ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 8, Issue 2, 2019

Design & analysis of steering system for FSAE race car

Lokesh Kalapala[1],

[1]Asst, prof.: Dept. of Mechanical Engineering., Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Satya Ravi Teja Donepudi[2] ,

[2]UG Students, Dept. of Mechanical Engineering., Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Lohith Kosana[2] ,

[2]UG Students, Dept. of Mechanical Engineering., Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Gadi Ganesh[2]

[2]UG Students, Dept. of Mechanical Engineering., Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Abstract.

An essential part of an automobile is the steering system. Its main objective is to transmit the driver's input to the wheels and deliver road feedback. To build a decent steering system, certain design specifications must be met; the same is true for FSAE vehicles. The design's main goal is to provide the driver with a system that doesn't need a lot of steering effort or wheel movement, offers enough feedback, and makes it simple to navigate even the tightest corners.. Two steps can be used to breakdown the design. The first step is to create the steering geometry. The steering system must be designed in the subsequent stage. The steering system and its components were designed and optimised in accordance with Formula Bharat 2021 rules. using the CAD programme SolidWorks 2018 and lotus simulation, geometrical validation and modelling of the whole steering system ANSYS Workbench is used for static analysis to examine the static stress distribution.

Keywords: Steering system, Rack &pinion, Ackermann geometry, solidworks.

ISSN PRINT 2319 1775 Online 2320 7876

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1. Introduction

FORMULA BHARATH event is conducted by Curiosum Tech Private Limited that provides a platform for students to demonstrate their technical ability, and also introduces them to other engineering fields like Design, Manufacturing, Quality, Sales, and Marketing. All students must follow the guidelines in the rulebook [1] and create their designs in compliance with them for this competition. A series of parts, linkages, and other mechanisms make up the steering system, which enables any vehicle to travel along a specified course. [2] The most common type of steering setup is a hand-operated wheel in front of the driver. The five main parts of a fundamental steering system are the steering box, linkages, knuckle or upright, column shaft, and wheel. Likewise, with regard to the formula student vehicle.

The main goal of the steering system is to provide an optimal and stable front geometry with a small turning radius, minimum steering effort [3], and good Ackermann percentage, which results in better outputs and to reduce the overall weight and cost of the steering system. Ona whole, the work is aimed at reducing the amount of steering effort and to minimize the car's turning radius

2. Methodology

The main goal of the steering system is to provide an optimal and stable front geometry with a small turning radius, minimum steering effort, and good Ackermann percentage, which results in better outputs and to reduce the overall weight and cost of the steering system.

The type of steering system geometry to be used is a major issue to consider while developing the steering system. Ackermann geometry (shown in Fig. 1), anti-Ackermann, and parallel-steer geometry are the three geometries that can be used for a vehicle steering system. The Ackermann steering geometry is taken as the event track contains more low-speed curves. The inner tyre turns more than the outer tyre in this design, providing an advantage on courses with slow corners.

a_o = outside wheel angle.

a_i = inside wheel angle.

T= track width.

B = wheelbase`.

b = CG point distance.

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$R=\sqrt{(R1^2+B^2)}$ = Turning radius.

$R1=\sqrt{(R^2+B^2)}$.

R=2500mm

B=1530mm.

R1=2424mm.

B=612mm.

Inner Wheel Angle(a_i)= B / [R –(T/2)] –=39.55degrees

Outer wheel angle (a_o)= B / [R +(T/2)] =27.05degrees.

Through calculations, we discovered that the steer angle for the inner tyre is 39.55 degrees and the steer angle for the outer tyre is 27.05 degrees for a turn with a maximum radius of 2.5 metres and all the geometrical details are given in Table:1

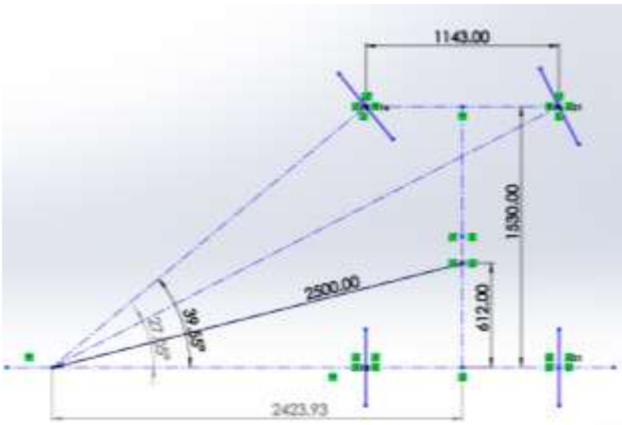

Figure 1 Representation of Ackermann principle

2.1 Steering arm in upright

To transfer the steering forces to the upright, two parallel tiny moment arms are employed. An imaginary line drawn from the moment arm to the rear axle and joining at its midpoint should have the moment arm inclined to that line. We thought about the Ackerman principle for it.

Tan α/2= (Track width/2)/Wheelbase=20.48 degrees.

