Indian J.Sci.Res. 17(2): 156-160, 2017

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

DESIGN & DEVELOPMENT OF MOTORIZED WHEELCHAIR FOR HANDICAPPED PERSON

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Abstract- In present world many people are suffering from spinal cord injury and disability in their lower extremities. In over to assist handicapped persons a manually motorized wheelchair has been developed. But, two handed manual wheelchair are difficult to propel and motorized wheelchairs are of high cost. In the present work an existing manual wheelchair was modified and fitted with power assisted components that can be alternatively attached to a wide range of manual wheelchairs. The design implements a motor which is coupled on both sides of wheel of the wheelchair is developed by using CATIA software. This modified wheelchair will help the handicapped person in ramp climbing with less exertion and even without by any other external assistance. The major advantage of this motorized wheelchair is that it can rotate about its centroidal axis. Further, this designed wheelchair reduces the cost of available motorized wheelchair.

keywords— Prototype, DC Motor, Couplings, CATIA

I.Introduction

The use of wheelchair has become crucial for people with spinal cord injury and lower disability in their lower extremities. The widespread use of various types of electric wheelchair is currently known including holding eye-level discussions with colleagues and shopping by balancing on two wheels, going up and down steep ramps, traversing outdoor surfaces (e.g., grass, dirt trails), climbing curbs and stairs. However, there are still limitations for indoor purposes due to small and confined spaces. There are many studies conducted in areas related to climbing robot and hence, a number of stair climbing mechanisms have been developed for wheelchair.

First successful working wheelchair was invented by "George Klein" who worked for the National Research Council of Canada, to assist injured veterans after World War II. Kayoko Komiya et al [1], did work related to development of a stair climbing wheelchair that can move in structured and unstructured environments, climbing over obstacles and going up and down stairs. The wheelchair design is vividly elaborated. The frame consists of a chassis embedded with two motorized locomotion units, a support for two electrical gear-motors, two idle triple wheels units and a battery pack. The seat is a tubular structure that consists of a chair and a pivoting wheel. The linkage mechanism is responsible for relative motion between frame and seat during stair climbing operation. Akira Murai et al [2], this paper is based on problem that is the wheelchair collides in the wall and obstacle by delaying the voice command. Then, our system applies the collision avoidance function (CAF) by which wheelchair avoids the wall or obstacle without voice command by using the information of two kinds of sensor. CAF assists the user to control the wheelchair without colliding in the wall or obstacle. Sundeep, Portia et al [3], introduces the voice control is through the feature based, language independent but speaker dependent, isolated word recognition system (IWRS) that uses DTW technique for matching the reference and spoken templates. A unique code corresponding to each recognized command is transmitted on a parallel port from the IWRS to the motor controller board that uses 80KC 196 microcontrollers. The output of these sensors along with positioned velocity sensors, employed on both the wheels, is the inputs to the fuzzy control algorithm. The feedback from these sensors is used in coordination with the voice command to provide an effective, easy and reliable control of the wheelchair. Richard C. Simpson et. al [4] proposed a NavChair Assistive Wheelchair Navigation System for reducing the cognitive and physical requirements of operating a power wheelchair. The NavChair is an adaptive shared control system. In this system the control is divided between the wheelchair and the wheelchair operator and adaptive in that how console is divided between the wheelchair and the wheelchair operator varies based on current task requirements, Muhammad Tahir Qadri Ahmed et al [5], suggested speech processing using Digital Signal Processor (DSP). The Texas Instruments TMS320C6711 DSP Starter Kit (DSK) is connected with the wheelchair for processing of the voice signal. The DSK calculates the energy, zero crossing and standard deviation of the spoken word. These digital signals are used to operate the stepper motor. The main idea of this inspiration is to process analog voice signal.

In the present work a wheelchair is developed by the help of two motors which is directly coupled to the wheels which help in climbing of ramp or any obstacle. The goal of this work is to design a smart wheelchair which is motorized and having stair climbing mechanism. We are going to use a DC motor which would be operated by a chargeable DC battery.

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II.Mechanical Principles of Wheelchair Design

a) Forces on Wheelchair

A force is the amount with which one object tries to push or pull another object. The earth exerts a force on every object, pulling it towards the ground. This is known as the force due to gravity. The application of force in wheelchair is as shown in fig. 1. When the forces are not balanced, the object will move. Forces are measured in Newton's. To convert kilograms to Newton's, multiply the number of kilograms by 9.81. One kilogram is equal to 2.2 lbs.

b) Centre of Gravity of Wheelchair

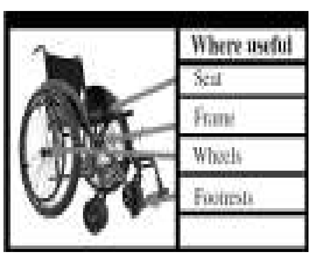
The center of gravity (CG) of an object is the point where it can be balanced. If you wanted to think of gravity pulling on an object at a single point, the CG is that location. Understanding CG location is important in wheelchair design. The force exerted by the person on the wheelchair is equivalent to the total weight applied at the CG of the body of the person as shown in fig. 2.

