Design and manufacturing of a system to measure the turning radius of Vehicle

Dishank Bari[1], Ankitkumar Wahane[2], Prakash Hakke[3], Prashant Tripathi[4], Shubham Suryawanshi[5]

[1]*Student, Mechanical Engineering, MET's BKC IOE Nashik, Maharshtra, India*, ***dishankbari@gmail.com***
[2]*Student, Mechanical Engineering, MET's BKC IOE Nashik, Maharshtra, India*, ***ankiboy94@gmail.com***
[3]*Student, Mechanical Engineering, MET's BKC IOE Nashik, Maharshtra, India****Prakash.hakke@gmail.com***
[4]*Student, Mechanical Engineering, MET's BKC IOE Nashik, Maharshtra, India*, ***prashanttripathi17@gmail.com***
[5]*Asst. Professor Mechanical Engineering.MET's BKC IOE Nashik, Maharshtra, India*,
shubhamsuryawnashi255@gmail.com

Abstract

Production cars are designed to understeer and rarely do they over steer. If a car could automatically compensate for an understeer/over steer problem, the driver would enjoy nearly neutral steering under varying operating conditions. Four-wheel steering is a serious effort on the part of automotive design engineers to provide near-neutral steering. Also in situations like low speed cornering, vehicle parking and driving in city conditions with heavy traffic in tight spaces, driving would be very difficult due to vehicle's larger wheelbase and track width. Hence there is a requirement of a mechanism which result in less turning radius and it can be achieved by implementing four wheel steering mechanism instead of regular two wheel steering.

Our 4 Wheel Steering System gives 39.56% reduction in turning circle radius of a hatchback which is reduced from 4.6 m to 2.78 m, considering Maruti Suzuki ALTO 800 as a standard car for our calculationswhich gives much better maneuverability and control on the car even while driving at high speeds

Index Terms: *Steering Mechanism, Turning Radius, 4WS, 2WS,Wheel Configurations, Four Wheel Steering.*

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Nomenclature

L-Wheelbase (mm)
R-Turning radius (mm)
a_2-Distance of CG from rear axle (mm)
δ_{if} - Inner angle of front tire (degree)
δ_{of} -Outer angle of front tire (degree)
δ_{ir}- Inner angle of rear tire (degree)
δ_{if} Outer angle of rear tire (degree)
R_1- Distance between instantaneous centre and the axis of the vehicle (mm)
W_f- Load on front axle (kg)
W - Total weight of car (kg)
C_1- Distance of instantaneous centre from front axle axis (mm)
C_2- Distance of instantaneous centre from rear axle axis (mm)
w_f- Front track width (mm)
w_r- Rear track width (mm)
δ - Total steering angle of the vehicle (degree)
δ_i- Total inner angle of the vehicle (degree)
δ_o- Total outer angle of the vehicle (degree)

1. INTRODUCTION

Four wheel steering is a method developed in automobile industry for the effective turning of the vehicle and to increase the manuverbility. In a typical front wheel steering system the rear wheels do not turn in the direction of the curve and thus curb on the efficiency of the steering. In four wheel steering the rear wheels turn with the front wheels thus increasing the efficiency of the vehicle. The direction of steering the rear wheels relative to the front wheels depends on the operating conditions. At low speed wheel movement is pronounced, so that rear wheels are steered in the opposite direction to that of front wheels. At high speed, when steering adjustments are subtle, the front wheels and the rear wheels turn in the same direction.By changing the direction of the rear wheels there is reduction in turning radius of the vehicle which is efficient in parking, low speed cornering and high speed lane change. In city driving conditions the vehicle with higher wheelbase and track width face problems of turning as the space is confined, the same problem is faced in low speed cornering. Usually customers pick the vehicle with higher wheelbase and track width for their comfort and face these problems, so to overcome this problem a concept of four wheel steering can be adopted in the vehicle. Four wheel steering reduces the turning radius of the vehicle which is effective in confined space, in this project four wheel steering is adopted for the existing vehicle and turning radius is reduced without changing the dimension of the vehicle.

2.LITERATURE REVIEW

The most effective type of steering, this type has all the four wheels of the vehicle used for steering purpose. In a typical front wheel steering system the rear wheels do not turn in the direction of the curve and thus curb on the efficiency of the steering.

Condition for True Rolling

While tackling a turn, the condition of perfect rolling motion will be satisfied if all the four wheel axes when projected at one point called the instantaneous center, and when the following equation is satisfied:

$$\cot Ø - \cot\theta = c/b$$

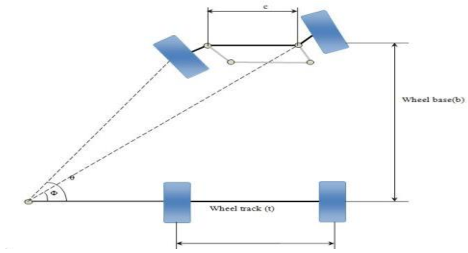

Fig 1: True Rolling Condition

Slow and High Speed Modes

At Slow Speeds rear wheels turn in direction opposite to that of front wheels. This mode is used for navigating through hilly areas and in congested city where better cornering is required for U turn and tight streets with low turning circle which can be reduced as shown in Fig 2.

