Design and Fabrication of PT (personal transporter) in using wiper motor

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Abstract

A recent transportation innovation is the PT (personal transporter). It is electrically activated and scales down to a compact size so a single user can be highly mobile within a tight maneuvering space. This has high potential to create a complementary commuter traffic system alongside highways and railways that would encourage commuters to use public transport, thereby minimizing traffic congestion. The PT (personal transporter) also has the potential to use sensors and actuators to help the elderly, physically disabled, or other sensory-impaired persons to be mobile and to access transportation systems.

This project involves the fabrication of three wheeled personal transporter. Existing personal transporter which uses several electronic systems such as sensors, control panels and the gyroscope, which makes it more costlier and it is not affordable for the normal people, so in order to reduce the cost involved in such electronic sensors and gyroscope, we have fabricated our project with alternative sources such as geared motor and then providing with third wheel. The three wheeled vehicle developed for the use in hazardous places where human interventions are prohibited and for physically disabled persons, and in robot cell etc., and since it is rechargeable it can be operated in the remote places. This has vast applications by superseding the disadvantage of an existing personal transporter. An attempt is made in the design and fabrication of an electrically powered System for a three-wheeler. This works on electric power distributed by the DC electric gear motor receiving the current from a battery. The motor and the various parts are fabricated with a simple design and with easily available materials to serve and fulfill the purpose of the project.

Keywords: *PT (personal transporter),wiper motor,*

1. Introduction

The present personal transporter is a two wheeled vehicle “Segway" is a homophone of "segue" (a smooth transition, literally Italian and Portuguese for "follows"). Computers and motors in the base of the device keep the Segway PT upright when powered on with balancing enabled. Users lean forward to go forward, lean back to go backward, and turn by using a "Lean Steer" handlebar, leaning it left or right. Motors driving the wheels are commanded as needed to bring the PT back into balance. Its limited capabilities compared to vehicles of similar price have limited the Segway's adoption by the general public. Segway have success in niche markets such as transportation for police departments, military bases, warehouses, corporate campuses or industrial sites.

A Segway is a self-balancing, two wheeled vehicle. The rider stands on a motor flat form between the two side by side wheels and moves forward and backwards by leaning front or the back while holding the handlebars that protrude upward from the front of the platform. To steer, the rider must move the handlebar column from side to side, or on earlier versions, rotate a collar on the handlebars. This is known as gyroscopic technology. Segway can travel up to a maximum speed of approximately 20km/h. In this project, fabrication of Segway personal transporter using gyroscope is more expensive and it not feasible cost in the level of students project. Even though gyroscopic coupled transporter possesses several advantages and gives a comfort and stable journey to the people, due to its high cost it cannot be owned by the normal people.

Here the alternative source for gyroscopic couple in the personal transporter is by providing third wheel and geared motor. This third wheel and geared motor is incorporated in personal transporter instead of gyroscopes with comparatively very low cost. Every object must have minimum three supports for balancing. So if we provide the third wheel the vehicle satisfies the purpose of gyroscopes with very low cost. Though it cannot satisfy the full purpose of the gyroscopes, it does same work similarly as the gyroscopes.

The system is steered and controlled by actuating the geared motor by switches. By alternatively switching the motor left and right directions can be controlled. There is pair of geared motors provided for the motion each wheel has it separate drive from each geared motor. So by giving supply alternately left and right motion can be achieved.So this fabrication can fulfill the basic functioning of the two wheeled personal transporter.

1.1 History of personal transporter

Once a mysterious invention created by Dean Kamen that had everyone speculating as to what it was - is now known as the Segway Human Transporter, the first self-balancing, electric-powered transportation machine. The Segway Human Transporter is a personal transport device that uses five gyroscopes and a built-in computer to remain upright

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1.2 Dynamic stabilization

Dean Kamen's team developed a breakthrough technology the company termed "Dynamic Stabilization," which is the essence of the Segway. Dynamic Stabilization enables Segway self-balancing emulation to work seamlessly with the body's movements. Gyroscopes and tilt sensors in the Segway HT monitor a user's center of gravity about 100 times a second. When a person leans slightly forward, the Segway HT moves forward. When leaning back, the Segway moves back. One battery charge (cost of ten cents) lasts 15 miles and the 65-pound Segway HT can run over your toes without causing you harm.

2. Materials and Methods

2.1. Selection of gear drive and its material

In this project worm and worm wheel gear drive is used in order to reduce the speed of the dc motor main spindle from 2650rpm (revolutions per minute) to 50rpm.

