Analyzing Foot Step Wheel on Stair Climbing Wheelchair

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Abstract — Wheelchairs are used by people for whom walking is difficult or impossible to due to disability. In world population, 7.3% of people where disable to walk. Most of the people have own wheelchair, problem due to conventional wheelchair is does not run in improper surfaces such as sudden raised path, stairs. To avoid this problem in wheelchair, we introduce the foot step wheel arrangement. In this paper, we designed and analyzed the stair climbing wheelchair by the moderation of foot step wheel arrangement. By the usage of ANSYS software, we simulate the elongation level on the foot step wheel, which are used to develop the perfect loading capacities on the wheelchair.

Keywords — Analysis, ANSYS, Climbing, Design, Disabled, Footstep, Stair, Testing.

1 Introduction

About 15% of the global population, i.e. about 850 million people, have disabilities. Studies indicate that, of these, some 15% require a wheelchair. It is thus estimated that about 1% of a total population – or 15% of a disabled population – need wheelchairs, i.e. about 85 million people worldwide.
In 2015, it was estimated that 20 million of those requiring a wheelchair for mobility did not have one. There are indications that only a minority of those in need of wheelchairs has access to them, and of these very few have access to an appropriate wheelchair. The wheelchair is a device which enables to walking or moving one place to another for using disabled people. A wheelchair is a chair with wheels, designed to be a replacement for walking. The device comes in variations where it is propelled by motors or by the seated occupant turning the rear wheels by hand. Often there are handles behind the seat for someone else to do the pushing. Wheelchairs are used by people for whom walking is difficult or impossible due to illness (physiological or physical), injury, or disability. People with both sitting and walking disability often need to use a wheelbench. The wheelchair is used in many applications such as commercials, hospitals, sports & etc.

2 Motive of Paper

One of the problems in conventional wheelchair is does not run or move in unproper surfaces such as sudden raised path, stairs. So we want to design the stair climbing wheelchair. But nowadays the stair climbing wheelchair is available in market also, the cost of it around 60000 INR. In that wheelchair, the operation contains fully robotics. We move to design the foot step wheel and setup in the conventional wheelchair. The foot step wheel is analyzed for elongation level and vibration level. The foot step wheel is analyzed by the ANSYS software. **We focus on analyzing the foot step wheel by using ANSYS software. We design the manual type stair climbing wheelchair. And this design as compare to last & previous models.**

3 Concept

The foot step wheel has created by the ideation of disabled people where the stairs climbs by using hand. They were climbs the stairs of backside position of body. The disabled people are using hand for moving in stairs or steps & upward position is backside of body. In this concept, we generate the foot step wheel for the attachment of conventional wheelchair.

4 Details About Foot Step Wheel

The foot step wheel designed for withstanding vibration due to moving of wheels from one stair to other & loading. The major design consideration is heavy load capacity. For selecting wheel material, we choose rubber, alloyed wheel, and plywood. Finally we select the plywood because of easy to manufacture & considerable cost.

