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A Review on Design and Assembly of Go-Kart Steering System

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***Abstract*—The theory is included in this work and the article focus on the conventional and general steering arrangement on the synthesis of design and analysis of go kart steering system. There is a significant role of the steering system in each and every vehicle too make the handling convenient and to enhance the stability of the vehicle, as to guide the motor vehicle through direction of the road is totally the responsibility of the driver for steering the car, it requires the driver to look straight ahead at the intended path relative to the car and somehow analyzing and give the car a controlled desired input with the path way. A steering wheel which is hand operated which is used on basis to turn the wheels on the front axle and is positioned by the driver controlling the steering wheel. Other aspects like wheels, tyres, steering assembly plays an important role to improve vehicle handling. Considering different steering modes changes the need of steering system of go kart. Under consideration of short turning radius, steady road conditions.**

***Index Terms*— Go-Kart, Steering System, Rack and Pinion, Ackerman Steering Mechanism, Design, Analysis.**

I. Introduction

Steering performance derives the ability of the steering system used in the vehicle as per the handling and stability and Life of the linkages and tyre life also and can be improved by reducing the tyre wear and resistance of steering torque. It acts significant role for making the handling and vehicle stability convenient. The steering system have experienced the development of many stages throughout past hundred years the newest technology of the steering system is the "Steer-By-Wire" system (SBW) which allows the rear wheels to be steered in the opposite direction as the the front wheels when the vehicle is in low speed condition, this allows the vehicle to turn in a significant smaller radius [4]. But this steering system is not currently applicable for conventional vehicles and also for go-karts. Steering system used in go karts are Yoke steering system and Rack and Pinion steering system. Rack and pinion having an advantage over yoke steering system is significantly allows smaller turning radius at critical driving conditions. Go kart steering system is different as compared to other vehicles because of no suspension system used. The steering system used in go kart is the conventional steering system in which basically wheels on the front axle are steered towards left or right, because the rear axle is to be considered as the dead steering axle [4]. Low ground clearance as compared to other vehicles. The steering geometry mainly used is Ackermann Steering Geometry consists of four bar linkages. Steering system used in design may content universal joints being a part of collapsible steering column design. Under consideration of design aspects like addendum curves, addendum curves. Truth profile pitch curves of the gears used in design [2].

II. Requirements Of Steering System

The steering system has the following requirement:

1. Excellent maneuverability when the vehicle is cornering on a narrow, twisting road, the steering system must be able to turn the front wheels sharply yet easily and smoothly.
2. Proper steering effort if nothing is done to prevent it, it will be greater when the vehicle is stopped and will decrease as the speed of the vehicle increase. Therefore, in order to obtain easier steering and better feel of the road, the steering should be made lighter at low speeds and heavier at high speeds.
3. Smooth recovery while the vehicle is turning, the driver must hold the steering wheel firmly. After the turn is completed, however, recovery-that is the return of the wheels to the straight ahead position should occur smoothly as the driver relaxes the force with which he is turning the steering wheel.
4. Minimum transmission of shock from road surface, loss of steering wheel control and transmission on kickback due to road surface roughness must not occur [4].

III. Steering System Used

Steering system used in go karts are Yoke steering system and Rack and Pinion steering system from which Rack and Pinion steering system and Rack and Pinion gear box is considered the most commonly used steering system in go-kart because it is more precise as it consists of fewer parts, its simple in construction, is compact, quickly responds to the inputs and less back lash [4]. The primary goals are to ensure that the wheel slip is minimum and the steering for the left and right turning conditions are symmetrically controlled, ensuring that there is the minimum cross-coupling between the axle oscillations and the steering, the favorable pressure angle to be maintained in the joints, the moving parts of the mechanism and

the steering interference is to be avoided and also between the body of the vehicle, to provide the gear reduction or steering ratio[2]. the main criteria for the steering system designing is the steering ratio it is basically the number of rotation of the steering wheel in degree to the number of degrees of rotation of the road wheels, the increase in the steering ratio will lead to increase in the degrees of rotation of steering wheel[4].

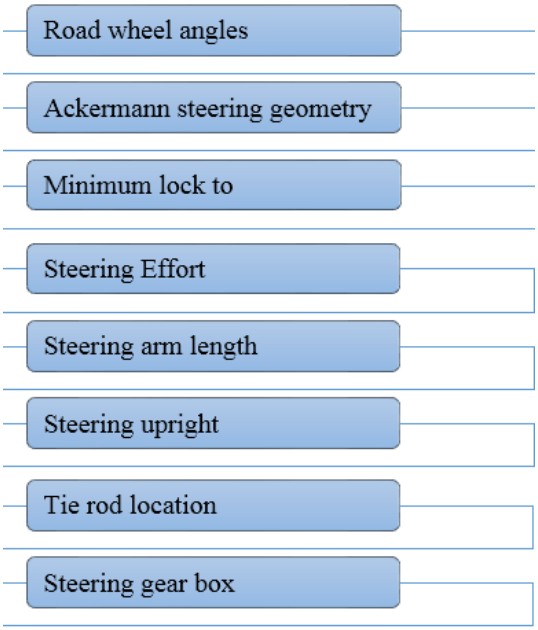

Fig. 1. Design methodology for steering system

IV. RACK AND PINION STEERING SYSTEM

This type of steering gear is simple, light and responsive, very small space is required, the number of linkage component used are lesser

