Design and Fabrication of Stretcher Cum Wheel Chair

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Abstract

In India the number of disabled individuals is increasing every year. Mobility aids are useful for patients for transportation and a replacement for walking especially in indoor and outdoor environment. Transferring the patients from wheelchair to stretcher or to the medical bed is always an issue for the attendant or helper. Understanding the various issues regarding the mobility equipment and introducing a better design will be an asset for the medical field and helping hand for disabled individuals. There is a need for a wheelchair cum stretcher to facilitate the disabled patient’s mobility and to provide a novel medical equipment for use in the Indian hospitals. Here we are developing a system which is capable of shifting various positions (Chair, Semi-Chair and Stretcher) manually. These positions can be achieved by a lead screw connected with a hinge joint. Lead Screw translates turning motion into linear motion. Also the height of the stretcher can be adjusted using a Hydraulic jack manually. It is placed horizontally which pushes against a lever which lifts the main arm. And also there is a lid on chair which can be opened to eliminate human waste. This is a cost reducing project which helps mainly paralyzed patients to do their daily things.

Keywords: Mobility Aid, Lead screw, Wheelchair cum Stretcher, hydraulic jack

I. INTRODUCTION

A wheelchair is a wheeled mobility device in which the user sits. The device is propelled either manually (by turning the wheels by the hand) or via various automated systems. Wheelchairs are used by people for whom walking is difficult or impossible due to illness (physiological or physical), injury, or disability. People with both sitting and walking disability often need to use a wheelchair. The earliest records of wheelchairs date back to the 6th century, and were found inscribed on a stone slate in China. Later dates relate to Europeans using this technology, dating back to the Renaissance. The various types of wheelchairs are manual wheelchairs, electric-powered wheelchairs and sport wheelchairs.

A basic standard manual wheelchair incorporates a seat and back, two small front (caster) wheels and two large wheels, one on each side, and a foot rest.

Wheelchairs are often variations on this basic design, but there are many types of wheelchairs, and they are often highly customized for the individual user's needs. The seat size (width and depth), seat-to-floor height, footrests/leg rests, front caster outriggers, adjustable backrests, controls, and many other features can be customized on, or added to, many basic models, while some users, often those with specialized needs, may have wheelchairs custom-built.

Various optional accessories are available, such as anti-tip bars or wheels, safety belts, adjustable backrests, tilt and/or recline features, extra support for limbs or neck, mounts or carrying devices for crutches, walkers or oxygen tanks, drink holders, and clothing protectors.

Experiments have also been made with unusual variant wheels, like the omni wheel or the mecanum wheel. These allow more directional movement options.

A. Manual wheelchairs:

Manual wheelchairs are those that require human power to move them. Many manual wheelchairs can be folded for storage or placement into a vehicle, although modern wheelchairs are just as likely to be rigid framed.
Manual or self-propelled wheelchairs are propelled by the occupant, usually by using large rear wheels, from 20-26 inches in average diameter, and resembling those of bicycle wheels. The user moves the chair by pushing on the hand rims, which are made of circular tubing attached to the outside of the large wheels. The hand rims have a diameter that is slightly less than that of the rear wheels. Skilled users can control speed and turning and often learn to balance the chair on its rear wheels - do a "wheelie". The wheelie is not just for show - a rider who can control the chair in this manner can climb and descend curbs and move over small obstacles.

One-arm drive enables a user to guide and propel a wheelchair from one side. Two hand rims, one smaller than the other, are located on one side of the chair, left or right. On most models the outer, or smaller rim, is connected to the opposite wheel by a folding axle. When both hand rims are grasped together, the chair may be propelled forward or backward in a straight line. When either hand rim is moved independently, the chair will turn left or right in response to the hand rim used. Another alternative is a lever-drive chair that propels the chair forwards by using a lever that is pumped back and forth. Some chairs are also configured to allow the occupant to propel using one or both feet instead of using the rims.

