Design of Easy Walker (E-Walker)

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Abstract
We have use an automated walker which using electric wheels as the base and the handicapped peoples are still able to gain their balance as the walker gives them grip to hold on to. The directions are control by the driver through easy access keys and speed is kept at minimum always. Rubber wheels are used for the grip and the direction changes are pointed out in the front panel. The use of automated walker reduces the effort required by handicapped people as they can reduces the effect required by handicapped people as they can relax their arm muscles and not get fatigue by the machine.

Keywords—*Electric wheels, access key, automated walker*

I. INTRODUCTION

We, in our present day situation, see the difficulties faced by old people in moving around from place to place even in their own homes. The present day solution for this problem is the result of the use of walkers. But even those people who are able to use walkers, on continuous use get tired as they have to balance the whole weight on their arms which causes great stress. The fact that any chance of them not balancing they're weight on the walker would results in them tripping over.

We as part of our project have come up with a creative and user friendly machine, which allows old people to move around with ease and without stress. The product involves a platform for the old people to stand on and they will be able to move around with the help of electric controls powered by an electric motor. The design is such that it can used both inside the house and also while travelling outside. The centre of gravity of the product has been maintained at such a level so that the product remains balanced at all conditions. Safety precautions have been taken care of to make sure no accidents take place. The product has been made at a low cost price so as to benefit the consumers too.

The product can also be used in future by people in industries and workshops to move around from one place to another for inspection, supervising etc. This would result in making the day to day life of everyone involved in such activities of moving from one place to another easier and thereby make them less tired.

II. LITRATURE REVIEW

One of the first patents of electrical bikes was registered almost 120 years ago by Ogden Bolton Jr. (Bolton, 1895). The concept Bolton Jr. patented is similar to the E-bikes of today. An E-bike is narrowed down to its basics a regular bicycle equipped with an electrical motor, a battery and some electronics and switches that controls power levels. Since it is powered by two energy sources, pedalling and electricity, it can be classified 4. Background 14 as a hybrid vehicle. For an E-bike to be legal in Sweden it has to fulfil a set of requirements according to the law (Law (2001:559))

Electrical motor may only be active while pedalling (unless speed is below 6 km/h).

- Maximum rated power of motor is: 250 W.
- No motor power may be provided at speeds above 25 km/h.

The EU directive 2002/24/EC also states that the power must be progressively reduce as the bike approaches 25 km/h, this is however not needed for E-bikes in Sweden. The fact that pedalling is not needed for speeds below 6 km/h can be especially practical when walking the bicycle uphill or cruising in walking speed. The requirements on E-bikes differs from country to country, but one that stands out is the U.S. who allows 750 W motor power and speeds up to 32 km/h without the need for pedalling (Morchin & Oman, 2006, p. 21). The motor is in this case placed in the hub of the front wheel (rated at 250 W) and the battery and its electronics is enclosed in the black box right of the rear wheel. Typically, there is also a small control panel on the handles. Reproduced with permission of Eco Ride (2014). The motor is usually placed in the front or rear wheel (called hub motor) but sometimes on the crank shaft (Atkinson, 2012) or mounted directly on the wheel (Rubbee, 2014). The location of the battery may vary depending on bike design but typically, the producers try to place it as low as possible for an optimum centre of gravity. There is usually also a control panel at the handle that is used to turn on and off the E-bike function, set different power level options and monitor the battery level.