As a result, to satisfy the Ackermann geometry requirements in the vehicle, the moment arm angle in the knuckle is estimated which is represented in Fig. 2

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 UGC CARE Listed (Group -I) Journal Volume 8, Issue 2, 2019

Table 1: Geometrical calculations table

S.no	**Parameters**	**Units**	Value
1	Track width(front)	Mm	1143
2	Wheel base	Mm	1530
3	Steering arm length	Mm	100
4	Ackerman angle (α)	Degrees	20.48
5	Inner wheel angle	Degrees	39.55
6	Outer wheel angle	Degrees	27.05
7	Tie rods length	Mm	305
8	Steering column length	Mm	135
9	Turning radius	Mm	2500
10	Ackermann percentage	%	82

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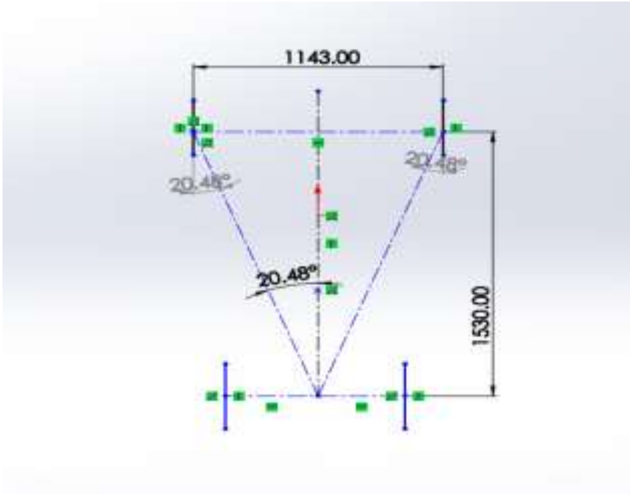

Figure 2 Graphical representation of steering arm angle

3. Results and Discussion

3.1 LOTUS software simulation

The inner and outer angles, inner and outer track ball joint positions, and turning circle radius are calculated using Lotus software. The tie rod must be close to the average of the upper and lower a-arms' size and must run parallel to both of the a-arms. Gains in bump steer and camber will be lessened as a result. The results shows that the Ackermann percentage fluctuates between 54 % to 82% during the simulation of dynamic conditions.

The steering ratio is the ratio of the steering wheel's degree of rotation to the wheel's degree of rotation. The steering ratio can be computed as S.R =160/40 =4:1 using an approximate maximum turn of 40 degrees and steering wheel movement of 160 degrees (since it eliminates the arm cross over when turning).

3.2 Steering Force

The basic idea is that the torque required to turn the wheel should be higher than the torque produced by the friction at wheel.

Friction force (on one wheel) = μ* g *mass on wheel = 0.7 *9.81 *64 = 439.48N

The torque due to friction force = 439.48*18(scrub radius to kingpin perpendicular distance) = 7910.784 N-mm.

Torque due to friction force = force on tie rod (ft)*100

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7910.784 N-mm=ft*100 mm

ft =79.10 N ; Total force on rack = 79.10 * 2 = 158N (considering it to be 200N)

Pinion radius = 22.5mm

Torque on pinion = 200*22.5 = 4500 N-mm= Torque by steering wheel(ts)

Radius of steering wheel(r) =139mm.

Force applied by the driver = (ts)/(r) = 4500/139 = 32.37N.

The rack &pinion system is used [4] .Beside having lightweight , less occupying space, it also very efficient in transferring the motion from steering wheel to the actual wheels.

Table 2: Geometrical calculations of rack & pinion

Quantity	Values
Rack length	300mm
Module of rack and pinion	1.5
Number of teeth on rack	22
Number of teeth on pinion	30
Diameter of pinion	45mm
Pressure angle	20°
dedendum	1.875mm
addendum	1.5mm

3.3 Effect of Material

After so many analysis iterations based on vivid materials in Ansys, fusion 360 software's and keeping of the points in view such as cost, manufacturability and availability in the market. It is concluded to use these materials based on the analysis of system [5].

Table 2: Material selection

Component	Material
Steering wheel	Al 7076
Rack and pinion setup	Al 7075 T6
Rack mounting plate, Tie rod	AISI-1018 steel

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3.4 Stress Analysis

The maximum equivalent(von-mises) stress is about 34.896mpa, the total deformation is 0.1356mm(max), and the factor of safety is 2.37, which is safe to use in real-life conditions. According to this static study, the components designed can withstand a load of 250N that the system is subjected to.

Fusion 360 software is utilised for the static study of the steering wheel. The highest stress (von-mises) is around 20.01 maps, the total deformation is approximately 0.0758 mm(max), and the factor of safety is approximately 8. The load conditions are derived from the design calculation.

