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DESIGN AND FABRICATION OF WHEELCHAIR FOR PARAPLEGIA PATIENTS

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Abstract - *In India the number of paralyzed individuals is increasing every year. Mobility aids are useful for patients for transportation and a replacement for walking especially in indoor and outdoor environment. Transferring the patients from wheel chair to other medium like bed, car etc is always an issue for the attendant or helper. Understanding the various issues regarding the mobility equipment and introducing a better design will be an asset for the medical field and helping hand for paralyzed individuals. This is an assistive mechanism to provide an easy, safe and convenient way of shifting wheel chair users from wheel chair to other mediums and ease the life of care givers. It drastically reduces the efforts of care giver in handling of patient especially giving transfer. The wheelchair also provides standing mechanism without any electronics components. This is a cost reducing project which helps mainly paralyzed patients to do their daily things.*

Key Words: Paraplegia, Gas Spring, Ball Bearing, Freewheel etc

1. INTRODUCTION

In India, the number of paralyzed population has a tremendous augment in the past few years. Huge number of people have congenital disabilities, another few percentages are the victim of accidents who suffers paralyzed condition and there is a large number of paralyzed people, they are mainly classified as,

- Monoplegia, which affects only one arm or leg.
- Hemiplegia, which affects one arm and one leg on the same side of your body.
- Paraplegia, which affects both of your legs.
- Quadriplegia or Tetraplegia, which affects both of your arms and both of your legs.

The person who suffers paralyzed conditions needs special care for day to day life and the meditation required to paralyzed persons is different according to classification of paralysis condition. Paraplegic patient suffers disability to both legs. So in this project we are designing an assistive device for paraplegia patients with mechanical components. The design has the following advantages of wheelchair with standing mechanism without any electrical components with shifting mechanisms for patients from wheelchair to another medium like bed, chair etc. and self-controlled movement system with levers to avoid frictional effect between users and wheels in a wheelchair. So the wheelchair is very useful to paraplegic patients as an assistive technology.

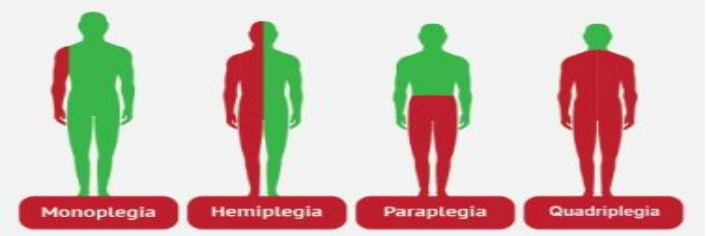

Fig 1.1: Types of Paralyzed Condition

1.2 PARAPLEGIA PATIENTS

Paraplegia, sometimes called partial paralysis, is a form of paralysis in which function is substantially impeded from the waist down. Paraplegia is due to the damage of brain, spinal cord or both. In most cases, spinal cord injuries to the thoracic, lumbar, or sacral spinal cord are to blame. When these injuries occur, signals cannot travel to and from the lower regions of the body, and the body is prevented from sending signals back up the spinal cord to the brain. Thus paraplegics not only struggle with movement below the waist, they also experience extensive loss of sensation. This sensation loss varies from a feeling of tingling or reduced feeling in the waist and legs, to a complete inability to feel anything below the waist.

Fig 1.2 Paraplegia Patient

2. METHODOLOGY

In the last year, our college conducted a program for paralyzed people known as Ilam Thennal associated with Palliative Care Unit. Nearly 200 paralyzed people came to the function from our Taluk. At that time we discussed with the paraplegia patient and found the major challenges faced by the paraplegia patients. The paraplegia patients opined the common difficulties faced by them are,

- Movement from one place to another in wheelchair alone cause hand burn due to hand contact with rubber tyres.
- They can't do anything themselves, even though they need a helper to do something.
- Shifting of them from wheelchair to another medium like bed, chair etc.

For solving the above problems, they need the help of caretaker. This leads the patients to loss their mental strength due to the dependent life. In this project we are helping the paralyzed people to achieve freedom from caretakers and this will give mental strength to paralyzed patients to partial cure from paralyzed condition. The movement of wheelchair using levers will help the paraplegia patients to achieve good health condition due to removal of the stiffness of body.

