FABRICTION OF MECHANICAL SEGWAY WITH HANDLE

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Abstract. Segway is a two-wheeled motorized personal vehicle consisting of a platform for the feet mounted above an axle an upright post surmounted by handle with two guiding wheels, controlled by the rocker switches. Segway is mainly used for the short distance travel where there is no use of fuel and no pollution. The main objective of this project is to produce an easy way to move and a comfortable space for the user and reduce pollution as this model is eco-friendly. The present project proposes a cost effective and innovative design compared to the existing segway available in the market. The proposed project also aims to reduce the e-waste by eliminating few electronic components.

1. Introduction

This Fabrication of mechanical Segway with handle is a personal transporter which moves in short distances from place to place [1]. This Segway is a device that moves in the forward and backward directions. It has a potential to speed up to (6-7 km/h) indoor and outdoor operation, capable of turning in place, and has a weight carrying capacity of up to hundred kilograms which carries the person while riding [2]. The main principle behind the load carrying capacity is the type of material used in building the Segway that is Iron which is durable and strong which in return supports high weight carrying capacity. Generally the expenditure of these components, conjoin with the expenditure of operating experimentation and testing[3]. This Segway is a human transporter (HT) conferred an contemporary economic product for the human transportation [4]. Segway which is working on batteries balances and moves on two wheels which are guarded by microprocessors and exclusive gyroscopes [5]. The robotic mobility platform has a miniature impression, a zero turning radius, the capability to carry over distinct terrains and the capability to bear up to the load setup. These properties made researchers experiment considering the locomotive part of their robotic systems [6]. It is furnished with a motionless T-shaped control shaft attached into a platform seated on two parallel wheels. Segway’s are directed continuing up and operate according to human body dynamics [7]. The Segway has no braking system or an accelerator to boost up the speed rather it has a handgrip on the handle of Segway which is helpful for the rider while operating it also it is used while taking turns by the switches attached on to the handle. The steering mechanism of Segway is also given by the switches attached which are used to turn in opposite directions forward and backward [8]. Basically, a segway is mostly used for personal transportation in urban environment. This was invented by Dean L. Kamen. Segway is like a scooter but the wheel arrangement is placed side by side instead of parallel to each other [9]. The advantages of segway’s are zero emissions, zero turn radius, no noise and higher degree of freedom. Segway is used for urban police patrolling, military surveillance, off road riding and urban sightseeing [10].
2. Literature survey

Meyer et al. [11] studied the HT segway which is regulated and powered by the consumer product safety commission rather than the national highway traffic safety administration. The study examined the challenges for transportation by HT segway which includes types of pavements, travels on sloped surfaces, and issues on safety purposes. Brain .G.R. huges [12] investigated on the onboard computers computer to control the power directly on to the wheels to balance the forces by the rider, this study also shown that the segway balances at various conditions such as constant velocity, acceleration and deceleration. Thompson et al. [13] studied on the mechanical segway design and fabrication by using gyroscopic sensors, and electric motors driven by battery. The designed model of segway costs around Rs. 20,000/- which is very much less compared to the one which is in the commercial market which made highly cost effective. Brett Browning et al. [14] studied on the RMP segway which is a balancing robot base and it is also be able to play soccer autonomously.

The existing segway’s in the market costs around Rs. 28,000/- which is most expensive and robust in design. The present project proposes a cost effective and innovative design which costs around Rs. 15,000/- which is very less compared to the existing segway available in the market [15]. The proposed project also aims to reduce the e-waste by eliminating few electronic components.

3. Components of Mechanical Segway

The following are components of mechanical Segway [16]:

3.1 Frame and Base plate
3.2 Suspension handle
3.3 Silicon tires
3.4 DC Gear motor
3.5 Pillow block bearings
3.6 Batteries
3.7 Rocker switches
3.8 Chain and Sprockets
   • Gears
   • Belt and Pulleys
   • Crank
   • Coupling
3.9 Guiding wheels

3.1 DC Gear motors

The Dc Gear Motor covert the electrical power into mechanical power. Two Dc Gear Motors; each of 12v are used in Segway each is attached to chain sprocket system which is further connected to wheel for the movement of Segway.
Table 1 Specifications of the Dc Gear Motor

| PARAMETER    | VALUE      |
|--------------|------------|
| Motor        | Dc 12 volts|
| Material     | metal      |
| Speed of the motor | 30 rpm  |
| Torque of the motor | 35kgcm  |
| Power of the motor   | 1.099kw   |

3.2 Pillow Block Bearings

A pillow block is a base which is used to give hold for a rotating shaft with the help of suitable bearings and different accessories. Two pillow block bearings are used in Segway each is attached to the wheel [17].

