Design and Analysis of Steering System for GO-Kart

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Abstract— Mechanical linkages steering systems are commonly used due to their simplicity in construction and compactness. The main purpose of this paper is to design, analyze and manufacture manual mechanical linkages steering system according to the requirement of the vehicle for better maneuverability. Quantities like turning radius, steering ratio, steering effort etc. are inter-dependent on each other and therefore there are different design consideration according to the type of vehicle. The comparison of result is shown using tables which will help to design an effective steering for the vehicle. A virtual mechanical linkages assembly can be created using software like Autodesk Inventor and analysis can be done in software like ANSYS.
Keywords: Steering Ratio, Tripod, Inner Wheel and Outer Wheel Angle, Steering Column, Stub Axle

I. Introduction

Steering system is one of most important part of an automobile that is used to give directional stability to the vehicle. This is typically achieved by a series of linkages, rods, pivots and gears. Ackerman Steering Mechanism is generally used in all vehicles. The significance of Ackermann geometry is to avoid the need for tires to slip sideways when following the path around a curve.

Our steering geometry is having 78.8% Ackerman and also gives 45 degree Ackerman angle. We also get turning radius of 1.767meter. We can decrease the turning radius of the kart by reducing distance between the two hinge points of the tie rod on the tripod, tripod is the triangular geometry on which both the tie-rods are hinged Tie-rods are then attached to stub axle and the stub axle is mounted with the front wheel by means of bearing. Third end of the tripod is attached to steering column and at the another end of the steering column steering wheel is attached by means of hub.

II. Design Methodology

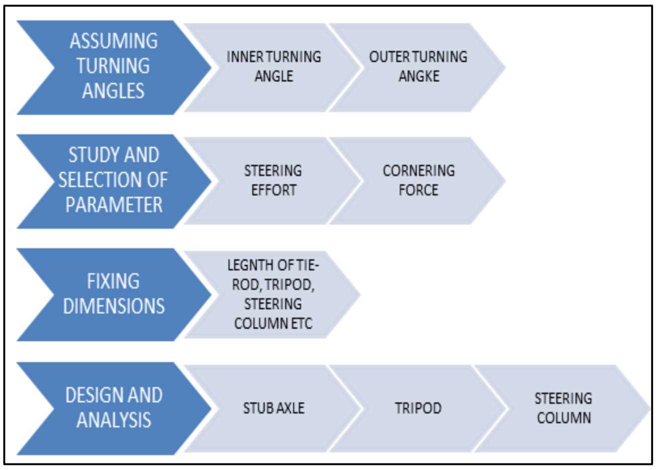

Fig. 1: Design methodology of steering system

Ackermann principal of steering to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radius, Ackermann principle of steering is used.

A. Assumptions

- 100% Ackermann steering geometry.
- Optimum kingpin inclination angle range is 15deg Front to rear weight ratio is 45:55.
- Taking acceleration due to gravity as 10m/s^2
- Inner wheel turning angle 45deg

III. Related Term

The caster angle or castor angle is the angular displacement of the steering axis from the vertical axis of the steered wheel, when we can give positive casters create a lot of aligns torque. Camber angle is the angle made by the wheels of a vehicle; specially, it is the angle between the vertical axis of the wheels used for steering and the vertical axis of the vehicle when viewed from the front or rear, negative camber improves grip when cornering.

King pin inclination or king pin angle is set relative to the true vertical line, as viewed from the front or back of the vehicle. King pin inclination is non-adjustable, since it would change only if the steering knuckles are bent.

Toe in or positive toe is the front of wheel pointing towards the centerline of the vehicle excessive toe-in will cause the tire to scrub on the outboards and so will shorten the tire-life.

It is used in the concept of ackerman steering. While going around a corner all the tires turn along the circle with a common center point (as shown in figure). The intention of Ackerman geometry is to avoid the need for tyres to slip sideways when following the path around a curve. The angles b and a can be calculated by

