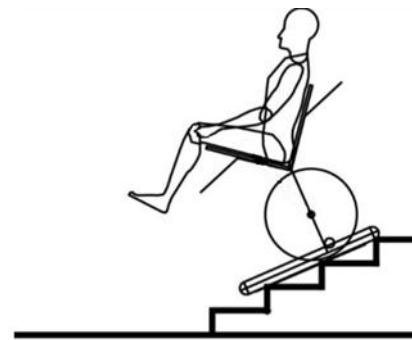


Fig -6: Stair Descending Operation

4. MODEL

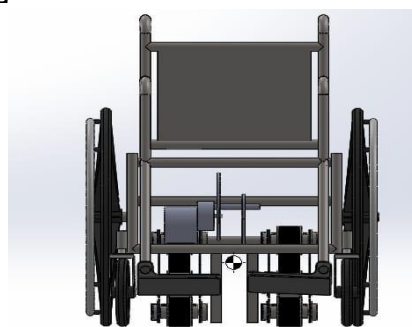


Fig -7: Rear View of Wheelchair

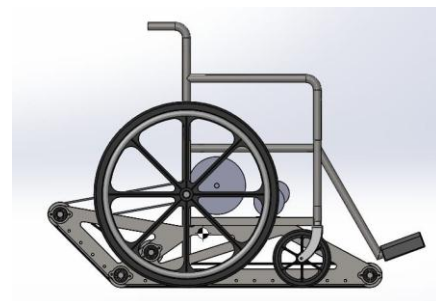


Fig -8: Wheelchair Side View



Fig -9: Isometric View of Wheelchair

5. CONCLUSIONS

This paper focusses on cost effective designing and manufacturing the stair climbing wheelchair in order to make the user feel more comfortable and convenient. This chair will increase the mobility of physically challenged

person. The product covered three modules viz frame, transmission system, tilting mechanism. The frame and motor are designed and developed through mechanical calculation based upon the statistical data of Indian dimensions of staircase. Based on these design calculations further the model will be manufactured with the help of CAD model and the design will be validate using analysis software.

6. Future scope

There is some work need to be done in future about our suggested design by improving the aesthetic look. We mainly think that:

1. The proposed model uses electric power only during climbing up and down the stairs but it can be modifying by using electric power on normal floor also.
2. Gravity Sensor can be used in tilting mechanism which sense the gravity during climbing helps to maintain the C.G in balanced position. Also, it reduces the load on motor.

7. REFERENCES

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