In last year, Kerala faced a big flood. Due to that flood many paralyzed patients lost their electronic controlled wheelchair by the contact of water with the main control unit of wheelchair. The maintenance cost is high for electrical wheelchair. So the people from poor background can't afford the maintenance cost or another wheelchair. For avoiding these problems, we designed a wheelchair with mechanical components of poor cost with high durability and efficiency. In this wheelchair there is no electronics components which will lead to reduce the cost of wheelchair.

3. WORKING

The wheelchair design and its working is mainly divided into three parts according to the different assistance need by paraplegia patients, three individual ways for solving the problems faced by paraplegia patients are given below,

Fig 3.1 : Division of Work

3.1 DIVISION OF WHEEL

For the easiness of shifting patients themselves from wheelchair to bed, car, chair etc. like any other medium or vice versa the wheel will obstruct their transfer through arm rest. For preventing this obstruction through the sideways of the wheelchair the arm rest and wheel of the wheelchair has been modified according to facilitate the transfer. The wheel is partitioned into part so that it can be act as medium for transfer. The part is made as lockable type so that when the time of transportation, the wheel will act as rigid part at the time of transfer and the part of wheel can be unlocked and facilitate the transfer. The modified arm rest is also plays an role in the transmission, like wheel the arm rest also obstruct the transfer. The modified arm rest is flexible so that it will be able to adjust the position so that shifting the patients can be facilitated. The whole wheel is made by mild steel sheet having 1mm thickness and rubber tyre is fitted on the wheel outer diameter. Then the part which is assembled and disassembled is cut into part. Then hinge was provided for folding and unfolding the divided part of the wheelchair. The arm rest is made into a removable one which can fit whenever it needed and can be removed at the time of transmission. Thus patients can able to easily shift themselves from wheelchair to any other external medium or vice versa.

3.2 FREEWHEEL CONCEPT

We know that freewheel or overrunning shaft is a device used in a transmission that disengages the drive shaft from the driven shaft when the driven shaft rotates faster than the drive shaft, exactly the same principle is used here. For preventing hand burn and facilitating faster transportation through wheelchair freewheel concept is used. Addition to freewheel extra lever assembly is provided for the fast transportation. The freewheel is mounted on the same shaft where the rear wheel were mounted so that it will act as driven shaft and the wheel will rotate fast at less force.

3.3 STANDING WHEELCHAIR CONCEPT

The standing aid of the wheelchair is mainly based on the gas spring device. We all know that gas spring is widely used in adjustable chairs, car doors, shelves etc. The same device is used for facilitating the standing aid in this wheelchair. Gas spring along with brake cable controlled mechanism will provide standing mechanism is made to possible. The wheelchair seat is modified for standing concept. The seat is fixed to structure using different hinges for re- adjusting the angle of the chair position according to standing position. Using brake lever control, the gas spring is made to expand at the time of expansion the seat will push the chair to the inclined position but the force will not be effective to push the weight of an entire person so that an equivalent force is applied on the arm rest for balancing the weight force thus after releasing the lever the chair will

locked exactly at the same position (it will not compress), also repeating the same procedure the patient will able to acquire to the standing position. Keeping the standing position patients can transport using this wheelchair by make use of extendable lever assembly. Then by engaging the brake lever the gas spring compresses and bought to initial position by make use of weight force. Extra belt and mounding is required for the safe operation of the standing mechanism. There should provide an extra soft mounting on the elbow side of the wheelchair so that at the time of standing the foot will not bend to make sure that the foot is assumed to be the rigid body. The gas spring is installed on the back side of the wheelchair where the end lug is attached on the bottom structure and rod is attached on the rear side of the chair. Thus the manual standing is made possible by using gas spring assembly. Thus by integrating these three ideas, a wheelchair which is useful to paraplegia patients is made for the society.

4. WHEELCHAIR DIMENSIONS

Table 9.1 Wheelchair Dimensions

Wheelchair Part	Dimensions (mm)
Width of chair	380mm
Length of sit rest	400mm
Length of back rest	540mm
Length of foot rest	340mm
Length of frame	400mm
Width of frame	380mm
Rear wheel of diameter	600mm
Hand lever length	400mm

5. DESIGN OF WHEELCHAIR

After identification of problem, we designed a wheelchair with providing maximum comfort to paraplegia patients in 3D modeling software SOLIDWORKS. The wheelchair was modeling by using Mild Steel as a material. Various parameters like Center of Gravity (CG) and forces are found out. We designed the wheelchair with multiple assistive technologies for simplifying the problems faced by the paraplegic patients while using wheelchair. Here we have done specific modification to the wheelchair for giving more freedom to the paraplegia patients while using wheelchair. We provided an extra feature for the wheelchair which will help patients for effective way to transport using wheelchair. As we have discussed earlier about hand burn while using wheelchair, we provided a lever assisted mechanism for pulling the wheelchair to forward. Here we used one way bearing hub for pulling the wheel forward while it is disengaged with the wheel while pulling backward so that efficient and less strain is used for transport using wheelchair. The lever is restricted to 270^0 rotation so that it will not affect the wheel movement.

