

# 360° Rotating Vehicle to Overcome the Problem of Parking Space

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## Abstract

Modern development and economical progression of Indian society resulted in increase of cars on roads. Due to space constraints, car parking is the major problem faced in most parts of the country. Present study aims for development of a system to reduce the turning radius of a car. The indigenously developed system consists of Ackerman steering and various mechanism with arrangement of the various kinematics links. In this system at first vehicle is stopped and wheels are then turned in the required direction with the help of steering system. It has turning radius nearly equal to negligible of the length of car itself. This system can be useful in better parking, traffic jam, back turning on narrow roads, etc.

## Keywords

Kinematic Link, Brake, Parking

## I. Introduction

The advanced new technology has led to various modifications in the automobile sector. Out of these, zero degree turning radius which is being analyzed in various vehicles e.g. hurricane jeep, JCB, Nano Pixel etc [1]. The turning circle of a vehicle is the diameter described by the outside wheels when turning on full lock. There is no hard and fast formula to calculate the turning circle but it can be calculated using this; Turning circle radius =  $(\text{track}/2) + (\text{wheelbase}/\sin(\text{average steer angle}))$  [2]. Zero degree turning radius of a vehicle implies the vehicle rotating about an axis passing through the center of gravity of vehicle i.e. the vehicle turning at the same place, where it is standing. No extra space is required to turn the vehicle. So vehicle can be turned in the space equal to the length of the vehicle itself. This technology exists in heavy earth movers like excavator which consists of two parts i.e. the upper part cabin and lower part crawler chain. The upper part of excavator can rotate about its center, so that the direction of cabin can be changed without changing direction of lower part. Conventional steering mechanism involves either the use of Ackerman or Davis steering systems. The disadvantage associated with these systems is the minimum turning radius that is possible for the steering action. This difficulty that is associated with the conventional methods of steering is eliminated by employing a four wheel steering system. In this system, the wheels connected to the front axles are turned opposite to each other, and so are the wheels connected to the rear axle. The wheels on the on left half vehicle rotate in one direction and the ones on the right half of the vehicle rotate in the opposite direction. This arrangement of the wheels enables the vehicle to turn 360 degrees, without moving from the spot, i.e. the vehicle has zero turning radius. This helps in maneuvering the vehicle in tight spaces such as parking lots and within small compounds.

The various functions of the steering wheel are, to control the angular motion the wheels; direction of motion of the vehicle, to provide directional stability of the vehicle while going straight ahead, to facilitate straight ahead condition of the vehicle after completing a turn, the road irregularities must be damped to the

maximum possible extent. This should co-exist with the road feel for the driver so that he can feel the road condition without experiencing the effects of moving over it.

Automobile giants in India like Tata, Maruti, Hyundai, Honda, Ford, Mahindra and Mahindra etc. are manufacturing more than 3 million vehicles per year [3]. These companies are designing and producing varieties of models to fulfill the market competition and consumer satisfaction. The companies are emphasizing more about the ergonomics, aesthetic features, fuel economy, space available and many other features. It includes broadly power window, center lock, power brake system, power steering, tubeless tires, etc. In development of new cars, the major or minor improvements were made in every car's feature. Furthermore, manufacturing and servicing automobiles has become one of the biggest businesses. The designers endeavor to produce a vehicle, which will function at all times under all conditions and will be more comfortable to ride and easy to operate. Increased life of tires, independent front wheel suspension, four-wheel hydraulic brakes, high compression ratio, high power, use of new materials, hundreds of other changes have been made. In power steering, front wheel steering is made easier by means of hydraulic, electrical or pneumatic system. Power steering reduces efforts required for steering but can't reduce the turning circle radius of vehicle or the minimum space required for the turning of the car.