- First wheel motor concept: Wellington Adams of St. Louis first conceived of building an electric motor directly in the vehicle wheel, though it was attached via complicated gearing. The Adams patent is US 300,827 in 1884.
- Practical wheel motor: Albert Parcelle of Boston, MA developed the first fully incorporated wheel hub motor in his "Electro-Motor Traction Wheel" and patented it in patent US 433,180 in 1890.
- High torque low RPM wheel motor invented: The motor was incorporated into the wheel without gearing and addressed torque considerations through the use of a new high torque, low rpm motor invented by Edward Parkhurst of Woburn, MA in patent 422,149 in 1890 (and miss mentioned in Parcelle's patent as 320,699).
- Electric wheel motor advantages revealed in patent: An early wheel hub electric motor was invented by Frenchman Charles Theryc and patented in 1896 as US patent 572,036 entitled Wheel with Electric Motor hub for Vehicles. In the patent he explained all advantages including no transmission losses because of the absence of classic transmission rods from engines to wheels.
- Diesel wheel motor: Not all wheel hub motors were electric. C F Goddard in 1896 invented a piston hub motor for horseless carriages patented in US 574,200. He envisioned it powered by expanding gas of some kind. His off centre flexible bent spoke designs later appeared in the Apollo moon rovers' wheels in 1960s.
- Using cams, another type of combustion wheel motor: In patent # 593,248 W C Smith in 1897 developed another explosive gas expansion motor inside a wheel hub that utilized cams on a track in the hub to transmit power to the wheel.

The electric wheel hub motor was raced by Ferdinand Porsche in 1897 in Vienna, Austria. Porsche's first engineering training was electrical, not internal combustion based. As a result he developed his first cars as electric cars with electric wheel hub motors that ran on batteries. The Lohner Porsche, fitted with one wheel motor in each of the front wheels, appeared at the World Exhibition in Paris in 1900 and created a sensation in the young automobile world. In the following years, 300 Lohner Porsches were made and sold to wealthy buyers.
Eventually the growth in power of the gasoline engine overtook the power of the electric wheel hub motors and this made up for any losses through a transmission. As a result autos moved to gas engines with transmissions, but they were never as efficient as electric wheel hub motors.

III. DESCRIPTION OF EQUIPMENT

A. *Rack And Pinion*

A rack is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod. Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii then derived from that. The rack and pinion gear type is employed in a rack railway.

A rack and pinion is a pair of gears which convert rotational motion into linear motion. The circular pinion engages teeth on a flat bar - the rack. Rotational motion applied to the pinion will cause the rack to move to the side, up to the limit of its travel. The pinion is in mesh with a rack. The circular motion of the pinion is transferred into the linear rack movement (Fig 1).

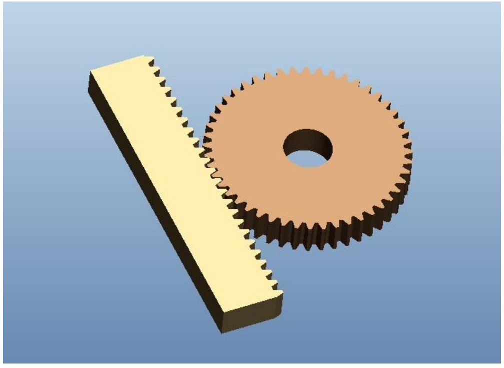


Fig 1. Rack and pinion mechanism

B. *Hub Motor*

The wheel hub motor (also called wheel motor, wheel hub drive, hub motor or in-wheel motor) is an electric motor that is incorporated into a hub of a wheel and drives it directly. (See Fig 2)

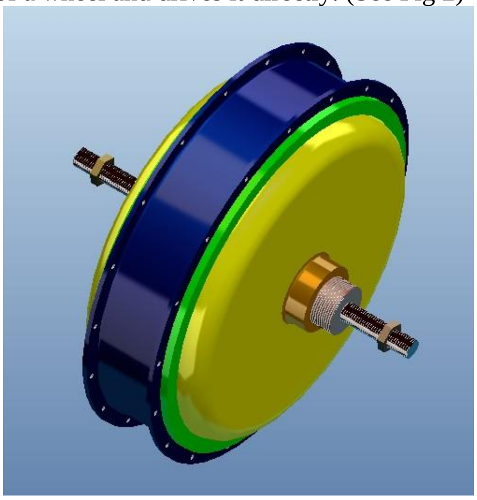


Fig 2. Hub Motor 3D model

C. Ratchet and Pawl Mechanism

A ratchet is a mechanical device that allows continuous linear or rotary motion in only one direction while preventing motion in the opposite direction. Ratchets are widely used in machinery and tools. Though something of a misnomer, "ratchet" is also often used to refer to ratcheting socket, a common tool with a ratcheting handle. (Fig 3)

A ratchet consists of a round gear or linear rack with teeth, and a pivoting, spring-loaded finger called a pawl that engages the teeth. The teeth are uniform but asymmetrical, with each tooth having a moderate slope on one edge and a much steeper slope on the other edge.

