Innovative Designof 'Staircase Climbing Wheelchair'

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Abstract

The average human age is increased and acommon problem that the elderly people are facing is 'impaired mobility'.New policies continue to make newly built areasaccessible 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 tothe 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 wheelchairscontinue 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 theobstacle negotiating ability of a wheelchair and that of the average able bodied person. Thisaspect is perhaps most apparent when considering stair-climbing.

While modern architecture andnew policies continue to make newly built areas as "accessible" as possible, to persons with awide 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.Rehabilitating is one more area of application of these wheel chairs.

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 paperproposes a new design of a stair-climbing capable mechanism for the wheelchairs for elderly ordisabled.

2. Drawbacks of existing designs

Many designs are proposed till date while 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 as mentioned in the references [8] to [40]. Due to the complex mechanisms and accessories, these products are so expensive that a common man can not afford it.

In an article [7] 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.

A stair climbing wheelchair 'VARDAAN'[5] 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.

The designs proposed by Murray Lawn [3],[4] are better acceptable but yet to be converted in actual products.

3. Proposed Design

In view of reducing the cost, we plan to modify the regular chair into staircase climbing chair. The logic used in this new design is the application of the concept of 'Conjugate Profile Generation'

The staircase is considered as a 'Rack' with triangular profile. Figure 1 shows a schematic of normal staircase with step proportions 1:2 (height to width)

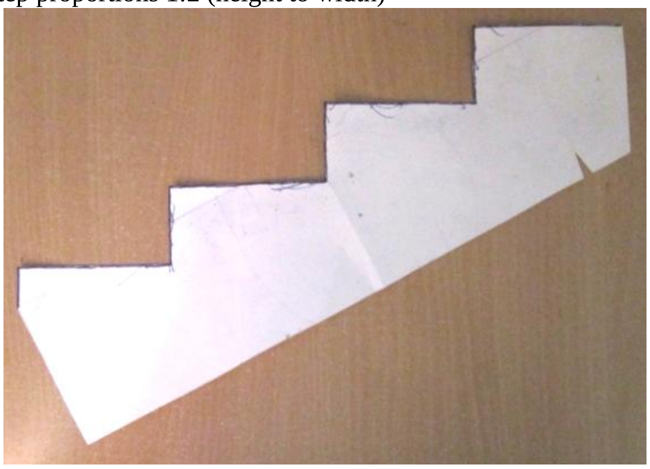

Figure 1.

Consider the centre line of ZigZag profile as shown in the figure 2

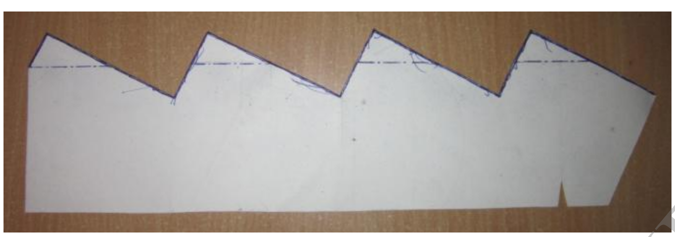

Figure2.

. This centre line is to be considered as the pitch line of the so called Rack. Thus the staircase 'Rack' is having Addendum = Dedendum

The pinion that we are going to generate will be similar to a lobe cam with specific number of petals (teeth). The pitch circle diameter of the pinion depends on the number of lobes. With two lobes, the pinion dimension will be minimum but then it is going to be the most unstable design. If the number of teeth is decided as four or more, the pinion size will be substantially large.

The process of pinion generation for staircase as a rack, is shown in the photographs given below:

