New Low-Cost Design of 'Staircase Climbing Wheelchair'

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Abstract

The average human age is increased and a common problem that the elderly people are facing is 'impaired mobility'. New policies continue to make newly built areas accessible to disabled, but old buildings can't be re-developed because they are without elevators. So 'Staircase Climbing Wheelchair' is a need of day, at least in the developing countries. Many designs are already converted into the actual products but they are not cost effective or affordable. This paper proposes a new and most importantly 'Affordable' design of a stair-climbing capable mechanism for the wheelchairs for elderly or disabled.

Keywords: *Staircase Climbing Wheelchair, impaired mobility, Low Cost Design.*

1. Introduction

It is rightly said that 'Necessity is a mother of Invention' and thus the main focus of technology is on providing comfort to the people.

Many countries are currently experiencing what is referred to as an "Aging Population," The average human age is increased and accordingly the Number of old people is also increased. A common problem these elderly people are facing is impaired mobility. In this regard, traditional wheelchairs and powered wheelchairs continue to play a vital role. However wheelchairs to date provide a high level of mobility in "barrier free" environments. There remains a significant gap between the obstacle negotiating ability of a wheelchair and that of the average able bodied person. This aspect is perhaps most apparent when considering stair-climbing.

While modern architecture and new policies continue to make newly built areas as "accessible" as possible, to persons with a wide variety of disabilities, 'Steps' will always be a reality in the "real world".

Many old buildings are without elevators and 'non availability of lifts' can not be a reason for re-development of these buildings, in densely populated areas of society.

Extensive research is being carried out in the field of 'Development of Staircase Climbing Wheelchair'. Many designs are put forth and some designs are already converted in the actual products.

Main problem that lies with all these designs is the 'Cost' factor. After giving due consideration to all the constraints, which are coming on the design process of these chairs, the final manufacturing cost of these chairs, goes so high that the product no longer remains affordable. This paper proposes a new design of a stair-climbing capable mechanism for the wheelchairs for elderly or disabled.

2. Drawbacks of existing designs

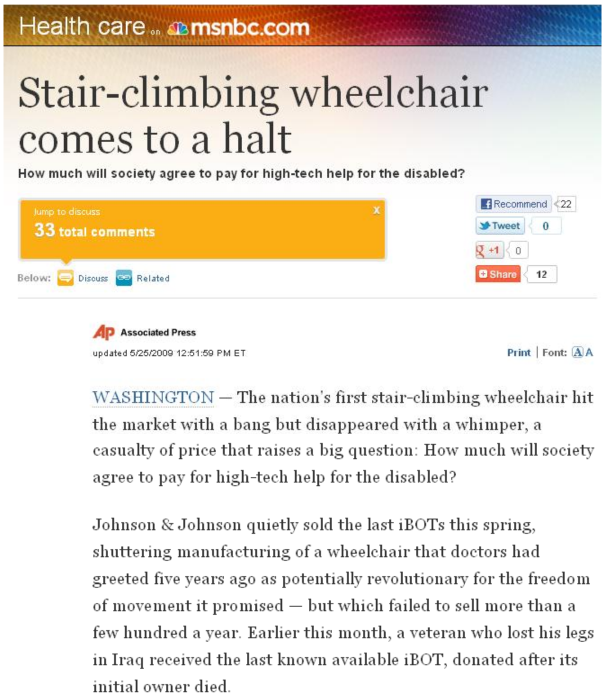
Many designs are proposed till date and some of them are accepted finally and are converted into reality. But the main problem with all these designs is the cost factor.

Too many considerations are involved in the design process of these chairs. Right from motion on flat surface with specific speed, the most critical consideration is 'Balancing of chair and maintaining Centre of Gravity within the base' during climbing the stairs.

To accommodate all these requirements in the design, very much sophisticated mechanisms are incorporated in the designs. Due to the complex mechanisms and accessories, these products are so expensive that a common man can not afford it.

In an article [6] published by MSNBC on 25th May 2009, it is mentioned that "By using the stair climbing chair we feel comfortable but while buying the chair we feel miserable". According to this article, The first ever practicable staircase climbing wheelchair is launched in 2009 in USA.

The said article is given below:


Health care on msnbc.com

Stair-climbing wheelchair comes to a halt

How much will society agree to pay for high-tech help for the disabled?

33 total comments

Associated Press
updated 5/25/2009 12:51:59 PM ET

WASHINGTON — The nation's first stair-climbing wheelchair hit the market with a bang but disappeared with a whimper, a casualty of price that raises a big question: How much will society agree to pay for high-tech help for the disabled?

Johnson & Johnson quietly sold the last iBOTs this spring, shuttering manufacturing of a wheelchair that doctors had greeted five years ago as potentially revolutionary for the freedom of movement it promised — but which failed to sell more than a few hundred a year. Earlier this month, a veteran who lost his legs in Iraq received the last known available iBOT, donated after its initial owner died.