**B. Electric-powered wheelchairs:**

The electric-powered wheelchair was invented by George Klein who worked for the National Research Council of Canada, to assist injured veterans during World War II.

Three general styles of electric powered chairs (EPWs) exist: rear, center, front wheel driven or four wheels driven. Each style has particular handling characteristics. EPWs are also divided by seat type; some models resemble manual chairs, with a sling style seat and frame, whereas others have 'captain's chair' seating like that of an automobile. EPWs run the gamut from small and portable models, which can be folded or disassembled, to very large and heavy full-featured chairs (these are often called 'rehab' chairs).

EPWs may be designed specifically for indoor use, outdoor use, or both. They are generally prescribed for persons who have difficulty using a manual chair due to arm, hand, shoulder or more general disabling conditions, and do not have the leg strength to propel a manual chair with their feet, a practice not generally recommended by most AHPs (Allied Health Professionals). They may also be issued to those with cardiovascular conditions. A person with full function of the arms and upper torso will generally be prescribed a manual chair, or find that their insurance will not cover an Electric Power Wheelchair. People that cannot get their insurance to cover an electric wheelchair or scooter are increasingly searching the Internet for "Pricing for the uninsured” with the word wheelchair or scooter for large savings.

EPWs can offer various powered functions such as tilt, recline, leg elevation, seat elevation, and others useful or necessary to health and function.

**II. Literature review**

Journal papers and patents explored here are related directly or indirectly to the proposed area of work that is design and development of a Wheelchair cum Stretcher. These papers are to support and enlighten the whole process of design in the specific area. A wheelchair is chair with wheels, designed to help the disabled individuals. Stretcher 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. Stretcher 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.

According to Mr. Peter Axelson, Mr. Jean Minkel, and Mr. Denise Chesney, [1] selection of an appropriate wheelchair will lead a comfortable living to the user. Performance, safety and dimensions are the three categories which have to be considered while selecting a manual or powered wheelchair. An excellent approach to the wheelchair selection is to set priorities based on user's mobility and seating needs. It is highly recommended that a novice can consult with there habilitation specialists in order to select the appropriate wheelchair.

James J. Kauzlarich, [2] says self excited vibration is one of the most interesting topics in the field of vibrations and is the science prevailing caster wheel shimmy. Self excited vibration is characterized by vibration that is produced by the motion of the system like wheel chair speed. It can be observed that in most of the cheapest wheelchairs, the design of the casters makes use of a sliding frictional damper in the spindle support to improve the shimmy characteristics. Understanding the theory of damping for the casters show how shimmy prevention works in ultra-light and powered wheelchairs.

Mr. Richard Simpson, [3] says almost 10% of all individual who are legally blind also have a mobility impairment and majority of these individuals are dependent on others mobility. A smart power assistance module (SPAM) for manual wheelchair is being developed to provide independent mobility for this population. The power assist wheelchair that provides for obstacle detection and avoidance for those with visual impairments. The control of the wheelchair will be carried out by the microprocessor and also allow the SPAM to provide a smoother and nuanced control.

According to Mr. Rory A. Cooper, [4] rehabilitation is a humanistic profession. Measurement of the user and wheelchair are critical to achieving maximum functional mobility. He says Biomechanics and ergonomics provide the information necessary to understand many aspects of wheelchair use. These factors affect seating comfort and posture, propulsion, efficiency and pain. Proper seating is an important aspect of wheelchair selection, and wheelchair cushions provide pressure relief and some postural support.

Dr. Daniel E. Jolly, [5] says personal preparation should be taken before transferring the patient from wheelchair to bed or vice versa. Use of sliding boards will be helpful for paraplegic patients. The best sliding board is made of hard wood, smooth, tapered
on ends. Support of two assistance, support straps, belts etc will facilitate easy transfer. The patient should not be slide into chair, lift from the wheelchair and transfer is the optional and safety method for patient transfer.