Gear drive in this fabrication posses the following properties.Worm gears are used for transmitting power between two non-parallel, non-intersecting shafts. High gear ratios of 200:1 can be got.Worm and worm gear pair consists of a worm, which is very similar to a screw and a worm gear, which is a helical gear they are used in right-angle skew shafts. In these gears, the engagement occurs without any shock. The sliding action prevalent in the system while resulting in quieter operation produces considerable frictional heat. High reduction ratios 8 to 400 are possible. Efficiency of these gears is low anywhere from 90% to 40 %. Higher speed ratio gears are non-reversible. Their precision rating is fair to good. They need good lubrication for heat dissipation and for improving the efficiency. The drives are very compact.

Table 1.Required Specification of Materials

NAME	DESCRIPTION	QTY
Motor power	17Watts (two motors)	2
Max. Weight Capacity	125 kgs.	-
Battery System	12Volts /40Ah	1
Charger	100V-240V	1
Battery life	Over 300 recharge times	-
Rated Speed	Up to 15kmph	-
Range per charge	15kmph	-
Recharge time	4-8hrs	-
Front Wheel Diameter	400mm air filled tires/aluminum rim	2
Rear Tires Diameter	100mm solid rubber tire	1
Net weight	30kgs	-
L-angle (mild steel)		-
Hollow pipes		-
Lamination Push buttons(bulb type)	Red ,green ,yellow colors	3
Push button element		3
16 gauge mild steel plate		-
1 square mm wire(14m)		-
Rollers(2 no’s)		2

2.2. Selection of gear drive and its material

In this project worm and worm wheel gear drive is used in order to reduce the speed of the dc motor main spindle from 2650rpm (revolutions per minute) to 50rpm.

2.3. Gear materials

The nonmetallic gear has lower hardness, lower fatigue strength and lower bending fatigue strength than metallic gear, but it has good corrosion resistance, good wear resistance, low weight, low friction, or quiet operation. It is typically used in gears with high speed, light-duty transmission and low precision.

Cloth, wood, plastic, nylon, and leather, use for conditions of high speed, and heavy loads.

Figure.1. Gear

3. Design And Fabrication

3.1. Design of Worm and Worm Wheel Gear Drive

Velocity ratio

Velocity ratio V.R $=N_1/N_2$ =14.72≈15

Number of starts

Velocity ratio (V.R) $=T_G$/n n=2.93≈3

Where T_G-no of teeth in worm gear n-no of starts

Module

D_g=m.T_G m=1

Where

$D_g - diameter of the gear$ T_G-no of teeth in worm gear

Selection of material

Worm=steel

Wheel=Nylon

Calculation of design torque

Design torque $[M_t]$=$M_t.k.k_d$

$M_t = \frac{60P}{2\pi N}$ M_t =0.0928N.m

Calculation of centre distance

Centre distance (a) $= \left(\frac{z}{q}+1\right)\sqrt[3]{\left[\frac{540}{\frac{z}{q}[\sigma_c]}\right]^2 [M_t]}$

=22.7785≈23mm

Where

Centre distance –a

σ_c-700kgf/cm²

Calculation of axial module

$m_x = \frac{2a}{q+z+2x}$ m_x =0.836≈1

Check for bending

$\sigma_b = \frac{1.9[M_t]}{m_x{}^3 \times q \times z \times y_v}$ $=7.637\times 10^{-3}$kgf/

cm²

$z_v = \frac{z}{\cos^3\lambda}$ z_v = 49.536≈50

Check for wear strength

$\sigma_c = \frac{540}{\left[\frac{z_2}{q}\right]}\sqrt{\left[\frac{\left[\frac{Z_2}{q}\right]+1}{a}\right]^3 \frac{[M_t]}{10}}$ σ_c =1.317 kgf/ cm²

Efficiency of worm gearing (Ƞ) $= \frac{\tan\lambda(\cos\phi - \mu\tan\lambda)}{\cos\phi.\tan\lambda + \mu}$ Ƞ =0.8354

Pitch diameter d_1=q×m_x d_1=11mm

d_2=z×m_x d_2=44mm

Pitch line velocity $V_1 = \frac{\pi \times d_1 \times N_1}{60}$ =1.526m/s

$V_2 = \frac{\pi \times d_2 \times N_2}{60}$ =4.027m/s

Sliding velocity $V_S = \frac{V_1}{\cos\lambda} = \frac{1.526}{\cos 16}$=1.587m/s V_S=1.587m/s

Face width b=0.75 d_1=0.75×10 =7.5mm

Height factor f_0=1

Bottom clearance C=0.25mm

Tip diameter (d_{a_1}) =d_1+2f_0×m_x d_{a_1} =12mm

Tip diameter (d_{a_2}) = (z_2+2f_0)×m_x d_{a_2}= 46mm

Root diameter = **-(2 × -(2×c)**
=7.5mm

Root diameter d_{f_2}=(z-2f_0)×m_x-(2×c) d_{f_2}=41.5mm

3.2. Load Bearing Design of Main Body Frame

In our load calculation we have designed for maximum load bearing condition. The L angle is of mild steel 30×30mmlength and height and of 4mm thickness.

