Design and Fabrication of Low Cost Modified Maneuverable Standing Stretcher Wheelchair Transport System

Srinidhi Acharya S R[1], & Suresh P M [2]

[1]Assistant Professor, Department of Mechanical Engineering,
ACS College of Engineering, Bangalore, VTU Research Centre, Belagavi, India
[2] Professor, Department of Mechanical Engineering, ACS College of Engineering, Bangalore, India
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Abstract - *Wheel Chairs are one of the convenient man made structure which are highly useful for person with disability. The major problem of this wheelchair is the architectural obstacles such as stairs etc. Many researchers around the globe have worked on wheel chair design so as to make the user independent. The question of overcoming these obstacles by a wheelchair always is the most discussed topics in recent days.*

This paper involves in fabricating a wheel chair which is motor operated. It is stair climbing wheelchair design which concept which overcomes the structural obstacles. The fabrication of an ergonomically designed battery operated wheel chair for multi usage is done. Concept of stairs climbing function is embedded in the design by adopting new design and mechanism. The design considerations of the wheelchair are based on the standard design of the stairs which are constructed in India. The work deals with design and fabrication of wheelchair convertible to bed. It is also equipped with a standing aid which helps the disabled individual to stand up and perform certain work.

The design involves the use of electrical linear actuators which consists of an assembly of motor driven power screw to make the transformation from sitting to a bed by using a hand held remote, overcoming the need of a another person to shift the patient from wheelchair to bed. This project offers multiple features over a standard wheelchair and is very economical in comparison to commercially available wheelchairs.

***Keywords:** Design; Actuator and Sensors; Stairs Climbing; Wheelchair; Lifting Mechanism; People with Disability*

I. INTRODUCTION

One-fifth of the population around the world has one or the other disabilities. Disabilities can be found in various parts of the human body such as eyes, ears, hands, legs etc. Limb disability is one such disability. The root cause for this includes deformation by birth, wars, and diabetic disorder. Lower limb for a sports person also suffers huge injuries during game. These injuries sometimes lead to permanent disability. Also there are many people amongst us who have walking disability that may be temporary or permanent. Many of these disabilities confine the patient to a wheelchair which has to be operated by the patient himself or by care taker person. But these conventional wheelchairs have its own limitation in terms of comfort and handling. Manually operated wheelchairs were first introduced during 19th century by war veterans. These manually operated wheelchairs are used disabled persons with enough upper-body movement in the shoulders, arms and wrists to push the rims of the wheelchairs as shown in figure 1. These are well equipped with foot rests, arm rests and brakes. Other fittings can be added wheelchair such as seat inserts

cushions etc. Over the years, the lightweight, rigid-frame wheelchair and the suspension mechanisms in the wheelchair have provided better alternatives when compared to conventional wheel chairs. The most commonly used powered wheelchair as shown in figure 2. These are operated by a lead-gel acid battery. This is majorly used by persons with less or zero movement in the upper body and limbs. These are controlled by a manually operated joystick which allows the wheel chair to accelerate, decelerate and move in reverse path.

Figure 1: Manually Operated Wheel chair

Figure 2: Powered Wheel Chair

Over the years, the wheelchair researchers have more interest in adopting newer materials with additional features for improving the stability of the wheelchairs. There by an elderly person with disability, a wheelchair provides access to the outside world. For sportsperson, a wheelchair is the means to participate in marathons and tennis.

II. LITERATURE SURVEY

The first ever wheel chair was introduced during 1595. Later, during 1655 Stephen Farfler designed and fabricated a self-propelling wheel chair operating on a three wheel chassis frame. In 1783 John Dawson of England introduced wheel chair which had two large wheels and one small wheel. A patented wheel chair with a rear push wheels and small casters were invented during 1869. In 1900 the first wheel chair with spokes was designed and fabricated. A battery operated motorized wheel chair was invented by British Engineers during 1916. Later a researcher by the name Harry Jennings built the first portable wheel chair in 1932.

Shahida Siddiqui.et..al., [1] designed a wheel chair which was used by Quadriplegics (the person affected by paralysis of all four limbs). This wheel chair works on the concept of head tilt movement which enables the user to move from one place to other. Different sensors were used in the entire wheel chair to reduce the errors and malfunctions. Later it was concluded that the head tilt motions controlled automated wheel chair provides a better solutions for quadriplegic disabled persons with 40% disability. This design proved better when compared to automatic joystick powered wheelchairs with respect to operation.