Mr. Debkumar Chakrabarti [6] says primary consideration should be given for comfort, so that people can sit for long time without feeling any physical discomfort. Considering the suitable materials for seat surface, frame and can make a comfortable seating for the design. Without considering the ergonomics and application can make a diverse effect to the user. Seat cushions are so important in the design of wheelchair.

### III. Design and Specifications

Design and analysis is done by using simulation express of solid works.

![Lead Screw Diagram](image)

**Fig. 1: Specification of lead screw**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P- Pitch</td>
<td>12.3 mm</td>
</tr>
<tr>
<td>OD- Outer Diameter</td>
<td>19 mm</td>
</tr>
<tr>
<td>H- Depth</td>
<td>24.5 mm</td>
</tr>
<tr>
<td>T- Thickness</td>
<td>4.7 mm</td>
</tr>
<tr>
<td>ID- Inner Diameter</td>
<td>15 mm</td>
</tr>
<tr>
<td>H- Depth</td>
<td>30 mm</td>
</tr>
<tr>
<td>d- Thread Diameter</td>
<td>4 mm</td>
</tr>
<tr>
<td>D- Thread Diameter</td>
<td>7 mm</td>
</tr>
</tbody>
</table>

![Wheelchair Position Diagram](image)

**Fig. 2: wheel chair position**

![Stretcher Position Diagram](image)

**Fig. 3: stretcher position**
IV. DESCRIPTION OF EQUIPMENT

A. Hydraulic jack

A Hydraulic cylinder (also called a linear hydraulic motor) is a mechanical actuator that is used to give a linear force through a linear stroke. It has many applications, notably in engineering vehicles.

Hydraulic jacks are jacks that are placed in a horizontal position. These jacks push against a lever, which lifts the main lift arm. Bottle jacks have a longer handle than most hydraulic jacks, however, and it is possible to get more lift per stroke with the increased leverage they provide when compared to regular models of jacks. Bottle jacks are versatile because their horizontal position makes it possible to place them in tight spots and provides good leverage. Recently bottle jacks have proven useful in search and rescue missions following earthquake damage. As a result, bottle jacks are standard equipment in firehouses and for search and rescue teams. They are also used for lifting, spreading, bending, pushing, pressing, or straightening requirements. The base and cylinders of bottle jacks are electrically welded for strength, and all models are capable of working in upright, angled, or horizontal positions.

B. Lead screw

A lead screw, also known as a power screw or translation screw, is a screw used as a linkage in a machine, to translate turning motion into linear motion. Because of the large area of sliding contact between their male and female members, screw threads have larger frictional energy losses compared to other linkages. They are not typically used to carry high power, but more for intermittent use in low power actuator and positioner mechanisms. Common applications are linear actuators, machine slides (such as in machine), vises, presses, and jacks. Lead screws are manufactured in the same way as other thread forms (they may be rolled, cut, or ground). A lead screw is sometimes used with a split nut which allows the nut to be disengaged from the threads and moved axially, independently of the screw's rotation, when needed (such as in single-point threading on a manual lathe).
Power screws are classified by the geometry of their thread. V-threads are less suitable for lead screws than others such as Acme because they have more friction between the threads. Their threads are designed to induce this friction to keep the fastener from loosening. Lead screws, on the other hand, are designed to minimize friction. Therefore, in most commercial and industrial use, V-threads are avoided for lead screw use.

C. Wheel

A wheel is a circular component that is intended to rotate on an axle. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel and flywheel.

Wheels, in conjunction with axles allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Common examples are found in transport applications. A wheel greatly reduces friction by facilitating motion by rolling together with the use of axles. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force.

