

Design and Analysis of Steering System for E-Bike

¹Sai Krishna Koleti, ²Rahul Reddy Boyapalli And ³Ravi B

^{1,2}Student, Sreenidhi Institute of Science & Tech, Hyderabad, Telangana

³Scholar, Department of Mechanical Engineering, Sreenidhi Institute of Science & Tech, Hyderabad, Telangana

Corresponding Author: Sai Krishna Koleti

ABSTRACT: The competitive and ever progressive world made mankind to channel the available natural resources for its own benefit devoid of the unfathomable conditions that would prevail in near future. The fear of running out of fuel reserves, forced mankind to depend on other forms of energy. Electrical energy had been amusing mankind with its diverse ways of existence, with which mankind was successful to exploit this energy in many fields. One of such field that needs generic concern of human kind is automobile engineering. This field had been successfully exploited and the production of electric vehicles was made feasible. E bike known for its advantages over petroleum engine in regards with the emission is likely to emerge in the market and become one of the fastest and progressing vehicle. With the scope of enhancing the performance of the e bike we have channelled efforts of all the team to achieve optimum design in Steering system. The prescribed engineering process for design is documented in the following report, including problem definition, project scheduling, design research, design development, and design analysis. The overall objectives are to increase the vehicle performance, quality and overall efficiency.

The design process of the vehicle was based on several engineering and reverse engineering methods. The following are the parameters that were taken into consideration while designing the steering mechanism, Endurance, Safety and Ergonomics, Availability, Kerb weight, Cost of the Components and Safe Engineering Practices.

We began the process of designing by conducting various researches for main parts of the vehicle. Our team had carried out market research for the desired parts. SOLIDWORKS 2016 was the CAD software used for designing and ANSYS 15.0 was used for analysis of the vehicle. Besides performance, consumer needs of serviceability and affordability were also kept in concern which we got to know through the internet research.

KEYWORDS:Rake, Trail, Opposing Torque, Tree turning angle, Turning radius, Lean angle.

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I INTRODUCTION

[1]. Steering is a governing subsystem which is collection of mechanical linkages to help the rider to guide the vehicle in desired direction or to negotiate a turn along circular pathway. Steering system of a two-wheeler involves crucial parameters which determine the stability and manoeuvrability of the vehicle.

A. ^{1,2,3}Rake:

[1]. Rake is the angle in degrees of the steering neck from vertical. Rake is a crucial parameter which accounts for the change of trail and front fork lengths. The rake angle is selected for the vehicle prioritizing stability and manoeuvrability.

Rake = **28degrees**

B. ^{1,2,3}Trail:

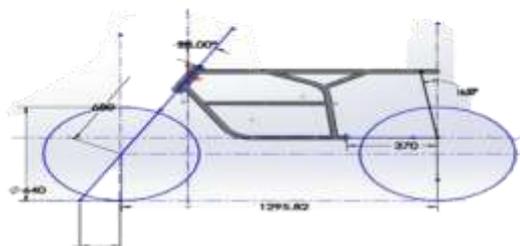


Fig. 1: Vehicle showing different alignments

[1]. Trail is the distance defined by the vertical line from axle to ground and the intersection of centreline of the steering neck and ground. Trail obtained by fixing rake angle is **165.43mm**. The trail is assumed to be true in working condition based on personal choice.

C. ^{1,2,3}Tree Turning angle:

[1]. The maximum angle that a tree could turn about the head is called tree turning angle. The semi angle through which a tree turns is **35 degrees**. Knuckles are provide on the head region to prevent the complete rotation of the handle bar.