Fig 5.1: 3D CAD model of Wheelchair Design

For standing aid for patient there is an extra feature within wheelchair for standing aid. Here it works based on chair cylinder (pneumatic compression cylinder) and lever assisted mechanism for standing in wheelchair without any external assistance. The rotatable seats will help to simplify the operation for standing and minimizing difficulty for standing. By using the adjustable lever transport while standing is also possible.

Fig 5.2: Standing Position of wheelchair.

There is an extra feature which will used assist patients to shift themselves from wheelchair to any external medium or vice versa by dividing the wheel of the wheelchair and using adjusting arm rest mechanism. The divided wheel can disassembled on the time of shifting and assembled after it is done by them.

6. BASE STRUCTURE ANALYSIS

After finalizing design on SOLIDWORKS, we have to analyse the design. It is very difficult to find out different types of forces, deflection, failure, etc. on our designed wheelchair by manually. So with the help of software, we analysed the design. There are number of software available for analysis of design such as Altair, ANSYS, etc. But the SOLIDWORKS software which was suitable for us, it gives better results on short time. We are assuming the total load of 981N is acting on it. Thus the analysis is based on the given net force value.

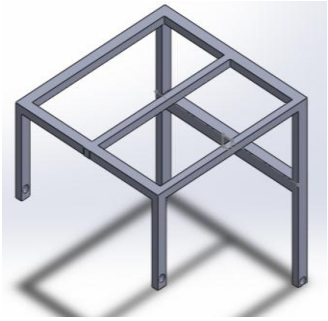

Fig 6.1: Base structure

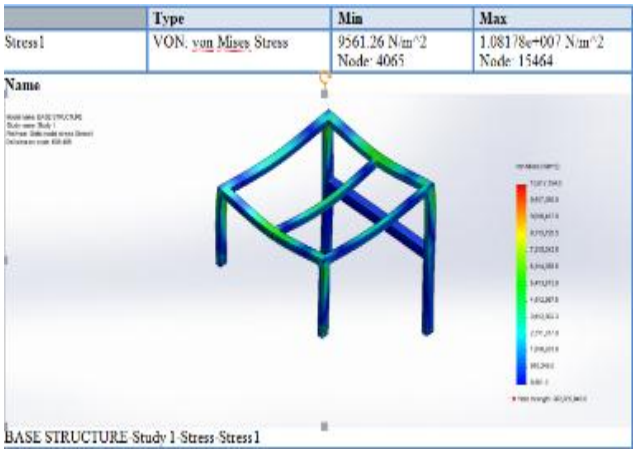

Fig 6.2: Base Structure Analysis

6.1 CONCLUSION OF BASE STRUCTURE ANALYSIS

We selected MS 1038 material for analysis of our structure. And on the basis of obtained by different resources and results, we selected the AISI 1038 as material. By applying all the relative values and prerequisite to the solver of the software SOLIDWORKS we get all the values of stresses, total deformation, elastic strain intensity and strain energy that is the minimum and the maximum values of all these factor and they are plotted on the above tables. By tables we know that the maximum stress in the base structure is1.08178×10^7 N/m^2. This is lower than ultimate 485MPa hence it is found as a safe selection of material and safe loading.

7. DESIGN CALCULATION

A) Torque required on a flat surface

Normal Force (F_n) = mg =100×9.81 =981 N

Friction Force (F_f) = μ F_n = 0.2×981 = 196.2 N

Torque Required = $F_f \times r_W$= 196.2×0.3 = 58.86 Nm

B) Force Analysis on wheels

Weight of body = 100kg

Weight of wheelchair = 12kg

Total Weight= 112kg = 1098.72N

[a] Force on wheel

$2F_{caster}+2F_{wheel} - F_{person} = 0$---a

$$2F_{Wheel} = \frac{Fperson}{Lperson + Lcaster} (L_{caster})$$ ----b

$$2F_{Wheel} = \frac{(1098 \times 68)}{79} =$$

=945.11N

F_{Wheel} = 472.5N

472.5N force on one back wheel

[b] Force on caster wheel

$2F_{caster}$+945.11= 1098.72

F_{caster}= (153.61/2) =76.805N

76.805N force on one caster wheel.