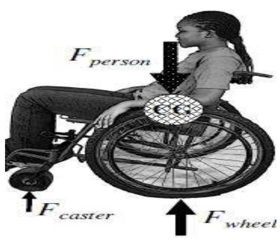
c) Tipping Angle and Balancing of Wheelchair

A wheelchair will tip over when the forces and moments acting on the chair become unbalanced. When the wheelchair tips to a point where the CG of the user is vertically aligned with the point where the wheel contacts the ground, the chair is unstable. The angle the wheelchair makes with the ground at this point is called the tipping angle (θtip), as shown in the fig.3. Tipping angle and height for different Wheelchair geometries is given in table 1.

d) Tipping Angle

We can calculate the tipping angle by using following relation.





$$\tan\theta_{tip} = (A/B) \text{ or } \theta_{tip} = \arctan(A/B)$$

Or

Fig.1 Application of forces in wheelchair

Fig.2 CG of Wheelchair

geometries.

A/B	θ_{tip}	h_{tip}
0.3	17°	11cm
0.4	21°	18cm
0.5	27°	28cm

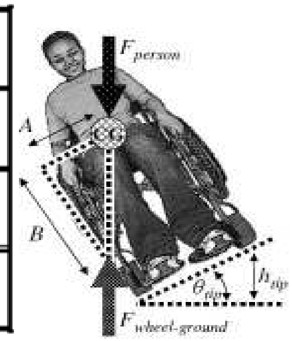


Fig.3 Tipping Angle of Wheelchair

e) Bending Stresses on Wheelch

When a part is bent the applied moment creates stresses in the material. On one side of the part the material is stretched and thus has tensile stresses, on the other side the material is compressed by compressive stresses. Most metals can be bent a little bit (elastically) and spring back to their original shape. If you bend metal too far it will pertinently deform because the tensile and compressive stresses will become larger than the yield stress of the material.

III.Design of Wheelchair Components

The designing of the wheelchair and its component has been done on CATIA software which is used for 3D modelling. The designing has been done with respect to the calculation been discussed.

Motor Torque Requirement

Determining of max load torque needed to maintain wheelchair stable on inclined plane. Assuming angle of inclination is 30° (Max.)

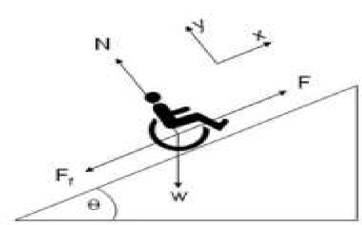


Fig.6 Mechanics of Wheelchair on ramp

Wu= Weight of User (100 Kgf) Assuming.

Ww= Weight of Wheelchair (25 Kgf)

Wt= Total Weight

= 100+25= 125 Kgf

Net force = 125*9.81 = 1227 N (Approx.)

Factor of safety=1.2

At Slope θ = 30° (At max. Slope)

Assuming μ (Coefficient of friction) = 0.3

Frictional Force (Ff)

Ff= μ*Wt*Sinθ

= 0.3*1227*sin30°= 184.05 N or Ff ≈ 185 N (Approx.)

Force need to hold the position on slope (F)

F = Wt*sinθ + Ff

= 1227*sin30° + 185 = 798.5 N

Force per push rims

Fpr = F/2

Fpr = 400 N (Approx.)

Hence the Tangential Force required holding 100 Kg person on Wheelchair at 30° Slope is 400 N

Radial distance from axle to push rims (d) = 0.305 m

Torque required for individual drive wheels (Tpr)

Tpr = Fpr* d = 400 * 0.305

Tpr= 122 Nm

Drive Wheel RPM Requirement

Diameter of Wheel (d) = 0.305 m

Circumference (C) = πd= 3.14*0.305 = 0.9577 m

Max Speed attain by the Wheelchair(S) = 5 Km/hr

S = 5*5/18 = 2.67 m/s

Or

S = 2.67*60 m/Min. ≈ 160 m/Min. (Approx.)