D. ^{1,2,3}Wheel Turning Radii

II SEMI TREE ANGLE VS TURNING RADIUS OF REAR WHEEL AND FRONT WHEEL

Table I: Turning radius of front and rear wheel

| TREE ANGLE | TURNING RADIUS OF FRONT WHEEL IN METERS | TURNING RADIUS OF REAR WHEEL IN METERS |
|------------|---|--|
| 5 | 14.85 | 14.8 |
| 10 | 7.45 | 7.34 |
| 15 | 5 | 4.83 |
| 20 | 3.78 | 3.55 |
| 25 | 3.06 | 2.77 |
| 30 | 2.59 | 2.24 |
| 35 | 2.25 | 1.84 |

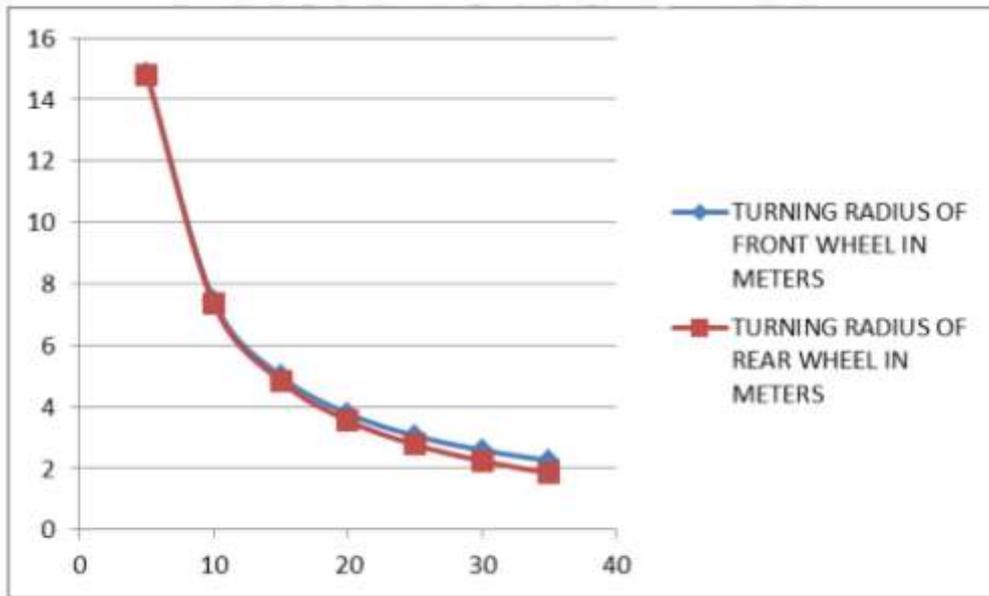


Fig. 2: Turning radius of front and rear wheel in meters

III ^{4,5,6}DESIGN OF HANDLE BAR

A. Opposing Torque Calculations:

[1]. Opposing Torque:

It is the torque facilitated by the frictional force arisen between the tire and the ground to oppose the steering handle during steering.

- [2]. Opposing Torque = $F \cdot a$
 F = Rolling Resistive Force
 a = Moment arm
 $a = n \cdot \tan \alpha$
 n = Trail, α = Steering angle

[3]. Various Torques have been obtained for different steering angles a graph is plotted between steering angles and opposing torque.

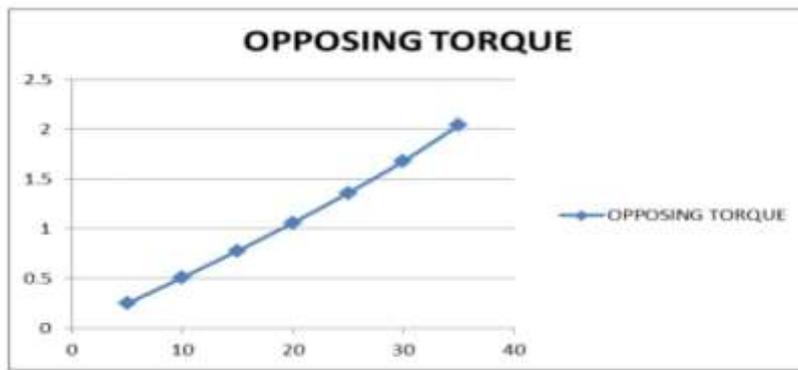


Fig. 3: Graph for opposing torque

IV REPRESENTATION OF HANDLE BAR



Fig. 4: The handlebar which is introduced in the vehicle to ensure safe and easy handling of the vehicle.