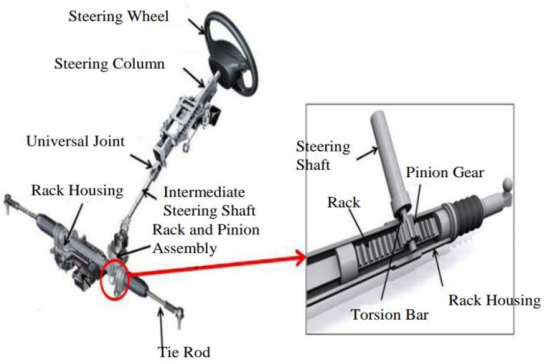

Fig. 2. A simplified rack and pinion steering system

A. *The steering system consists*

1. Steering wheel
2. Steering shaft
3. Steering shaft joints
4. Steering pinion
5. Steering rack
6. Steering gear case
7. Tie rod
8. Steering knuckle

The basic working of the system is that through the universal joints the steering wheel rotary motion is transmitted to the steering gear to the pinion, the pinion and rack are meshed with each other in such a way that the circular motion of the pinion is transferred into the linear movement of the rack, further relayed through the ball joints and tie rods to the stub axles for the wheels to be steered. There are two design used mainly first is the center take off design and second is the end take off design [8]. For the side profile of the pinion is to be made curved the tooth profiles of both the pinion as well as the rack are of the involute form, the pitch circle of the rack being straight line the side profile of the rack is also straight line. For the operation of the gears to be operated with smooth and the quite behavior of the system helical teeth are invariably employed so that the teeth engage progressively to maintain some amount of contact between the teeth. For the given movement of rack the effective pitch radius increased when the pinion is placed generally tilted to the direction of the rack travel [8].

V. ACKERMANN STEERING MECHANISM

Ackermann steering geometry is an arrangement of linkages in the steering system mainly designed to solve the problem of wheels on the front axle on the inside and outside while taking turn on the road by the guidance of the driver tracing out the circle of different radii able to observe the path way to drive through and find a solution. For the purpose of improving maneuverability at low speed, controllability and stability at high speed, a general method of optimal synthesis of steering mechanism is developed by the displacement matrix and constraints [2]. The intention of the Ackermann steering geometry is to avoid the need for tyres to slip sideways when following the path around the curve. The geometrical solution to this is for all wheels to have their axles arranged as radii of a circle with common center point. As the rear wheels are fixed, this center point must be on a line extended from the rear axle. Intersecting the axes of the front wheels on this line [4].

During taking turns, centrifugal forces acts on the wheels. Two cases of steer can arise:

A. *Under steer*

When the slip angles of the front wheels are greater than those of the rear wheels, radius of the turn is increased, the vehicle will turn less sharply. In general, the vehicle will try to move away from its normal direction of motion, at this state the steer applied should be little more than theoretical [8].

B. *Over steer*

When the slip angle of the front wheels are less than those of the rear wheels, radius of turn is decreased, the vehicle will turn more sharply. In general, the vehicle will try to move from its normal direction of motion, at this state the steer applied should be little less than theoretical [8].To reduce this type of

steer cases let's consider or represent quadrilateral MNOP as the Ackermann steering gear mechanism on the basis of four bar kinematic chain.

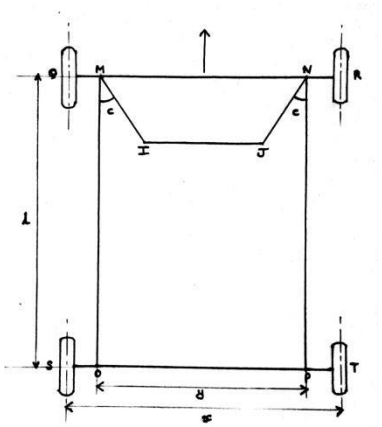

Fig. 3. Ackermann steering gear mechanism (a) outline

Where, M-N is the front axle, O-P is the rear axle, Q-R are the front wheel, S-T are the rear wheels, the vehicle turning condition is on the left side hence, R and T are the inner wheels, Q and S are the outer wheels, also consider Z as the centre of the turning circle, x is the distance between pivots of stub axle, y is the track width and l is the wheel base. Links MI and NJ are equal in length and they are inclined at an angle C with the vertical when the vehicle is moving on the straight path. The link IJ is the track rod and is shorter in length than link MN but both are parallel to each other on straight path. Links QMI and RNJ from the bell crank levers and are pivoted at M and N respectively. In order to satisfy the correct steering condition the links MI and NJ are suitably proportioned and angle C is selected the mechanism forms four turning pairs only.