Vignesh S.N.,et.al., [2] designed and fabricated a wheelchair in which it included an accelerometer sensor which recognises the head movement. Controller processes the signal and the same is transmitted to the wheelchair for further movement. It was simple in its construction when compared to others wheel chairs. Apart from accelerometer sensor there

were other sensors such as motor, obstacle sensor, eye blink sensor, motor driver, etc. used during designing.

Narender Kumar et.al., [3] research introduced a new design by adopting a novel hands free control system. This was suited for a blind person with disability in limbs. This wheel chair worked in accordance with the head movement. The novel hands-free control system works on works on real time basis. Here, the robotic wheelchair was divided as Automatic and semiautomatic. Later it was concluded that wheel chair with hands free control technology are best suited for blind persons. This was also economical and simple in design.

Monika Jain et.al., [4] investigated on a wheelchair which was based on the eyeball movement of person. The eye ball movement was controlled using IR sensors. These IR sensors modules were installed on an eye frame to mark the movement of the iris. This wheel chair was equipped with IR sensors which detect white objects, recognizes head and chin movements, sip-n-puff control, voice recognition etc. But this wheel chair was inconvenient since it had its own drawbacks in usability. Later after much analysis a new model was designed with less cost, flexible and stream-lined alternative.

Olawale O.E., et.al., [5] worked on Electronic driven wheelchair (EDW). This was useful for the person with motor impairment. These wheel chairs clearly served against the effects of the above mentioned disabilities. This was developed at an average cost and for outdoor use. It consisted of rear motor driven wheels (two numbers), 12V DC batteries, angle bars and metals. The Joystick controls the EDW system. The batteries are charged by using 220V AC mains. The framework of the wheelchair consisted of 55% metal, 30% rattan and remaining 15% with bamboo material. The main aim of this thinking is that this wheel chair should afforded eve by the average income holder.

Another type wheel chair with stair-climbing capacity and its components consisted of a leg shaped elements which was useful for climbing the stairs. It was designed by Jianjun Yuan et al. [6]. It is an eight legged structural wheelchair fitted with wheels which is attached to each leg. All eight legs were driven independently using eight motors giving zero carrier which enables the possibility to compress or expand any leg independently.

Josefina Chaves Poss et.al., [7] in association with Alberta university designed a manual operated stair climbing wheel chair. It was observed that zenith propagates on two different tracks on flat terrain and climbing stairs. Also, the cluster of three legs with small wheels at the ends helped during stairs climbing

III. OBJECTIVE OF THE WORK

The main Objective of the work is

- To design and fabricate manual standing wheelchair with lifting mechanism which converts into a bed and to improve its design so as to provide standing assistance.
- By using simple mechanism, lighter material the model obtained will be at low cost and affordable by common people.

IV. MATERIALS AND METHODOLOGY

Materials employed for this work consists of electrical components and mechanical components. The Electrical components includes: 12 V battery with 0.92 retention capacity, 2 Nos 18AH, 1 No solar module with 0.87 operating factor and 2 Nos of 180W motor. The mechanical materials includes Mild steel rod, Nut and Bolt, Frames, tyres, Wheels, Brakes, casters, Push rims, Tilt Bars, head rest, back rest, etc. The electrical components arrangements are shown in figure 3.

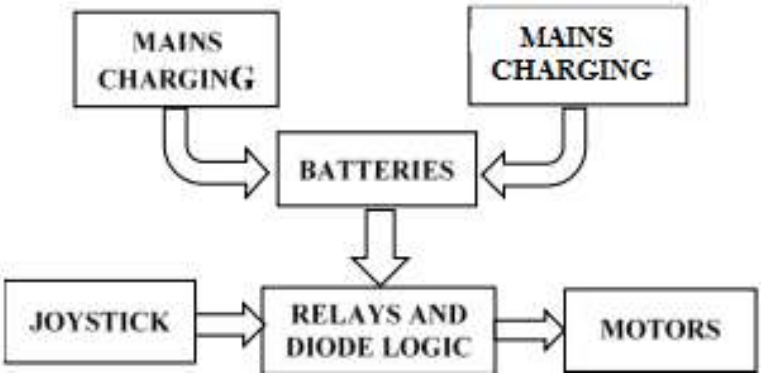

Figure 3: Electrical set up for the wheel chair

METHODLOGY: The method adopted to complete the work is as follows. The detailed design and fabrication process of wheel chair is shown in Figure 4.