RPM = 160/C = 160/0.9577

RPM = 167

Tpr= 122 Nm

IV.Modelling and Design of Wheelchair

The designing of the wheelchair and its component has been done on CATIA software which is used for 3D modelling. The designing has been done with respect to the calculation been discussed. The frame consists of a chassis that carries two motorized locomotion units, a support for two electrical motors, two wheels units and a battery pack. The chassis consists mainly of two tubular structures, connected by means of crossbars; two tubular structures on the front support wheel units. Connection points are hinges for the linkage mechanism. The wheel units consist of two wheels rotating around a central axis, two casters wheels placed at its front. Wheel size was chosen on the basis of the consideration that large wheels can better absorb vibrations caused by uneven terrain, while small wheels reduce overall dimensions. Accordingly, larger wheels were selected for the locomotion unit and for the pivoting wheel, which are in contact with the ground most of the time, while smaller ones were chosen for turning in different direction.

a) Rear and Front Wheels of wheelchair

The design of wheel is not new even a standard wheel has been used instead of making a new one because the availability of standard wheel is easy in the Indian market. The different view i.e. isometric, side, front and top of wheel chair structure developed in CATIA is as shown in fig.5.

A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. Couplings do not normally allow disconnection of shafts during operation of transmitting power. To couple the motor output shaft to the wheel hub which is threaded one side a new type of coupling has been designed as shown in fig.6. It consists of two Allen Key bolt of 4mm diameter which helps in clamping of motor's output shaft to the hub of the rear wheel.

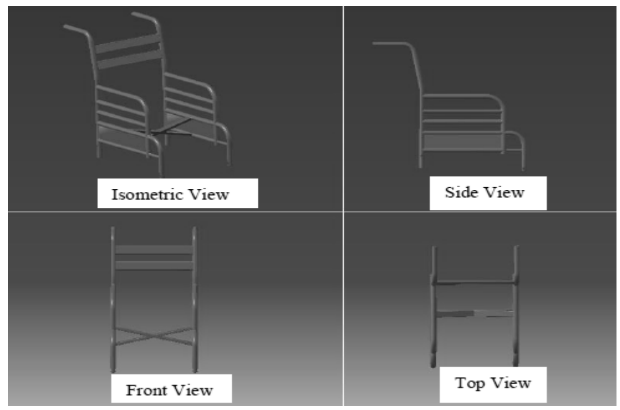


Fig.5 Views of Wheelchair Structure on CATIA Software

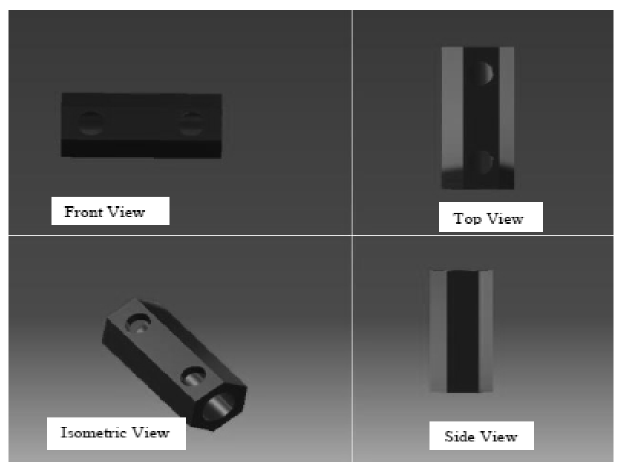


Fig.6 Designed Coupling in CATIA

b) Power Wheelchair Drive DC Motor with Worm Gear

To drive the Wheelchair, DC motor has been used which is having arrangement of worm and worm wheel. The technical specifications of the power DC Motor are given in table 2. The power supplies of these motors are controlled by two DPDT switches (Double Pole, Double Throw). DPDT is a type of electrical switch which can control two separate circuits, switched together by a single actuator. It is a module which consists of two switches operated by one lever, as shown in fig.7(a) and 7(b).

Table 2: Technical Specification of DC Motor

Voltage	Current	Torque	Speed	Quantity
22 V	2.5 A	150 Nm	150-155 RPM	2

Fig.7(a) DPDT Switch Front view

Fig. 7(b) DPDT Switch Back view

Pole refers to the number of circuits controlled by the DP switches control two independent circuits (and act like two identical switches that are mechanically linked). Throw refers to the extreme position of the actuator: DT switches close a circuit in the Up position, as well as the Down position (On-On). A DT switch can also have a center position (frequently On-Off-On).

c) Assembly of Motorized Smart Wheelchair

The proposed system is focused to reduce manual dependency to operate Wheelchair. Motorized and ramp climbing based low cost wheelchair assists physically challenged people. The system can easily be operated by physically handicapped person by operating switch simply. It is aimed to make cost effective and efficient wheelchair by using motor and switch with mechanical assembly.