Photograph 1

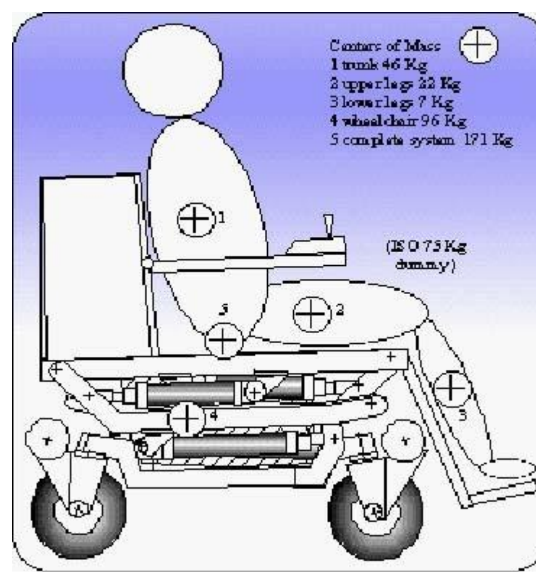
The photograph of the said wheelchair is given below:

Photograph 2

A stair climbing wheelchair 'VARDAAN'[4] developed by four students of IIT,Kanpur, is a low cast solution to the problem, but operation of that wheel chair is purely manual. So, substantial driving force is needed to operate the chair. Considering the health and weakness of the elderly people, it may not be useful all the time. This Design is shown below

Photograph 3

The designs proposed by Murray Lawn [2],[3] are better acceptable but yet to be converted in actual products. The schematic configuration of the said chair is as shown in photograph 4



Photograph 4

Cost wise all these designs are not so efficient as compared with the proposed design explained below.

3. Proposed Design

In view of reducing the cost, we plan to modify the regular chair into staircase climbing chair. The driving mechanism is basically an epicyclic drive. (Refer Figure 1 below)

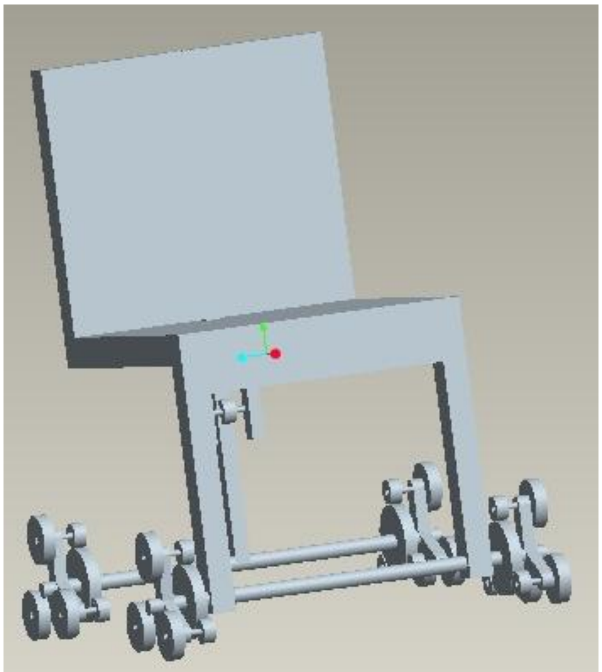


Figure 1

The drive system can be called as selective drive system. The drive shaft will be a compound concentric shaft with inner solid shaft and outer partial hollow enveloping shaft.

When the chair is travelling on horizontal surface, power will be supplied to inner solid shaft and in turn to the sun gear of the epicyclic gear train. The sun gear transmits motion to the planets, which are finally driving the wheels. The arm of the gear train remains stationary in this period. Top gear of the epicyclic gear train and hence the corresponding top wheel rotates freely.

Four such epicyclic units are mounted at the base of the four supporting legs of the chair. But the main difference is: The two frontal epicyclic units are directly connected to the frontal legs, without any height controlling rack and pinion arrangement.

The rear leg supports of the chair are telescopic, using either hydraulic cylinder or the rack and pinion arrangement. The epicyclic unit to the rear leg supports is fitted to the extendable leg.

When the front most wheels touch the first step of the staircase, the person seating on chair needs to operate the selector clutch, thereby the power is supplied to the outer hollow shaft which is directly connected to the arm of the epicyclic gear train. So the arm starts rotating and the front portion starts climbing the step.