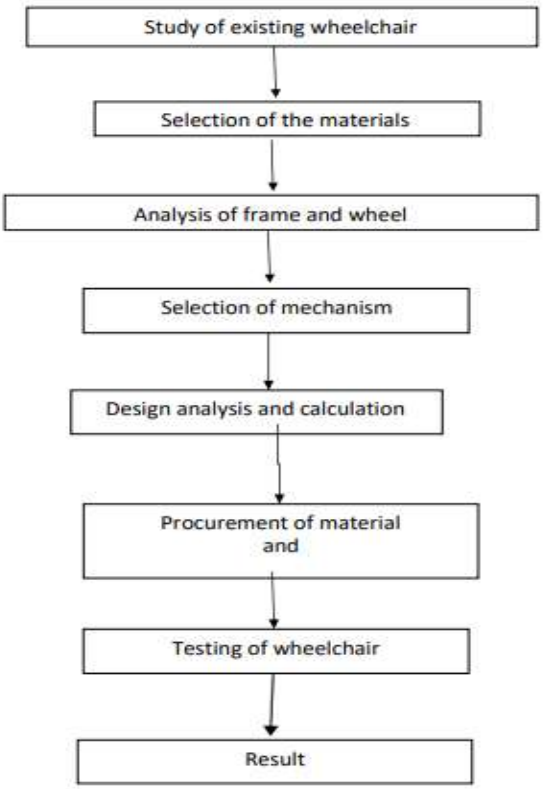

Figure 4: Design Process

The CAD Model of the wheel chair was created using CATIA V5R 20. ISO metric view of the wheel chair is as shown in figure 5.

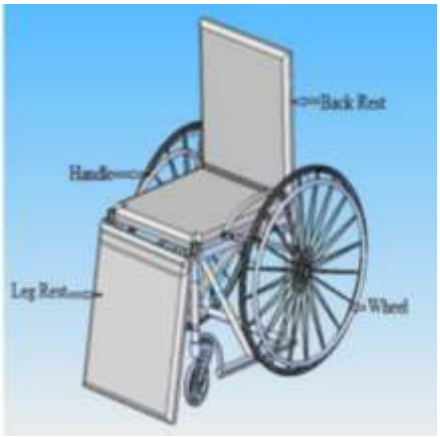

Figure 5: ISO Metric View of the Wheel Chair Design.-CAD Model

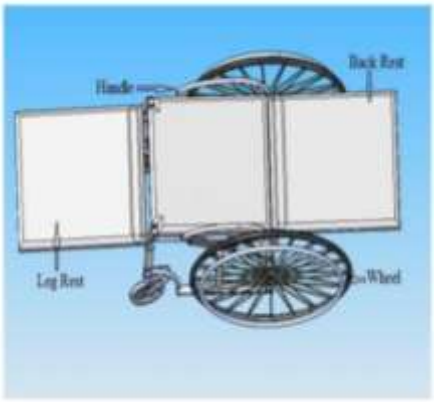

Figure 6: CAD Model of Wheel Chair Convertible to Bed

The work is being conducted with the aim of developing a wheelchair in order to make it more convenient for the quadriplegic persons to have free movement to lead an independent life. The wheel chair being designed should be tested after being constructed for measuring its precision. It also consists of sensors such as pressure sensor in order to limit the chance of an error in case if the patient falls asleep or sneezes. It also has the sensors to detect the head gestures, that is, the motion sensors. Overall the wheel chair automation is done by using head gesture based on the accelerometer and the motion sensors. Microcontroller (program) is mainly used to control the navigation of the wheel chair system. The lightest material is used in order for a better regulation of the speed.

V. FABRICATION PROCESS

During fabrication, the scientific data and proportions required for the measurement of the adult human body in terms of percentage body weights are collected and tabulated table 1. People with disabilities generally have distorted frames. This paper considers the data for an average adult wheel chair structure in order to accommodate different parts such as sensors, actuators, joysticks etc. All the load calculations are tabulated in Table 2. The wheel chair during up moving the surface and moving down the surface and its force mechanism is as shown in figure 7 and 8 respectively.

Table 1: Percentage of Body Weights

Segment	Male	Female	Average
Leg	**10.5**	**5.35**	**7.925**
Forearm & Hand	**0.65**	**2.07**	**1.36**
Thigh	**16.82**	**11.75**	**14.285**
Forearm	**3.93**	**1.57**	**2.75**
Foot	**4.92**	**1.33**	**3.125**
Abdomen	**13.06**	**12.24**	**12.65**

Whole Trunk	**54.9**	**53.2**	**54.05**
Pelvis	**13.66**	**15.36**	**14.51**
Total Arm	**5.92**	**5.01**	**5.465**
Upper Arm	**3.18**	**2.9**	**3.04**
Thorax	**20.1**	**16.98**	**18.54**
Hand	**1.42**	**0.57**	**0.995**
Head	**8.31**	**8.28**	**8.295**
Total Leg	**2.81**	**18.47**	**10.64**

