Fabrication of Collapsible Chair Cum Bed Model- An Engineering Approach

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Abstract— The need for wheelchair is especially present in case of immovable people (people with persistent vegetative state, paraplegia, stroke and spinal cord injuries), where the care requires a lot of time and labour. This model can be used in hospitals and in emergency cases and for the patients suffering from Paralysis, Back problems and in emergency cases. The processes used in this project are welding, cutting, grinding, centring, drilling, punching etc. Mostly the material used is mild steel and hollow pipes of stainless steel. The teamwork, planning, execution, guidance and support leads to the efficient completion of this project. At last it can be concluded that this basic model can be used in emergency cases too. It can be a boon for patients, working staff and hospitality management. The cost of our model was very low (approximately 50%) as compared to the same product available in the market. Our work will be very useful for students of Engineering.

Index Terms— Strecher, Wheelchair, Rack and Pinion, Screw Mechanism, Design, Analysis, Mild Steel

1 INTRODUCTION

STRETCHER, sometimes called litter or pram ia an apparatus used for moving patients who require medical care. A wheeled stretcher (known as a gurney, trolley, bed or cart) is often equipped with variable height frames, wheels, tracks, or skids. In American English, a wheeled stretcher is stated as a gurney.

Stretchers are primarily used in acute out-of-hospital care situations by emergency medical services (EMS), military and search and rescue personnel. In medical forensics, the right arm of a corpse is left hanging off the stretcher to let paramedics know it is not a wounded patient. They are also used to hold prisoners during lethal injections in the United States.

EMS stretchers used in ambulances have wheels that makes transportation over pavement easier, and have a lock inside the ambulance and straps to secure the patient during transport. An integral lug on the stretcher locks into a sprung latch within the ambulance in order to prevent movement during transport. Modern stretchers may also have battery-powered hydraulics to raise and collapse the legs automatically.

This eases the workload on EMS personnel, who are statistically at high risk of back injury from repetitive raising and lowering of patients. Stretchers are usually covered with a sheet, and are cleaned after each use to prevent the spread of infection. Many more facilities, like shelves, hooks and poles for medical equipment and intravenous medication are also frequently included.

Standard stretchers have several adjustments. The bed can be raised or lowered to help patient transfer. The head of the stretcher can be raised so that the patient is in a sitting position (especially important for those in respiratory distress) or lowered flat in order to perform CPR, or for patients with suspected spinal injury who must be transported on a spinal board. The feet can be raised which is called the trendelenburg position, indicated for patients in shock.

Now with the more demands, manufacturers have begun to offer hybrid devices that combine the functionality of a stretcher, a recliner chair, and a treatment or procedural table into one device.

1.1 Wheelchair

A wheelchair or simply a chair with wheels, used when walking is difficult due to illness, injury, or disability. Wheelchairs come in a wide variety of formats to meet the specific needs of their users. They may include specialized seating adaptions, individualized controls, and may be specific to particular activities, as seen with sports wheelchairs and beach wheelchairs. The most widely recognised distinction is between powered wheelchairs (power chairs), where propulsion is provided by batteries and electric motors, and manually propelled wheelchairs, where the propulsive force is provided either by the wheelchair user/occupant pushing the wheelchair by hand (self-propelled), or by an attendant pushing from the rear (attendant propelled).

1.2 Stretcher cum wheelchair

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Wheelchair with adjustable portion of backrest and leg rest which also convert to bed to wheelchair and vice versa. Wheelchair sections (leg positions adjusting).Disabilities have affected thousands of families in the world. As of today, 700 million people are suffering from disability. Their disabilities can be empowered and enable them to live a normal and independent life with the help of wheelchair. Engineers are continuously applying their ideas to make these products more and more sophisticated by using electrically driven so as to facilitate the doctors, patients and staffs more.

Wheelchair is one of the easiest modes which serves the purpose of transportation for patient and is considered as basic necessities in hospital. Studies showed that 40% of the helpers who helped physically challenged person for the translation from bed to chair and vice versa are suffering from the back and joint pains. To tackle this problem many people have designed wheelchairs with various applications which could be converted into a bed or visa-versa using mechanical linkages or with the help of an electrical motor. A slipping mechanism or pulling mechanism is used for lowering the back portion. Then the implementation of hydraulics and pneumatics improved the efficiency as well as eliminated the need of external help but it had a drawback as it created noise and it was bulky.

In simple words a wheelchair can be described as a structure having a set of wheels attached to a chair. Wheelchair is a device which can empower and enable a person with a disability to live a normal and independent life. Over the years wheelchairs have evolved rapidly from the manual wheelchairs to the powered wheelchairs. But still these wheelchairs have not been able to satisfy the needs of the disabled people. It is therefore critical that the problems of disabled be understood and accordingly wheelchairs are developed fulfilling their needs. So we have designed a multipurpose wheelchair that can work as wheelchair as well as a Stretcher. Its construction is so easy and can be operated and maintained easily. We have used simple mechanical linkages along with seat back recliner mechanism to achieve the required motion. This paper is the result of a design and development of a multi-functional Wheelchair that would perform all the required functions.

