

Design and Development of Multipurpose Wheelchair

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Abstract : The main objective of the project is to provide stability to the person when climbing the stairs. A disabled person with lower limb does their daily activities on wheelchairs. The disabled person encounters difficulties when they have to ascend or descend the stairs. This leads to a risk of injury for both the disabled person and the assistants. Therefore, this project presents a prototype of a stair-climbing system for a wheelchair. This research was aimed to enhance the quality of life for the lower limb disabled person by enabling the wheelchair to climb the stairs with only one assistant to control the wheelchair. The designed stair-climbing system consisted of two 5-spokes wheels and the slot plates. The 5-spokes wheels were used for climbing the stairs. The slot plates were used for sliding the rear wheels of the wheelchair. The 5-spokes wheels were installed at the rear of the wheelchair and were driven by power from an electric motor. When climbing the stair, the rear wheels were slid to the front of the wheelchair. To move on the floor, the rear wheels were slid back to the rear of the wheelchair. From test results, the wheelchair with the stair-climbing system could ascend and descend the stairs with the maximum riser height of 200 mm. The maximum payload was 80 kg. The stair-climbing system could reduce the number of the assistants to only one person and the wheelchair could still move on the floor as a general wheelchair.

IndexTerms – Wheel Chair, Disabled person, Stair-Climbing.

I. INTRODUCTION

In present conditions, the wheelchairs available in market are generally used to transport the patients to and from different wards, e.g. ICU to operation theatre. But what if mobilizing or shifting of patient from wheelchair to stretcher or vice versa causes discomfort. So keeping in mind, this research propose a design of simple & steady wheelchair that can be easily convert to stretcher. With the help of this wheelchair a patient can be seated on wheelchair on which he can also be operated by converting it to stretcher. That means no movement of patient is required which reduces fatigue and discomfort to him and the nursing staff. Wheelchair is a device used by disabled people to improve their personal mobility. There are multiple types of wheelchairs present in the market like hand-operated or automatic wheelchair and the selection of wheelchair depends upon the physical and mental condition of the user. Wheelchair has some demerits against architectural difficulties on its way. As per PWD 1995 act it is compulsory to provide a hospitable environment in every public property but many buildings in India are constructed without considering convenience for disabled people and wheel chair users. Many rural as well as urban of India have addressed the problem by providing substitutes for the constructional barriers like building ramps at entrance, wheel chair ramps, lifts etc. yet a wheelchair user had to face few architectural difficulties .In this study we will attempt to design a wheelchair prototype which can reduce the problem faced by a wheelchair users. Stair climbing wheelchairs currently available for sale in market are costly for the users and are not easy to afford an automatic Stair-climbing wheelchair can be a good solution for the user and can enhance the mobility to access most of the buildings.

II. LITERATURE REVIEW

This project has been made by lot of people around the globe and also in India but the mechanism behind it is what our innovation is. The Mechanism which are available as – 1. Lobe Type Mechanism 2. Tri-Wheel Type Mechanism Lobe Mechanism was made in Japan and it was found that it had some limitations where the lobe could climb only a particular kind of steps of particular dimensions only. Taking this into consideration was first what we did before designing the mechanism. This mechanism becomes a disadvantage because the person using the wheelchair cannot carry different types of lobes all the time and by himself won't be able to attach it. The three wheel mechanism has same problems and so the mechanism which we are making it to solve is an experiment to solve the previous problems faced.

A wheelchair is chair with wheels, designed to help the disabled individuals. Stretchers are mobility devices used to transport the patients from one place to other. These both medical mobility aids are used in hospitals and clinics for helping the patients. Stretchers are simple in construction and the patient needs the support of an assistant to transport from one place to other. Whereas wheelchair is designed in such a way that either patient can control the device manually or with the help of someone's assistance. The device consists of proper handle with cushion in hand rest and seating area. The direction movement is a critical part when it comes to emergency situation. Proper selection of caster wheels facilitates to overcome the situations

Wheelchair is a wheeled chair consists of various parts and each part with different functions. This is an ergonomically designed medical equipment consists of a foldable frame type mechanism for easy carry. Seating and hand resting position are well designed for a comfortable sitting. Adjustable foot rest with a heel loop on the harper bracket is provided so that user won't get problems while transportation. Handles are placed in the back rest of wheelchair with suitable grip on that. Push rims are the other features of the wheelchair when into comes to the indoor purpose for the user. The user can be independent by the help of push rim, which may help the user to move from one place to other. Brakes are provided for stopping the wheelchair on both the push rim wheels. Caster wheels are another major part which directs the way and for easy transportation.

