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Wheelchair with Readily Detachable Drive Handle

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Abstract

People suffering from paraplegia (a condition where the lower extremities of the body stop responding) have a major problem getting around and doing simple tasks. To help them in these situations, we developed a wheel chair which has a detachable drive handle which can be attached to any wheel chair with minimal modifications and drive around effortlessly. Our product is not only for the disabled, as it is relatively cheap, older people can take it to the parks, and have a pleasant evening stroll, which is both peaceful and healthy.

1. INTRODUCTION

The ability to move from one place to another is one of the most important thing, but it is not a privilege that every person has. The existence of the simple wheelchair can be found to as early as 3rd Century BC, in old Chinese paintings[5]. And the actual use of a wheeled chair used for transport is seen much later. The first documented use of wheelchairs for handicapped persons is seen in 1887, where the differently abled persons are reported using wheelchairs to enjoy Boardwalk.But the wheelchair we commonly see was not developed until 1933, when two mechanical engineers, Harry Jennings and Herbert Everest designed a collapsible wheelchair made of steel which unlike the previous designs was lightweight and foldable[5]. They then saw its commercial potential and started mass production. To this day, we see that same design with slight modifications .A simple wheelchair has four wheels, the small front wheels are called as caster wheels, they help in turning the chair and the large back wheels usually comes with hand rims, these are used to move the chair forward or backward at the will of the person using the chair. They also have push handles at the back of the chair to allow the caretaker to guide the wheelchair. Along with these they also come with seat, footrests and leg rests. Now a days, there are many types of these which range from Self-propelled, One-arm drive to transport wheelchairs. There are sports wheelchairs and those with the capability of dynamic tilting which allows the occupants to sit in a much more comfortable posture. These are manually propelled, and the occupant uses a large rim

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surrounding to propel forward. There are also some leg propelled models which are used by those who have limited hand movement. The pricing depends on the material, model, customizations and the brand the wheelchair belongs to. According to Census India 2001 there are 21,906,769 differently abled people in India [1]. Of this 21 million people 6,105,477 have a movement related disability. The percentage of disabled people is more in rural areas than that of urban areas. Hence there is an urgent need to find a solution, which is cheap, versatile and reliable and a system that would make these differently-abled people as independent as possible. For this reason, we have proposed a wheelchair concept with a detachable handle. The main problem of the motorized wheel chairs available presently is that they are costly, heavy and immediate maintenance isn't available in most of the places[3]. Our proposed design is such that any existing wheelchair can be modified to fit the handle and make it motorized. The detachable handle inherently holds all the mechanical components, so whenever the battery is down or if there isn't any need for it, it can be easy removed and the chair can be used as a normal wheel chair. This is very useful inside buildings and when you have company accompanying you.

The Objectives of this study are to:

- Make a motorized wheel chair accessible to everyone.
- Design a wheelchair with the benefits of both a manual and motorized wheelchair.
- Minimize the weight, relative to a regular motorized wheelchair.
- Make the prototype and check for the changes required to make it market ready.
- Theorize on various other methods that the design can be improvised.

2. Research Methodology

Wheelchair International Standards

As with any thing being mass produced, and the fact that this is for disabled people,there has been a lot of research done to find the right measurements for each and every part of a wheelchair. And the fig 1.1 below details the widely accepted results of the research. Though these are the accepted standards, people can have a wheelchair made exactly to match their requirements. The measurements mentioned in fig 1.1 are for the mass produced wheelchairs use in hospitals, and public places like railway stations etc.