$$b = arctan\left(\frac{H}{R - W/2}\right)$$

$$a = arctan\left(\frac{H}{R + W/2}\right)$$

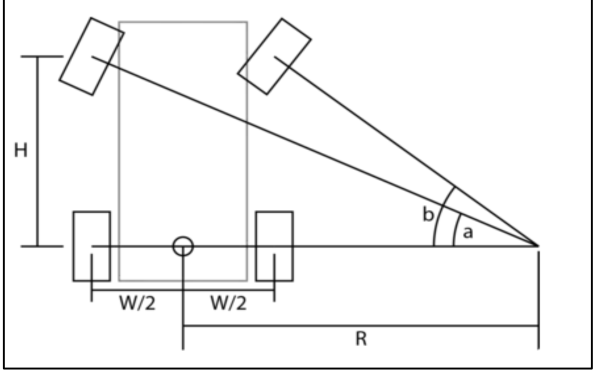

Fig. 2: constructional geometry of Ackerman

IV. CALCULATIONS

Radius of gyration (k) = W^2/8
=1272/8
=2016.125mm
Friction torque on arm length (h)
= (k+e^2) ^1/2
= (2016.125+63.723^2)^1/2 =77.953 mm
Moment at king pin= g*w*h * friction coefficient
=9.81*38.25*77.953*0.7
=20475.47 N-mm
Force at tie rod= moment/steering arm length
=20475.47/100
=204.7547
Force at tri pod = 204.7547/0.9
=227.505 N
Moment at tri pod = 227.505*100
=24638.82 N-mm
Moment at tri pod = Moment at steering Wheel
24638.82 = 330 * steering effort
Steering Effort = 74.6631 N
Consider vehicle taking turn,
Cornering force = v^2/Rg
=12.5^2/ (1.767 *9.81)
= 9.01 N
Weight transfer on right tyre during cornering = cornering force * height of C.G * front axial load/track width
= 9.01 * 13.35 * 76.5/52.36
= 19.819 kg
Weight on right tyre = w + weight transfer
= 38.25 + 19.819
= 58.069 kg
Weight on left tyre = W – weight transfer
= 38.25 – 19.819
= 18.431 kg
Lateral force on left tyre = Weight on left tyre * V^2 /Ri
= 18.431 * 12.5^2 /1.4478
= 2021.49 N
Lateral force on right tyre = Weight on right tyre * V^2 /Ro
= 58.069 * 12.5^2 / 2.0816
= 4358.8 N
Total force = 2021.49 + 4358.8
= 6380.29 N
Moment at king pin = total force * mech. Trail
= 6380.29 * 46.59
=296938.69 N/mm
Self-aligning torque= 6380.29 * 127/6
= 135049.47 N-mm
Total torque = moment at king pin + Self aligning torque
= 296938 + 135049
= 431987N-mm
Force at tie rod = 431987/100
=4319.87 N
Force at inner tie rod = 2 * Force at tie rod
= 2 * 4319.87
= 8639.74 N
Moment at steering shaft * tri pod length = 8639.47 * 100
= 863947
Theoretical steering effort = moment at steering shaft/ steering dia.
= 863947/300
= 2879.9 N

V. TABLE OF RESULTS

Parameter	Dimensions
Wheel Base	1330 mm
Track	750 mm
Tyre Width	127 mm
Front Axel Load	76.5 kg
Load on each wheel	38.25 kg
King pin offset	100 mm
Steering arm length	100 mm
Scrub Radius	83.77 mm
Turning Radius	1.767 m
Inner Wheel Turning Radius	1.418 m
Outer Wheel Turning Radius	2.0816 m
Coefficient off friction	0.7
Length of steering wheel	300 mm
Turning Velocity of vehicle	12.5 m/s
Height of C.G of vehicle	17.35”
Mechanical Trail	46.54 mm

VI. ANALYSIS

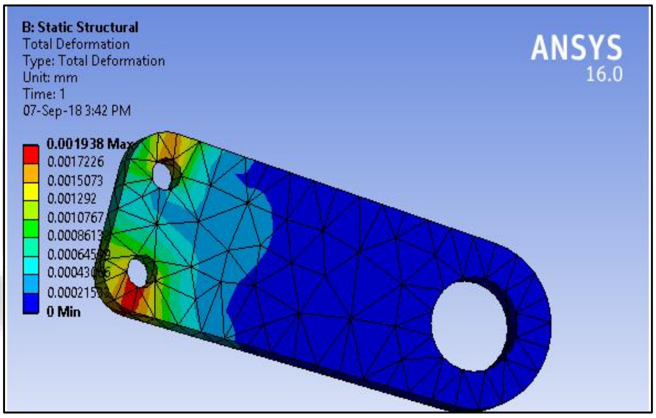

Fig. 3: Tripod analysis

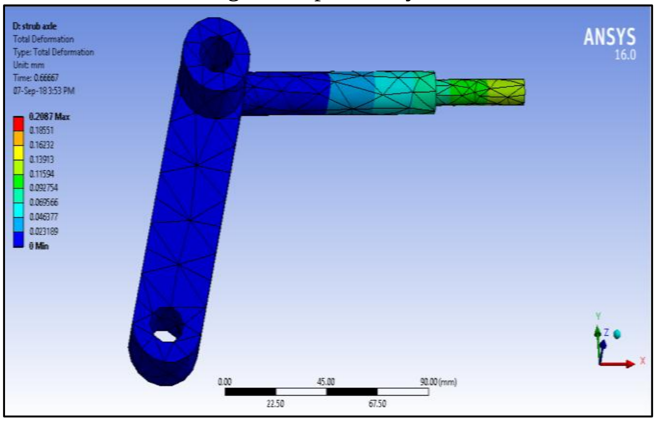

Fig. 4: Stub axle analysis

VII. STEERING GEOMETRY

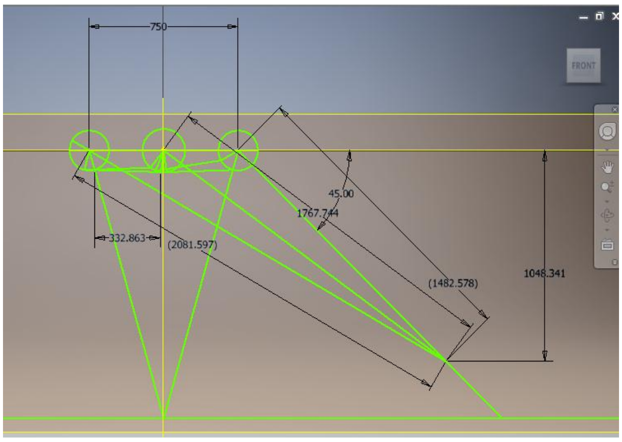

Fig. 5: Steering design

VIII. ACTUAL STEERING SYSTEM

Fig. 6: Actual steering system

IX. CONCLUSION

The manual mechanical linkages steering system is not used in heavy weight vehicles due to high axle loads, although it is simple in design and easy to manufacture, therefore it is commonly used in light weight vehicles.

The values calculated in the paper may differ practically due to steering linkages error or due to improper steering geometry, so these values are useful to understand the interdependency of the quantities on each other and to design an ideal manual mechanical linkages system for the vehicle.

Practical values are decided by the trial and error method.

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