Fig 2: Slow Speed

At High Speeds, turning the rear wheels through an angle opposite to front wheels might lead to vehicle instability and is thus unsuitable. Hence the rear wheels are turned in the same direction of front wheels in four-wheel steering systems. This is shown in Fig 3.

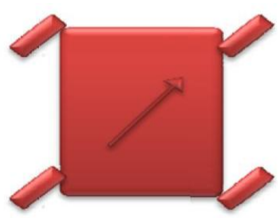

Fig 3: High Speed

In-Phase and Counter-Phase Steering

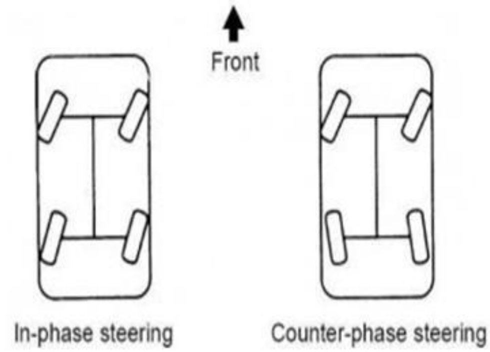

Fig 4: In-Phase and Counter-Phase Steering

The 4WS system performs two distinct operations: in- phase steering, whereby the rear wheels are turned in the same direction as the front wheels, and counter phase steering, whereby the rear wheels are turned in the opposite direction. The 4WS system is effective in the following situations:

- ✓ Lane Changes
- ✓ Gentle Curves
- ✓ Junctions
- ✓ Narrow Roads
- ✓ U-Turns
- ✓ Parallel Parking

3. THEORETICAL COMPARISON BETWEEN 2WS AND 4WS

Calculations:

ALTO 800

The data of vehicle considered are,

Wheel base:- (L)=2360 mm

Wheel track:- (W_f)=1300 mm(approx.)

Turning radius:-4.6 m= 4600 mm

Four wheel steering system

Calculation for steering angles for the turning radius of 4.6 m.

We know that,

$R^2 = a_2^2 + R_1^2$------(1)

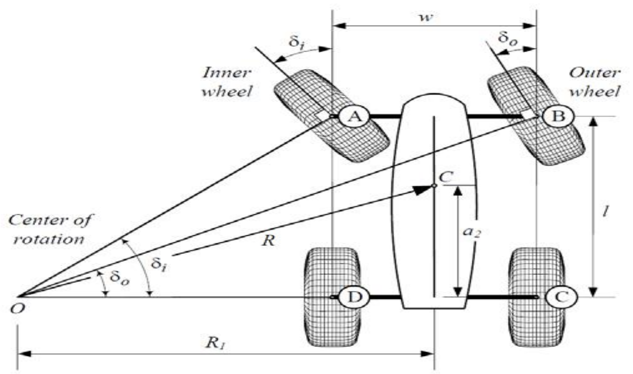

Fig-5:Geometry of Two Wheel Steering

To find a_2,

$W_f=(W*a_2)/L$ ------(2)

a_2 =1416 mm

∴From equation (1),

R_1 = 4376.6361 mm

To find steering angles,

From experiment we found the angle of tyre,

$\partial_{if} = 25.6°$

$\tan\partial_{if}=C_1/(R_1-(W_f/2))$ ------(3)

∴$\tan 25.6 = C_1/(4376.6361- (1300/2))$

C_1 = 1785.50 mm And

$C_1+C_2=L$ ------(4)

∴$C_2= L – C_1$

C_2 = 574.5 mm

To find ∂_{of}

$\tan \partial_{of}=C_1/(R_1+(W_f))$ ------(5)

∂_{of} = 19.6°

To find ∂_{ir}

$\tan\partial_{ir}=C_2/(R_1-(W_r/2))$ ------(6)

∂_{ir}=8.7637°

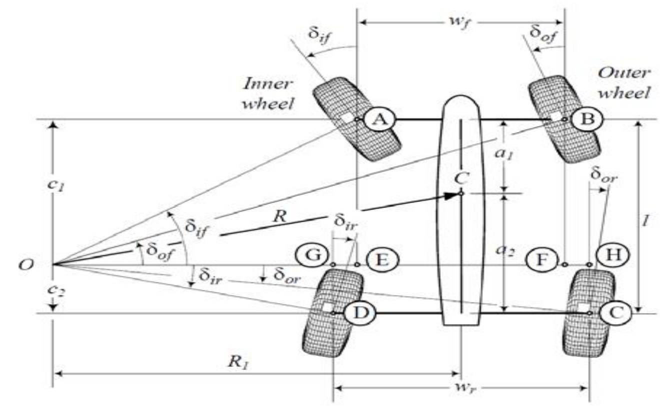

Fig-6: Geometry of Four Wheel Steering

To find ∂_{or}

$\tan\partial_{or}=C_2/(R_1+(W_f/2))$ ------(7)

∂_{or} = 6.5201°

Now, considering the same steering angle for front and rear wheel, we reduce in turning radius of the vehicle but keeping the wheelbase and track width same as reference vehicle.