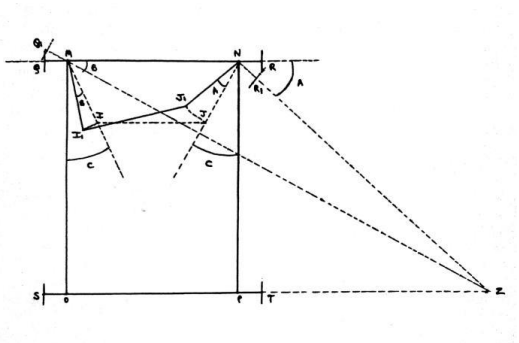

Fig. 4. Ackermann steering gear mechanism (b) angular details

This mechanism does not meet exactly the condition of correct steering and gives correct steering condition only at the following three positions:

1. When the vehicle moves on the straight path.
2. When the vehicle moves to the right and angle C of turning is such that the wheel axes MQ_1 and NR_1 intersect on the axis of back axle.
3. When the vehicle moves to the left and the angle C, the similar condition is obtained as above.

In other positions, the wheels will not have pure rolling motion and they have tendency to slip. The mechanism gives only three positions for correct steering one when the angle C is in the straight path steering condition and other two each corresponding to the turn to right or left (at a fixed turning angle), however, for other angles also it gives a close approximation to deal the condition. Further this has advantage that it employs pivots and not sliding constraints due to which reason its maintenance is easier, and hence that's the reason they are universally employed [8].

C. Terms Considered in Steering Mechanism

1. Wheel Base
2. Ackermann Angle
3. Inner steer angle
4. Outer steer angle
5. King pin angle
6. Caster angle
7. Camber angle
8. Steering ratio
9. Steering effort
10. Steering wheel lock angle
11. Minimum turning radius
12. Maximum turning radius
13. Toe in
14. Scrub radius[3]

D. Assumptions

1. 100% Ackermann steering geometry.
2. Maximum road bank angle is 20 degree.
3. 4 to 8 degree optimum king pin inclination angle.
4. 42:58 or 40:60 front to rear weight ratio.
5. Taking 10m/s^2 as acceleration due to gravity [3] [5].
6. Steering ratio is considered approximately 1:1 for Go-kart.

VI. Analysis Of The Steering System Components

In order to determine the components safety some external factors such as loads, temperature, pressure etc are external factors which are applied on the components for analyzing the components and obtaining the approximate or appropriated values such as stresses (bending, tangential and normal), deformation in the components after the application of external load when implemented in practical use. To understand various factors with an ease applicable in the process it gives optimum results of the safety of component. This analysis gives the approximate or appropriated, optimum result of the safety of component and by minimizing the chances of failure. ANSYS, Solid works, HYPERWORKS, and FLOTRAN etc., this are the various computer simulation software packages available in the markets to carry out such type of analysis under various loading conditions [7].

A. Two Major Analysis Carried Out

1. Deformation analysis
2. Stress analysis

B. Various Components Analyse

1. Steering gear
2. Steering rack
3. Steering pinion
4. Intermediate steering shaft

C. Analysis Performing Process

1. Making or importing the geometry to software interface (GUI).
2. Defining the field.
3. Applying the material properties.
4. Meshing the components with appropriate element size.
5. Applying the actions such as load, pressure etc on the component body.
6. Applying the boundary conditions such as fixed supports (constraints).
7. Solving the problems using the solver.
8. Obtaining the required reactions or values of stresses acting on the components and the deformation of the body member under certain acting loads [7].

VII. Conclusion

In this review paper, the best to the knowledge basics with design and assembly of the go-kart steering system is gathered with the help of the researchers and their documentations, the purpose of the steering system their requirements, the design methodology, the overview of the steering system used in the go-karts, the steering system current used rack and pinion their components to be consider, working of the system. The steering mechanism used which is Ackermann steering geometry is discussed with the steer cases and is explained in simple quadrilateral notation form with terms considered in mechanism and the assumptions made during the solution of the Ackermann steering geometry problems. The analysis of the steering system components through various software's can be performed which determines the stresses, loads and deformation of the steering system from which the design engineers can predict the safety of the system and can also be modified and minimization of the errors in the systems can be done, this is the knowledge and data about the design, assembly and analysis without any mathematical considerations.

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