Now-a-days peoples are preferring the bigger cars that are powerful, have better aesthetic and ergonomic features and easy to drive like Ford Icon, Maruti SX4, Tata Indigo, Honda City, Mercedes Benz, Volkswagens, Nissan etc. Till recently all vehicles were steered by turning the front wheels in the desired direction, with the rear wheels following. Conventionally the front axle is the dead axle. However, these days this is true for heavy vehicles only. In four wheel drive vehicles and most of the cars, front axle is a live axle. Due to increasing demand and supply of cars, roads are over flowed by vehicles. There is severe problem of parking at home, parking at public places and multiplexes, traffic jam etc. figure below shows the above ,mentioned problems.



Fig. 1: Problem at Parking

Zero turning radius of a vehicle implies the vehicle rotating about an axis passing through the center of gravity of vehicle rather than describing a circular path as in conventional turning, i.e. the vehicle turning at the same place, where it is standing. No extra space is required to turn the vehicle. So, vehicle can be turned in the space equal to the length of vehicle itself.

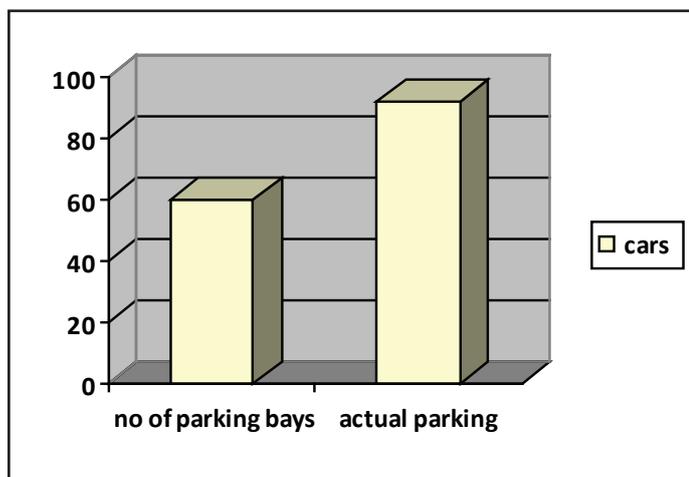


Chart 1: Data of parking space in India [5]

The literature and market survey shows that at present there is not any commercially available car, which has lifting and turning system. This paper describes the development of a system for reducing the turning radius of car. It describes the methodology of developing the system.

**II. Problem Definition**

The most frequently used type of steering, are using the front two wheels of the vehicle. This type of steering suffers from the comparatively larger turning circle and the extra effort required by the driver to negotiate the turn. Some types of industry battery trucks and industry backhoe loaders use this type, where only the two rear wheels control the steering. It can produce smaller turning circles, but is unsuitable for high speed purposes and for ease of use. Many modern cars use rack and pinion steering mechanisms. The rack and pinion design has the advantages of a large degree of feedback and direct steering feel. The recirculating ball mechanism is a variation on the older worm and sector design; the steering column turns a large screw which meshes with a sector of a gear, causing it to rotate about its axis as the worm gear is turned; an arm attached to the axis of the sector moves the Pitman arm, which is connected to the steering linkage and thus steers the wheels. At either end of the apparatus the balls exit from between the two pieces into a channel internal to the box which connects them with the other end of the apparatus, thus they are recalculated. Power steering assists the driver of an automobile in steering by directing a portion of the vehicle’s power to traverse the axis of one or more of the road wheels. As vehicles have become heavier and switched to front wheel drive, particularly using negative offset geometry, along with increases in tire width and diameter, the effort needed to turn the steering wheel manually has increased, thus power steering systems have been developed. There are two types of power steering systems, hydraulic and electric/electronic. A hydraulic-electric hybrid system is also possible. An outgrowth of power steering is speed adjustable steering, where the steering is heavily assisted at low speed and lightly assisted at high speed.



Fig. 2: Less Space for Parking

**III. Methodology**

**A. Modeling of Parts**

The parts used for fabrication of vehicle are sprockets, steering system, wheels, forks etc. mounted on rectangular chassis are shown in figures below respectively.

