Developing A System Having Zero Turn Mechanism

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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 country. Present study aims for development of a system to reduce the turning radius of a car. 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. This vehicle has all the three modes of steering described above, though it sports a truly complex drive-train and steering layout with two transfer cases to drive the left and right wheels separately. The four wheels have fully independent steering and need to turn in an unconventional direction to ensure that the vehicle turns around on its own axis.*

Keywords- Fast lane changing, Parking problem Turning radius, Zero turn mechanism.

I. INTRODUCTION

The various functions of the steering wheel are To control the angular motion the wheels and thus the 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. To minimize tyre wear and increase the life of the tyres. Depending on the number and position of the wheels being steered, steering systems can be classified as follows: Speed adjustable steering, Power steering ,Rear wheel steering ,Zero turn steering . This paper explains more about zero turn mechanism.

II. ZERO TURN MECHANISM

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 front wheels. Nevertheless, such a turn of rear wheels is very small and driver's 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 (deterioration of directional stability). New generation of active steering systems distinguishes a need of steering of rear wheels for the reason of directional stability from a need of steering of rear wheels for the reason of cornering at slow speed. 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 disconcordant steering, meanwhile the increase of the driving stability at higher speeds is achieved through concordant steering.

In a typical zero turn 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 ZERO TURN MECHANISM systems. However, a few cars like the Honda Prelude, Nissan Skyline GT-R have been available with ZERO TURN MECHANISM 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 ZERO TURN MECHANISM 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:

2.1 Slow speed - Rear Steer Mode

At slow speeds, the rear wheels turn in the direction opposite to the front wheels. This mode comes in particularly useful in case of pickup 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.

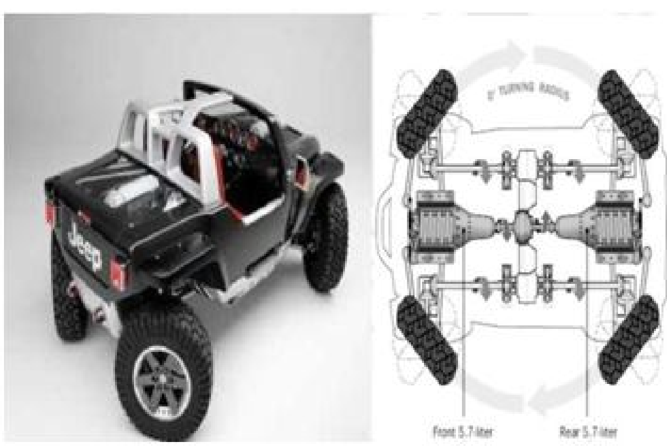
2.2 High speed

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 80 km/hr. The steering ratio, however, can be changed depending on the effectiveness of the rear steering mechanism, and can be as high as 1:1.

Such a system requires precise calculation from a servo motor with real-time feedback to make certain that all three steering modes function perfectly. The concept didn't make it to production, possibly due to the high costs involved in the power train layout. But the idea presented by the concept continues to find importance. The only major problem posed by this layout is that a conventional rack-and-pinion steering with pitman arms would not be suitable for this mode, since the two front wheels are steered in opposite directions. Steer-by-wire systems would work fine, however, since independent control can be achieved.

2.3 Zero turning circle radius - 360 Mode

In addition to the aforementioned steering types, a new type of four-wheel steering was introduced by the concept vehicle Jeep Hurricane, one that could significantly affect the way our vehicles are parked in the future. Its shown in the following FIG



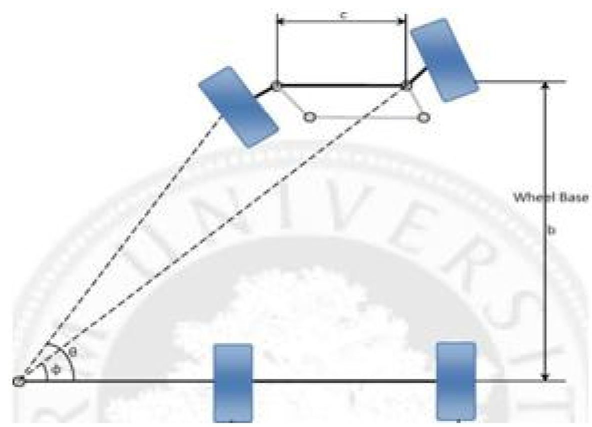
The Jeep Hurricane concept with Zero Turning Circle Radius. This vehicle has all the three modes of steering described above, though it sports a truly complex drive-train and steering layout with two transfer cases to drive the left and right wheels separately. The four wheels have fully independent steering and need to turn in an unconventional direction to ensure that the vehicle turns around on its own axis.