When the teeth are moving in the unrestricted (i.e., forward) direction (see Fig 3.5), the pawl easily slides up and over the gently sloped edges of the teeth, with a spring forcing it (often with an audible 'click') into the depression between the teeth as it passes the tip of each tooth. When the teeth move in the opposite (backward) direction, however, the pawl will catch against the steeply sloped edge of the first tooth it encounters, thereby locking it against the tooth and preventing any further motion in that direction.

Fig 3. Ratchet With Round Gear and Pivot

D. Spring

A SPRING is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the Load is removed. The springs used here are open coil helical springs which are used where there is compression load. These springs are made from oil tempered carbon steel wires containing 0.60 to 0.7 5% carbon 0.6 to 1% Manganese. (See Fig 3.6)

The automobile chassis is mounted on the axles not direct but through some form of springs. This is done to isolate the vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. These tendencies give rise to an uncomfortable ride and also cause additional stress in the automobile frame and body. All the parts which perform the function of isolating the automobile from the road shocks are collectively.

Fig 4. Open Coiled Spring

E. Wheel

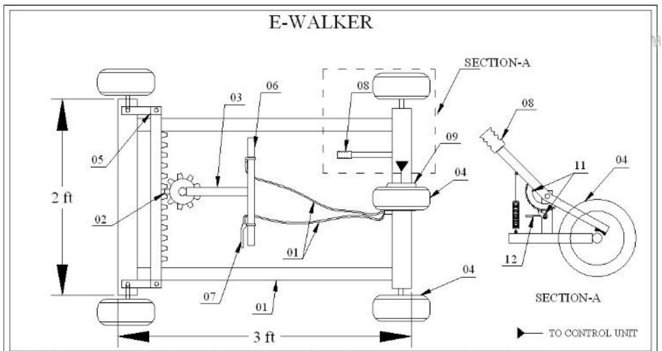
A wheel is a circular component that is intended to rotate on an axle. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel and flywheel.

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.

IV. DESIGN OF EQUIPMENT AND DRAWING

The E-WALKER is consists of the following components to fullfill the requirements of complete operation of the machine. (Refer Fig 5)

1. Ratchet and pawl mechanism
2. Rack and pinion arrangement
3. Wheel
4. Hub motor
5. Spring



S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME
01	BASE FRAME	04	WHEEL	07	BRAKE ARRANGEMENT	10	CABLE
02	RACK & PINION	05	LINK	08	HAND BRAKE	11	PAWL RATCHET MECHANISM
03	STEERING ROD	06	ACCELERATOR	09	HUB MOTOR	12	ROD FOR PAWL RELEASING

Fig 5. E-Walker Drawing

Motor specification
Rpm =200
Volt= 36
Power = 350W

Electrical (electric) power equation:

Power $P = I \times V$
Where

V= 36 V
P=350W
I=350/36
=9.72 A
H.P = 0.4758

To find the torque of the motor

T = 5252 x H.P / rpm
= 5252 x .4758 /200
=2498.9/200
=12.49 lbft

T =16.91 Nm
Torque of the hub motor is = 16.91 Nm
Hub motor weight = 6 kg

DESIGN OF RACK AND PINION
Parameters Known:
For rack:
Length of Rack = 204 mm
No of teeth on the rack = 52
Total Height of the Rack = 25 mm
Thickness of the rack = 10 mm
For Spur Gear:
Diameter of gear = Ø30mm
No of teeth =24
Thickness of the gear =10mm