3.3 Batteries

Battery is the main power source in the mechanical Segway. There are two batteries used each is connected to Dc Gear Motor by means of cables. The power of the batteries is 12v each these are the rechargeable in both ways electric socket and solar plates. Definite contrasting sequence of electrode materials and electrolytes are used along with lead-acid, zinc-air, nickel-cadmium(NiCad), nickel-metal hydride,(NiMH), lithium-ion(Li-ion), and lithium ion polymer. The type of batteries used in segway are rechargeable batteries which are more costlier than the disposable batteries but by the usage of this batteries the cost of ownership and environmental impact will be low. Recharging requires electricity while disposable batteries require the change of whole battery [18].

Table 2 Specifications of Battery

| PARAMETER     | VALUE |
|---------------|-------|
| Type          | lead-acid |
| Normal Capacity | 7.6 Ah  |
| Voltage Nominal | 12V    |

3.4 Rocker Switches

Rocker switch is a type of switch that breaks and connects the electrical circuit by” Rocking” in one direction to break the circuit, and the other direction is connected to the circuit. These rocker switches are placed on the suspension handle the main function of these rocker switches is for the steering mechanism. The power is given to the mechanical Segway for its movement only when the switch is pressed [18].
3.5 Chain and Sprockets
The power generated from the electric motors, car engines and wind generators is by the rotary motion of the drive shaft. The commonly used method for the transmission of motion and force from the output drive shaft in a mechanism is by the means of a component called as SPROCKET.

Fig. 3 Rocker Switches [17]

A sprocket is generally a toothed wheel used in the bicycles and motorcycles to transmit the motion from one shaft to another whereas the chains used along with it are used to transmit the motion and force from one sprocket to another. One such chains are called as power transmission chains.

Fig. 4 Energy Transmission Process

The mechanism that is used in the bicycle for the movement is used in mechanism with the help of Chain and Sprocket system.

Fig. 5 Chain and Sprocket [18]

4. Fabrication of Mechanical Segway
4.1 Making the basic design for the Segway

First, we make a basic design for the Segway, as our requirement. This design is made as
comfortable for the transporter to run the Segway. This helps the passenger to move freely at his own place. This Segway is not self-balancing so that there are two guiding wheels at front and back for the support. This device consists of switches attached to handle to be controlled by the personal transporter. This basic model is made by using CATIA software.

In the above chapter we selected the materials for the components required to make this project. Now we make the components ready by using some engineering techniques for the step by step assembly. First, we prepare the frame initially in which we have to attach the motors to it. This attachment is done by arc welding which we have discussed earlier and surface grinding too to get a good finish of the metal. Frame is 120 centimeters. The arc welding process and the surface grinding process is carried out accordingly. Now the motors of the 12volts DC motors are taken along with the chain and sprocket setup. Then these motors are fixed by used the arc welding technique, which is also used to attach the frame of the mechanical Segway.

One motor is fixed in the left is established on the right direction and the other motor is fixed to the frame in the reversed direction as the turning requirements. These motors are checked thoroughly before fixing them to the frame and they must be in the center of the shaft as the chain must be fixed. The sprocket must be at the center of the shaft as the center is taken between the tire and the frame where the bearings are fixed. Now the chain and sprockets are taken according to the shaft size. These sprockets are fixed to the shaft at the time when we attach tires and bearings itself, this helps us to not to work hard, so that we have to remove again the whole frame setup to fix this. Then the chain must be fixed to the motor output and to
the sprocket according to the bits and according to the length required. We have taken 51 bits of chain to attach one side of the tire and motor which is sprocket and the motor output. These bits which are the ends ones must be fixed by the clevis pin and link plates of the chain. For this model we require a suspension so that the passenger can move easily and in case if he loose balance, he can rely on the handle which is a suspension handle and gets compressed at the bottom of the handle. Suspension handle is likely to be the whole handle of a bike. This handle is fixed by the bolts at the top and at the bottom it is welded to the frame. We can’t just weld the suspension handle to the frame so that first we weld a nut and bolt slot so that the suspension handle can be fixed further and have a little movement front and back. This come onto action when the person on the mechanical Segway lose the balance, he can rely on it. These wheels are used to give support for the mechanical Segway while driving it. These wheels are fixed one at the front end and he back end of the frame so that middle silicone tires are used make front and back movements and also the turning movement. These small wheels which are attached at the front and back end are used to get the required turn additionally helping the main tires, as a result we get the turn. This works as if we want to take a left turn then we must hold the right rocker switch one for forward movement and the left rocker switch in the backward action. Similarly, if we want to take a right direction, we must hold the right rocker switch one for backward movement and the left rocker switch in the forward action.

Apart from the battery cables the connecting wires are used to connect the motor and the rocker switches in order to move the mechanical Segway. These connecting wires are used to give the electric connection from the motors, batteries and the rocker switches. The circuit connection of the mechanical Segway is as below.

