Design and Fabrication of Multiutility Wheelchair

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Abstract

In this project we propose a design of wheelchair whose backrest and a footrest can be controlled through a switch by the patient which will convert the wheel chair into a stretcher. This helps the patient to rest without getting shifted to a bed. This will also eliminates the efforts of assistant required for handling of handicap patients by providing an arrangement of desk with wheelchair. We went through a number of designs before arriving on the final design. Our requirement of motion could be achieved either with the help of belt and pulley arrangement or through gear transmission. Belt and pulley arrangement was avoided because of the high speed reduction and the factors like slip and weight involved. The purpose of locking also could not be addressed easily in this arrangement. The idea of spur gear transmission was also eliminated because the requirement of high torque, self-locking could not be satisfied. Also, this arrangement demanded two separate motors. Considering the above mentioned shortcomings, Worm and Worm wheel arrangement was selected. The advantage of this drive was it provided self-locking, since the motion is transmitted only from the worm to the worm wheel and not the other way round. The arrangement was compact too. Chain and sprocket arrangement has been used for transmitting the motion provided by the motor through Worm and Worm wheel arrangement. Another advantage is, it provides high speed reduction.

Keywords: Chain, sprocket, Stretcher, wheel chair, Worm and worm wheel

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I. INTRODUCTION

There are lots of handicaps and old aged people in the world. Many of them are not able to move as easily as normal people. It is useful if we develop an automatic wheelchair to help them move more easily. In this project we propose a design of small-area automatic wheelchair to help handicaps or elders are able to move easily in a small area. The most concern in this project is low cost with acceptable performance rather than high velocity or high accuracy. The design integrates several technologies to apply on the wheelchair. Our design of small-area automatic wheelchair can cost very little. The project has three sections - mechanical, electric and electronic. The mechanical section has the frame and adjustable backrest, shaft, wheels, flanges, chain and sprocket arrangement. The electric section has a permanent magnet DC motor of high torque. The electronic section has a remote control to guide the movement of the wheel chair.

II. OBJECTIVES

- To help the patient to rest without getting shifted to a bed
- To help patient to transfer from stretcher to wheel chair
- To merge the concept of wheel chair and stretcher with desk.
- To facilitate disabled patient's mobility.
- To eliminate the efforts of assistant required for handling of handicap patients.

III. RESEARCH METHODOLOGY

We went through a number of designs before arriving on the final design. Our requirement of motion could be achieved either with the help of belt and pulley arrangement or through gear transmission. Belt and pulley arrangement was avoided because of the high speed reduction and the factors like slip and weight involved. The purpose of locking also could not be addressed easily

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IV. DESIGN PARAMETERS AND CALCULATIONS

Considering actual human weight.
Moment produced due to load = (60x 9.81) x 0.4=235.44N-m.
Similarly, torque required to lift this load = 250 N-m
Power required to lift this load = 1570 W

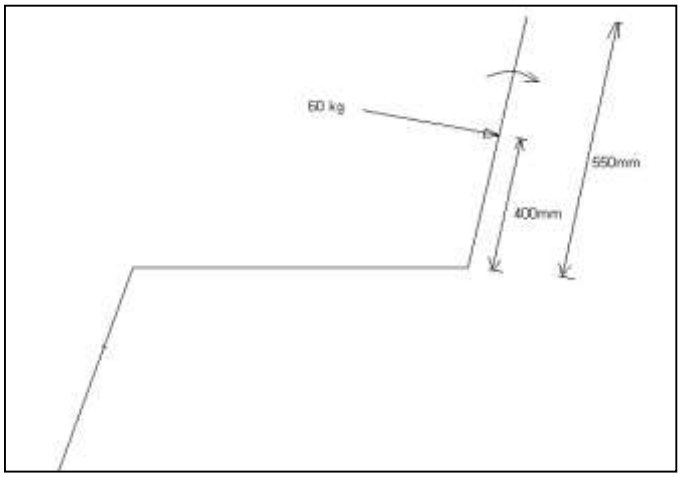

Fig. 1:

Following elements are design:

After review from literatures the power required for the movement of assembly of wheelchair for a maximum load of 5kg is 60W.Therefore assuming standard dc worm motor of 65W.