III. DESIGN OF ZERO TURN MECHANISM

Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii.We chose to use a simple control circuit to demonstrate the effectiveness of a ZERO TURN MECHANISM system, and at the same time, simulated the suspension-steering assembly of a typical car to predict the Ackerman angles for corresponding steer angles. The design calculation for the model follows shortly.

3.1 Condition for true rolling motion

Fundamental condition for true rolling motion , As observed from FIG 2.3, perfect steering of the wheels can be achieved only when all four wheels are rolling perfectly for all dynamic conditions. 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 centre, and when the following equation satisfied: Cot 9- cot 0= c / b ----------- ►(!)



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It is seen that the inside wheel is required to turn through a greater angle than the outer wheel. The larger the steering angle, the smaller the turning circle. It has been found that the steering angle can have a maximum value of about 44 degrees under dynamic conditions. The extreme positions on either side are called lock positions. The diameter of the smallest circle which the outer front wheel of the car can traverse and obtained when the wheels are at their extreme positions is known as the turning circle.

3.2 Benefits of ZERO TURN MECHANISM

With the 360 mode, the vehicle can quickly turn around at the press of a button and a blip of the throttle.

Complicated three-point steering maneuvers and huge space requirements to park the vehicle are entirely phased out with this. Crab mode helps simplify the lane changing procedure. In conjunction with rear steer mode, four-wheel steering can significantly improve the vehicle handling at both high and low speeds. Due to the better handling and easier steering capability, driver fatigue can be reduced even over long drives. The only major restriction for a vehicle to sport four-wheel steering is that it should have four or more wheels. Hence, every kind of private and public transport vehicle, be it cars, vans, buses, can benefit from this technology. Military reconnaissance and combat vehicles can benefit to a great extent from 360 mode, since the steering system can be purpose built for their application and are of immense help in navigating difficult terrain.

Applications:

By steering a vehicle's rear wheels as well as its front wheels, a four-wheel steering system, either mechanical or electrical, offers improved handling stability and other benefits. The 4WS/E-4WS system used by Honda 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.TheHonda4WS/E-4WS system is effective in the following situations:

3.3 Lane changes

During lane-change maneuvers at high speed, the system performs in-phase steering. This operation enables the vehicle to move in a crab-like manner rather than in a curved path. As a result, the vehicle is more stable and controllable.

3.4 High speed straight line operation

Even when travelling in a straight line at high speed, a vehicle's driver frequently needs to make small steering corrections to maintain his/her desired course. With the Honda 4WS/E-4WS system, in-phase steering of the rear wheels minimizes these corrective steering inputs.

3.5 Side wind sand other disturbance

When a vehicle is subjected to side winds, bumpy road surfaces, or other external disturbances, the driver needs to make steering corrections to maintain his/her desired course. The Honda 4WS/E-4WS system enables the driver to make these corrective steering inputs without causing significant changes in the vehicle's body attitude.

3.6 Gentle curves

On gentle curves; in-phase steering of the rear wheels improves the vehicle's stability.

3.7 Parking

During a parking maneuver, a vehicle's driver typically turns the steering wheel through a large angle to achieve a small turning radius. By performing counter-phase steering of the rear wheels, the Honda 4WS/E-4WS system realizes a smaller turning radius than is possible with a two-wheel steering (2WS) system. As a result, the vehicle is easier to maneuver into garages and other parking spaces.

3.8 Junctions

On a crossroads or other junction where roads intersect at 90 degrees or tighter angles, counter-phase steering of the rear wheels causes the front and rear wheels to follow more-or-less the same path. As a result, the vehicle can be turned more tightly as it negotiates the junction. With a 2WS system, the vehicle would need to follow a relatively curved path.

