On Inclined Smooth Surface Automatic Speed Control System of Manual Wheelchair

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ABSTRACT

It is hard to understand that about 15% of world population has a severe physical disability including 5% of children, according to new report prepared jointly by world health organization and the World Bank. Some people are born with disability, other becomes disabled as a result of an illness or injury, and some people develop them as they grow. Though it is possible to help the disabled people by external application it is to be analyzed thoroughly whether the system is generated is reliable safe and comfortable.

Wheelchair is a mobility device designed for shifting patients, moving physically disabled people from one place to another with the help of attendee or by means of self-propelling. As a person who manually drives a wheelchair often comes in situation that has to move up or down on a ramp. In this case while moving on an inclined ramp, gravitational force pulls the wheelchair down. While moving up a ramp the person applies effort not only to move up on the ramp but also to hold the wheelchair so that the wheelchair will not roll down. While moving down the ramp person has to take effort so that the wheelchair moves slowly on the ramp, causing interference of human efforts.

In this research work, the safety and reduction of human effort is ensured by the speed controlling system. The speed controlling mechanism controls the speed of wheelchair by applying brakes so that the wheelchair moves down on a ramp slowly without any human effort. The mechanism also restricts the wheelchair to roll back while moving up on the ramp. This reduces the effort of the person to hold the wheelchair while moving up on the ramp. Further, paper discloses an automatic braking mechanism which is based on centrifugal principle. This mechanism actuates when the wheelchair crosses the safe speed while moving down the ramp. The term 'safe speed' defined as the maximum speed with which wheel chair can safely roll down the ramp.

Keyword: - *Speed control, Wheelchair, Automatic braking system, Safe speed, Ramp*

1. Introduction

Manual wheelchair users can be divided into three main categories: people disabled through a spinal cord injury (SCI), people who have suffered a stroke, and some whose mobility is affected by old age. Other manual wheelchair users are individuals with spina bifida (a developmental congenital disorder), amputation, cerebral palsy (a group of brain and nervous system function disorders) and multiple sclerosis (MS) (an autoimmune disease that affects the Brain and spinal cord).

These users come across a situation like climbing or rolling on inclined surface. The user has to apply efforts to climb up as well as to hold the chair on inclined surface. When the length of inclined plane is more so the user cannot climb continuously instead the user has to climb taking some halts on inclined plane. The user holds the hand rim of wheelchair to take halt on the inclined plane. The user cannot hold the wheelchair for long time since stress is developed on hands resulting in severe pain. The user also comes across a situation that the user has to roll down the inclined plane. While rolling down the inclined plane, the speed of wheelchair increases gradually. So to roll down safely the user holds the hand rim of the wheelchair to control the increasing speed and roll down safely. In some situations the user might get injury to his hand while rolling down on inclined plane.

This paper describes that a mechanism that restricts the downward motion of wheelchair while climbing up the inclined plane and a speed controlling mechanism that controls the speed of wheelchair while rolling down the inclined plane.[1,5]

Figure 1: Manual rigid wheelchair

1.1 Types of Manual wheelchair

Most manual wheelchairs are designed to be propelled by the user, who grasps a push rim on each wheel to move the chair forward or back. Many wheelchairs have push handles so they can be propelled by someone other than the user, such as a friend or caregiver. There are also one-hand manual wheelchairs for people with the use of one arm, and for people with limited use of the legs there are wheelchairs with a lower, or hemi, frame that are designed to be propelled by the user's legs. Manual wheelchairs can generally be placed in one or more of the following basic categories. [2,5]

- Standard/everyday wheelchairs
- Child/youth/growing wheelchairs
- Institutional/nursing wheelchairs
- Home/depot wheelchairs
- Lightweight wheelchairs
- Reclining/tilt-in-space wheelchairs
- Specialty wheelchairs
- Sport wheelchairs
- Standing wheelchairs
- Transit wheelchairs
- Transport wheelchairs

2. Objectives

- To restrict downward motion of manual wheelchair while climbing up on an inclined smooth surface.
- To reduce the speed of manual wheelchair up to certain speed called as safe speed while rolling down on an inclined smooth surface.