Von Mises stress of rack and pinion, steering systems are shown in Fig. 3 &4

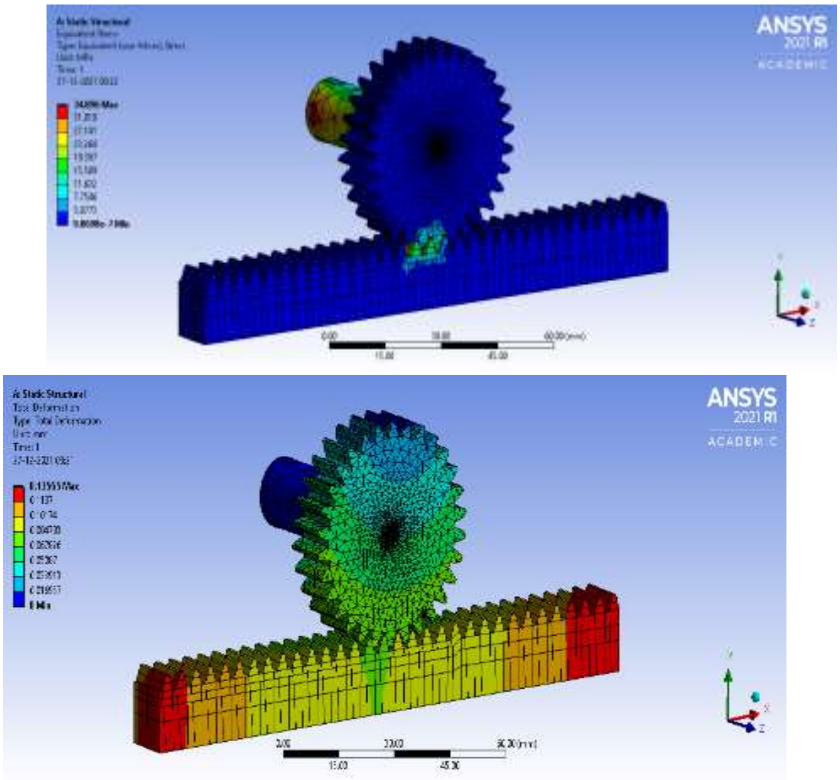

Figure 3 Von Mises stress and deformation of rack and pinion assembly

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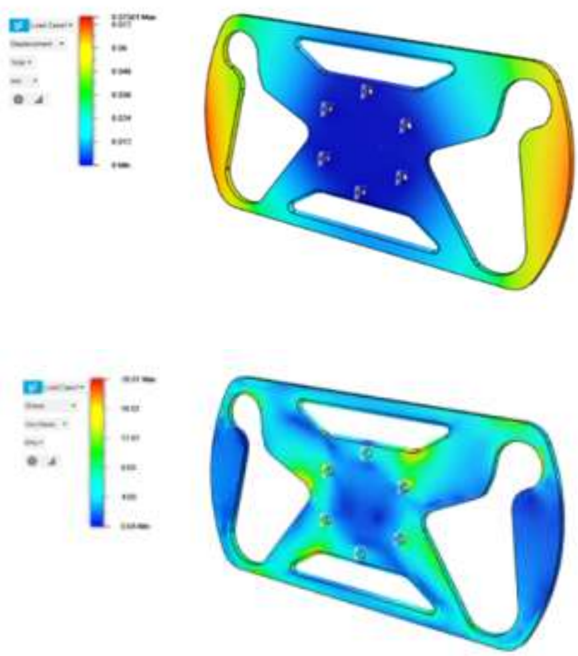

Figure 4 Von Mises stress and deformation of steering system

4. Conclusions

This paper provides detailed information about designing of the steering system. The design targets and goals are achieved by using various software including cad, analysis and calculations. The components designed can tolerate the loads faced by the vehicle during dynamic conditions. Results achieved are suitable for the formula student vehicle and the design meets all the rules of Formula Bharath.

References

[1] Formula Bharath Rule book from https://www.formulabharat.com/downloads/

[2] Chinmay Raut, Rahul Chettiar, Nikunj Shah, Chandraprakash Prasad, Dhiraj Bhandarkar" Design, Analysis and Fabrication of Steering System Used in Student Formula Car". May 2017 www.ijraset.com Volume 5 Issue V, May 2017 IC Value: 45.98 ISSN: 2321-9653.

ISSN PRINT 2319 1775 Online 2320 7876

  UGC CARE Listed (Group -I) Journal Volume 8, Issue 2, 2019

[3] Saurabh Bores, Pranav Chille, Shubham Dabhade, Swapnil Deshmukh, Atul Kulkarni, "Design and Manufacturing of an effective steering system for ATV and performance enhancement using yoke-nut assembly", NCMMM-2016, E-ISSN: 2321-9637,19 March 2016.

[4] Prashant L Agrawal, Sahil Shaileshbhai Patel, Shivanshu Rajeshbhai Parmar, "Design and Simulation of Manual Rack and Pinion Steering System", IJSARTVolume 2, Issue 7-July 2016.

[5] Design & Analysis of Steering System for a Formula Student Car Dinesh Babu S.1 , Farug H.2 , Tanmay Mukherjee3 UG Student, 3rd year, Dept. of Mechanical Engineering, Kumaraguru College of Technology, Coimbatore, IndiaISSN (Online): 2319-8753 ISSN(Print) : 2347 – 6710.