Spur Gear Tooth Proportions
Module:
This is the standard term used in S.I.units. It can be defined as the length on the pitch circle diameter per tooth. It is the reverse of the diameter pitch.

m = D/T
m = 30/24
m = 1.25 mm

Addendum (a)
The radial distance between the pitch circle and the tip circle is known as Addendum.

a = 1 m
a = 1 x 1.25
a = 1.25 mm

Dedendum:
The radial distance between the pitch circle and the root circle is known as Dedendum (d).

d=1.25m
d = 1.25 x 1.25
d = 1.5625mm

Circular pitch (p_c):
The distance between the corresponding sides of two adjacent of a gear measured on the pitch circle is known as circular pitch.

Pc =3.14*D/T
Pc = 3.14* (30)/ 24
Pc = 3.926mm

Diametric pitch (P_d):
It is the ratio of the number of teeth per unit pitch diameter. This is a mostly used in F.P.S. system.

P_d=T/D
P_d = 24/30
P_d = 0.8mm

ClearanceC = 0.25m = 0.25 x 1.25 = 0.3125mm.
Total depth= a + d = 1.25 mm + 1.5625 mm = 2.8125 mm
Working depth= (a + d) – Clearance
= (1.25+1.5625) – (0.25 x 1.25) = 2.5 mm.
Tooth thickness = 1.5708 m = 1.5708 x 1.25 = 1.9635mm.
Tooth space = 1.5708 x 1.3 = 1.9635 mm.
Diameter of Addendum Circle for pinion
= D_p + 2a = 30 + (2 x 1.25)
= 32.5 mm
Diameter of Dedendum circle for pinion
= D_p - 2d = 30 - (2 x 1.575)
= 26.85 mm

RACK TOOTH PROPORTIONS
Module m = (Distance of 10 pitches / 10) / 3.14
= (36/10) / 3.14 = **1.15**
Constant Pressure Angle = 20^0
Addendum H_A = m (1 + x) = 1.15 (1 + 0) **= 1.15mm**
Dedendum H_D = m (1.25 - x) = 1.15 (1.25 + 0) = **1.4375mm**
Whole Depth h = 2.25 x m = 2.25 x 1.15 = **2.5875mm**
Height of Pitch Line H = Total Height – addendum = 25 – 1.15 **= 23.85mm**

Force acting on the rack
Calculation for tangential force acting on the Rack:

Let us assume speed = 2 m/s
Acceleration time t = 1s
Mass m = 100kg
a = $\frac{v}{t}$

Angular Speed a= 2 /1 = **2 m/s^2**

Tangential Force for driving axle F_U
$F_U = \frac{m\,g\,\mu + m\,a}{1000}$
F_u = [(100 x 9.81 x0.1) + (100 x 2)] / 1000 = **0.298 KN**
Assume Feed force for this specification of Rack (i.e.) module, Linear Pitch, thickness etc…, **$F_{U\,tan}$ = 11.5 KN**
$F_{Upermissible} = \frac{F_{Utan}}{K_a S_B f_n L_{KH\beta}}$

$F_{Upermissible}$= 11.5 KN / (1.5 X 1.02 X 1.5 X 1.5) = **0.98 KN**
For this Condition of Tangential Force **Fu< Fu perm.Must be fulfilled.**
Here in this Design Fu (0.298 KN) **< Fu perm**. (0.98 KN) it's fulfilled.

CALCULATION FOR SPRING:
PARAMETERS KNOWN:
Spring Outer diameter Do =14.52 mm
Wire diameter (d) = 2 mm
Number of coils in the spring=20
Free length of the spring = 50mm
Axial Load = 5kg = 5 x 9.81 = 49.05 N
TO FIND:
Mean diameter of the spring:
$D = D_O - d$ = 14.52 – 2 = 12.52 mm
Spring index:
C = D / d = 12.52 / 2 = 6.26
Solid length of the spring:
$L_S = n \times d$ = 20 x 2 = 40 mm
Shear stress factor:
K = 1 + (1 / 2C) = 1 + (1 / 2 x 6.26) = 1.08
Maximum Shear Stress occurs on the spring:

$$\tau = k\frac{8\,W\,D}{\pi\,d^3}$$

τ= (1.08 x 8 x 49.05 x 12.52) / (3.14 x (2)^3
= 211.21 N/mm^2
Let us assume,
Modulus of Rigidity = 82 x 10^3 N/mm^2