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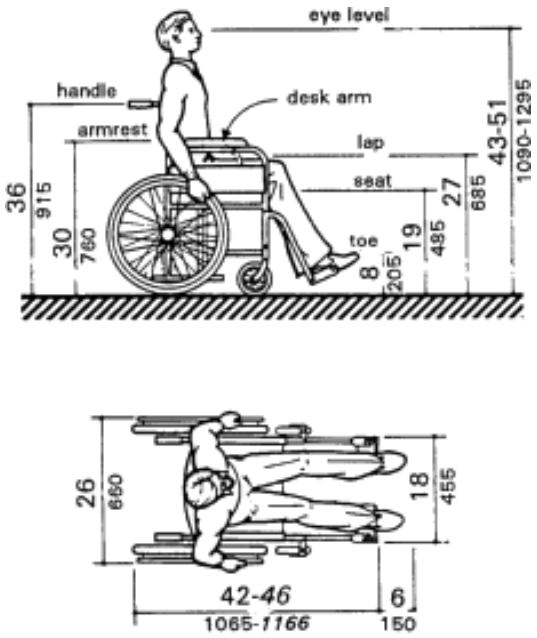

Figure 1.1 Wheelchair Standard Dimensions

The following components are used to make our design:

2.1) DC Motor

Most electro-mechanical movement in equipment is caused by either DC Motor or AC Motor. A DC Motor works on Direct Current that can be stored in batteries. Therefore DC motor is the best choice for automobiles as they are always on the go. It works on the principle of motoring action. It is a phenomenon that a conductor placed in a magnetic field has a tendency to move when current is passed through them, hence generating torque. People have found many uses for the torque generated, like in Motor Pumps, Electric Vehicles, Drills, Fans and the list just goes on.The internal of a DC motor is exactly same as that of a DC generator, but electrically it is exact opposite. In a DC generator mechanical energy is provided to produce electric current, but in a DC motor electric current is provided to produce mechanical energy.

Mechanical energy produced by a DC motor is in the form of rotary motion. This with the help of a chain and sprocket is transferred to a shaft. Wheels attached to the shaft move along with it. In this way, a DC motor can be used in automobile industry. And

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this is exactly how we have in this project. The torque and rpm generated from a DC motor depended on the type of winding done inside the motor thick wires with few turning will give high rpm and thin wires with dense windings will give better torque.

Figure 1.2 DC Motor used for the project.

2.2) Shaft

A shaft is mechanical component used to transfer torque to other components with the help of a gear system. As they transfer large amounts of energy, they are subjected to torsion and shear stress, which will be equal to the difference between the supplied torque and the load applied on the shaft. So, the material of the shaft has to be decided in such a way that it will be able to withstand such forces. And the designer should also allow for some safety factor, in case excess load is applied. The forces applied on the shaft include shear stress (from the torque applied) and bending stress caused from the interaction with other mechanical components such as gears. And last, the stress caused due to the interaction shear and bending stress.

2.3) Sprocket

A sprocket is a toothed wheel which is used to pull over something which it is attached to just by turning around. Sprocket looks very similar to a but, unlike gears, these are not used to engage with themselves. They are used in

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many places like in bicycles, automobiles, old printers and cameras, and in cinema halls where the film is threaded on a sprocket. One downside of a sprocket is that when the alignment is lost, the whole machine becomes useless, so the use of sprocket is losing its flair these days. But in case of a gear, if a tooth brakes and falls down, in most situations the load will just shift to other teeth.

2.4) Gear Ratio

When we use a gear or a sprocket there is always a need to change the speed, direction, change of axis or just keep the two axis synchronized. In such cases, there is a need to understand gear ratios. The speed and torque depend on the gear ratio in such a way that when power is transferred from a smaller gear to a large gear, the speed is reduced and in turn, we obtain higher torque. Similarly, if the power is transferred from a larger gear to a smaller gear, torque is lost and speed is gained. So when a vehicle is cursing on a flat highway, we would opt for high speed. But in situations where we need take heavy load or where we travel in inclined roads we need to have more torque, so we shift to a gear respectively.

For our project, we used 11 tooth sprocket to transmit power from the motor to a 22 teeth sprocket mounted onto the shaft, hence providing a better load caring capacity.

2.5) Controller

Controller is a crucial part of any automobile operating on a electric motor as it controls the RPM of the motor, a controller has the ability to change the current levels in a motor such that the output from the motor can be controlled according to the need of the operator. If the need of motor control is very simple, like switching it or off, there is no need of a controller, but in real life most situations have the requirement to control acceleration, speed, motor positioning and some controllers even have the ability to sense load and change the torque accordingly.

