Design and Fabrication of a Cost Effective and Reliable Segway

[1]Nishant Kiran Nikam, [2]Dipu Ramkishan Mourya, [3]Chirag Sudhakar Patil, [4]Ninad Vilas Patil, [5]Sangam Rane
[1,2,3,4]Bachelor of Engineering Student, [5]Assistant Professor
Department of Mechanical Engineering
St. John College of Engineering and Management, Palghar(E), Palghar, India

***Abstract*— In the 21st century, transportation has become a major concern. A Segway being compact and reliable is best suited for short distance applications in urban areas. The Segway is based on the principle of inverted pendulum that will keep an angle of Zero degrees with vertical at all times. The Segway is an intelligent vehicle which uses gyroscopic sensors to detect the motion of rider, so that he can accelerate, brake or steer the vehicle. The conventional seaways available in the market are very costly as they are not available locally. Hence the need to design and fabricate a cost efficient Segway which could be affordable and the same time be reliable to withstand a rider up to 100kgs. In this project an attempt has been made to design and fabricate a Segway with minimum resources.**

***Keywords* – Arduino (software), Gyroscope, Segway, Steer.**

I. INTRODUCTION

The Segway is a two-wheeled, self-balanced, battery- powered electric vehicle invented by Dean Kamen. It is a vehicle that maintains its own balance and that of its passenger. It is equipped with a stationary T-shaped control shaft fitted into a platform mounted on two parallel wheels. Segways are driven standing up, it handle's according to human body dynamics: lean forward to move forward, stand straight up to stop, and lean backward to reverse. The device has no brakes or accelerator, but has a handgrip for making turns. It is the only vehicle able to turn in place, just like a person, because its wheels have the ability to turn in opposite directions. The first problem with the Segway is the price. This technology is not affordable to low-income individuals. The Segway is not only a great innovation, but it is also environmental friendly since it is fully electrical and does not release any emissions and this would appeal to a lot of people if they knew it existed. The Segway has a bright future, because after most of the problems are taken care of, it will eventually be widely used and accepted as a form of transportation that is better than the bicycle.

II. PRINCIPLE COMPONENTS

1. Frame or chassis

The Segway we have fabricated has a square tube rectangular shaped chassis with diagonals. This chassis is made from mild steel pipes. The pipes used are medium gauge one inch hallow square pipe. These pipes are welded together to form the chassis of the Segway. These are joined in such a way it form a 600X400 mm square shaped member. At the center of the frame two square members in "X" shape are added to increase the strength and weight carrying capacity of the frame. On top of the frame aluminum sheet is added to provide the platform for standing on the frame. A T-shaped mild steel bar was used to make the handle.

2. Driving mechanism

The drive train is the heart of the automobile. In our segway the drive train includes two DC motor and four rechargeable batteries which are charged to drive the motor. The type of drive in a segway is two-wheel drive. In which both the wheels are driving wheels. The powers from the motors are transferred to the wheels independently or separately. The motors shaft is welded to the wheel shaft for the transfer of motion between the wheels and the motor. The final parts of the drive train are the wheels and tires, which transfer the power generated by the motor to the ground.

3. Motors

The motors used in our Segway are dc motors with a voltage of 24Volt, 300 rpm and with a power of 250watt.

4. Battery

The batteries which we used for our Segway are two 12v and 9.8amph lead acid batteries and these batteries are rechargeable. The batteries are connected in series and are connected to the control unit from which the power is transferred to the motors. The total charging time will be some 4-6 hours.

5. Control unit

The control unit of a Segway is the brain of the Segway. It plays a very important role behind every operation of the Segway. The signals which ever are given to the Segway are transmitted through the control unit to the motors. For the Segway to run the control unit is needed. The operation of the control unit will be in accordance with the angle of inclination, when the angle is changed the signals are transferred from the control unit to the motors. When the angle is changed the signals will be passing through the microcontroller where the required instructions are obtained from the gyroscope.

6. Wheels

Two TVS Scooty ES wheels of R10" are used. The wheels are best suited as they were light weight and easily available.