4.1 Dimensions

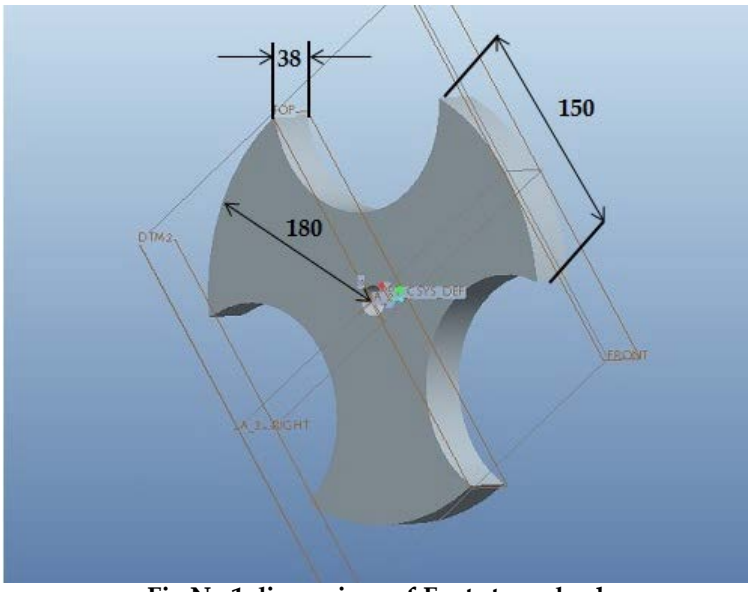

Fig.No.1 dimensions of Foot step wheel

We machined the Foot Step wheel with circular diameter of 360 mm with 3 legs each have 150 mm length and gap between two legs are 210 mm as shown in fig.no.1. The Foot Step wheel can able to stand on two legs without falls by balancing its own centre of gravity on its base. By considering the factor of safety we provided 1.5 inches width to the legs of each Foot Step wheel.

4.2 Material

The foot step wheel is made up of plywood. The properties of plywood while loading conditions are better than the steel properties. The plywood, while moving on the stairs it should be capable of absorbing sudden damping vibrations. Plywood is a product made of thin pieces of wood known as veneer as shown in fig.no.2.

Fig.No.2 3D view of Foot step wheel

5 Components

The Foot step wheelchair is consists of hydraulic Jackie, lever & ratchet mechanism and hydraulic brake for betterment of climbs the stairs. The hydraulic Jackie is used to withstand the load & to balance the centre of gravity of total load in wheelchair. Hydraulic brake is used to stop the wheelchair while climbs down. The main part of wheelchair is chassis which made up of stainless steel bars as shown in fig.no.3.

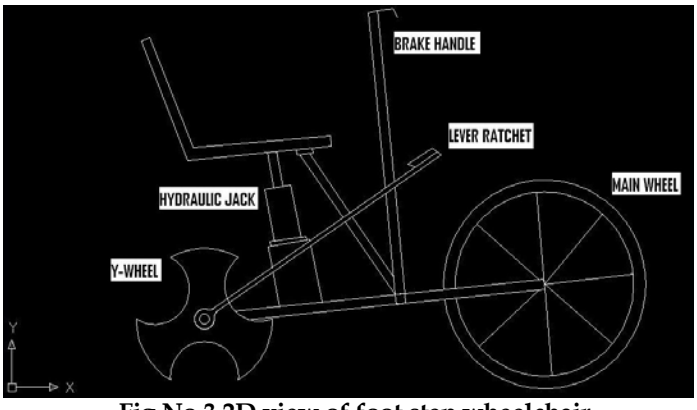

Fig.No.3 2D view of foot step wheelchair

6 Design Calculation

We designed chassis or base frame by adding three segments. First we consider main wheel is arranged at lower first step and Foot Step Wheel is arranged at third step. Then entire project where placed on three steps only. The base length of the step is **300 mm**. Height of the step is **144 mm**. Three segments are full step length, radius of main wheel and radius of Foot Step Wheel. Addition of these three we get,

300 + 305 + 180 = 785 mm

Due to step angle, the deviation or tolerance of the total chassis length is **40-50 mm**. Finally, we design the chassis by adding 40 mm tolerance. We get the chassis total length is **825 mm**.

Not only has that step sized which suitable for range:

Width of the step = **210 mm to 350 mm**

Fig.No.4 Overview of our stair climbing wheelchair

Height of the step = **140 mm to 180 mm**

We machined the Foot Step Wheel with circular diameter of 360 mm with 3 legs each have 150 mm length and gap between two legs are 210 mm. The Foot Step Wheel can able to stand on two legs without fall by balancing its own centre of gravity on its base. By considering the factor of safety we provided 1.5 inches width to the legs of each Foot Step Wheel.

For the safe downhill operation the main wheels are placed with a distance of **22 inches** between them. Each main wheel connected to the base frame for the maintenance alignment of the wheels.

The distance between pitch of the Foot Step Wheel & main wheel should be around **800 mm**. So, we have to assemble every required component with in this length.