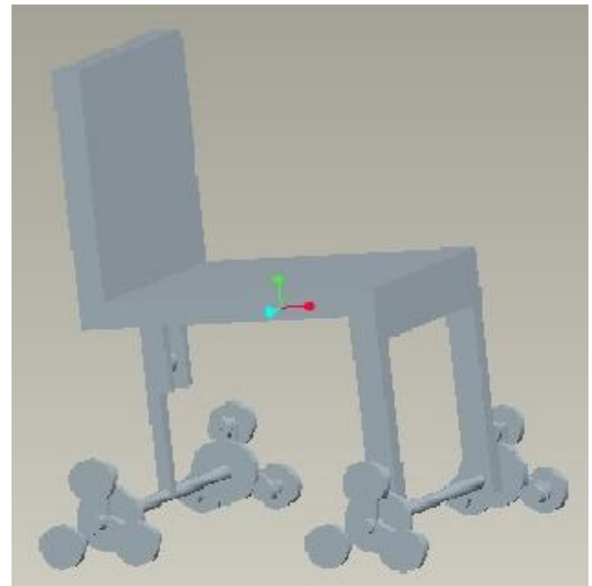


Figure 2

Simultaneously the rack driving pinion rotates and pushes the rack down, thereby increasing the height of the rear leg supports. This extension of rack continues till the height of one step is reached. The power is still supplied to the inner solid rear shaft so that the rear epicyclic units are still operating in the 'Fixed Arm' mode or 'Flat Travel' mode and the planet gears along with the planet wheels rotate taking the chair forward. This continues till the free wheels touch the next step.

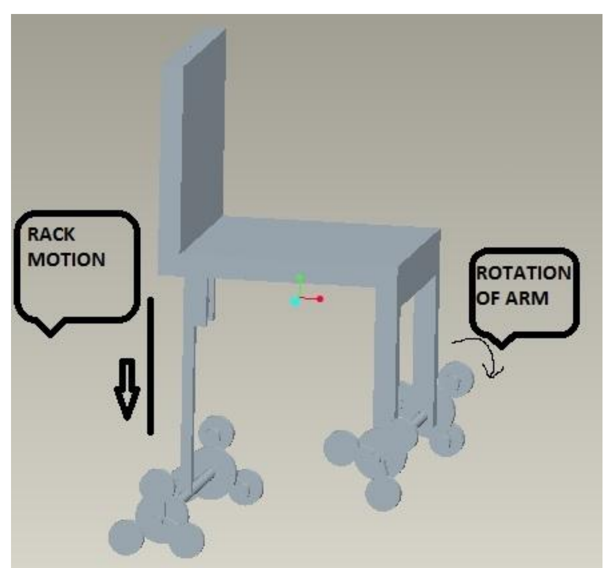


Figure 3

Then after the rack extends further till the height of two steps is reached. Simultaneously the front epicyclic units work in 'Moving Arm Mode' or 'Climb Mode' and lift the frontal part of chair, maintaining the level of the seat horizontal.

In short, while climbing the staircase, there is a level difference that is deliberately created between the two front legs and two rear legs. The comparison between the two positions of chair will be more clear from the figures 4 and 5 below.

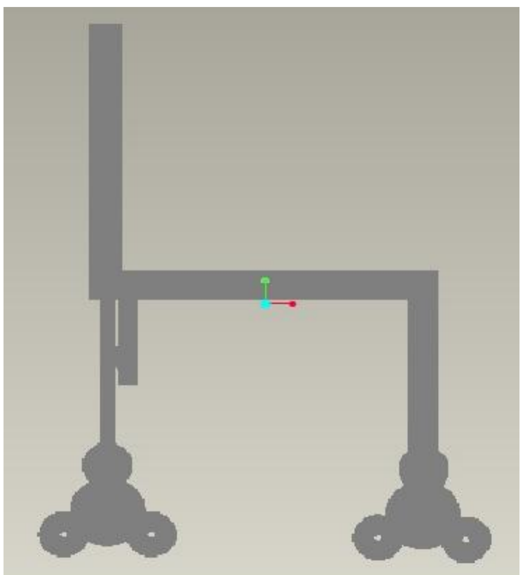


Figure 4

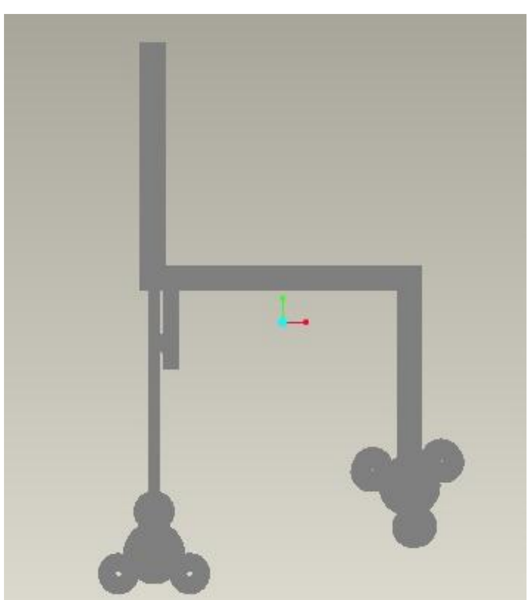


Figure 5

Figure 4 is showing the two epicyclic units in the same horizontal level when the chair is moving on planes.