VI. LOAD CALCULATIONS

Table 2: Load Calculations Details

Particulars	**Weight (kg)**	**Weight (N)**
Weight of the body (Front Caster)	**14.24**	**139.6944**
Weight of wiper motor (2 Nos)	**4.5**	**44.145**
Human body weight (Approximate)	**80**	**784.8**
Vertical Component of the Force : $F_{vertical}$ =		**(139.552 + 784) = 923.552**
Load on each caster = $\frac{923.552}{2}$ N		**461.776**
Inclination Angle	**10 Degrees**	
$F_{inclined} + F_{vertical}$ x Cos θ = 923.552 X $Cos10^0$ = N		**909.52**
Load on each caster = $\frac{909.52}{2}$ N		**454.759 N**
Weight of body (Rear wheel)	**14.2**	**139.552 N**
Human back weight	**31.693**	**310.91**

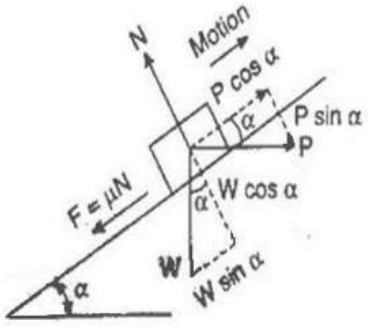

Figure 7: Force Diagram for Wheel Chair Lifting

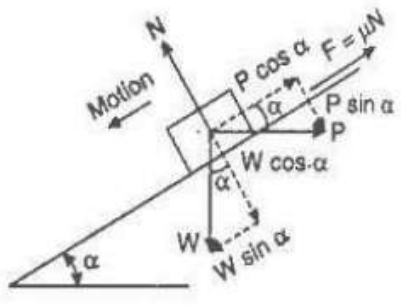

Figure 8: Force Diagram for Wheel Chair Lowering

Torque (M_t) required raising the load,

$Mt = W \sin\frac{dm}{2} \tan(\emptyset + \alpha)$ (i)

$$Mt = W \sin\frac{dm}{2} \tan(\emptyset - \alpha) \quad \text{(ii)}$$

Where W- Load raised or lowered (N)
P- Imaginary load acting at the mean radius (N)
d- Nominal or outer diameter (mm)

The final product fabricated using various electrical and mechanical components are fabricated and its various views are shown in figure 9, 10, 11.

Figure 9: Isometric view of Wheel Chair

Figure 10: Front View of Wheel Chair

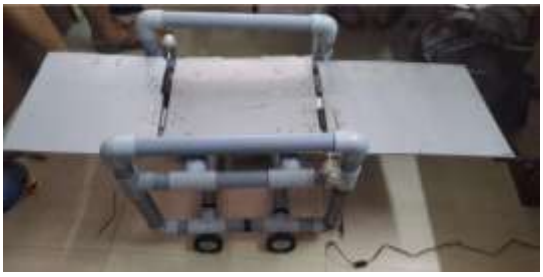

Figure 11: Wheel Chair Convertible to Bed

VII. RESULTS AND DISCUSSION

A LCD plate is fixed to battery voltage in real time and for charging indication. Even solar panel can be installed for the power charging. In order to enhance the charging time with mains, a higher rated charger is utilized. After successful fabrication a various tests was conducted. The data obtained from the tests was on served, analyzed and recorded for different trails. During each test persons with different mass were selected. The structure supported up to a mass of 110kg. The battery life is 100 minutes approximately for an average person of 90 Kg.

The battery needs 5 hours continues power supply for full charge from mains and 12 hours from solar units. This variation in solar charging is due to varying solar angles and the installations of solar panels.

VIII. CONCLUSIONS

- A wheel chair was fabricated successfully using electrical components such as batteries, actuators and various sensors. This wheel chair is used by a person with disability who

wants climb stairs move around the house thereby making it an integral part of day to day activities.

- This wheel chair is not only cost effective but also a simple mechanism that provides multiple functions as compared to conventional wheelchair.
- Hence the design and fabrication of wheelchair convertible to bed is more effective as a whole.
- The design tests are conducted for various trails and the results obtained clearly indicate that the overall design is safe and hence a no chance of failure.
- According to the tests conducted, the stair climbing wheelchair has a capacity of carrying a load of 90 kgs on flat surface. It has the ability to ascend a flight of stairs of 35-degree elevation carrying a weight of 55kgs.
- It was designed with the facilities of bed conversion, height adjustment, massaging provision and voice control mechanism for movements.

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