The primary shaft is placed in between Foot Step Wheel. The Secondary shaft is placed in disc brake arrangement. The primary shaft & secondary shaft are constructed in the frame separated by a distance of **13 inches**. This distance depends only on the capacity of brake & requirement of brake to apply.

In primary shaft Foot Step Wheel separated by distance **16 inches**. We made this separation distance very close because

to carry the whole weight of both the human & components between the Foot Step Wheels.

The main component to balance the centre of gravity hydraulic jack, which placed with an elevation of **8.5 inches** above the frame. The hydraulic jack has capability of lifting 2 ton weight, over a height of **200 mm**. It also favours to increase height of 60 mm further.

We can able to use this wheelchair with a stair height range between **140 mm to 180 mm** because we machined the Foot Step Wheel with diameter of 360 mm and the centre of gravity balancing of the Foot Step Wheel is completely safer with in the stair height limit of above mentioned as shown in fig.no.4.

The width of the stair should be greater than 220 mm because the Foot Step Wheel legs are machined with a gap distance of 210 mm (10 mm clearance). The width of the stairs should be limited within 350 mm (10 mm clearance).

The lever-ratchet is selected with a capacity of lifting **350 kg** by only using manual effect. We increased the handle length to **23 inches** for the comfort of the user during the operation of the ratchet & by means of lever arrangement; only user gives less amount of energy to move the Foot Step Wheel. The main frame constructed by two square channels separated by **8 inches** to provide the elevation for the foot rest of the handicapped.

Handle bar fixed at the front of chassis with height of 34 inches & width of **20 inches**. From the chassis, the seat is fitted at the height of **18 inches**. And the seat is oscillation able by using two hollow bushes which has 0.5 inches length, 1.05 inches diameter and 0.5 mm thickness. Pillow block bearings are fitted both primary & secondary shafts ends with the size of 1 inch.

Where ever stainless steel using, that places are joining by TIG welding and where ever mild steel using, that places are joining by ARC welding.

7 WORKING MECHANISM

The working of foot step wheelchair is consists of two operations such as climbs up & climbs down.

For the user to climb upwards the following mechanism is employed. For climbing upwards, the hydraulic jack is made to be rest in its original position. When the jack is in original position, the seat that the user is being seated will be tilted in such a way so that the centre of gravity acts favourable to climb upwards. Due to this tilting of the seat the user will be made to sit in a certain angle that makes him to climb up easier.

The user has to make use of the lever & ratchet for climbing up. Two levers and ratchets will be attached at the two extreme ends of the shaft that the Foot Step Wheel is positioned. The lever will be welded at the ratchet in order to extend the shaft for users comfort. When the user pushes one of the lever ratchets backwards, one of the shoes of the Foot Step Wheel will climb up. At this point of time, the ratchet acts as a brake also due to its internal in built components in it in order to avoid the down coming or slipping. After making the ratchet to be fixed, another ratchet on the other end have to be pushed backwards to a certain extent. This will further move the Foot Step Wheel to be seated fully in one of the step. When the two ratchets are in the same position i.e. on the same line, one of the ratchets is pushed forwards again and second ratchet is pushed forwards, which means the two ratchets cannot be moved forwards again simultaneously. The two ratchets have to be operated one after the other. By repeating the above said process in a cyclic manner, the wheel is made climb upwards successfully as shown in fig.no.5.

Fig.No.5 Test drive on our college stairs

For climbing downwards, the hydraulic is lifted to a certain extent so that the weight of the user acts downwards. Due to this lifting of the hydraulic jack along with the seat, the centre of gravity of the whole wheelchair is made to support the down climbing of wheelchair. This change will create a natural angle in the wheelchair. This angle will make the wheelchair to come down without any effort from the user. All the user needs to do is use the brake for his safety. There will be slight vibrations in the wheelchair when the user fails to use the disc brake efficiently. This vibration can be counteracted by using some additional components. The braking action is made safer and efficient by using the disc brake. By the effective use of the disc brake, the down climbing of the wheelchair is made successful.