The following assumptions were made for loading conditions

- Mild steel grade (1090)
- Yield strength=248 Mpa (mega Pascal)
- Tensile strength of 390 N/mm²
- Ultimate strength=841 Mpa (mega Pascal)
- Density =7.58gm/cm²
- Factor of safety=1.5(assumption)
- Weight of the personal transporter=25kg
- Weight of the person=80kg
- Total mass=125kg
- Weight=1177N

Moment of inertia for L-section

$I=\frac{b_1 \times d_1^3}{12}-\frac{b_2 \times d_2^3}{12}$ I≈29419mm^4

Considering the weight of the person as a uniformly distributed load according to the dimensions of the feet

Taking feet length as 250mm to calculate uniformly distributed load

Udl=1177/250 Udl=4.708N/mm

Dimensions of the top most layer from the neutral axis(y)

For rectangle-1 Area=30×4 a_1=120mm^2

Centroidal distance from edge x_1=2mm = 240mm^3

for rectangle-2 Area=26×4 a_2 =104mm^2

Centroidal distance from edge x_2=17mm =1768mm^3

$\varepsilon_{ax} = ax_1 + ax_2$ =2008

$\varepsilon_a = a_1 + a_2$ ε_a =224 Y = y =21.035mm

Maximum bending moment $\frac{M}{I}=\frac{\sigma_t}{y}$ σ_t =189.3536N/mm²

Thus the induced stress (189.3536N/mm²<248Mpa) is less than the permissible stress and so the design is safe.

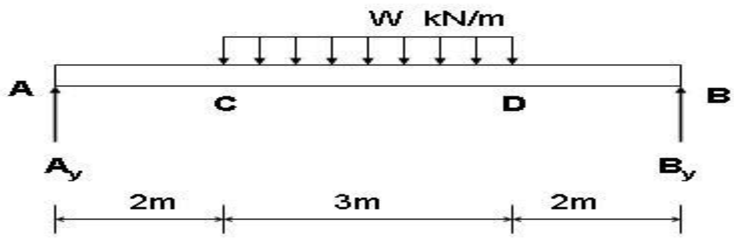

Figure 2. Bending Moment Diagram

Reaction at the support R_A+R_B= (4.708×250)

Taking moment about R_A

R_B×600= (4.708×250) ×300 R_B=588.5N R_A =588.5N

Dimensions of the top most layers from the neutral axis(y) for the front frame

For rectangle-1 Area=30×4 a_1=120mm^2

Centroidal distance from edge x_1=2mm = 240mm^3

For rectangle-2 Area=26×4 a_2 =104mm^2

Centroidal distance from edge x_2=17mm =1768mm^3

$\varepsilon_{ax} = ax_1+ax_2$ =2008

$\varepsilon_a = a_1+a_2$ ε_a =224

Y =$\frac{\varepsilon_{ax}}{\varepsilon_a}$ y =8.964mm

Taking moment about R_c

R_D×900= (588.5×360) + (588.5×540) R_D =588.5N R_C =588.5N

Moment of inertia (I) I=29419mm^4

Maximum bending moment M_{max}=211860Nmm

$\frac{M}{I}=\frac{\sigma_t}{y}$ σ_t =189.3536N/mm²

Thus the induced stress (189.3536N/mm²<248Mpa) is less than the permissible stress and so the design is safe.

3.3. Design of Motor

Power requirement

P=2πNT/60 Power =34 watts
T=9.652Nm

Torque requirement

T=F.r r-radius of the output Shaft

F=9.652/0.010 N-motor output revolution per minute

F=965N F-force

F=98.4kg

Table 2.Specifiction of motor

Type	Link permanent type magnet wiper motor.
Voltage	12v &24v (Approx.)
Weight	2kgs
Torque	18.0to 30.0 Nm @13.5v
Angle of Wipe	90° to 120°
Arm Length (Typical)	400-525 mm
Blade Length (Typical)	450-575 mm
Blade Pressure	900 gms
Arm/Blade	2Nos