Deflection of the spring

$$\delta = \frac{8\,W\,D^3\,n}{G\,d^4}$$

δ= [8 x 49.05 x (12.52)^3 x 20] / [(82 x 10^3)(2)^4]
= 11.7 mm (Deflection active per turn)

Pitch of the coil
= Free length / (n-1)
= 50/(20-1) = 2.63mm
Spring Rate (or) Stiffness of the spring
K = W / γ = 49.05 / 2.63 = 18.95 N/mm
Buckling of compression Spring
$W_{CR} = K \times K_B \times L_F$
K = Spring Rate
K_B = Buckling Factor $= L_F / D$ = 50/12.52 = 4
W_{CR} = Critical Load
$W_{CR} = K \times K_B \times L_F$
= 18.95 x 4 x 50 = 3790 N
Volume of the Spring V
V= (π x D x n) x (π/4 x d^2)
= (3.14 x 12.52 x 20) x (3.14/4 x (2 x 2))
= 786 x 3.14 = 2468 mm^3
Energy stored in helical spring of Circular Wire

$$U=\frac{\tau^2\,V}{4\,k^2 G}$$

Energy StoredU = (211.21)^2 x 2468 / (4 x 1.05^2 x82 x 10^3)
= 11 x 10^7 / 361620 = 304.62 N mm

V. WORKING PRINCIPLE

The main components involved in this project consist of rack and pinion arrangement, hub motor, wheel, hand brake and ratchet-pawl mechanism. Here hub motor is used to drive the vehicle and it's controlled by the accelerator/brake like a bike ride. The front side of the e-walker, rack & pinion arrangement is fixed. The pinion is directly connected to the steering shaft. We rotate the pinion in right side the two front wheels are turn right side, and we rotate the pinion in left side the two front wheels are turn left side. We can easily control the direction of the vehicle by using the rack & pinion arrangements. Additionally we provide the hand brake for brake purpose by ratchet-pawl mechanism

VI. MERITS AND DEMERITS

A. *Merits*
- No fuel supply requirement
- Less maintenance
- Good efficient
- Easy to control the vehicle

B. *Demerits*
- Need some electric power
- To drive only some short distance

VII.CONCLUSION

The E-walker will help a lot of people who are not able to walk due to age or other difficulties. It will help them to move from one place to another with ease. Old people don't have to worry about their balance as they don't have to exert any pressure on the E-walker. The centre of gravity is ensured so that the E-walker will be balanced at all the loads, hence the problem of tripping over due to the uneven distribution of the weight is eliminated. The wheels are so decided on the basis that they are able to overcome small obstacles, maintain grip and at the same time retain they're balance throughout. Suspensions are provided to provide efficient movement. The E-walker will prove to be a great help for all those people who are not able to travel due to their physical condition. In future, the E-walker can be used in industries and workshops for supervising and inspection. This will help the workplace be easier to handle for the supervisors as they will not get tired. The same can be used in malls for security purposes. The E-walker proves to be advantageous in all cases due to its low cost.

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ABBREVIATION

m	- Module
a	- Addendum
d	- Dedendum
P_C	-Circular Pitch
P_D	-Diametric Pitch
F_U	-Tangential Force for driving axle
K_A	-Load factor
S_B	-Safety coefficient
f_n	-Life time factor
$L_{KH\beta}$	-Linear Load Distribution Factor
τ	- Shear Stress
K	- Shear Stress Factor
δ	- Deflection of the spring
W_{CR}	-Critical Load
K_B	-Buckling Factor
U	- Energy Stored in Helical Spring