III. ASSEMBLY OF FABRICATED PARTS

List of electronic components used:

1. Battery unit
2. Potentiometer
3. 3-axis Gyroscope
4. Motor drivers
5. Arduino board
6. Connector wires
7. DC geared motor

Fig 3.1 Assembly of Segway

Fig 3.2 Model of Segway

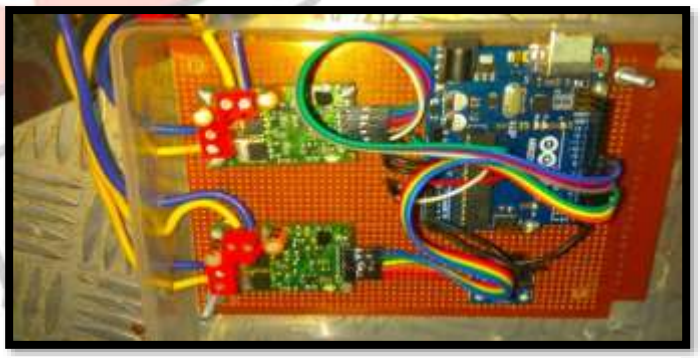

Fig 3.3 Electronic Components Mounting

IV. ANALYSIS OF FRAME

Square Tube 20 x 20 x 2 mm

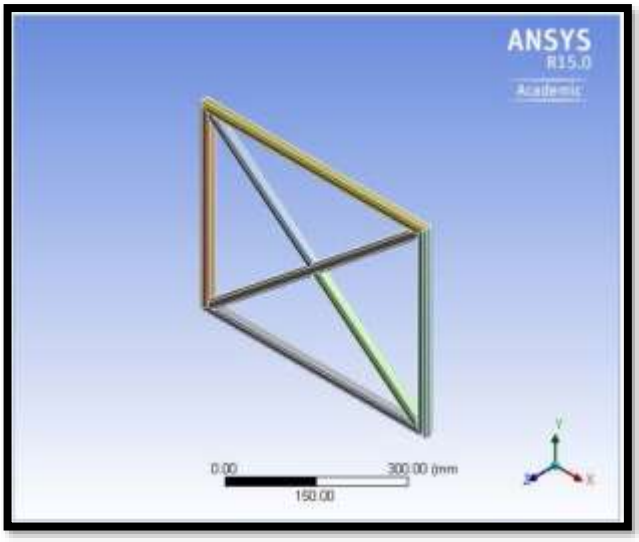

Fig.4.1: Model of Frame

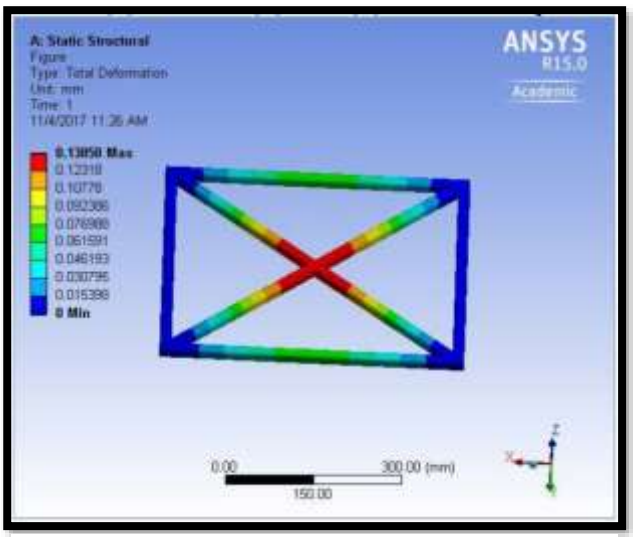

Fig. 4.2: Total Deformation of Frame

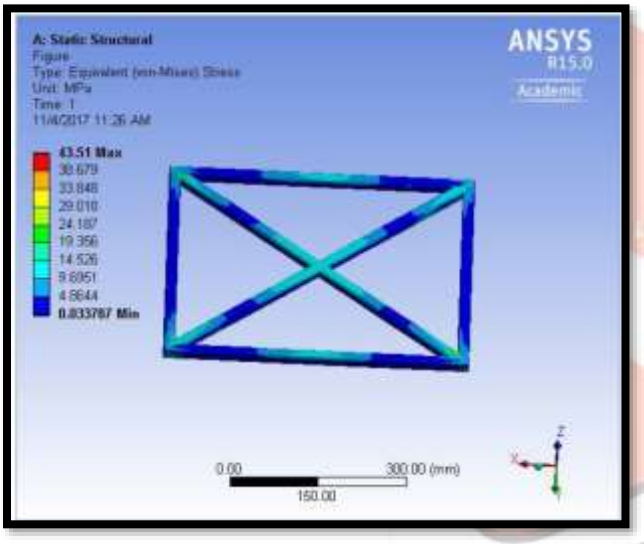

Fig. 4.3: Equivalent Stress of Frame

Object Name	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Equivalent Stress
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
Definition				
Type	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Orientation		Z Axis		
Coordinate System		Global Coordinate System		
Results				
Minimum	0. mm	-0.13858 mm	1.264e-006 mm/mm	3.3787e-002 MPa
Maximum	0.13858 mm	8.3339e-004 mm	2.3625e-004 mm/mm	43.51 MPa

Table 8.1: Result of Frame

The square tube of 20 x 20 x 2 mm was selected as the deformation is 0.13858 mm. and stress is 43.51 MPa which are in acceptable limits. It is optimum in weight, cost and is convenient for mounting components motors, footboard, battery pack and handle bar. The fabrication is also easier with this member of frame.

V. CALCULATONS

1. Power Calculation

- The weight acting on the segway = weight of the segway + weight of the user.
- Weight of the segway =24kg
- Max Weight of the user = 80kg
- Total weight acting on the segway = 24+80 = 104kg
- Load acting on the segway= 104X9.81 = 1020.12N.
- Area of the segway chassis = 600X400mm = 240000mm2