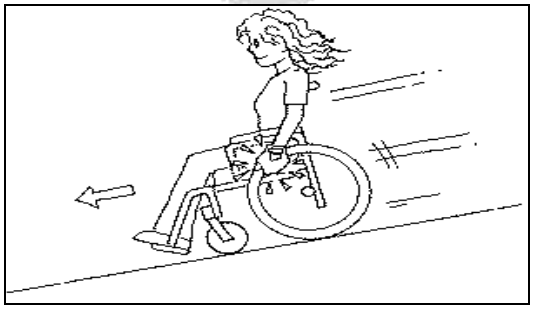

Figure 2: Wheelchair descending of inclined plane

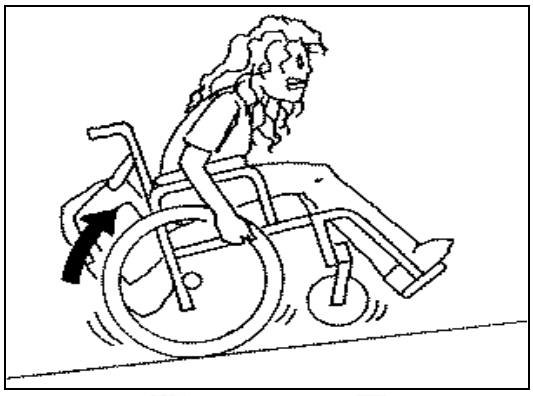

Figure 3: Wheelchair climbing on inclined plane

3. Literature Review

In the 5th century a wheelchair nothing but a chair is invented. The device comes in variations first one is self-propelled and another one is power wheelchair. Generally wheelchair is use by physically handicapped people. Wheel chair also called as "rolling chair". Harry Jennings and his disabled friend Herbert Everest, both mechanical engineers, invented the first lightweight, steel, collapsible wheelchair in 1933.

In 1887, rolling chairs were introduced to Atlantic City so invalid tourists could rent them to enjoy the Boardwalk. Soon, many healthy tourists also rented the decorated "rolling chairs" and servants to push them as a show of decadence and treatment they could never experience at home.

In earlier days there was little need for a consumer fact sheet on manual wheelchairs as there were no decisions to be made when selecting a wheelchair. If someone needing a wheelchair simply went to a doctor and received a prescription for a wheelchair. That chair was fairly standard in size and appearance. It would have been a boxy chair with a heavy steel frame and black or dark green art. Very few was available. Now that era has passed, and today's active wheelchair user has literally hundreds of options available. Manual wheelchairs come in sporty styles and stylish colors, and are often made of lightweight composite materials that greatly reduce the weight of the chair. Today is challenge to select the wheelchair that most directly meets an individual's needs. [3,4,5]

History of the Manual Wheelchair

- U.S. Civil War: First record of wheelchairs being used in the United States.
- 1907: First patent applied for a folding wheelchair with a tubular steel frame.
- 1936: First single cross-brace wheelchair patented by Everest & Jennings.
- 1948: Removable armrests introduced.
- 1950's: Lightweight chairs developed for sports use.
- 1980's-present: New composite frame materials developed to further reduce the Weight of chairs.

Currently many mechanisms have been developed for climbing on stairs. Some wheelchairs use electric power for their propulsion and to climb on stairs. But for manual wheelchairs mechanism are not developed. One of the drawback of the electric powered wheelchair is their cost. The electric wheelchairs are expensive than manual wheelchair. This paper describes a mechanism which is designed considering that a common man can afford the wheelchair.

4. Problem Statement

To design a mechanism which restricts the downward motion of the wheelchair while moving up on an inclined plane. Also the mechanism should apply brakes while descending on the inclined plane.

5. Solution Methodologies

The solution is divided in two parts i) A mechanism which restricts downward motion of wheelchair and

ii) A braking mechanism which allows to rolling down with safe speed.

To restrict the downward motion of the wheelchair, integration of Geneva wheel and pawl mechanism is used. The input from wheelchair is given to Geneva wheel and the pawl mechanism restricts the opposite motion of Geneva wheel.

To control the speed of wheelchair while moving down the inclined plane a braking mechanism is used which works on centrifugal force principle. The brake actuates after attaining a certain speed. This speed is called safe speed with which the wheelchair can roll down safely.