2.6) Bearings

A bearing is a mechanical component use to constrain the relative motion to a specific required direction. At the same time, they provide free motion in a particular direction by decreasing the friction between the specific moving parts.

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All bearing are high precision components, carefully engineered to provide the machinery to move at very high speeds, and help them carry huge loads with great efficiency and ease. Bearings are found in many places airplanes, automobiles, construction equipment, electronics, refrigerators, and many more.

2.7) Caster

A Caster Angle is the angle at which the steering axis makes with the vertical axis; it can be forward or rearward depending upon the requirement. There are two types of caster, positive and negative. In simple terms, if the tilt is backward then it is called as positive caster and if the tilt is forward that will be called as a negative caster.

3) Calculations

Torque Required:

For calculating the torque requirements of the motor, these are the forces that act on the body of the vehicle

1. The rolling resistance of the tires.
2. The aerodynamic drag of the vehicle body any resistance due to the climbing of an incline.
3. Overcoming the inertia of the vehicle (as a whole) and the rotating parts, while the vehicle is accelerating. The force required to overcome the inertia is only prominent at lower gears, so it is neglected in the calculations.

Under the steady state conditions, resulting forces can be given as:

Total Running Resistance Force (Ftot) = $F_{Ro} + F_{Ae} + F_{Cl}$

Where

F_{RO} = Rolling Resistance = $f$mg

m = Vehicle mass = 150 kg

f = Coefficient of rolling resistance, generally between .013-.015 for normal roads, but increases with speed.

F_{Ae} = Aerodynamic Resistance = $0.5\rho C_d A(v + v_h)^2$

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Where

ρ= 1.2-1.3 kg/m^3= air density

C_d = drag coefficient, range between 0.3- 0.4

A = frontal area of the vehicle in m^2 = 1

ν= vehicle sped= 5.55 m/s

ν_h = headwind speed = 0 m/s

Climbing Resistance (F_{ci}) = mg sin β

Where β = the gradient of the hill being climbed =5

Along with these a vehicle would have to get over other forces such as the work engine may be doing and if the wheelchair is moving on a smooth road, the friction from the road will increase. These forces may be negligible or be so that the wheelchair would stop moving altogether. But considering all those condition is not feasible. For our calculation, we are also neglecting the climbing resistance as the wheelchair is being designed for simple situations where the road inclination is non-existent.

By Appling all the values, we calculate each force that is being applied on the wheelchair, with that total force abstained we will calculate the torque required to pull the wheelchair. Now considering the forces that are being applied, we can calculate the torque required to move the wheelchair

Torque = $F_{tot} \times$ Rolling Radius

= 38.075 × .08

= 3.04 Nm

No. of Chain Links:

Centre Distance (a) = 13 cm

Teeth on driving Sprocket (z_1) = 11

Teeth on driven Sprocket (z_2) = 22

Pitch (p) = 3/8 inch = 0.95 cm

No. of chain links (L_n) is given by

$= 2\frac{a}{p} + (\frac{Z_1+Z_2}{2}) + (\frac{Z_2-Z_1}{2\pi})^2 \times (\frac{P}{a})$

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$$= 2\left(\frac{13}{95}\right) + \left(\frac{11+22}{2}\right) + \left(\frac{22-11}{2\pi}\right)^2 \times \frac{0.95}{13}$$

$$= 44.08$$

So, as per the formula applied for the standard bicycle chain of pitch .95 cm, applied for the centre distance of 13 cm taken from the design we get the required number of chain links as approximately 44.