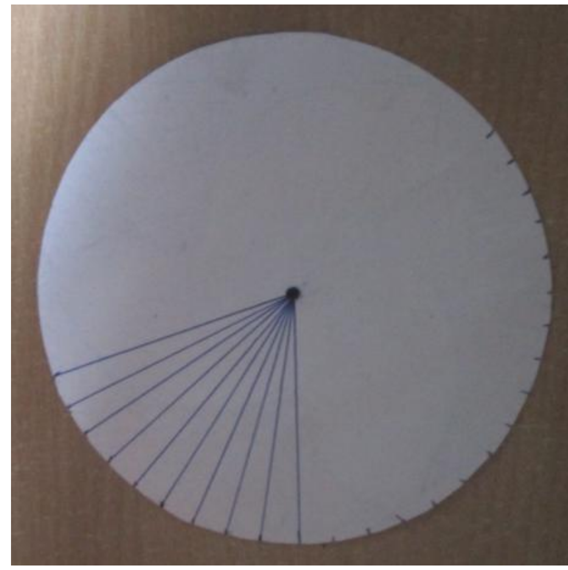

Figure 3.1The Gear Blank

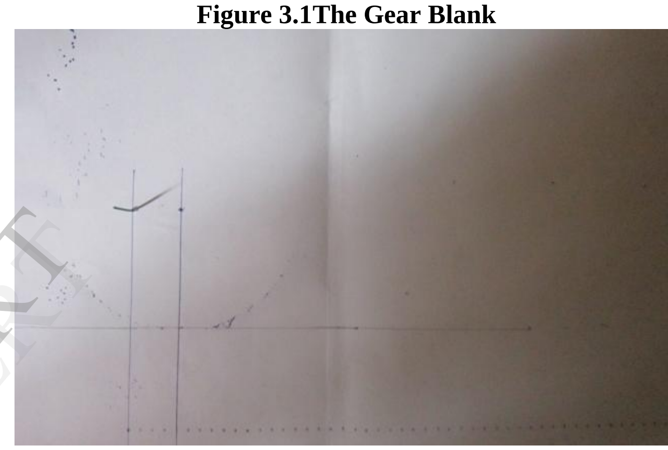

Figure 3.2 Rack Markings

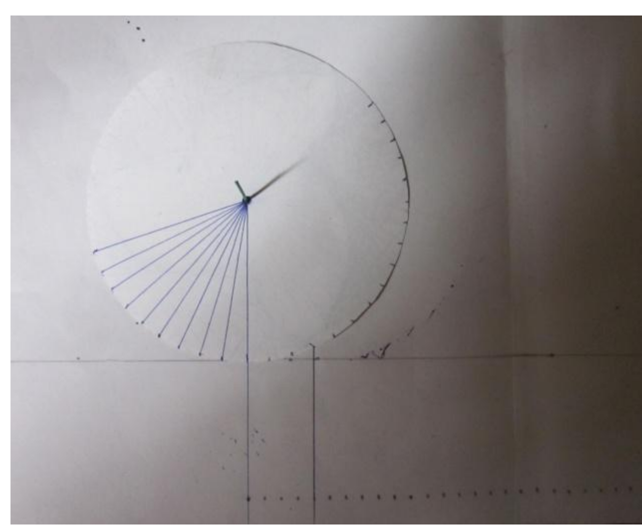

Figure 3.3 Setup

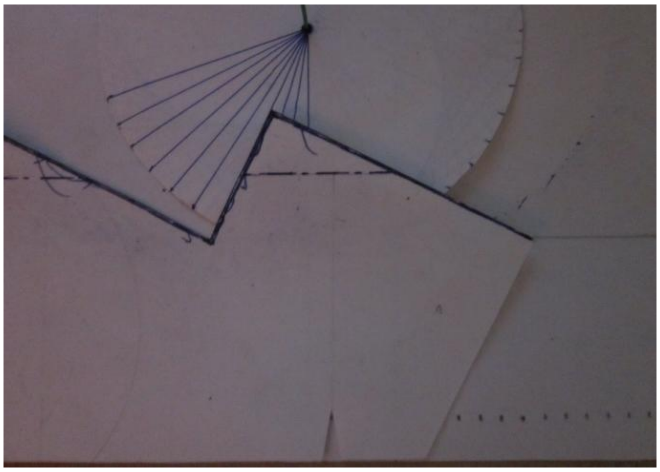

Figure 3.4 Gear Generation Starts

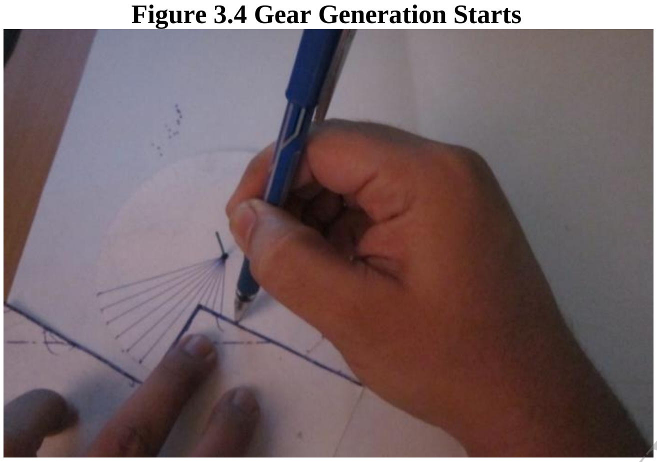

Figure 3.5 Gear Generation Starts

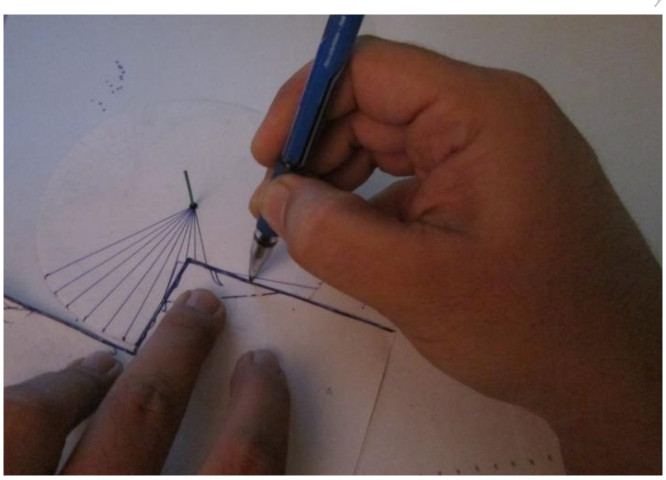

Figure 3.6 Gear Generation Process phase 1