The Mechanical assembly consists of Wheelchair frame having two wheels, two casters, footrest, Brushless DC motor which is directly coupled into wheels i.e. used to drive wheel chair with high torque and low speed, this motor are connected to the wheelchair via sheet of metal plates. The assembled view of wheelchair on CATIA software is as shown in fig. 8.

Fig.8 Assembled View of Wheelchair on CATIA software

Fig.9. Assembled Wheelchair Side View

Fig.10. Assembled Wheelchair Back View

The Mechanical assembly prototype of wheelchair is developed with sideview and backview assembly is shown in fig. 9 and fig. 10 respectively.

V.Trial and Testing of Wheelchair

After the complete assembly of Wheelchair and its components in the Workshop, the mechanical devices were selected and trial testing was done to find the maximum weight capacity. The driving speeds were obtained by driving the Motorized wheelchair in right, left, forward and backward in directions as shown in fig.10.

a)Turning Radius Test

The minimum turning radius is an important aspect of performance of Wheelchair. Turning radius determines the ability of the wheelchair to take the sharp turns in left, right directions. While calculating the minimum turning radius of the chair the approximate readings are given in table 3.

Table 3: Turning Radius Test Results

S.No.	Direction of Turning	Minimum Turning Radius (m)
1	Right	≈ 0.703
2	Right	≈ 0.705
3	Right	≈ 0.71
4	Left	≈ 0.712
5	Left	≈ 0.72
6	Left	≈ 0.71

VI. Cost Estimation of Designed Wheelchair

The cost estimation for the assembly and manufacturing of developed Smart Wheelchair prototype has been discussed in Table 4.

Table 4: Cost Estimation of Smart Wheelchair

S.No.	Particulars	Quantity	Amount (INR)
1.	Part's for Wheelchair assembly	1	3,400
2.	DC Brushless Motor	2	8,700
3.	Rear wheels	2	480
4.	Battery	2	3,000
5.	Switches, wires, Cardboard	—	1,480
6.	Bearings, Hub, Steel plates and pipes	—	1,275
7.	Others	—	3,000
Total Amount			21,335

In Indian market the cost of motorized wheelchair is very high hence not every physically handicapped person can afford it. The Power assisted Wheelchair available presently costs around 1,45,000/- INR.

VII. Conclusions

A manual wheelchair was minimally modified and fitted with power assisted components that could alternatively be attached to a wide range of manual wheelchairs. The design implements a motor coupled to the wheel on both sides of wheelchair which help the handicapped person for the ramp climbing without any external support. Further, the cost of developed wheelchair is very less as compared to the available motorized wheelchair with Battery.

References

[1] Kayoko Komiya, Kiyosi Morita, KouuKagekawa And Kenji Kurosu Kayoko Komfy, A.Kyusllu, Guidance of a Wheelchair by Voice, School of Engineering, Kinki University IEEE ©2000 IEEE

[2] Akira Murai, Masaharu Mizuguchi, Masato Nishimori, Takeshi Saitoh, Tomoyuki Osaki and RyosukeKonishi, Voice Activated Wheelchair with Collision Avoidance Using Sensor Information, ICROS-SICE International Joint Conference 2009 August 18-21, 2009, Fukuoka International Congress Center, Japan

[3] Sundeep, Portia, H.R. Singh, Abdul Mobin and S. S. Agrawal Central Electronics Engineering Research Institute, CSIR Complex, New Delhi (INDIA), Design and Development of Voice-Cum-Auto Steered Robotic Wheelchair Incorporating Reactive Fuzzy Scheme for Anti-Collision and Auto Routing, 2000 IEEE

[4] Richard C. Simpson And Simon P. Levine, Voice Control Of Powered Wheelchair Ieee Transactions On Neural Systems And Rehabilitation Engineering, Vol. 10, No. 2, June 2002

[5] Muhammad Tahir Qadri, Syed Ashfaque International Conference on Signal Acquisition and Processing 2009 IEEE Computer society, Voice Controlled Wheelchair Using DSK TMS320C6711.

[6] G. Pacnik, K. Benkic and B. Brecko, Voice Operated Intelligent Wheelchair – VOIC, IEEE ISIE 2005, June 20-23, 2005, Dubrovnik, Croatia.

[7] M. Dechrit, M. Benchalak and S. Petrus, Wheelchair Stabilizing by Controlling the Speed Control of its DC Motor, World Academy of Science, Engineering and Technology,Vol: 58 2011-10-25.