Design of Steering System in Race Cars: A Review

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Abstract— Formula one cars deals with high speed and moderate down force. Under this dynamic condition, car needs to maintain maximum traction to use maximum torque generated at output of engine. This is achieved by appropriate design of steering system. The design begins with study of basic parameters, calculations giving required values, followed by analysis of various conditions. Then a prototype is made to find out flaws and feasibility, proceeded by material selection, analysis, manufacturing, design validation, final assembly, and testing. The design is then validated by measuring performance in terms of turning radius, turning angle and steering effort .Selection and design of steering system gives ease in manoeuvrability and best cornering ability and desired turning radius which leads to winning the race.

Key words: FSAE Car, Design, Vehicle, Steering System, Ackermann Steering System, Camber

I. INTRODUCTION

Steering is one of the most vital sub-system of any car. In case of formula SAE car, it is even more significant. Since this vehicle is designed to compete in circuit races and the objective of the team is to win, any failure in the system will lead to disastrous effect to the car and the driver. Although the designing starts with study of parameters used for any general passenger car, it forms the foundation for designing the steering system for an FSAE car which is quite different.[1]

The main purpose of any steering system is to guide the wheel so that the driver directs the vehicle in desired trajectory. It works on the principle of Ackermann steering geometry. The design of steering system has the influence on directional response and behaviour of vehicle that is often not fully appreciated.

Firstly we did literature survey of the present automobiles related books FSAE and other reference papers like Thomas D. Gillespie, Bill and Doug Mikkiken, Kripal Singh.

After studying these papers we were able to conclude some of the major points which are necessary for the final manufacturing of the vehicle.[9]

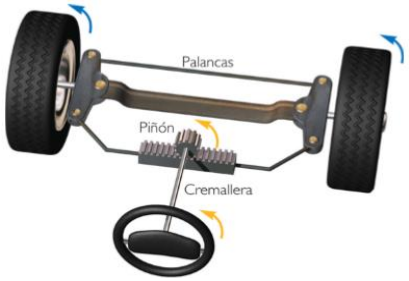

Fig. 1: Rack & Pinion

Then we studied formula SAE rules, the general rules and the rules which govern the design of steering system, with the constraint of restrictions established by the completion.

Subsequently we also studied the theoretical knowledge and technical fundamentals about the various components in order to apply the same practically.

So to proceed we have started our basic design of the components on Catia followed by analysis on softwares such as ANSYS, Hypermesh etc.

Exact and appropriate mathematical calculations of each component was done in order to precise the final design and manufacturing which will be done in upcoming period.[8]

II. RULES FOR DESIGN

Our design of steering system is based on rules and restriction imposed by FSAE:

- The steering system must affect at least two wheels.
- The steering system must have positive steering stops that prevent the steering linkages from locking up (the inversion of a four-bar linkage at one of the pivots). The stops may be placed on the uprights or on the rack and must prevent the tyres from contacting suspension, body, or frame members during the track events.
- Allowable steering system free play is limited to seven degrees total measure at the steering wheel.
- Real wheel steering is permitted only if mechanical stops limit the turn angle of the rear wheels to (+-3) degrees from the straight ahead position.
- The steering wheel must be mechanically connected to the front wheels, i.e. ``steer-by-wire´´ of the front wheels is prohibited.
- The steering wheel must be attached to the column with a quick disconnect. The driver must be able operate the quick disconnect while in the normal driving position with gloves on.
- The steering wheel must have a continuous perimeter that is near circular or near oval, i.e. the outer perimeter profile can have some straight sections, but not concave sections, or cut-out wheels are not allowed.
- In any angular position, the top of the steering wheel must be no higher than the top-most surface of the front hoop.[3]

The design of steering system includes studying theoretical knowledge that has influenced on overall performance of the vehicle and based on this fundamentals we will design and manufacture steering system elements.

III. STEERING SYSTEM DESIGN

A. Steering System Requirements

It should be quick enough so that the vehicle response to the steering and its correction happens instantaneously along with self-returning action. The feel and self-returning action

are based on kingpin inclination, scrub radius, castor angle and self-aligning torque characteristic of front tire.

B. Design of Steering System Geometry

1) Ackermann Steering

When a vehicle travels around a corner the inside wheel must follow tighter curve than the outside wheel. To achieve this steering geometry must be arranged such that the inside wheel turns through a larger angle than outside wheel. The Ackermann geometry provides a solution here. This geometry results in the inside wheel turning through small radius than the outside wheel.

C. Thrust Angle

It is the angle between centre axis of the vehicle to the direction in which the wheel mounted on the rear axis is pointing.

1) Advantages

- Sliding pair is used hence friction is less
- Easy to use and manufacture

D. Wheel camber or camber angle

Camber angle is regarded as inclination of wheel plane to vertical. Negative camber is inclination of top tire towards centre line of the vehicle.

E. Wheel Castor

- Castor angle: It is the angle between inside elevation between steering axis and vertical. It is considered as positive when steering axis inclined towards rear and negative when steering axis inclined forward. Positive castor induces a self-correcting force that provides straight line stability but increases steering effort.
- King-pin inclination: It is the angle in front elevation between steering axis and vertical. It is also called as steering axis inclination. A right value of this parameter will reduce steering effort.
- King-pin offset: It is the horizontal distance measured at ground in the front view between the point where steering axis intersects the ground and centre of tire contact.

IV. CONCLUSION

We have studied all dependents and independents parameters for design of steering system which forms the base for further manufacturing and execution of complete design. This design not only allows in achieving a better directional stability but also proves beneficial for manoeuvrability.[7]

REFERENCES

International Papers and Journals:

[1] A Mihailidas, Z. S. (November 28, 2008). The design of a formulae student race car. IMechE2009, Dept of mechanical engineer, Journal of Automobile , Vol 223, No D6.
[2] Car, T. S. (1989). Price list of parts. Retrieved 0322, 2010, from Tornado Sports car.
[3] Interactive, C. (2004, June). Fabricating metalworking. Retrieved march 22, 2010, from Brush Research Manufacturing Metalworking/Making-a-Comeback-/1$711
[4] International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Vol-2, Issue-1, 2012
[5] Richard Fine, "Correlation of Vertical Acceleration and Human Comfort in a Passenger Car." SAE Paper No. 630314(733C),Sept1963
[6] Wright, P. (2001). Formulae 1 Technology. SAE International.
[7] Genta, G. (1997), Motor Vehicle Dynamics: Modelling and Simulation, World Scientific Publishing Co. Pte. Ltd. Matschinski, W. (2000)
[8] Road Vehicle Suspension, Professional Engineering Publishing Ltd. London Dixon, C.J. (1996), Tires, Suspension and Handling, Society of Automotive Engineers, Inc. Warrendale, PA Haney, P. (2003)
[9] The Racing and High-Performane Tire, TV MOTORSPORTS and Society of Automotive Engineers Heisler, H. (1999)
[10] Vehicle and Engine Technology, Second Edition, Arnold, 338 Euston Road, London NWI 3BH Smith, C. (1984)