5.1. Design considerations for braking mechanism:

- Std. wheelchair weight =15.87kg.
- Weight of human body assumed to be100kg.
- Range of inclined plane assumed to be 10^0 to 40^0.
    - For $\theta=10^0$, m=60 kg, mgsinθ=197.38N
    - For $\theta=40^0$, m=100 kg, mgsinθ=730.64N
- Friction factor road & bicycle μ=0.75
    - Fmin=96.93N and Fmax=547.98N

Total force acting on wheel of wheelchair = total mass x acceleration
Total mass (M) = mass of person + mass of wheelchair
Torque acting on wheel = total force x radius of wheel
Torque acting on wheel = torque acting on centrifugal brake
Torque acting on wheel = frictional force x radius of hub
Frictional force = coefficient of friction x Normal force = centrifugal force
Centrifugal force = mass of shoe x radius x (speed in radians per second) ^{2}

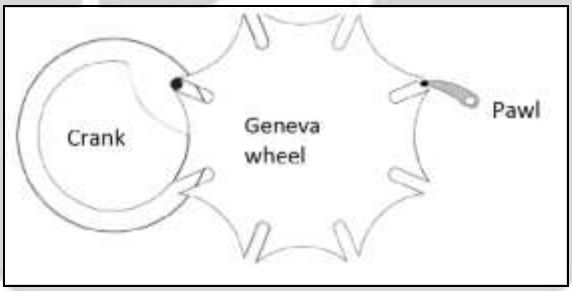

Figure 4: Geneva mechanism with pawl

Figure 5: centrifugal brake

5.2 Design considerations for Geneva wheel

The minimum rotation of wheel is assumed to be 30°. Since the displacement of wheelchair depends on the person driving the wheelchair. Therefore the minimum displacement of wheel is assumed to be 30°.

So the number of slots = 360/30=12.

5.3 Assembly Integration

Figure 6: Assembly of whole mechanism

The two mechanisms are integrated in one single assembly as shown in figure. The Geneva wheel and the braking mechanism are mounted on a shaft. The pawl mechanism is engaged with Geneva wheel. The motion is transferred from wheel to shaft through gears.

6. Analysis

The static analysis of the pawl mechanism is done with ANSYS. At static condition the effect of person's weight on the Geneva wheel is observed at different inclination that is at 10^0 and 40^0.