4. TECHNICAL DETAILS OF THE SETUP

4.1 Weight and Dimensions

Height	33 inch
Weight	6 Kg
Material	Mild Steel

Table 1.1 Frame Specifications

4.2 DC Motor

Table 1.2 DC motor Specifications

Watts	372.84
Rpm	3500
Ampere	39
Weight	8Kg
Dimensions	Length 6 inch, Diameter 5 inch

4.3 Batteries

Table 1.3 Battery Specifications

Voltage	12V
Weight	9 Kg
Dimensions	Height 3.5 inch Width 2.5 inch Length 6 inch

4.4 Tires

Table 1.4 Tires Specifications

Type	Heavy Duty
Width	2 inch
Rim Diameter	7 inch

4.5 Wheelchair

Table 1.5 Wheel Chair Specifications

Weight	9 Kg

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Seating Height	20 Inches

4.6 Material's properties

Material	Mild Steel
Melting Point	1350-1530 ^{o}C
Percentage of Carbon	.05% to .26%
Percentage of Manganese	.70% to .90%
Young's Modulus	210,000 Mpa
Density	7.85 g/cm^3
Properties and Characteristics	Ductile, Good tensile strength, Good Weldability, Poor resistance to corrosion, Malleable

5) Construction

5.1) Design: First and foremost step was to create a design of frame and motor assembly in the solidworks. For this, we took an exact replica of the wheelchair and made the frame to match with its height. In this way we were able to get all the dimensions and angles required for cutting in further stages of the project.

Figure 1.3 Design of Wheelchair

5.2) Purchase of Materials and Survey

In this stage, a market survey was conducted to find out where the best quality product is available and then, we purchased the required materials and equipment to start the project.

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Materials Purchased:

- Mild Steel Rods, DC Motor, Fork, Tire, Shaft, Sprocket, Wheelchair

5.3 Cutting

Cutting is a phenomenon where a compressive and shearing force is used to cutting. But the actual cutting is possible only when the total stress generated is greater than the ultimate strength of the material the cut object is made of.

From the equation: Stress = Force / Area

It can be seen that stress being applied on the body is directly proportional to the force applied on the body, and inversely proportional to the area in contact. For accurately cutting the rods we first prepared notches from the cut sections of each individual part to be cut. Then, we made print in 1:1 scale. After cutting the rods to required length, this print out was pasted on to the rod and grinded to form the required notches. This helps in getting the best welding process.

5.4 Drilling

Drilling is the method of making holes on a material using a multi-point cutting tool, twist drill bits. It is attached to motor which rotates it at high speeds which is used to make holes. When the drill bit is pressed against the material, the force caused due to the rotation of the bit which can range from a hundred to thousands depending up on the strength of the material. Drilling can also be used to enlarge an existing hole.

We used this process to drill holes for the locking mechanism of the frame to the wheelchair and other parts.

Figure 1.4Drill Bits

5.5 Welding of Frame

Welding is the process of joining to similar or dissimilar materials using fusion,

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but it is done well below the lower melting point of the materials. There are many different types of weldings, each with their advantages and disadvantages.

For this project we used arc welding with consumable electrodes to form the weld joints of the frame. The cut metal rods according to the notches are placed and welded accordingly, taking the required safety precautions.

Figure 1.5 Frame

5.6) Mounting of DC Motor and Sprocket

Once the frame welding was done, it was time for mounting the motor and sprocket, first motor is fixed on to the plate on the frame. Then, the shaft carrying the drive wheel and the sprocket was attached to the frame. And the chain was connected to complete joint between motor and sprocket.

5.7) Testing The Frame Clamping System

It is the system used for clamping and unclamping the frame to the wheelchair. Before attaching it to that wheelchair, it is necessary to see that everything is working as it is intended to. To this all the parts associated system are placed in their rough position and we tried to clamp the frame to the wheelchair. Once everything was checked we proceed to the next stem of manufacturing process.