A. *Design Procedure for worm and worm wheel.*

After review from literatures the power required for the movement of assembly of wheelchair
Power =65W
i.e PR = 65W
Nw = 900 rpm
Ng =60 rpm
V.R = Nw /Ng = 900/60
V.R = 15

1) Design Power (T-XIV – 15)

Pd =PR x Kl
Kl = Load factor - XI-5
Kl = 1.75
Pd = 65 x 1.75
Pd = 113.75 W
No. of teeth on worm – from V.R = 15.
Tw =3
V.R = tg/tw
15 = tg/3
Tg = 45

2) Tooth Load :

Ft = pd/Vp
For pitch line velocity (Vp):

$$Vp = \frac{\pi DgNg}{60x1000}$$

Let "m" be the module:
∴ m = Pc/π & m = D/T

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Dg = tg x Pc/π = 45 x Pc/π
Dg = 14.32 x Pc

$$Vp = \frac{\pi \text{ x Pc x } 60}{60 \times \prod}$$

Vp = Pc

$$ft = \frac{113.75}{Pc}$$

3) Beam Strength by Lewis equation:
Fb = So. Cv . b. Y . m
So Basic strength - T XVI – 10
(So)g = Ph Bronze SAE 65
(So)g = 84 Mpa
Cv = 6/6+Vp = 6/ 6+ 0.0239 x Pc
b = face width of gear - T XVI – 19
b = 2.38 Pc + 6.25 Selecting single & double threads
y = 0.314 + 0.0151 (φn – 14.5º)
Lead Angle ( ) - T XVI – 16
= 6º per worm tooth
= 6º x 3 (i.e tw =3)
= 18º
Φn = Pressure Angle
Φn = 14.5 - for upto 18º
Y = 0.314 + 0.0151(14.5º - 14.5º)
Y = 0.314mm

$$FB = 84 \text{ x6} \times \frac{(2.38\ Pc^2 + 6.25Pc)}{6 + 0.0239\ Pc}$$

Using linear condition
FB ≥ Ft

$$\frac{119.89\ Pc^2 + 314.83\ Pc}{6 + 0.0239\ Pc} = \frac{113.75}{Pc}$$

∴ Pc = 1.22mm
Take multiple of five
∴ Pc = 5mm
∴ m= 5 / π
m = 1.59mm
Actual parameters
Dw =6.38mm≈8mm
Dg = 71.55mm≈72mm

B. Design of shaft

$$T = \frac{\pi}{16}\ x\ fs\ x\ d^3$$

Considering material carbon steel SAE 1030
Sys = 186 MPA
Taking FOS = 4
Fs = 186/4
= 46.5 N/mm^2

$$5886 = \frac{\pi}{16} x\ 46.5\ x\ d^3$$

d= 8.63 as per standard say 8 mm
Therefore, Dia of shaft will be 8 mm.

C. Selection Of Chain No. And Pitch (Single Strand)

From Fig. 14.1 Of D.D.B
Chain No.=25 And Pitch=5.67
Diameter of sprocket = 60mm
Number of teeth on sprocket = 28

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V. WORKING PRINCIPLE

Working of the wheel-chair is controlled by a two way switch provided at the hand rest of the chair. When the button is switched to the bed position the RC circuit is activated and motor rotates in clockwise direction transmitting power through worm and worm wheel with high velocity reduction, which further operates chain drive and then shafts making the backrest move backwards and the leg rest upwards. As soon as it reaches the bed position the cam pushes the micro switch thus breaking the circuit and the motor stops. Similarly for the chair position the motor rotates in anticlockwise direction making the backrest move upwards and the leg rest downwards. When it reaches the chair position the micro switch is pushed by the cam again and the motor stops.

VI. STRUCTURAL DESIGN

The structural design is basically a modification of a conventional wheel chair. It consists of three main parts:-

- Back rest
- Main rest
- Leg rest

Out of these backrest and leg rest are movable, whereas the main rest is stationary. The positions of the backrest and leg rest are not exactly perpendicular to the main rest but at an angle of 100 degree and 80 degrees respectively. These panels have been made out of Steel sheets supported by angle plates or steel plates. The panels have been connected to each other with the help of rods inserted through them and their motion is supported by bearings. The main rest consists of hand rest on either side. Sprockets are mounted on the ends of the above mentioned rods.

