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Study and Design of Four Bar Link Steering System

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Abstract – Various steering systems are used in automobiles. Among these systems rack and pinion is commonly use. As per the safety concern, a perfect, reliable, and cost-effective steering system is needed in society. The present invention provides a novel steering system. The proposed system uses a hub for smooth transmission, Skeleton to reduce cost, wear and tear, and light in weight. No leakage of power steering fluid, magnetic joints to reduce vibration and directional stability by using Bell Crank Lever mechanism. By making the above changes in steering mechanism achieved a low-cost steering system, reduction in vibration and wear and tear, precise steering stability, high comfort and good reliable steering system. This steering system is very useful in the automobile industry to increase productivity.

Key Words: steering systems, Mechanical Damper, CATIA V5 Software.

I. INTRODUCTION

A steering system is a group of parts that transmit the movement of the steering wheel to the front, and sometimes the rear, wheels. The primary purpose of the steering system is to allow the driver to guide the vehicle. When a vehicle is being driven straight ahead, the steering system must keep it from wandering without requiring the driver to make constant corrections. The steering system must also allow the driver to have some road feel (feedback through the steering wheel about road surface conditions). The steering system must help maintain proper tire-to-road contact. For maximum tire life, the steering system should maintain the proper angle between the tires both during turns and straight-ahead driving. The driver should be able to turn the vehicle with little effort, but not so easily that it is hard to control. Two main types of steering systems are used on modern cars and light trucks: the rack-and-pinion system and the conventional, or parallelogram linkage, steering system. On automobiles, the conventional system was the only type used until the 1970s. It has been almost completely replaced by rack-and-pinion steering. Many light trucks continue to use the conventional system. The two types of systems are discussed below. Among these two systems, Rack and pinion is the most preferred system.

There are some drawbacks in existing systems like vibration, product cost, maintenance cost, bulky, less reliability and complicated structure. To eliminate these drawbacks research and development department of the automobile engineering sector still working. [1]

II. BACKGROUND THEORY

The first automobiles were steered with a tiller, but in 1894, Alfred Vacheron took part in the Paris–Rouen race with a Pan hard 4 hp model which he had fitted with a steering wheel. Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion). This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm. BMW began to use rack and pinion steering systems in the 1930s, and many other European manufacturers adopted the technology. American automakers adopted rack and pinion steering beginning with the 1974 Ford Pinto.[2]

III. ANALYTICAL CALCULATIONS

Ackerman Steering Principle: This principle defines the geometry that is applied to all vehicles (two Or Four-wheeler drives) to enable the correct turning angle of the steering wheels to be generated when negotiating a corner or a curve. Before this principle was developed the vehicles of the time (horse drawn) were fitted with parallel steering arms and suffered from poor steering performance. A Mr. Rudolf Ackerman is credited with working out that using angled steering arms would cure these vehicles of such steering problems. **It is considered that the steering system which satisfy Ackerman principle is a perfect steering system.**[3]

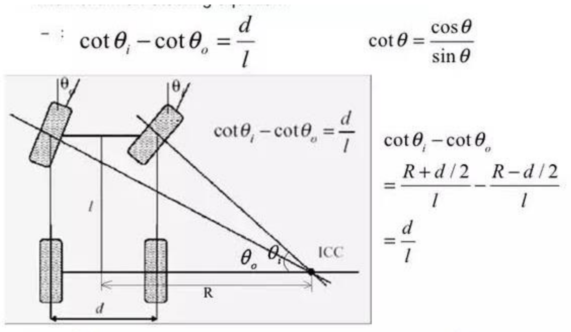

Figure:01 Ackerman principle

1. **Design consideration**
   - Wheel base (B)= 2570 mm
   - Turning radius = 5200 mm
   - Track width(L) = 1505 mm
   - Inner tire angle = 30^0
   - Outer tire angle = 24.789^0
   - Steering ratio = 6

- Skelton links travel = $46.22\ mm$
- King pin angle = 8^0
- Caster angle = 1.14 degree
  Where,
  θ_0 = turning angle of the wheel on the outside of the turn
  θ_i = turning angle of the wheel on the outside of the turn
  B = wheel base
  L = track
  b = distance from rear axle to center of mass

2. Steer angle

- Steering wheel diameter = 356 mm, 51 mm thick
- Inner steering angle = 30^0
- Outer steering angle = 24.789^0

3. Steering Ratio

Approximate maximum turn to be 30^0 & steering wheel movement to be 180^0 the steering ratio calculate
S.R = 180/30 = 6

4. **Angle Calculations**

Requirement of outer and inner angle of wheel will be satisfied by 4 bar link steering system. Angular motion of first magnet is transferred by repulsion phenomenon to second magnet as the second magnet turned by specific angle at that position achieve the steering means rotation of wheel which is evident in table1. It is as simple rotation of screw is directly proportional to rotation of gear and aging if nut is mesh with screw, then nut also make same rotation. Following table provide angle of inclination inner wheel with respect to steering wheel.