Figure 5 is showing the rack in extended position and thereby we can see the level difference between front and rear legs of the chair.

4. Key elements in the design

As we see from the above description, the key elements in the proposed design are Epicyclic Gear Unit (EGU) Drive Selection System (DSS) and Rack and Pinion Arrangement (RPA)

Details of these elements are given in next section

5. Details of the Key Elements

5.1 Epicyclic Gear Unit (EGU)

This is the main driving unit of the chair. Its construction is as shown in figure 6 below.

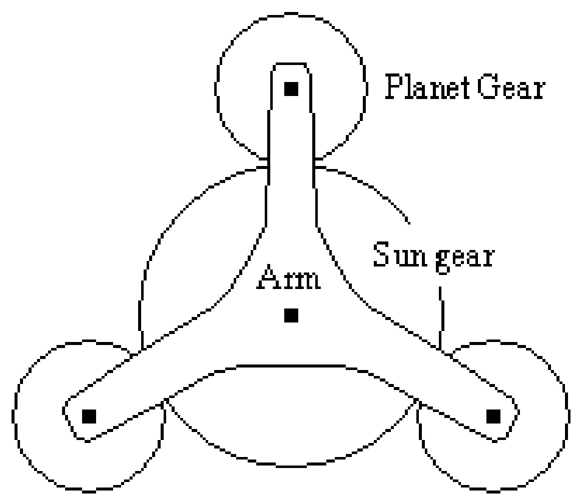


Figure 6

During normal running on the plain surface, Arm is stationary and Sun gear is powered. The two bottom wheels per EDU i.e. total eight wheels will be driving the chair.

5.2 Drive Selection System (DSS)

This is the sideways Dog Clutch arrangement as shown in figure 7.

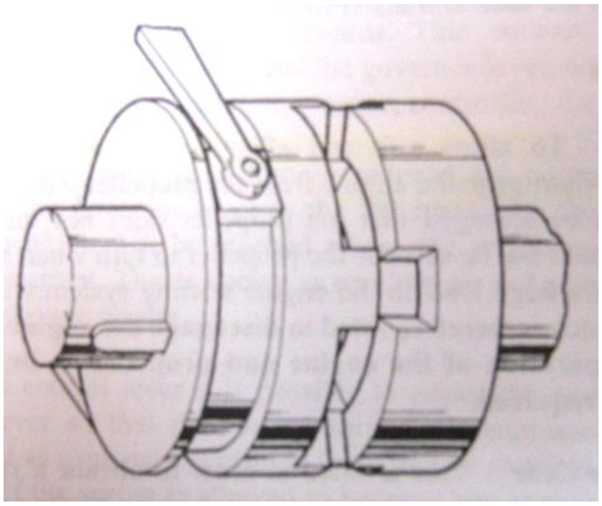


Figure 7

As discussed earlier, while the chair is moving on flat surface, the power is to be supplied to the 'Sun' from the EGU where as during climbing the step, the drive must be given to the 'Arm'. This change over is to be accomplished via Dog Clutch similar to the one shown above.

5.3 Rack and Pinion Arrangement (RPA)

This is a normal rack and pinion arrangement arranged in vertical direction as shown in figure 8 below.

Figure 8

The pinion is mounted on the elevating motor attached to the frame of the chair i.e. rear legs. The moment when front epicyclic units enter in the 'Climb' mode, the power is supplied to the motor driving the pinion. Due to this, the rack moves down lifting the rear end of the chair. The joy stick, controlling the pinion motor, is to be pushed forward till this extension of rack is accomplished.

Thus, as shown in figure 5, the front legs of chair are elevated two to three times the step size of the stairs during the normal climbing conditions.

6. Landing on the top floor

The chair climbs the stairs in the position as shown in figure 5. But the landing of chair on the top floor at the end of the stairs is equally crucial.

The moment when the front legs land on the top floor, at the end of the stairs, the person on the chair moves joystick backwards so as to drive the pinion motor in reverse direction, thus retracting the rack, back to the initial position.

The EGU during this process is in 'Climb Mode'. The two rear legs of the chair climb the remaining two to three steps and the whole chair finally lands on the top floor.

7. Crucial Elements

Some of the elements in the design are very much crusial.

The DSS actually switches the system from 'Flat travel' mode to 'Climb' mode and vice versa. It is to be controlled by the user sitting on the chair.

RPA is also to be controlled by the user using joystick. A proper coordination between the control of RPA and DSS is the skill of user and that can be developed after continuous use of the chair.

10. References

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