The motor is mounted centrally below the main rest. The speed reduction is obtained through the worm gear drive of which the worm is mounted on the shaft of the motor and the wheel is mounted on a shaft perpendicular to the shaft of the motor. On the shaft of the worm wheel two sprockets are mounted, one of which provides motion to the back rest and the other to the leg rest. Roller chain moves over the sprockets. All the sprockets are of the same size since there is no speed reduction caused by the chain drive.

The legs of the chair are kept inclined so as to overcome the toppling effect thus giving the lower end of the chair a trapezoidal shape.

Wheels are mounted at the base of the legs which gives it the required mobility.

VII. CREO MODEL

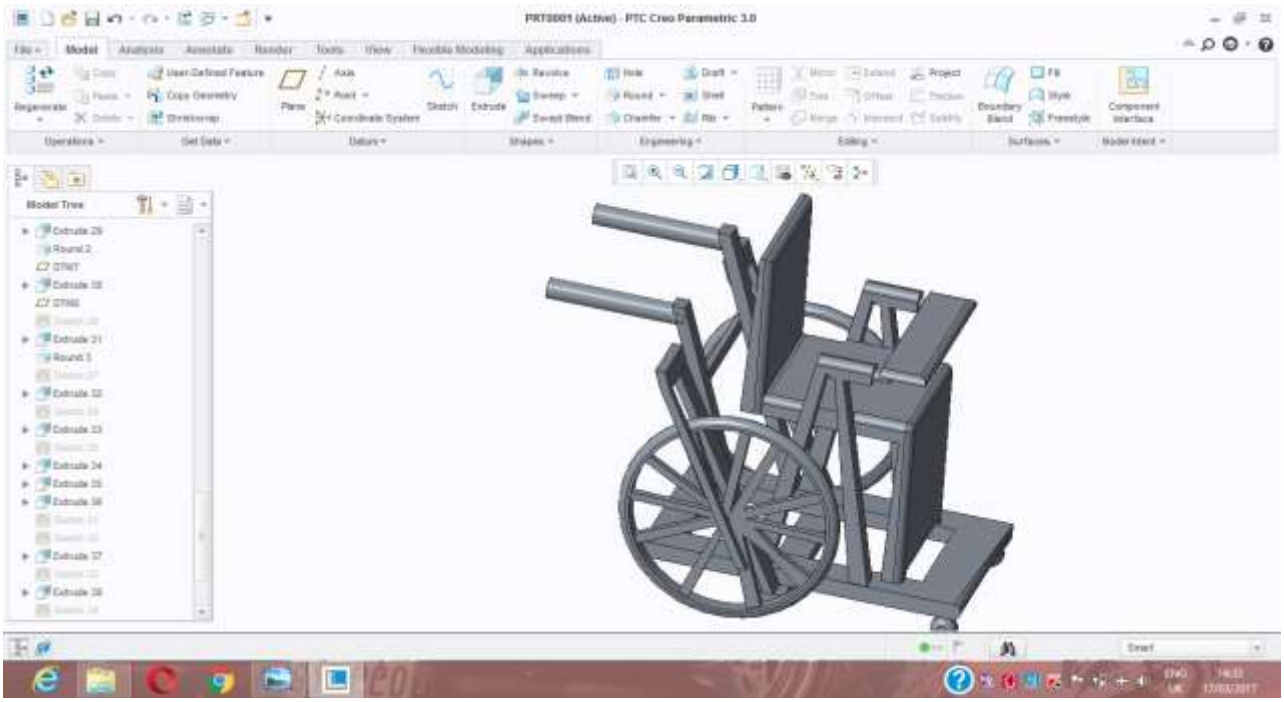

Fig. 2:

VIII. FABRICATION

The fabricated model has the following main components

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A. Diamension:

Parameters	*Dimension*
Weight of wheelchair	*40kg*
Height of wheelchair	*966mm*
Length of wheelchair	*1143mm*
Width of wheelchair	*864mm*
Back rest	*400mm x 410mm x 10mm*
Main rest	*370mm x 410mm x 10mm*
Leg rest	*400mm x 410mm x 10mm*