![Connection of Motors, Batteries with Rocker Switches](image)

**Table 3** Weights of Individual Components

| Components                | Quantity | Weight (Kg) |
|---------------------------|----------|-------------|
| Frame                     | 1        | 3.5         |
| Tires                     | 2        | 5           |
| Motors                    | 2        | 2.4         |
| Batteries                 | 2        | 2.3         |
| Pillow block bearings     | 2        | 2           |
| Chain and sprockets       | 2        | 1.5         |
| Shaft                     | 1        | 2           |
| Suspension Handle         | 1        | 5           |
| Guiding wheels            | 2        | 0.5         |
| Other small components    | 1        |             |
| **Total**                 |          | **25.2**    |

when testing the mechanical segway in the initial trails the operator advantages were naturally lower as a sign of safety. This trail was made to check the system performance and its efficiency also the steering mechanism which is controlled by the rocker switches was also tested. Which worked well in taking left and right turns along with this the expected speed was attained and the safety of the operator was also as expected.
5. Basic Modeling in CATIA V5

Fig. 10 Basic Design for Making the Mechanical Segway

Fig. 11 Top view of Segway
6. Design Calculations

Design Factors for the proposed Segway
- Load Capacity = 90Kgs.
- Base Width = 22"
- Base Length = 26"
- Mast Length = 32"
- Types of motion = Forward, Backward, Left, Right
- Travel Speed = 5-7 Km/h
- Power Supply = 12V, 7AH Lead-Acid Battery

Materials Used for Each part
- Body of the Segway = Iron
- Mast: Suspension Handle = steel
- Wheels = Silicone -Eco-friendly

Power of Driving Motor
\[ P = \frac{2\pi NT}{60000} \]
Where, \( P \) = Power of Motor (KW), \( N \) = Speed (in rpm), \( T \) = Torque (Nm), \( T = W \times R \)
Formula for power = \[ 2\pi N T / 6000 \]
Speed of the Motor = 30 RPM
Max Torque Produced, \( T = 35 \text{ kg-cm.} \)
Therefore, the power of the motor, \( P = 2 \times 3.14 \times 35 / 600 = 1.099 \text{ KW} = 1099 \text{ WATTS} \)

Selection of the Sprockets
- Number of Sprocket Teeth \( n = 15 \)
- Chain Pitch = 0.490m
- Sprocket diameter = 40mm

Stress acting on the Base
- Weight of the user = 100 kg (max)
- Weight of the personal transporter = 25.2 kg (approx.)
- Total weight = Weight of the user weight of the personal transporter = 125.2 kg.
- Loads acting = Total weight*Gravity \( g = 10\text{m/sec} \)
- Thus, load acting = \( w \times g = 125.2 \times 10 = 1252\text{N}. \)
- \( P = N \text{ Area of the base, } A = 660.4 \times 558.8 = 369032.52 \text{ mm}^2. \)

Yield Stress
- Maximum weight on the base = 125.2 kgs
- Yield stress = maximum weight*gravity/area of base
- Yield stress = 125.2*10/369032.52 = 0.033928\text{ = 3.34*10}^{-3} \text{n/mm}^2.

Factor of Safety
- FOS = ultimate stress/allowable stress
FOS = 1252/1000 = 1.252
FOS = 1.25

7. Results and Discussions

Firstly, it is balancing the mechanical segway without the usage of any type of sensors and programming. This is observed by some initial trails made and as per the initial driving results and why the vehicle was unable to get the expected result so we made a lot of advancements in terms of loads and motor capacity and shaft and bearing which helped us to get desirable results we expected for. The results obtained are tabulated in table 4 and table 5.

| Observations | Speed  |
|--------------|--------|
| Speed expected | 9-10 km/h |
| Speed obtained | 6-7 km/h |

Table 4 Driving Results

| Observations     | Result     |
|------------------|------------|
| Stopping time    | 1.1 seconds|
| Stopping distance| 0.3 ft.    |

Table 5 Results observed

Initial Driving Results:

The initial driving attempts were made to run the segway by controller and resulted in positive way. This test was made to check the mechanical segway operated by the rocker switches to move forward and backward as required. After many tests and changes, the operating planning with the remaining error serving as a origin of speed, turned out to be as successful and the speed controlled by the rocker switch is very good for the forward and backward movement. Also the changes are made by replacing capacity and wires brought very good results overall.

Conclusions

In this project a mechanical Segway is modeled and fabricated which is cost effective and innovative model as compared to the existing segway available in the market.

The following conclusions can be drawn from to the present study.

1. The designed model of mechanical Segway is thoroughly tested in all the aspects and proved to be effective.
2. The designed mechanical Segway can be used for a full extent for personal transportation use and safe to use for travelling at low speeds.
3. The model which is designed is cost effective compared to the model which is available in the market.
4. The study also reduced the e-waste by eliminating few electronic components.
5. Much advancement can be made in future to this model to make it more effective by using sensors and servos to move and turn the vehicle smoothly.
6. Also the load carrying capacity of the vehicle can be changed by using heavy motors and reduce vehicle weight by using light weight durable materials for body.

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