Now, $\partial_{if} = \partial_{ir}$ =25.6° and

$\partial_{of} = \partial_{or}$ =19.56°

∴$\partial_i = \partial_{if} +\partial_{ir}$ = 25.6°+25.6° =51.2°

$\partial_o = \partial_{of}+\partial_{or}$ = 19.56°+19.56° = 39.12°

∴To find cot ∂,

$\cot \partial = (\cot \partial_i+\cot\partial_o)/2$ ------(8)

$\cot \partial = (\cot 51.2+\cot 39.12)/2$

∴$\cot \partial = 1.01682$

To find turning radius R,

$R^2 = a_2^2 + L^2\cot^2\partial$ ------(9)

R = 2786.32 mm

R= 2.78m

Now same step is to find the C_1 and C_2,

∴From equation (1),

$R^2 = a^2 +R_12$

∴$R_1^2 = R^2 – a^2$

R_1 = 2.4 m

∴From equation (3),

tan ∂_{if} = {C_1/2.4-(1.3/2)}

∴C_1= 0.8385 m

C_1 = 838.5 mm

and, $C_1 + C_2 = L$

∴C_2 = L- C_1

∴C_2 = 2360-838.5

C_2 = 1521.5 mm

Table 1: Comparison between 4WS and 2WS

Turning Radius	Four wheel steering	Two wheel steering
By calculation	2.78 m	4.6 m

4. CONCLUSION

From the kinematic analysis it is evident that the turning radius of the vehicle can be reduced up to 39.56% by using four wheel symmetric steering system without crossing the practical limitations.

5. FUTURE SCOPE

Having studied how 4WS has an effect on the vehicle's stability and driver maneuverability, we now look at what the future will present us with. The successful implementation of 4 Wheel Steering using mechanical linkages & single actuator will result in the development of a vehicle with maximum driver maneuverability, uncompressed static stability, front and rear tracking, vehicular stability at high speed lane changing, smaller turning radius and improved parking assistance. Furthermore, the following system does not limit itself to the benchmark used in this project, but can be implemented over a wide range of automobiles, typically from hatchbacks to trucks. This coupled with an overhead cost just shy of Rs. 15,000 provides one of the most economical steering systems for improved maneuverability and drivers‟ ease of access. With concepts such as "ZERO TURN" drive as used in "Tata Pixel" and "360^o Turning" used in "Jeep Hurricane", when added to this system, it will further improve maneuverability and driver's ease of access.

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BIOGRAPHIES

Dishank Bari is pursuing his Bachelor of Engineering (Mechanical Engineering) from MET's Bhujbal Knowledge City, Nashik .This is his first journal publication. He is leader of the project group.He has volunteered technical events under MESA at college level.Apart from these,he has also done technical internship at KLT Pvt Ltd in June 2012.He has a profound knowledge on AUTOCAD 2012 and ANSYS. Currently he is in final year of engineering.Email:dishankbari@gmail.com

AnkitWahane is pursuing his Bachelor of Engineering(Mechanical Engineering) from MET's Bhujbal Knowledge City,Nashik.This is his first journal publication.He has also volunteered technical events at college level. Apart from these,he has also done technical internship at NPCIL(Nuclear Power Corporation India Ltd.),Tarapur. Currently he is in final year of engineering.Email:ankyboy94@gmail.com

Prakash Hakke is pursuing his Bachelor of Engineering(Mechanical Engineering) from MET's Bhujbal Knowledge City, Nashik.This is his first journal publication. At college level he has worked as a secretary for MESA(Mechanical Engineer Student Association).He has also volunteered technical events at college level. Apart from these, he has also done technical internship at Nuclear Power Corporation India Ltd (NPCIL) in Dec 2013 and Electrical Loco Workshop Bhusawal in Jan 2015. He has a profound knowledge on Mastercam and ANSYS. Currently he is in final year of engineering.Email:prakash.hakke@gmail.com

PrashantTripathi is pursuing his Bachelor of Engineering(Mechanical Engineering) from MET's Bhujbal Knowledge City,Nashik.This is his first journal publication.At college level he has worked as a treasurer for MESA(Mechanical Engineer Student Association).He has also

volunteered technical events at college level.Apart from these, he has also done technical internship at JINDAL STEELS,Vasind in June 2014.He has a profound knowledge on Mastercam and ANSYS.Currently he is in his final year of engineering.Email:prashanttripathi17@gmail.com

Prof.ShubhamSuryawanshi is pursuing Ph.D. in Mechanical Engineering from SPPV, Pune. He did his Bachelor of Engineering (Mechanical Engineering) and. Masters of Engineering (Design Engineering) from SPPV, Pune. He has 6 years of teaching experience. He has published more than 12 research papers in National/International Conferences & Journals, and handled conferences as a session chair. He is the member of IIIE, SMFRA. He is the mentor for this project. Currently he is working as an Assistant Professor at MET's IOE, Nashik. His main areas of interests include Design, Vibration Analysis, Tribology,AutomobileEngineering. Email:shubhamsuryawanshi255@gmail.com