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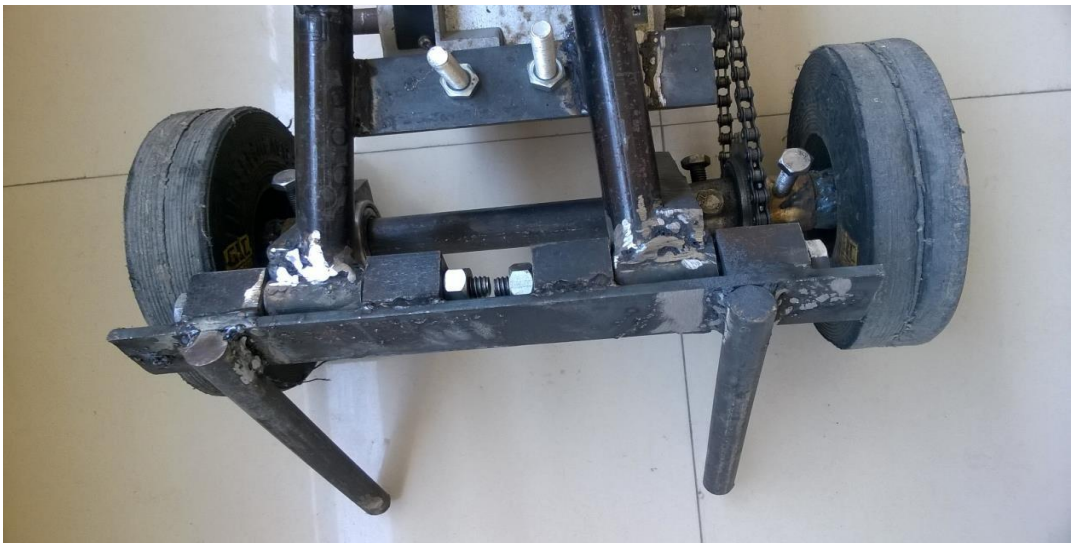

Fig1.6 Frame Clamping System

5.8) Mounting of Clamping System

Once the testing is done, we assembled the clamping system on to the wheelchair. Then we treated it again to clamp it with the person sitting on the wheelchair, to see if the person is able to do it comfortably by himself or not.

5.9) Attaching the Wheelchair

Now that all parts are either attached or welded together we attached the wheel to the fork, to complete the whole assembly. This done simply attaching the wheel to the fork and then bolting it tight. Then the brake assembly is fixed to the wheel.

5.10) Testing the Assembly

As all whole manufacturing process is completed, it was necessary to see that everything was working as per the design. As there are many parts that move relate to each other it is we tested them individually. Once this was done we took the wheelchair to a test run, this helped us see how the motor was working and we could also assess how much load it was able to pull.

5.11) Adjustments

After the test run, at this stage we did all small changes and adjustments in places where it was necessary. By doing this we could ensure that everything was operating smoothly.

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Figure 1.7 Final Assembly

These are the main results we wanted to get by completing this project.

- To design a wheelchair that has the advantages of both a manual and motorized wheelchair.
- To minimize the cost of buying a motorized wheelchair.
- To come up with a design which can be used on any existing wheelchair.
- To study other possible solutions to attain the same result.

6) Result and Discussions

These are the main results we achieved by completing this project.

- To design a wheelchair that has the advantages of both a manual and motorized wheelchair.
- To minimize the cost of buying a motorized wheelchair.
- To come up with a design which can be used on any existing wheelchair
- To study other possible solutions to attain the same result.

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6.1 Advantages

- Less expensive than normal motorized wheelchairs.
- Easy to install.
- Simpler controls.
- Can be installed on any manual wheelchair.
- No need of any major changes to the existing wheelchair.

6.2 Disadvantages

- Cannot attain high speeds.
- Can't be used for travelling on elevated paths.

7) Conclusion

There are many people with various health problems that cause a motion related problem and there has to be solution to make them independent and help feel confident to move around and reach places by themselves. Though a simple wheelchair is a solution but it causes fatigue and exhaustion after prolong usage. Also, a motorized wheelchair could be a solution for that problem but they are highly priced. A basic model in India costs around Rs 21000 and most people cannot afford to buy at these prices and they are also very bulky, so if the charging is out, one has to carry all the dead weight with their bare hands. So, this is a design to help shrink the gap between these two products and help a common man have his comfort.

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