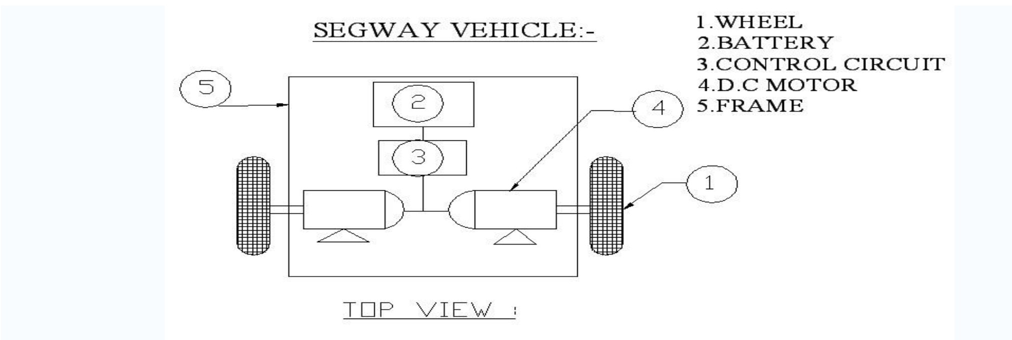

Figure.3. P.T Elevation

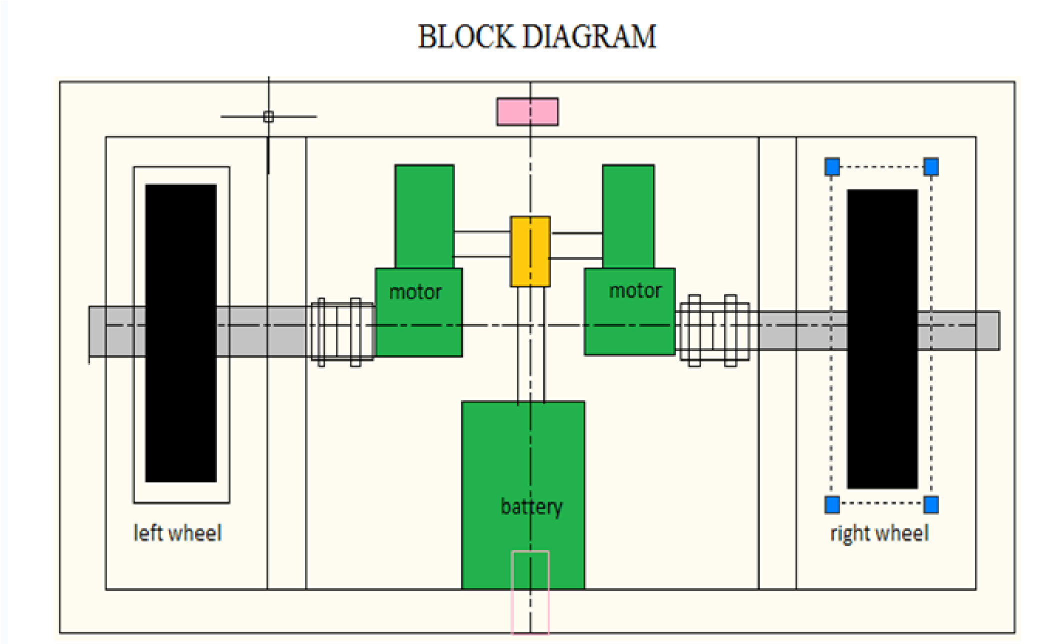

Figure.4. CAD Modeling

Figure 5.wiper motor

Figure 6.Frame

Figure 7.Bas

Figure 9.Wheels

Figure 10.Handle and handle bar

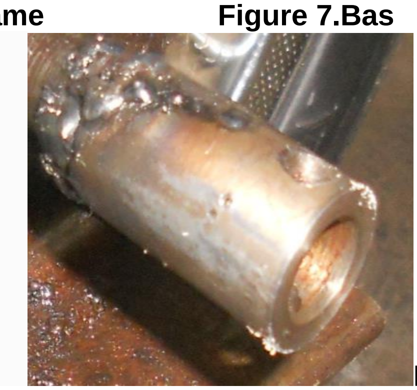

Figure11.Bush

Figure.12.Frame Figure 13.Castor wheel Figure 14.Battery

Figure 15.P.T Transport

4. Conclusion

Thus the fabrication of three wheeled personal transporter is carried out by using third wheel and geared motor which is incorporated in personal transporter instead of gyroscopes and several electronic sensors with comparatively very low cost. Instead of controlling the direction by sensors we alternately control it by switching geared motors, and so the proposed design is comparatively less costly than existing two wheeled personal transporter. Though it cannot satisfy the full purpose of the gyroscopes, it does same work similarly as the gyroscopes. So this fabrication can fulfill the basic functioning of the two wheeled personal transporter.

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Future Enhancement

Thus the fabrication of three wheeled personal transporter is carried out by using third wheel and geared motor which is incorporated in personal transporter instead of gyroscopes and several electronic sensors with comparatively very low cost. Instead of controlling the direction by sensors we alternately control it by switching geared motors, and so the proposed design is comparatively less costly than existing two wheeled personal transporter. Though it cannot satisfy the full purpose of the gyroscopes, it does same work similarly as the gyroscopes. So this fabrication can fulfill the basic functioning of the two wheeled personal transporter.

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