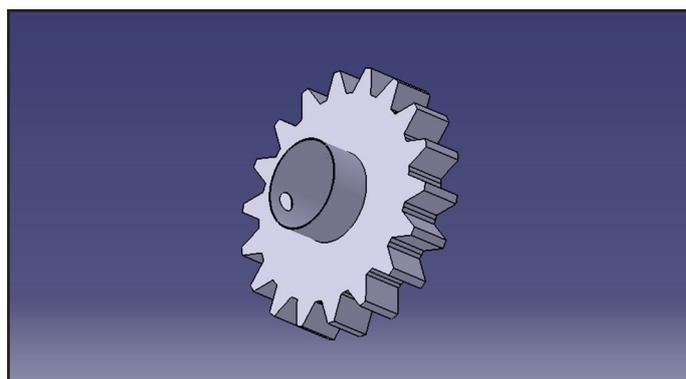


Fig. 3: Sprocket Gear

Therefore, the active system means that rear wheels are possible to be turned either coincidently or non-coincidently.

The increase of the maneuverability when parking the vehicle is achieved by means of 4 wheel steering, meanwhile the increase of the driving stability at higher speeds is achieved through concordant steering front wheels. Nevertheless, such a turn of rear wheels is very small and driver will independent. A disadvantage of this so-called passive steering system is that it operates even when driving in straight direction when single wheel of an axle hits surface irregularity. Contemporary rear axles allows for coincidental steering through the influence of variation of elasto-kinematic steering; rear wheels rotate, due to an influence of variation of vertical load of wheels (tilting), in the same direction as 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. Normally, this system has not been the preferred choice due to the complexity of conventional mechanical four wheel steering systems.