- Stress acting on the frame or chassis of the segway = 1020.1/240000 = 4.2151X10-3kN.

*The stress acting on the frame of the segway is very less than the allowable stress of the mild steel. So, the design is safe.

Speed of transporter = $10 \times \frac{5}{18}$

=2.778m/s

Coefficient of friction between wheels and road surface = 0.4

$$V=\frac{\pi DN}{60}$$

$$N=\frac{v\times 60}{\pi D}$$

$$=\frac{2.77\times 60}{\pi\times 0.4}$$

$$=132.63\text{rpm}$$

Torque Required = $coeff.of\ friction \times force \times Radius\ of\ wheel$

$$= 0.4 \times \frac{110}{2} \times 0.2$$

= 4.4 kg-m

= 43.164N-m

Power required is = $\tau \times \omega$

$$=\frac{2\pi N\tau}{60}$$

$$=\frac{2\pi\times 132.63\times 43.164}{60}$$

$$=259.36\ W.$$

2. Bearing Calculation

Static load = 7850N
Dynamic load =14000N
Diameter: 25mm.

$$L_{mr}=\frac{N\times 60\times L_{hr}}{10^6}$$

$$=\frac{324\times 60\times 8}{10^6}$$

=0.156 mr.

$$C = (\frac{L}{10})^{\frac{1}{K}} \times P$$

$$14000= (\frac{0.156}{1})^{\frac{1}{3}} \times P$$

P = 26006.775N (max. capacity of bearing)

But our max. load is 1100N. Hence the selected bearing is **safe**.

V. Conclusion

In this paper, the design and fabrication of a two wheeler personal transporter namely 'Segway' is discussed. The attempt to change the existing design of a luxurious Segway was successfully completed. This was implemented with an idea to find an effective solution to transportation problem. The main objective was to achieve cost reduction and hence it was made at a cost of ₹ 21,000. It is a clean and eco-friendly mode of transport as there is no fossil fuel. The speed achieved was up to 10 km/hr.

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