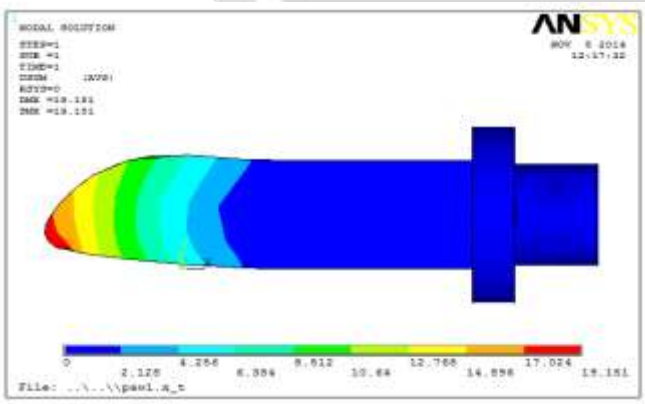

Figure 7: Deflection diagram of pawl

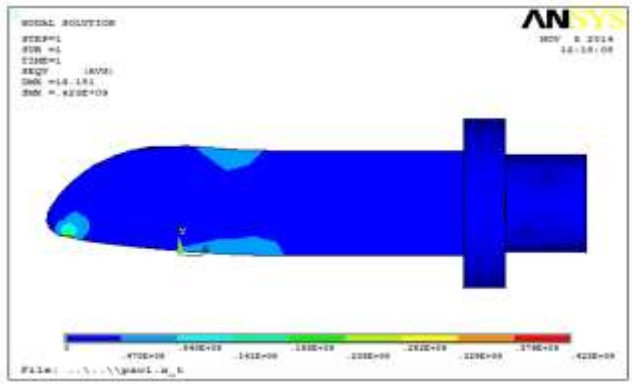

Figure 8: Stress distribution of pawl

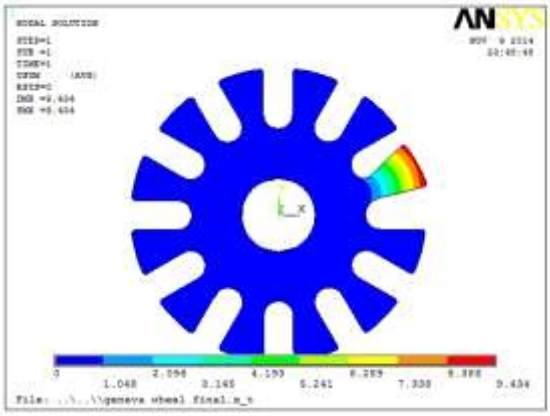

Figure 9: Displacement diagram at 10°

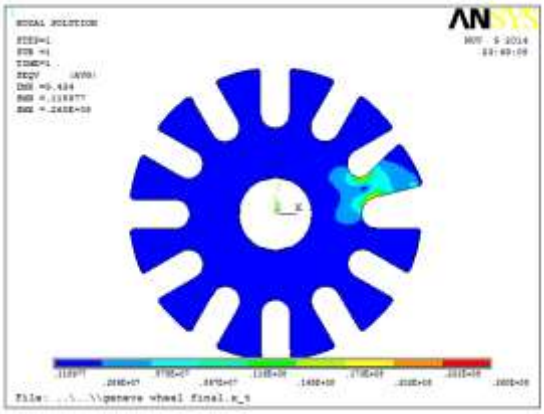

Figure 10: Stress diagram at 10°

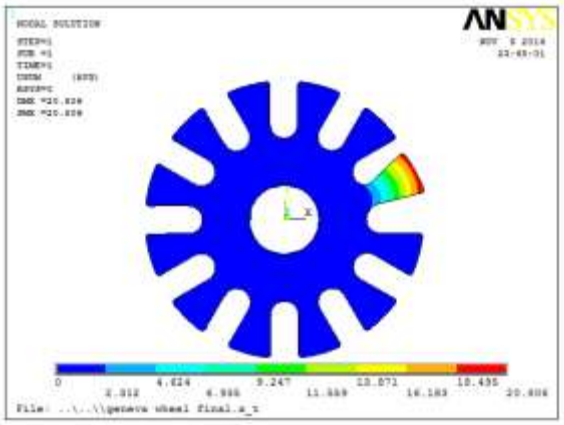

Figure 11: Displacement diagram at 40°

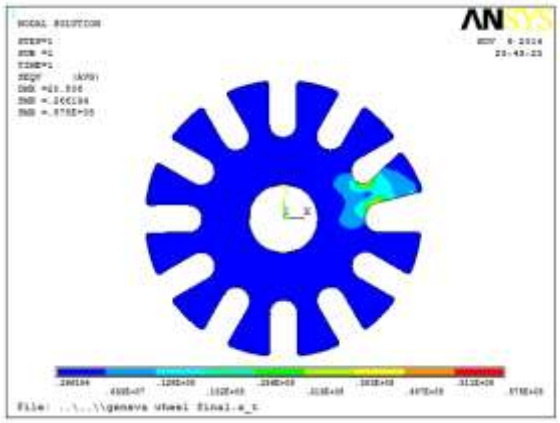

Figure 12: Stress diagram at 40°

7. Results and Discussions

In this system a mechanism with braking system is presented for safe mobility of the users using wheelchair on an inclined plane. The main goal of this paper is to restrict the downward motion of wheelchair while climbing the inclined plane and to control speed while rolling down the inclined plane. During static analysis of pawl get maximum deflection found to be 19.151mm and stress distribution is 0.423×10^9 N/mm^2.

8. Future Scope

There is always scope for improvement in wheelchair. In our wheelchair, when it exceeds safe speed automatic braking systems start operating. A person seating on it has no control on safe speed, as it is already specified. Different persons who are seating or operating wheelchair may feel comfortable on different speed, hence there is further scope to modify wheelchair such that one can put its speed limit or safe speed limit over which one wants control, We have designed the wheelchair according to functional requirement which can be available at low cost easily. If it is needed we can add digital indicator on it, so person will get the idea of its speed.

One can add safety feature such as if person is feeling unsafe or anything bad happens to, he can convey the message to hospital or home by GPS.

9. References

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