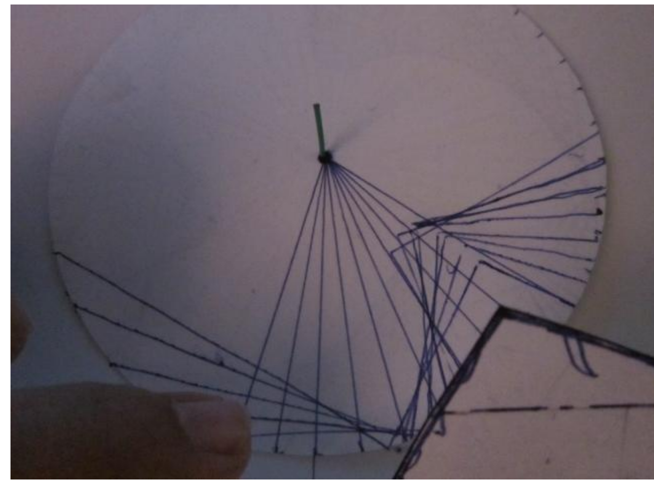

Figure 3.7 Gear Generation Process phase 2

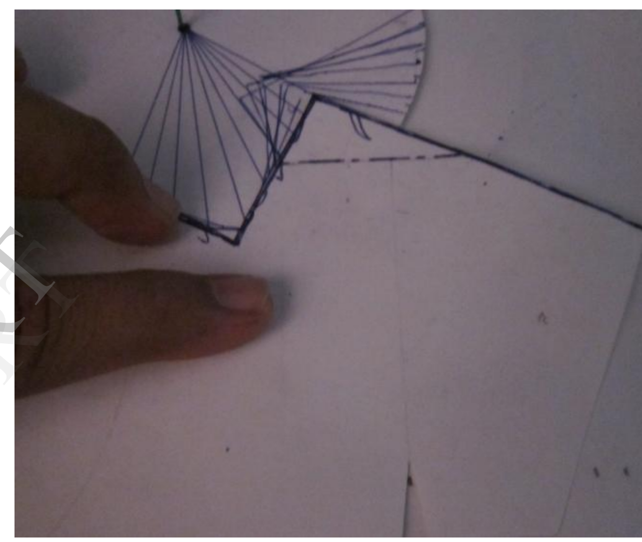

Figure 3.8 Gear Generation Process phase 3

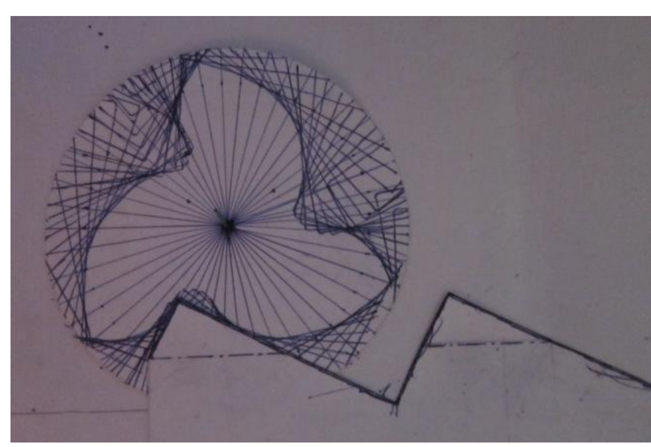

Figure 3.9 Gear Generation completed for three teeth

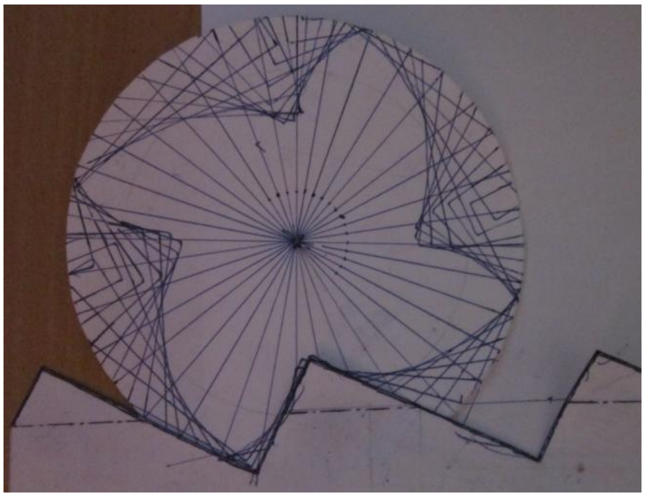

Figure 3.10 Gear Generation completed for four teeth

Comparing the sizes of the gears, we find that three teeth design is most favourable.

