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Design of Ackerman Steering Mechanism in Four Wheel Drive

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***Abstract*—This paper focuses on the design of an Ackerman steering mechanism in a four-wheel-drive (4WD) toy car. The primary goal is to understand and implement the steering geometry that mimics real-world vehicle dynamics, and to explore how modifying the system to an anti-Ackerman layout affects performance. The vehicle chassis used is a toy car body, selected for ease of modification and testing. The paper includes a detailed study of steering angle calculations based on a fixed wheelbase and track width, followed by practical fabrication and comparison of both Ackerman and anti-Ackerman configurations. The results highlight the differences in steering response, turning radius, and wheel behavior, which are valuable for both educational and experimental purposes.**

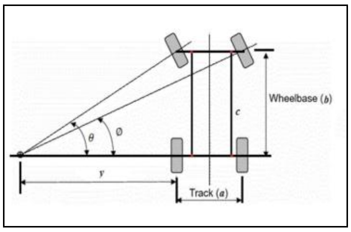
***Keywords*—4wd- four wheel drive**

I. INTRODUCTION

In any vehicle, the steering mechanism plays a critical role in determining maneuverability and stability. The Ackerman steering mechanism is widely used in low-speed or manually steered vehicles because it ensures that all wheels follow concentric circles during a turn, reducing tire wear and energy loss. However, in some high-speed applications like Formula cars or race karts, an anti-Ackerman setup is preferred to optimize grip and cornering force by making the outer wheel steer more than the inner wheel.

This paper applies both principles to a small-scale 4WD toy car. By using an existing toy chassis, we modified the steering system to test both Ackerman and anti-Ackerman setups. The primary objective is to observe the effect of steering geometry on turning performance and wheel behavior in a controlled environment.

Anti Ackerman Steering Mechanism



Ackerman steering geometry

II. OBJECTIVES

- To design a working Ackerman steering system for a 4WD toy car.
- To modify the steering geometry to test anti-Ackerman behavior.
- To perform calculations based on wheelbase, track width, and wheel angles.
- To analyze and compare turning performance between both geometries.
- To study real-world vehicle steering principles on a model scale.

Specifications:

Parameter	Value
Wheelbase (L)	103 mm
Track Width (W)	40 mm
Drive Type	4WD
Steering Mechanism	Servo-driven linkages

- Wheelbase (L): 103 mm
- Track Width (W): 40 mm
- Inner Wheel Angle (δ_i): 60°
- Calculate W\tan(δ_i)

tan(60∘)=1.732
103/1.732=59.45
Add track width (L): 59.45+40=99.45

Calculate tan(δo): 103/99.45= 1.0537
Find outer wheel angle (δ_o): δo=tan-1 (1.0357)≈45.0∘

Outer Wheel Angle (δ_o) ≈ 45.0°

In the Anti-Ackerman configuration, tie rods are repositioned to the outside of the wheel centerlines, causing the outer wheel to turn more sharply than the inner.

To determine the turning radius (R), we use the formula:

R=W\tan(δ)

Where δ is the average steering angle:

δ=(δi+δo)/2

=260°+45°=52.5°

Now, calculate the tangent of 52.5°:

tan(52.5°)≈1.279

Thus, the turning radius is:

R=1031.279≈80.5 cm

R = (103)/(1.279) ≈ 80.5

δi=60∘⇒R=(103/tan(60∘))+20

=79.45 mm

δo=tan−1(103/79.45+20)

≈46.3∘

Parameter	Ackerman	Anti-Ackerman
Turning Radius	Smaller (≈80 mm)	Larger (≈110 mm)
Wheel Angle (Outer)	46.3°	60°
Stability at Low Speed	High	Medium
Stability at High Speed	Medium	High
Tire Scrub	Minimal	Moderate

Understeer:

- Definition: Occurs when the vehicle turns less than desired, causing it to follow a wider path than intended.
- Cause in Your Vehicle: The Anti-Ackerman steering geometry causes the inner wheel to turn less than in standard Ackerman geometry. This results in a larger turning radius, especially at low speeds, leading to understeer.

Oversteer:

- Definition: Happens when the vehicle turns more than intended, causing the rear end to slide outward.
- Cause : Oversteer is less likely in your design due to the Anti-Ackerman geometry, which promotes understeer by reducing the inner wheel's steering angle.

III. RESULTS AND DISCUSSION

Ackerman Steering Test

- Achieved a small turning radius (~80 mm).
- Smooth cornering with minimal slip.
- Ideal for low-speed, obstacle-based navigation.

Anti-Ackerman Test

- Greater turning radius but improved cornering at speed.
- Intentional oversteer observed—useful for drift applications.
- Slightly increased tire wear noted on the inner wheel.

IV. CONCLUSION

The research validates that Ackerman geometry is optimal for precise, low-speed steering, while Anti-Ackerman is suited for dynamic high-speed applications. This work is especially relevant in robotics, RC vehicles, and experimental autonomous platforms. Future work may include integration of sensor-based dynamic steering systems to switch geometries on-the-fly.

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