8 ANALYSE THE FOOT STEP WHEEL

First we draw the 2D view of stair climbing wheelchair in Auto-CAD software and implement in the PRO-E / CRE-O software. And finally foot step wheel is analyzed in the ANSYS software as shown in fig.no.6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h.
Applying boundary conditions & von mises stress; then the deformation, maximum & minimum stress values are obtained.

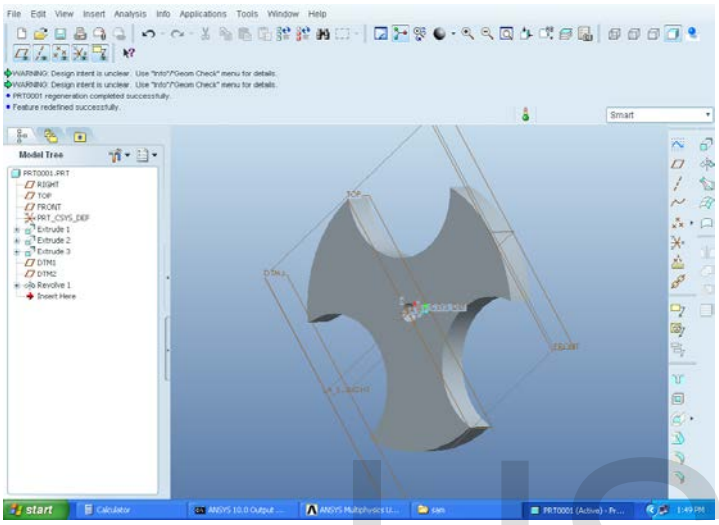

Fig.No.6a 3D view of foot step wheel

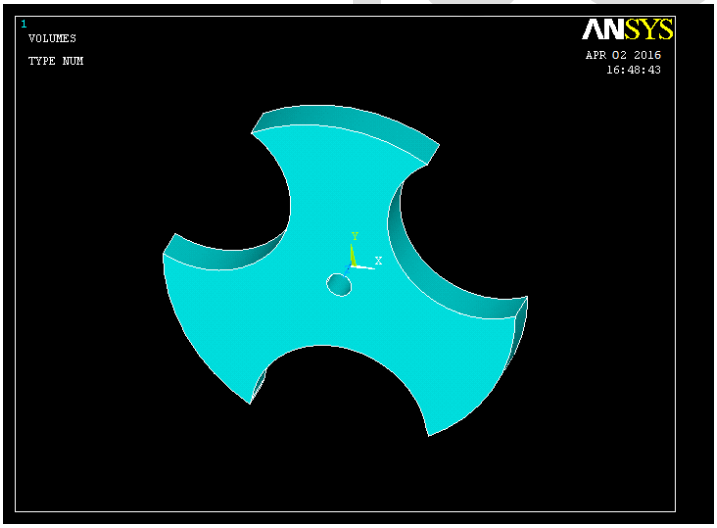

Fig.No.6b foot step wheel in ANSYS

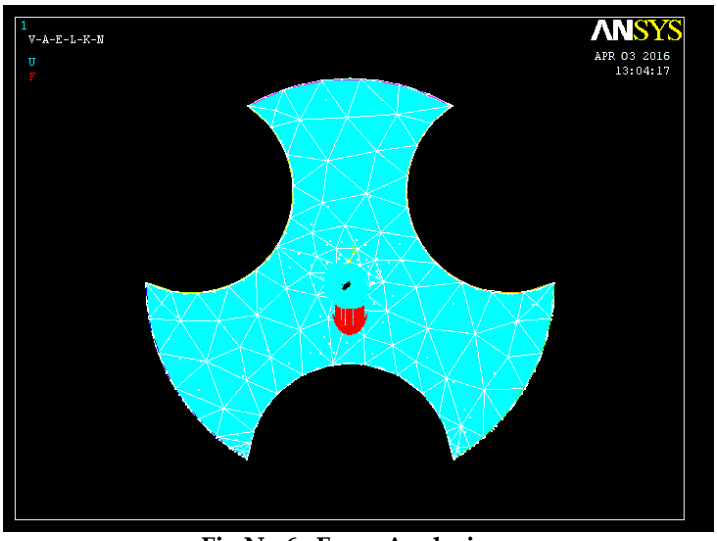

Fig.No.6c Force Analysis