B. Components:

Motor	*Dc*	*12v*
Wheel and tyre	*Steel rim, Rubber tier*	*16"*
Motor Shaft	*MS*	*8mm*
Worm	*Phosphor bronze*	*10mm(3 teeth)*
Castor wheels	*rubber*	*50mm*
Aluminum shaft	*Al*	*D= 1'',L=100mm*
Square pipe	*MS*	*30m*
Table	*Plywood*	*900×180mm*
Battery	*lithium*	*8V (2)*
Chain	*MS*	*100mm*
Sprocket	*MS*	*6cm(t-28)*

IX. FRAMEWORK

The entire fabrication of the device has been done around a basic framework. The framework has been made by welding together mild steel pipes of square and rectangular cross sections. The relative low cost, availability and properties like decent tensile, compressive strengths and weld ability favoured the choice of mild steel over other metals. The frame has three main sections, namely the head, seat and foot sections. The frame work along with the support surfaces bears the patients weight. The seat section forms the basis as far as the assembling is concerned. The head section and foot section are hinged to the seat section. Arm rests are attached on either sides of seat section. The leg of the fabricated prototype is integral to the frame section. Wheels of 150mm diameter have been used here. The wheels provide the mobility to the device both in the stretcher and chair position. Front wheel has the ability to facilitate steering.

A. MECHANISM

The chair uses a worm and worm wheel mechanism coupled with chain and sprocket for transmission of power. The worm is rotated with the help of a 12v dc motor. When the worm is rotated by motor the worm wheel rotates. On the shaft of worm wheel two sprockets are fixed. From these two sprockets two chain drives are attached. One chain drive is to drive the back rest of chair and the second chain drive is used to drive the leg rest.

Fig. 2:

Fig. 3:

X. STRETCHER- CHAIR CONVERSION

The framework represents the wheelchair-stretcher convertible unit which acts as the chassis on which all other components are assembled. In the stretcher forming position of the unit, the three sections viz. back rest, seat and foot rest sections are disposed horizontally to form a continuous mattress support surface. The sections can be secured in position by locking mechanisms on the worm and worm wheel .In the wheelchair forming position of unit, the sections viz. the back rest and foot rest are positioned vertical with slight inclination. The seat is secured in horizontal position only.

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Fig. 5: Image of device in wheelchair position

Fig. 6: Image of device in stretcher position

XI. TESTING

Sr. No.	*Mass (in Kg)*	*Weight (in N)*	*Torque Required (in N-m)*	*Power(in W)*
1	*0.25*	*2.45*	*0.5*	*3.14*
2	*0.5*	*4.9*	*0.98*	*6.15*
3	*0.75*	*7.35*	*1.47*	*9.23*
4	*1*	*9.81*	*1.962*	*12.32*
5	*1.25*	*12.26*	*2.45*	*15.39*
6	*1.5*	*14.79*	*2.95*	*18.53*
7	*1.75*	*17.16*	*3.43*	*21.55*
8	*2*	*19.62*	*3.9*	*24.5*
9	*2.25*	*22.07*	*4.4*	*27.64*
10	*2.5*	*24.52*	*4.9*	*30.78*
11	*2.75*	*26.9*	*5.38*	*33.8*
12	*3*	*29.4*	*5.88*	*36.94*
13	*3.25*	*31.88*	*6.37*	*40.02*
14	*3.5*	*34.33*	*6.86*	*43.10*
15	*3.75*	*36.78*	*7.35*	*46.18*
16	*4*	*39.24*	*7.84*	*49.26*
17	*4.25*	*41.69*	*8.33*	*52.33*
18	*4.5*	*44.14*	*8.82*	*55.46*
19	*4.75*	*46.59*	*9.31*	*58.54*
20	*5*	*49.05*	*9.81*	*61.63*

XII. ADVANTAGES

1) Decreases the dependency of patient.
2) Simple in design and construction.
3) Can be use both as wheelchair and stretcher.
4) Can be stopped at any comfortable position.
5) Chain drive system has maximum efficiency

XIII. CONCLUSION

The advanced wheelchair cum stretcher is designed, fabricated and tested. The developed system is a low cost option when compared to other wheel chairs in the market for lower extremity paralysis patients to lie down and rest at will. Therefore the physically disable person can move and rest on the wheel chair itself without any external help and cost is very much less than the electrical wheel chairs available in market .

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