III. MATERIALS AND METHODS

We have used 1inch width and 3mm thickness mild steel angles in this project. Mild steel (iron containing a small percentage of carbon, strong and tough but not readily tempered), also known as plain-carbon steel and low-carbon steel, is now the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Mild steel contains approximately 0.05–0.25% carbon [1] making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.

In applications where large cross-sections are used to minimize deflection, failure by yield is not a risk so low-carbon steels are the best choice, for example as structural steel. The density of mild steel is approximately 7.85 g/cm³ (7850 kg/m³ or 0.284 lb/in³)[4] and the Young's modulus is 200 GPa (29,000 ksi). [5]

Low-carbon steels suffer from yield-point runoff where the material has two yield points. The first yield point (or upper yield point) is higher than the second and the yield drops dramatically after the upper yield point. If a low-carbon steel is only stressed to some point between the upper and lower yield point then the surface develop Lüder bands Low-carbon steels contain less carbon than other steels and are easier to cold-form, making them easier to handle. In this research, the prototype of a stair-climbing system was designed to attach to general unfoldable wheelchairs. This concept had an advantage since it was more convenient than creating a customized wheelchair. In addition, it could be applied to other sizes of wheelchairs. Figure 1 shows a wheelchair used in this study before attached with a stair-climbing system.

A spoke wheel was selected for climbing the stair because it was lighter and easier to maintain than a caterpillar track. The spoke wheel was designed to climb the stair that had the maximum riser height of 200 mm and minimum tread depth of 220 mm as shown in Fig.-1. These values were based on the Bangkok regulation on the building construction control B.E. 2544. The spoke wheel was designed to install at the rear of the wheelchair below the seat. Therefore, the diameter of the spoke wheel used in this research was 400 mm due to available space between the wheelchair seat and the floor. In order to select the appropriate number of spokes, the wheels from 3-spokes to 6-spokes with the diameter of 400 mm were studied as shown in Fig-1.

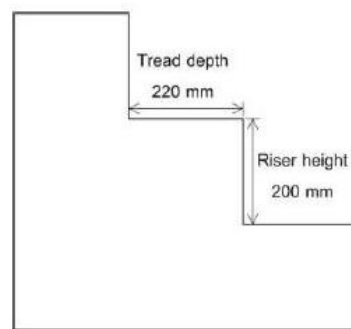


Fig-1 Standard Stair Size

In our project the fabrication consists of three phases. The first phase consists of fabrication of chassis including cluster wheels, the second phase consists of fabrication of frame (i.e.) the part below the seating arrangement and the third phase is the fabrication of two penta wheels.

Phase 1: The seat arrangement consists of eight hollow square steel tubes and it is joined by gas welding. The cluster wheels are fitted in the mild steel hollow circular tubes is then welded at the front portion of the seat arrangement. Since the selected material has low thermal conductivity, gas welding had been done.

Phase 2: The frame was fabricated as per the standard design, as it requires high accuracy; it determines the centre of gravity and stability for the person who is travelling. The frame was made of thick mild steel tubes, w. The frame arc welded with the shaft between the two penta wheels. The kinematic links have been used to link the frame and seating arrangements.

Phase 3: The bottom part of the rolling chair consists of penta wheel arrangement. Circular wheels were fitted to the each end of penta projection. The shaft is welded with the frame.

PROCESS: In our project, we are welding a frame with ARC Welding method, these processes use a welding power supply to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. They can use either direct current (DC) or alternating current (AC), and consumable or non-consumable electrodes. The welding region is sometimes protected by some type of inert or semi-inert gas, known as a shielding gas, and filler material is sometimes used as well.