The staircase used for verifying conjugate action consists of step size of 15cm height by 30cm width, whereas the paper cut-out of rack is having 5cm height by 10cm width. So the generated profile of three teeth pinion is magnified proportionately.

For conducting trials, thermocol prototypes of the pinion are mounted on an axle as shown in figure 4 below

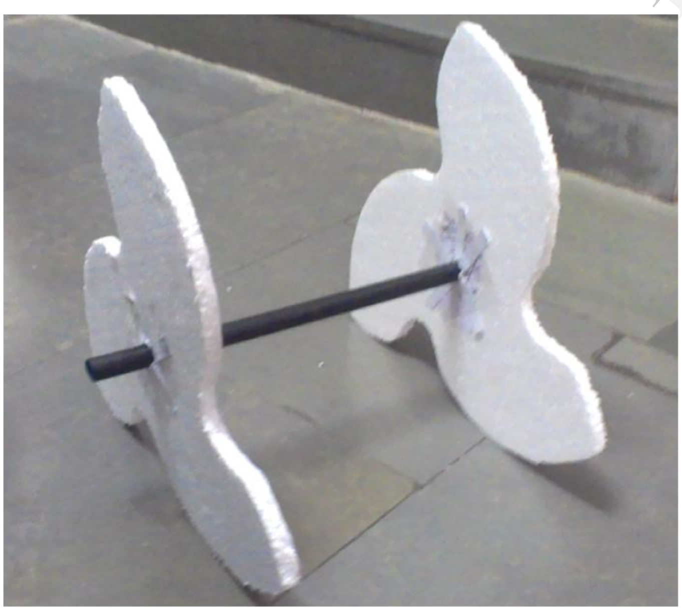

Figure 4.Thermocol prototype of the axle.