[1]. The handle is designed keeping the handling ergonomics of the vehicle, it is so designed that it does not deflects with the opposing torque acting on it and is also comfortable to the driver to hold the handle hours together.

V ^{7,8}LEAN ANGLE OF THE VEHICLE

[1]. The angle with which the vehicle must be inclined to the road to negotiate a turn is called lean angle. Various lean angles to negotiate a turn of different radii are plotted on a graph.

[2]. The lean angle is calculated using the formula

$$\beta = \arctan\left(\frac{v^2}{R} * 2mr + \frac{ML}{MLg}\right)$$

- $M=180$ Kg
 $m=12.5$ kg
 $L=0.70627$ m

For the vehicle to negotiate a turn of radius 5 m of road the graph is plotted at different speeds using above formula

Table 2: Lean angle of the vehicle

| VELOCITY IN M/S | LEAN ANGLE |
|-----------------|------------|
| 2.77 | 9.4 |
| 4.1 | 20.3 |
| 5.55 | 33.7 |
| 6.94 | 46.25 |

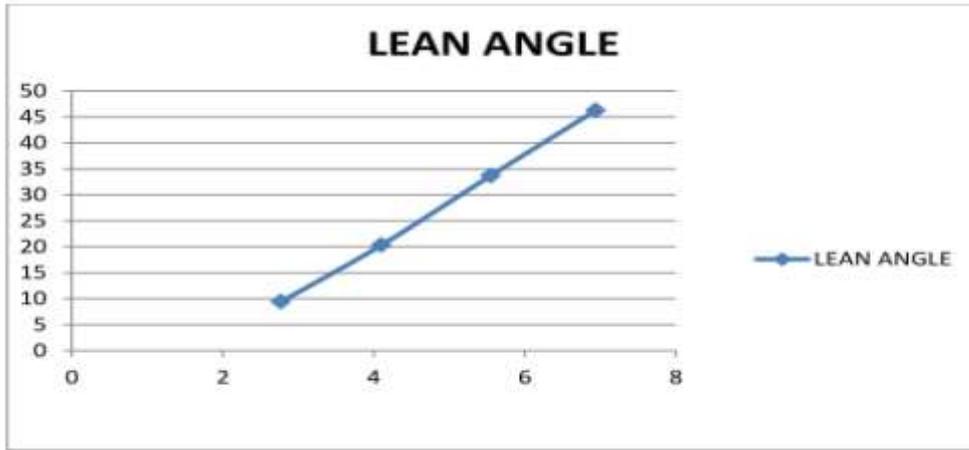


Fig. 5: Graph for lean angle variation

Table 3: Steering parameters and specifications of the vehicle

| <u>STEERING PARAMETERS</u> | <u>SPECIFICATIONS</u> |
|--|-----------------------|
| Rake angle | 28 ⁰ |
| Trail | 165.43mm |
| Maximum lean Angle (for 25kmph and Radius of curvature = 5 meters) | 46.26 ⁰ |
| Max. Semi-Tree Turning angle | 35 ⁰ |
| Least Turning Radius of Front wheel | 2.25 meters |
| Least Turning Radius of Rear wheel | 1.84 meters |

VI CONCLUSION

[1]. The present work is optimum design and analysis of Steering system for an E-Bike subjected to statistical analysis of Rake, Trail, Tree angles and Wheel turning radii which are used for the design of Handle bar and calculation of Lean angle.

i. The variation of Opposing torque for different Rolling resistive force(F) and Moment arm(a) is shown in the graph(Fig: 3).

ii. The lean angle is calculated using the formula

iii. $\beta = \arctan \left(\frac{v^2}{R} * 2mr + \frac{ML}{MLg} \right)$

[2]. We have obtained Lean angles for different velocities. We have also drawn a graph showing the variation of Lean angle for different velocities and mass.

[3]. The desired turning radius and stability has been achieved at different angles. Also the acceptance criteria is that the vehicle has to move in a straight path when handle is in center and required to turn the vehicle with turning radius of approx. 2 m.

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