C) Ball Bearing Design

Assume mass of person = 100kg

Factor of safety = 0.9

Total mass = 100+(100×0.9) = 190kg

Total weight = 190×9.81 = 1863.9N ~ 2000N

Axial load = W_A = 2000N

Radial load = W_R = 1500N

Rotational speed of wheel = 30rpm

Average life of the bearing is 5 years at 10hr/day

Life of bearing in hours = L_H = 5×365×10 = 18250 hrs

Life of bearing in revolutions, L = 60N × L_H = 60×30×18250 = 32.85×10^6 rev

Basic Dynamic equivalent radial load, W = XVW$_R$ + YW$_A$

Assume W_A/C_0 = 0.5

X = Radial load factor

Y = Axial load factor

W_A/W_R = 2000/1500 = 1.33

By selecting from PSG Data book

X = 0.56 and Y = 1

W = (0.56×1×1500) + (1×2000)

= 2840N ~ 2900N

C = W×$(L/10^6)^{1/k}$

k= 3 for ball bearing

C = 2900×$((32.85\times10^6)/10^6)^{1/3}$ = 9287.73N = 9300N = 9.3kN

From PSG Data book Bearing number for 9.3 kN is Deep groove ball bearing SKF6303 with ISI No.17BC03.

D) Gas Spring Design

Reaction force, F = $\frac{W \times A}{B}$ ×1.1

Where W = Weight of seat

A= Horizontal distance between upper and lower seat rest hinge and center of gravity

B= Vertical distance between upper and lower seat rest hinge and axis of gas spring

Mass of seat = 12kg

Therefore weight of seat = 12×9.81 =117.72 N ~ 120N

A = 45cm

B =80cm

F = $\frac{120\times45}{80}\times1.1$ = 74.25N ~ 80N

For 80N we select 22300B with 300mm stroke length.

8. MERITS AND DEMERITS

8.1 MERITS

- Simple to implement
- Easy to operate
- No electrical components
- Affordable
- Safe and convenient way to shift users themselves from wheelchair to any medium or vice versa
- Reduces the effort of caregivers in handling the patients
- Eliminating any friction between users hand and wheels

8.2 DEMERITS

- Limited control
- Backward motion is not possible
- Slow action of gas spring

9. COST OF PROJECT

Table 10.1 Cost Details

ITEMS	COST [₹]
Wheelchair Components	4500
Freewheel + Lever	500
Back wheel Fabrication	3000
Front wheel	500
Gas Cylinder	3000
Other Miscellaneous Cost	2000
TOTAL COST	₹13500

10. RESULT

A person weighing about 70kg had tried the prototype with good success. By operating the levers, the user can steer the wheelchair easily than a manually operated wheelchair by avoiding hand burn. He can also lift up to standing position in the wheelchair easily and come back down to the seated position. The user changed the position from wheelchair to bed in easy way without the help of a caretaker.

10.1 FINAL PROTOTYPE

Fig 10.1: Mechanical Assisted Wheelchair for Paraplegia Patients

Fig 10.2 Mechanical Assisted Wheelchair in Standing Position

11. CONCLUSIONS

The design of wheelchair is compact and helpful for many people who are disabled with paraplegia disease. They can make use of this wheelchair without any external aid or a caretaker. So this is a multi functional medicinal aid focusing on the improvement and self reliability of paraplegia patients. Modifications made in the prevailing equipment meant for the disabled ones will be great use in upcoming time and we were able to apply our theoretical knowledge into practice. All data provided are precise to the best of our ability.

The project was aimed at designing and fabrication of wheelchair for paraplegia patients that can overcome the shortcomings of a conventional wheelchair, with focus on cost effectiveness and utility. The model presents a wheelchair that is controlled by using without any electrical components providing maximum functions to paraplegia patients. The wheelchair can be controlled by the paraplegia patient alone and lever is used to steer the wheelchair, making the movement and control of the wheelchair easy for a paraplegia patient. This will help the paraplegia patients to achieve social respect from the society by doing small works and mental strength. It will help the patients to cure from paraplegia condition.

By the project work, we gained a lot of practical knowledge regarding planning, purchasing, machining and assembling. We feel that the project work is a good solution to bridge the gates between the institution and the industries. We are proud that we have completed the work with in time successfully.

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