IV. MAIN COMPONENTS OF WHEEL CHAIR

THE BRUSHLESS DC MOTOR

The brushless DC motor (BDCM) is very similar to a permanent magnet DC motor, but does not have any brushes to replace or wear out due to commutator sparking. Therefore, little heat is generated in the rotor increasing the motors life. The design of the brushless motor eliminates the need for brushes by using more complex drive circuits where the rotor magnetic field is a permanent magnet which is always in synchronization with the stator field allows for a more precise speed and torque control. Then the construction of a brushless DC motor is very similar to the AC motor making it a true synchronous motor but one disadvantage is that it is more expensive than an equivalent "brushed" motor design.



Fig-2 Brushless motor

BATTERY CAPACITY

A rechargeable battery, storage battery, secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Battery Capacity 12VOLTS and 7.5AH.



Fig-3 Battery

IR REMOTE CONTROL

A remote control vehicle is defined as any vehicle that is teleoperated by a means that does not restrict its motion with an origin external to the device. This is often a radio control device, cable between control and vehicle, or an infrared controller. A remote control vehicle or RCV differs from a robot in that the RCV is always controlled by a human and takes no positive action autonomously



Fig-4 IR Remote Control

PENTA WHEEL MECHANISM

In general, lower limb disabled people do their daily activities on wheelchairs. Although there are many facilities for the disabled people, the facilities still not cover in every place. Many times, the disabled people encounter difficulties when they have to ascend or descend the stairs. For example, enter or exit buildings that have no ramps, go up or down in buildings that have no elevators or cross pedestrian bridges. For these situations, many assistants are required to carry a lower limb disabled person and a wheelchair.



Fig-5 Penta Wheel



Fig-6 Penta Wheel

V. DESIGN AND DEVELOPMENT

One-fifth of the estimated global population, i.e. between 110 million and 190 million people, experience significant disabilities. Disabilities of various parts such as eye, ear, hand, leg etc. Limb disability is one of the disabilities which are caused due to various reasons such as deformation by birth, war, disorders such as diabetes. Lower limb of sports person also suffers huge blows while playing and are always at the risk of suffering severe injuries. These injuries sometimes may be a permanent disability. Wheelchair has limitations against architectural barriers on its way. Although as per PWD 1995 act it is mandatory to provide an accessible environment in every public building but numerous buildings in India are designed without considering accessibility for physically challenged and wheel chair users.

- Design the frame and wheels.
- Analyze the frame and wheels under different loading conditions.
- Fabricate the frame and wheels.
- Assemble the parts.
- Testing

Design of frame and wheel

- The frame and wheels were designed using solid edge V20
- The frame is compact in design so that it can be used in any stair width
- MS was selected as material for frame due to its strength and availability
- Special 8-lobe wheels are designed for stair climbing purpose
- This is selected based on human gait.
- Wood is selected as material for wheels as it is light and also act as damper

Analysis of frame and wheel

- Analysis of frame and wheels was carried out using Ansys16.0
- A load of 1500N is applied on the frame with maximum deformation of 0.104mm
- The loading point is the point where the seat is placed.
- A load of 350N is applied on each lobe of the wheel.
- Maximum deformation of 0.004mm was observed.

Scope of Future Work:

- For stair climbing at varied load conditions the motor capacity should be increased along with suitable power source.
- The frame weight can be reduced by using high strength lightweight materials such as composites, carbon fiber.
- The wheelchair can be automated by using electronics so that it will automatically sense and climb the stairs.

VI. WORKING MODEL

In our project we are going to design a manually operated wheel chair cum stretcher that can travel on both plane terrains and also in the staircases. Instead of using normal wheels we are going to use a penta wheel. The steel rod will be made into a penta shape and each rod will be inclined of 72° from each other. The wheel chair can be adjusted as a stretcher too. At the time of climbing, one wheel that is the idle wheel will be in contact with the ground and the other wheel will be in contact with the stair. The motion takes place only when we pull the wheel chair backwards towards the staircase.



Fig-7 Wheel Chair

VII. CONCLUSION

In this research, the prototype of a stair-climbing system for a wheelchair was designed based on simplicity and easy maintenance. The 5-spokes wheels were used for the stair-climbing system. From the results, the system could ascend and descend the stairs with the maximum riser height of 200 mm. Only one assistant was required to control the wheelchair. It could also move on the floor as a general wheelchair. The maximum payload was 80 kg. The sliding of the rear wheels of the wheelchair will be improved to enable the assistant to slide both rear wheels simultaneously. This will reduce the time required for sliding the rear wheels.

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