V. WORKING PRINCIPLE

The main components involved in this project consists of hydraulic jack, screw rod, wheel, free wheel, waste lid and braking lever. In this project, we provide two lead screw setup with hinge joint is used to form the stretcher or bend to wheel chair. At the present position this model is a wheel chair type. Below the chair we provide two lead screw setup to connect the right or bottom side plate and left or top side plate by using hinge joint. For movement of bottom side plate, rotate the screw handle in counter clockwise direction then hinge goes inwards to form a flat plate. For movement of top side plate, rotate the screw handle in clockwise direction, then hinges goes outward to form a flat plate. Now obtain the stretcher. To attain wheel chair we must rotate the lead screw handle in to reverse direction. At the middle part port with lid is provided to eliminate the human waste. Hydraulic jack is provided at the centre to vary the height of stretcher or wheel chair. The purpose of free wheel is to balancing the weight acting on the right and left side plates. Brake lever is provided to stop the wheel chair movement.

VI. CALCULATION FOR LEAD SCREW

Parameters taken from standard lead screw (Approximate only):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch of the lead screw $P$</td>
<td>12.3 mm</td>
</tr>
<tr>
<td>Speed of Lead Screw $N$</td>
<td>30 rpm</td>
</tr>
<tr>
<td>Outer diameter</td>
<td>19 mm</td>
</tr>
<tr>
<td>Inner diameter</td>
<td>15 mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>4.7 mm</td>
</tr>
</tbody>
</table>

The linear velocity of the lead screw $V = N \times P$

$= 30 \times 12.3$

$= 369$ mm/min

$= 6.15$ mm/s

The angular velocity of the lead screw $= 2\pi N/60$

$= 2\pi (30)/60$
Power of the lead screw  $P = 3.6$ W
Torque of the lead screw  $T = P \times 60/2\pi N$
$= 3.6 \times 60/2\pi N$
$= 0.57$ Nm

Maximum withstanding capacity  $= \text{torque/radius of lead screw}$
$= 0.57 / 9.5 \times 10^{-3}$
$= 60$ N

**A. Lead screw Formulas:**

The torque required driving load $W$ using lead screw with pitch ($p$) and efficiency ($\eta$) has the following components:

$$T_{\text{Total}} = T_{\text{Friction}} + T_{\text{Acceleration}}$$

Calculation for Frictional Torque Friction torque can also be an assist in engineering. Bolts and nuts, or screws are often designed to be fastened with a given amount of torque, where the friction is adequate during use or operation for the bolt, nut or screw to remain safely fastened.

Frictional force , $F = \mu_s W$

Where  Coefficient of static friction, $\mu_s = 0.15$

Let us assume the torque required to accelerate the sliding parts as 200 pounds

1 pounds  $= 0.453$ kg
200 pounds  $= (0.453 \times 200)$
$= 90.6$ kg

1kg  $= 9.81$ N
90.6 kg  $= (9.81 \times 90.6)$
$= 888.76$ N

$W$ is the weight of the load.

Frictional force , $F = 0.15 \times 888.76$
$= 133.314$ N

Frictional Torque , $T_{\text{friction}} = (F \times p) / (2 \times \pi \times \eta)$

Where:

$F =$ frictional force in newton

$p =$ pitch in rev/ mm $= 1/12$

$\eta =$ lead screw efficiency, 65%

$= (133.34 \times 12.3) / (2 \times 3.14 \times 0.65)$
$= 32.96$ N-mm

**VII. Conclusions**

The project was aimed at designing and manufacturing a wheelchair cum stretcher that can overcome the shortcomings of a conventional wheelchair, with focus on cost effectiveness and utility.

The existing system has the limitation of shifting patients from wheel chair to stretcher. This product will be helpful for paralyzed patients, movement impaired personals, as well as for old age persons. Our product will eliminate the use of separate wheelchair and stretcher in the hospitals, so that we can eliminate the step of shifting patients from bed or stretcher to wheel chair and vice versa. The wheelchair will consume less space and is manufactured at low cost. Such equipment can induce self-reliability and satisfaction in the users.

We achieved our goals by the use of engineering tools such as CADD/Analysis software’s and knowledge of subjects such as Design of Machine Elements, Strength of Materials and Engineering Mechanics.

We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between the institution and the industries. We are proud that we have completed the work with the limited time successfully.

**Acknowledgement**

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REFERENCES