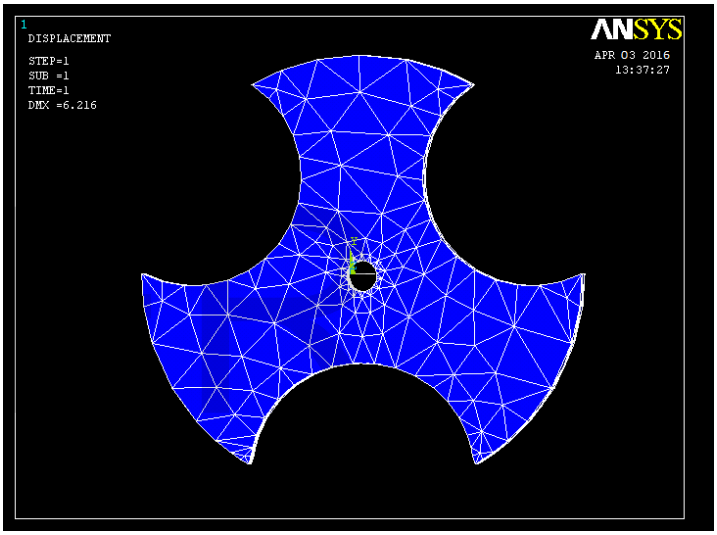

Fig.No.6d minimum deform position

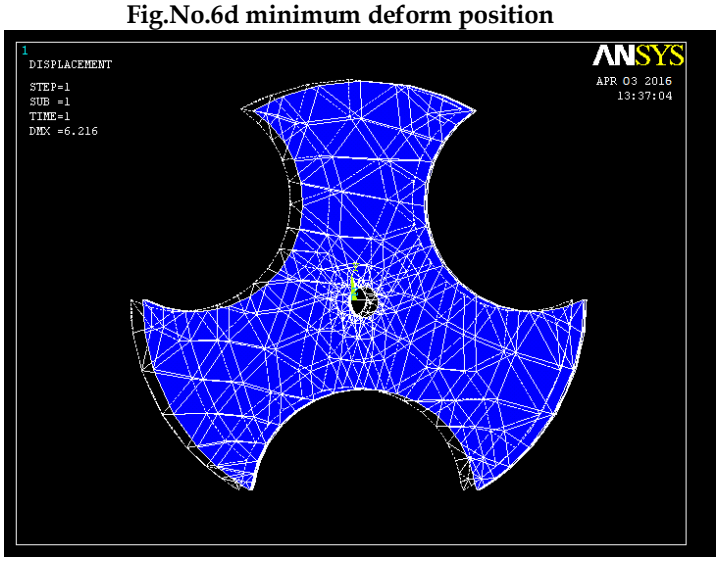

Fig.No.6e fully deform position

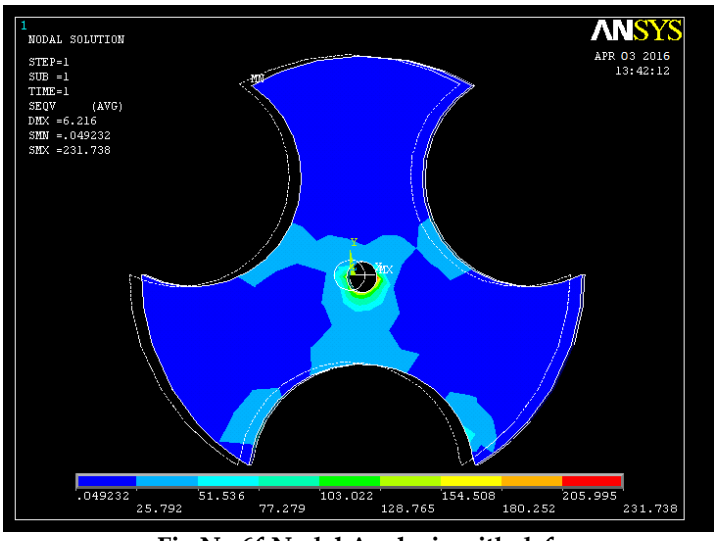

Fig.No.6f Nodal Analysis with deform

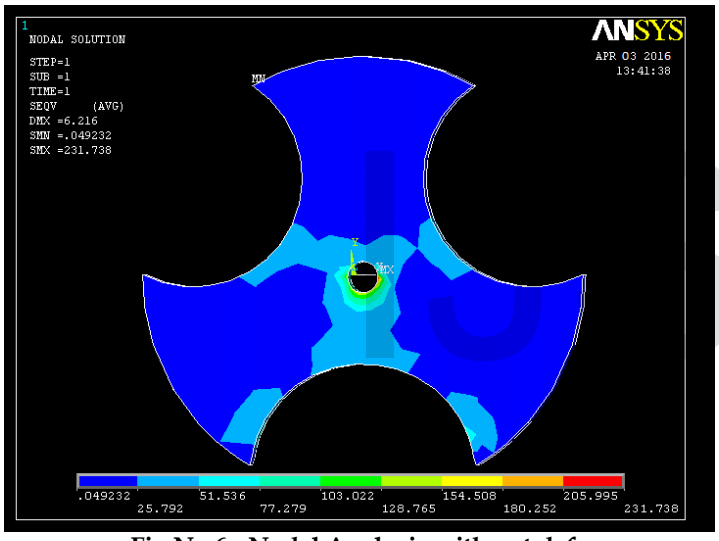

Fig.No.6g Nodal Analysis with out deform

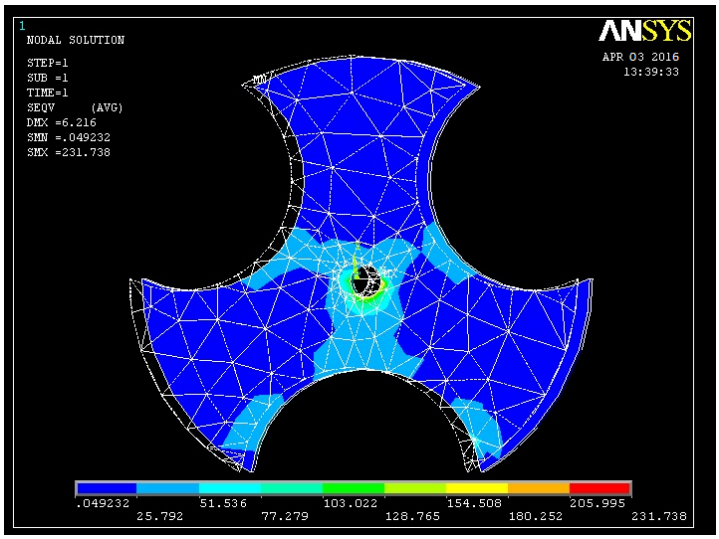

Fig.No.6h Entire Analysis

9 Result & Discussion

From the analysis, we conclude our paper;

S.No	Analysis	Values
1.	Deformation (MIN)	0.13 mm
2.	Deformation (MAX)	6.216 mm
3.	Stress (MIN)	0.0492 N/mm^2
4.	Stress (MAX)	231.73 N/mm^2

Table No.1 Results

The foot step wheel has considerable deform only due to heavy loading conditions. The elonagtion in the wheel due to central axial load, tractional force and gravity force is allowable. These are compared to existing result in the journal. The vibrational & deformational level is much better than the other conventional manual type wheelchair as shown in the table no.1. So, the foot step wheel is emerging method of stair climbing wheelchair through lever & ratchet mechanism. In order to develop further technology where will be used for changing the foot step wheel to normal wheel for riding in the straight path.

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