The conjugate action of the 'pinion wheel axle' is verified as shown below.

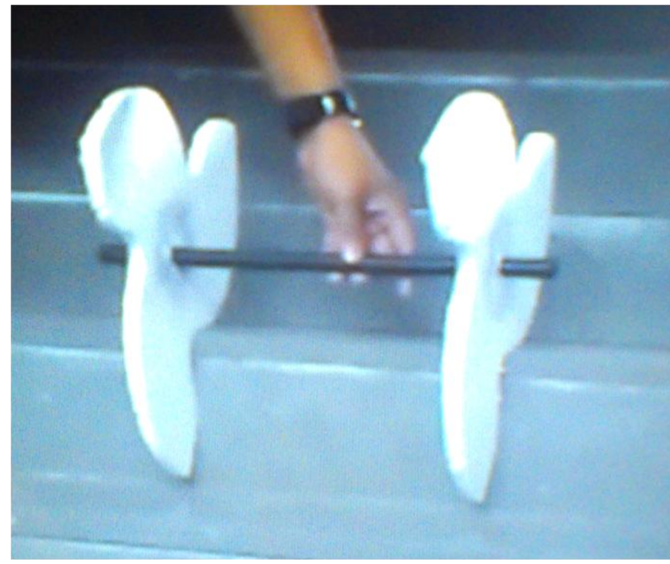

Figure 5 Verification of conjugate action 2

It is observed that the axle is perfectly moving along a straight line parallel to the 'pitch line' of the so called 'staircase rack'.

Hence this design can be conveniently adopted to develop a 'Staircase Climbing Wheel chair'. The basic construction of the chair platform can be similar to one mentioned in our paper [1]. While climbing the staircase, there is deliberately created level difference between the two front legs and two rear legs. The rear leg supports of the chair are extended whereas the front legs remainelevated two to three times the step size of the stairs during climbing, as shown in figure 6.

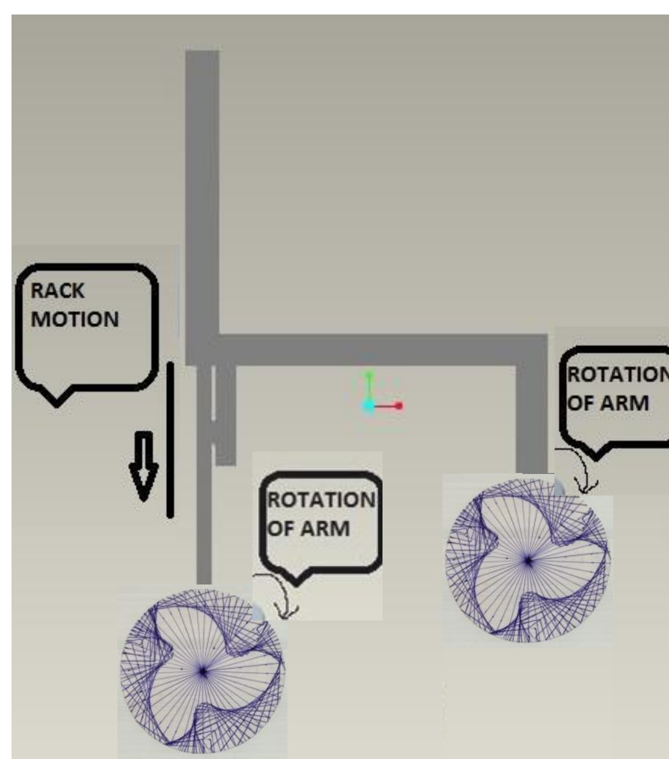

Figure 6. Position of front and rear legs during climbing

4. Power drive

Both the axles will be carrying sprockets as the driving elements. They will be driven by a common chain passing over the sprocket mounted on central motorshaft.

The motor will be a DC motor, operated by rechargeable battery.

5. Further developments

This paper is to put forth the totally new concept that can be adopted for developing 'Low cost design' of 'Staircase Climbing Wheelchair'. Actual design calculations of the full fledge and full scale staircase climbing wheelchair will be added as the supplement to this paper.

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