2 MATERIALS AND METHODOLOGY

The various factors, which determine the choice of material, are discussed below.

2.1 Properties

The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service, life, reliability etc.

The various physical properties concerned are melting point, thermal conductivity, specific heat, coefficient of thermal expansion, specific gravity, electrical conductivity, magnetic purpose etc. The various Mechanical properties concerned are strength in tensile. Compressive shear, Bending, torsion and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit, and modulus of elasticity, hardness, wear resistance and sliding properties.

Sometimes the demand for the lowest possible manufacturing cost or surface qualities obtainable by the application of suitable coating substances may demand the use of special materials.

2.2 Availability of Material

Some material may be scare or in less supply, it then becomes compulsory for the designer to use some other material which though may not be a perfect substitute for the material designed. The delivery of materials and the delivery date of product should be kept in mind.

2.3 Space consideration

Sometimes high strength materials have to be selected because the forces involved are high and space limitations are there.

For an efficient working of our model, we are using two mechanisms e.g., lead screw mechanism and linkage mechanism.

2.4 Leadscrew mechanism

A leadscrew also known as a power screw or translation screw, which is used as a linkage in a machine, to translate turning motion into linear motion as shown in Fig. 1. 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 tools), vices, presses, and jacks.

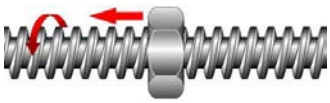

Fig.1 Nut and Screw Mechanism

2.5 Linkage mechanism

This mechanism has been developed to provide movement to the lowermost part of the model. The power is provided from leadscrew to the uppermost part which causes movement in upper part by providing linkages to the model, it causes transfer in the power from upper part to lowermost part, allowing both the parts to work co-ordinately. Since it leads to the conversion from bed to wheelchair and vice versa takes place as shown in Fig. 2

Fig.2 Linkage Mechanism

TABLE 1

MATERIAL USED

Parts	Dimension(mm)
Mild steel hollow cylindrical bar diameter	26.55
Mild steel triangular bar cross section	41.92

TABLE 2

MILD STEEL PROPERTIES

Density	7200 kg/m^3
Thermal expansion	10.1 to 16.6 * 10^{-6} mm/^{0}c
Young's modulus	68.9-207 GPa
Melting point	1230 to 1530^{0}c
Ultimate tensile strength	450 to 500 MPa
Poisson's ratio	0.23 to 0.3

3 RESULTS AND DISCUSSION

For our project work, we are taking the average weight of the person as 80 kg. It may vary and thus accordingly the whole calculation also.

TABLE 3

HUMAN BODY WEIGHT DISTRIBUTION

Part of Human body	Weight (%)	Weight of Human body parts (kg)
Trunk	48.3	38.64
Head and Neck	7.1	5.68
Thigh	10.5	8.4
Shank	4.5	3.6
Foot	1.5	1.2
Upper arm	3.3	2.64
Forearm	1.9	1.52
Hand	0.6	0.48

TABLE 4

PARTS DIMENSION (mm)

Parts	Dimension (mm)
Wheel diameter	123.76
Front width	762
Back width	762
Height from ground	812.8
Bolt diameter	9.3
Pitch (lead screw)	8.3
Diameter of Lead screw shaft	16.9
Overall length	1854.2

3.1 Load Calculations

3.1.1 Front Caster

Weight of the wheelchair = 14.24 kg = 139.552 N
Human body weight (W) = 80 kg = 784 N
$F_{vertical}$ = (139.552 + 784) N = 923.552 N
Load of each caster = 923.552 N/ 2 = 461.776 N
Force on each caster = 909.5/2 = 454.760 N

3.1.2 Back Rest

Human back weight = 31.693 kg = 310.91 N
Incline = 25^0
Back rest weight = 6 kg = 58.8 N

3.1.3 Leg Rest

Inclination = 55^0
Weight of one human leg = 4 kg = 39.2 N
Force = 39.2+39.2 =78.4 N
Force (actual) = 78.4* sin55^0 = 64.22 N

3.1.4 Specifications of Lead Screw

We have got the lead screw of the other wheelchair and after measurements, their dimensions are:
Pitch of Lead Screw, P = 8.3mm
Thickness, T = 4mm
Outer Diameter, d_2 = 20.2mm
Inner Diameter, d_1 = 16.9mm
Speed of Lead Screw, N = 50 rpm (no load condition)
N = 30 rpm (load condition)