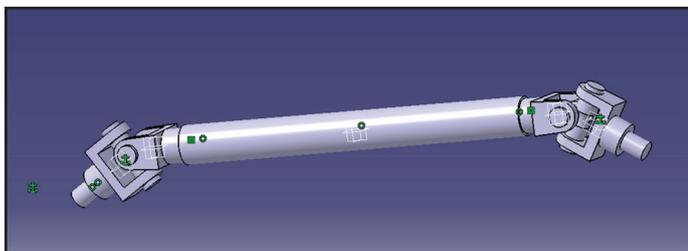


Fig. 4: Steering Rod

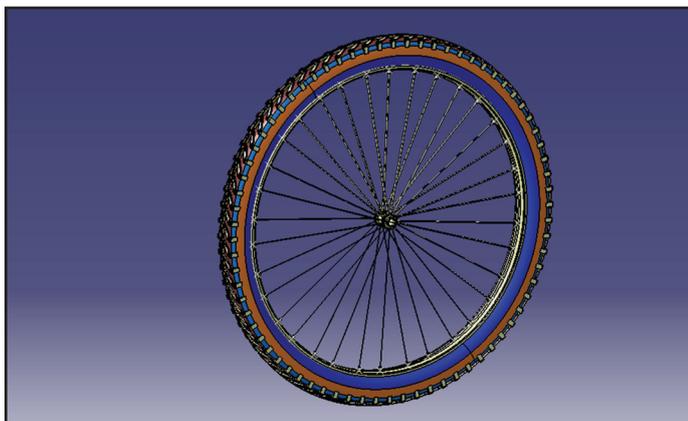


Fig. 5: Wheel

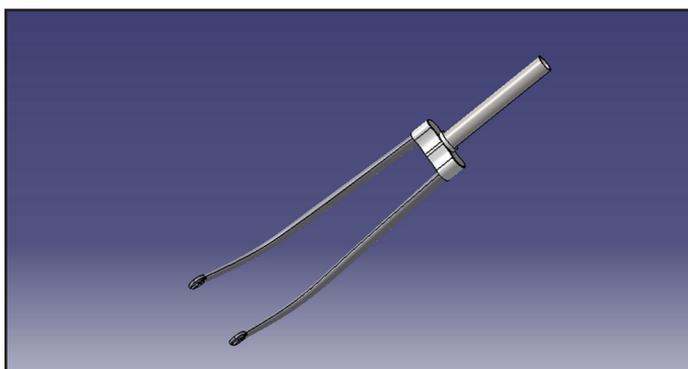


Fig. 6: Forks Used for Balancing of Tires

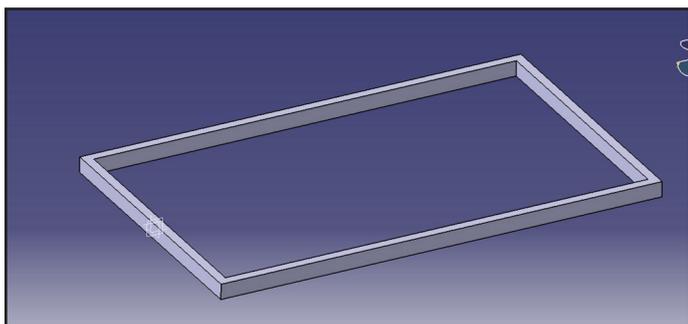


Fig. 7: Chassis

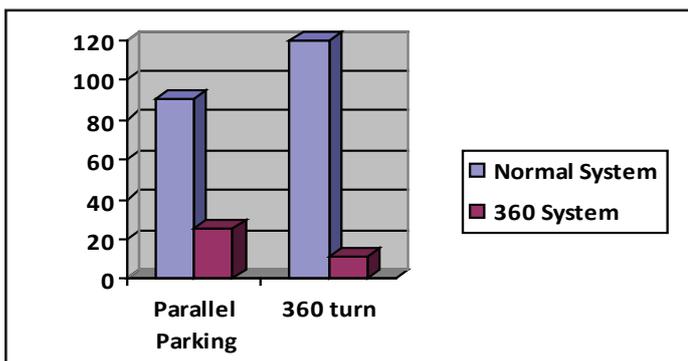


Chart 2: Testing Data of 360 Vehicle Time Taken [5]

However, a few cars like the Honda Prelude, Nissan Skyline GT-R have been available with four wheel steering systems, where the rear wheels turn by a small angle to aid the front wheels in steering. However, these systems had the rear wheels steered by only 2 or 3 degrees, as their main aim was to assist the front wheels rather than steer by themselves. With advances in technology, modern four wheel steering systems boast of fully electronic steer-by-wire systems, equal steer angles for front and rear wheels, and sensors to monitor the vehicle dynamics and adjust the steer angles in real time. Although such a complex 4WS model has not been created for production purposes, a number of experimental concepts with some of these technologies have been built and tested successfully. Two modes are generally used in these 4WS models:

**1. Tires are Rotating in Opposite Direction**

At slow speeds, the rear wheels turn in the direction opposite to the front wheels. This mode becomes particularly useful in case of pick-up trucks and buses, more so when navigating hilly regions. It can reduce the turning circle radius by 25% and can be equally effective in congested city conditions, where U-turns and tight streets are made easier to navigate.

**2. Tires are Rotating in Same Direction**

In high speeds, turning the rear wheels through an angle opposite to front wheels might lead to vehicle instability and is thus unsuitable. Hence, at speeds above 80 kmph, the rear wheels are turned in the same direction of front wheels in four wheel steering systems. For a typical vehicle, the vehicle speed determining the change of phase has been found to be 80kmph. The steering ratio, however can be changed depending on the effectiveness of the rear steering mechanism, and can be as high as 1:1.

**B. Methods used for 360° Rotation**

To facilitate turning of the vehicle the rear tires of the car should rotate at least 25-30° in the opposite direction of the front tires. To rotate tires in the opposite direction a dc motor is used as shown in the fig. 7. It also shows the steering motor. This motor helps in rotating tires to the prescribed angle necessary for the driver. Switches for both the steering motor will be in the hands of the driver so he can rotate the rear tires to the prescribed rotation angle. The steering motor configuration includes; voltage -6v, speed – 1200 rpm, power – 52 w.