Steering wheel	**Motor gear, screw gear**	**Rotation of hub**	**Motion of link connected to magnet In mm**	**Angle of tire**	**Angle of magnet**
22.5^0	3.560^0	3.560^0	2.85^0	4.25^0	7.5^0
45^0	7.12^0	7.12^0	5.7^0	8.5^0	15^0
67.5^0	10.68^0	10.68^0	8.55^0	12.75^0	22.5^0
90^0	4^0	4^0	11.4^0	17^0	30^0

Table: 1 Angle Calculations

Note: above readings are for left turn and angle of tire, which is outer wheel while turning.

Simultaneously: other wheel is inner tire for left turn so that additional angle provide to road wheel by second magnet this is achieve by bell crank lever mechanism.

- **Additional angles are required to inner wheel**

Tire	**2 magnets**
5.5^0	**9.7^0**
11^0	**19.41^0**
16.5^0	**29.11^0**
22^0	**38.82^0**

Table: 2 Additional Angle Calculations for inner wheel

- **Additional angle given to second magnet for maximum angle at inner wheel**

Additional angle
2.2^0
4.41^0
6.61^0
8.82^0

Table: 3 Additional Angle Calculations for outer wheel

This angle is produced by bell crank lever which is operated by opposite side magnet power.

FOR LEFT TURN

For Inner Wheel		For Outer Wheel	
Magnet2	**Magnet1**	**Magnet1**	**Magnet2**
9.7^{0}	7.5^{0}	7.5^{0}	7.5^{0}
19.47^{0}	15^{0}	15^{0}	15^{0}
29.11^{0}	22.5^{0}	22.5^{0}	22.5^{0}
38.82^{0}	30^{0}	30^{0}	30^{0}

Table: 4 Angle Calculations

FOR RIGHT TURN

For Inner Wheel		For Outer Wheel	
Magnet 2	**Magnet1**	**Magnet1**	**Magnet 2**
7.5^{0}	7.5^{0}	7.5^{0}	9.7^{0}
15^{0}	15^{0}	15^{0}	19.41^{0}
22.5^{0}	22.5^{0}	22.5^{0}	29.11^{0}
30^{0}	30^{0}	30^{0}	38.82^{0}

Table: 5 Angle Calculations

IV. SCHEMATIC DIAGRAM OF PROPOSED SYSTEM

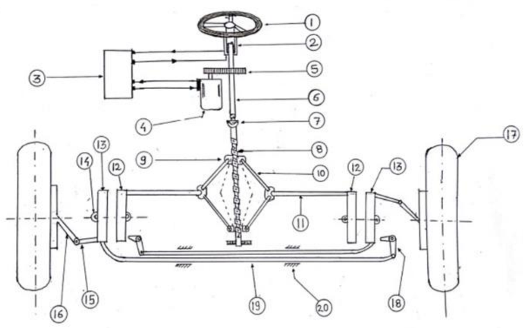

Figure:02 Ackerman principle

Name of The Component
1]Steering wheel
2]Torque Sensor
3]ECU
4]Motor
5]Gear
6]Steering Column
7]Universal Joint
8]Helical Thread
9]Skeleton
10]Tie Rod
11]First Magnet
12]Second Magnet
13]Fulcrum
14]Drag Link
15]Stub Axle
16]Wheel
17]Bell Crank Lever
18]Link

Table: 6 Components Name

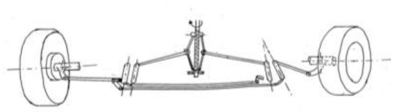

Figure:03 Front view (Right turn)

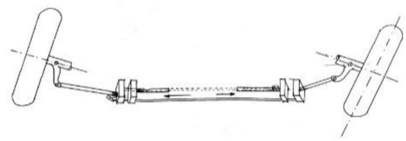

Figure:04 Top view (Right turn)

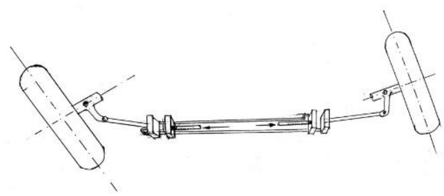

Figure:05 Front view (Left Turn)

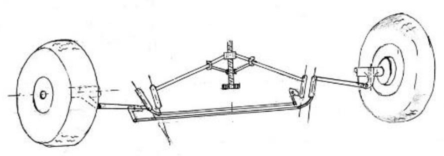

Figure:06 Top view (Turn Left)

V. ADVANTAGE

1. smooth transmission
2. skeleton to reduce cost
3. magnetic joints to reduce damping vibration
4. wear and tear
5. light in weigh
6. directional stability by using bell crank lever mechanism
7. high comfort Reliable

VI. CONCLUSION

The present research work is concluded that the above steering system is cost effective and better in performance than present steering systems. This steering system is very useful in automobile industry to increase productivity.

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Gaurang Madhukar Gulwade Researcher Received Diploma in Mechanical Engineering in 2016 From VYWS Polytechnic Badnera. Published 2 Research papers. In 2019 Completed Bachelors of Mechanical Engineering from G .H Raisoni College of Engineering and Management, Amravati.