3.1.5 Calculations

Linear velocity of the lead screw = N*P = 50*8.3 = 415 mm/min
Angular velocity of lead screw = 2πN/60 = 2π50/60 = 5.236 rad/sec
Mean diameter (d_m) = (d_2 +d_1)/2 = (20.2+16.9/2) =18.55 mm

Friction angle (ϕ) = $\tan^{-1}\mu$
$\phi = \tan^{-1} 0.23$ = $\phi = 12.95$
Torque required to raise the load (T) = W* d_m/2*tan (ϕ +α) [7]
= 784*9.275*tan (12.95 + 11.23) = 3264.94 N-mm
= 3.26 N-m
Power of lead screw = T* 2πN/60 = 17 W

4 DESIGN AND ANALYSIS

The basic design of the device has developed from the concept of a convertible wheelchair. Thus the initial sketches for the project

design included only the skeletal structure of a wheelchair. Then the convertible feature was included to the design at a conceptual level and tremendous amount of brainstorming was done. Since the fundamental aim is to provide comfort to the patient. We have operated this manually as shown in Fig. 3 with the help of screw mechanism. Further, electric motor may be added in this to raise and lower the patients smoothly.

Fig. 3 Lead Screw Mechanism

Figures numbers from 4 to 7 are showing the final images of the wheelchair cum bed model after fabrication with successful testing.

Fig. 4 Stretcher Condition

Fig. 5 Stretcher Condition with Testing

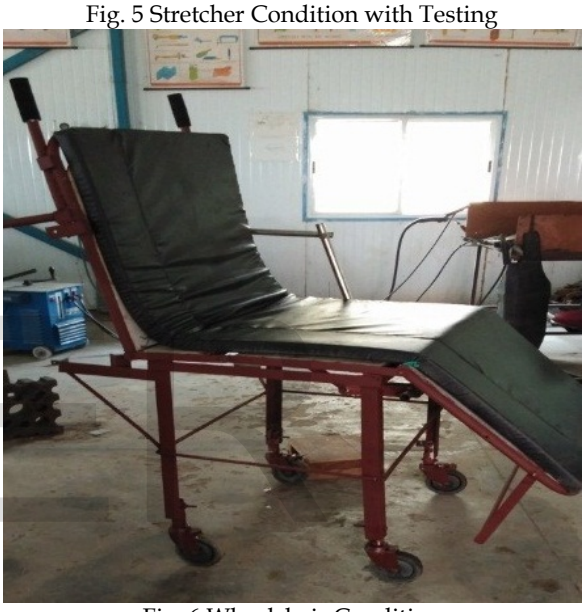

Fig. 6 Wheelchair Condition

Fig. 7 Wheelchair Condition with Testing

4.1 Costing

As in any other problem, in section of material the cost of material plays an important part and should not be ignored. Sometimes factors like scraps utilization, appearance, and non-maintenance

of the designed part are involved in the selection of proper materials.

4.1.1 Cost Estimation

Material cost = 5700
Labour cost = 2000
Drilling, Welding, Power hacksaw, Grinding, Painting cost = 1500

4.1.2 Overhead charges

The overhead charges are arrived by 'Manufacturing cost'
Manufacturing cost = Material cost + Labour cost
Overhead charges = 20% of manufacturing cost

4.1.3 Total cost

Total cost = Material cost + labour cost + overhead charges
Total cost for this project = Rupees 9200/-

4.2 Advantages, Limitations and Applications

4.2.1 Advantages

- ✓ Increase in comfort level of the patient.
- ✓ Prevents further damage to patient and the helper while transferring him/her from chair to bed or vice-versa.
- ✓ Patients with serious injuries need not be moved to aggravate their injuries even more.
- ✓ No special training required to operate them.
- ✓ Is more efficient than other chairs.
- ✓ Less costly than electrical version of the same chair

4.2.2 Limitations

- ✓ Increase in weight of chair.
- ✓ Increase the cost of the chair.

4.2.3 Applications

- ✓ It is used in hospitals.
- ✓ It can also be used in houses.

5 CONCLUSION

In this report it is discussed that the need for the wheelchair beds system in current world and the different mechanisms that can be implemented. It is concluded that now-a-days in hospitals fully atomized beds, wheelchairs and stretchers are used for the patient handling purpose. But they are very costly and are not affordable to all the hospitals. The stresses developed during the handling of the patient in both, i.e. patient and staffs are same for all hospital. A new design of wheelchair cum stretcher for patient handling has been done. Cost of such type of wheelchair cum stretcher will be affordable for all type of hospitals and it will beneficial for patient handling. The product will thus likely be an efficient mobility aid in hospitals.

Future scope/outcomes regarding this project work will be:

- ✓ Another material may be selected for light weight.
- ✓ Motor may be added for lifting the weight instead of applying manual force.
- ✓ Another mechanism may be adopted.
- ✓ Sensor may be added in order to adjust the positions.

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