For front tires, a rack and pinion arrangement is used for rotation of the tires. Normal rotation of rack and pinion arrangement ranges between 25-35° [2], to increase the rotation of the tires the length of the rack is increased keeping in mind the relation ( $\theta = 8 t/l$ , where  $t$ = track width and  $l$  = wheelbase) [2]. This relation is used in the Ackerman steering system which facilitates the rotation of the outer tires more than the inner tires as they have to cover a larger distance as compared to the inner tires. Power or simple Steering could be used as per the needs of the driver.

The drive to the vehicle is provided by a dc series motor. The configuration includes; voltage-24 v, speed-1200 rpm and power-150 w.

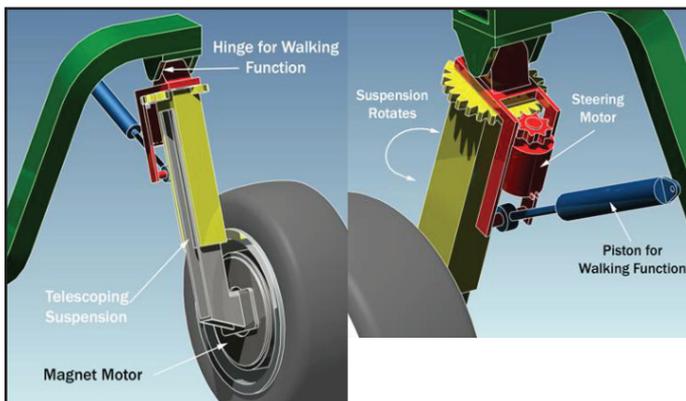


Fig. 7: Rear Wheel Design

### C. Design of the Vehicle

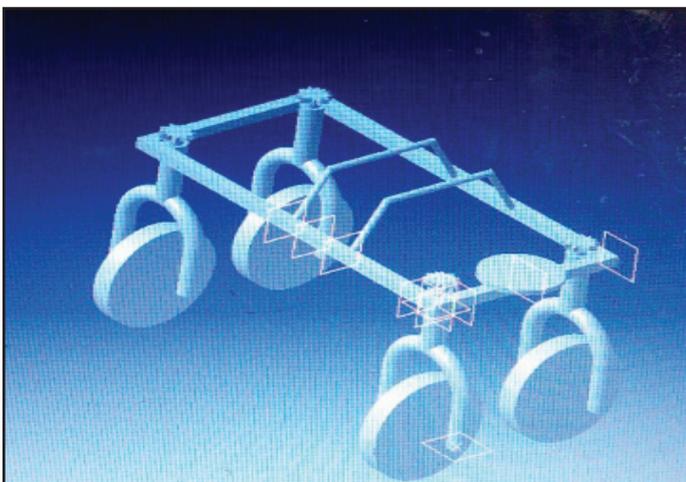


Fig. 8: Concept of Parking Vehicle Designed in CATIA V5.

### IV. Conclusion

A vehicle featuring low cost and user friendly steering mechanism has been introduced. This paper focused on a steering mechanism which offers feasible solutions to a number of current maneuvering limitations. A prototype for the proposed approach was developed by introducing separate mechanism for normal steering purpose and 360 steering purpose. This prototype was found to be able to be maneuvered very easily in tight spaces, also making 360° steering possible.

The time analysis, for the time required to perform a parallel parking maneuver and a 360 degree turn was carried out, and it was established that the implementation of the modification, led to decrease in the time required for the performance of the above operations.

The prototype was tested to ensure the conformity with same. The steer forces required on each wheel was obtained and applied. The disadvantages associated with the current prototype were the need to pull two different levers to engage the system, and the space constraints for incorporating the system.

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