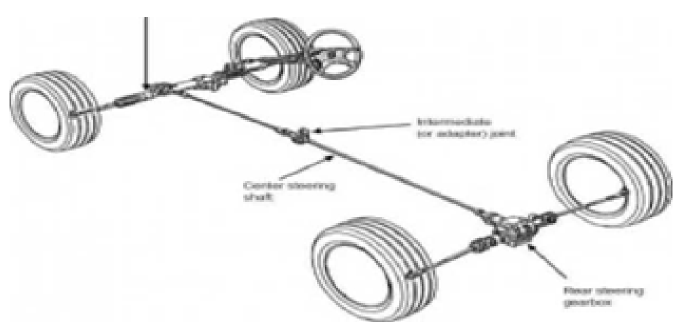
3.9 Narrow road

On narrow roads with tight bends, counter-phase steering of the rear wheels minimizes the vehicle's turning radius, thereby reducing side-to-side rotation of the steering wheel and making the vehicle easier to maneuver.

3.10 U-Turns

By minimizing the vehicle's turning radius, counter-phase steering of the rear wheels enables U-turns to be performed easily on narrow roads.

3.11 Construction and function



The main components of a Honda 4WS system are the front steering gearbox, which turns the front wheels, the rear steering gearbox, which turns the rear wheels, and the center steering shaft, which links the two gearboxes. When the steering wheel is turned, the front wheels are steered in the same way as with a 2WS system. A rack-and-pinion mechanism in the front steering gearbox transmits this movement to the rear steering gearbox via the center shaft. (The rack-and-pinion mechanism is separate from the one to which the steering wheel is connected.) Via the rear tie rods, the rear steering gearbox steers the rear wheels by the appropriate angle and in the appropriate direction.

3.12 Steering of rear wheels

When the steering wheel is turned from its straight-ahead position by an angle of 120 degree or smaller, the 4WS system performs to increase in-phase steering of the rear wheels angle. When the steering wheel angle exceeds 120 degree, the rear wheels gradually straighten up then turn in the opposite direction.

3.13 Parallel parking

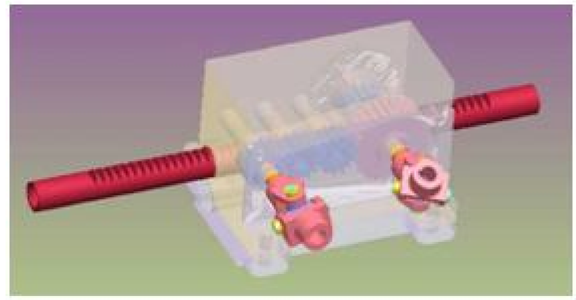
As has been discussed previously, zero steer can significantly ease the parking process, due to its extremely short turning footprint. This is exemplified by the parallel parking scenario, which is common in foreign countries and is pretty relevant to our cities. Here, a car has to park it between two other cars parked on the service lane. This maneuver requires a three-way movement of the vehicle and consequently heavy steering inputs. Moreover, to successfully park the vehicle without incurring any damage, at least 1.75 times the length of the car must be available for parking for a two-wheel steered car. As can be seen clearly, the car requires just about the same length as itself to park in the spot. Also, since the 360 mode does not require steering inputs, the driver can virtually park the vehicle without even touching the steering wheel. All he has to do give throttle and brake inputs, and even they can be automated in modern cars. Hence, such a system can even lead to vehicles that can drive and park by themselves.

3.14 High speed lane changing

Another driving maneuver that frequently becomes cumbersome and even dangerous is changing lanes at fairly high speeds. Although this is less steering-intensive, this does require a lot of concentration from the driver since he has to judge the space and the vehicles behind him. Here is how Crab Mode can simplify this action, The vehicle with arrows is our model under study. As can be seen from the above figure, the vehicle can turn with hardly any space requirement with a single steering action and also resume without any corrective inputs. Thus, it also acts as a driver aid, helping relatively inexperienced drivers make quick lane changes even at high speeds,

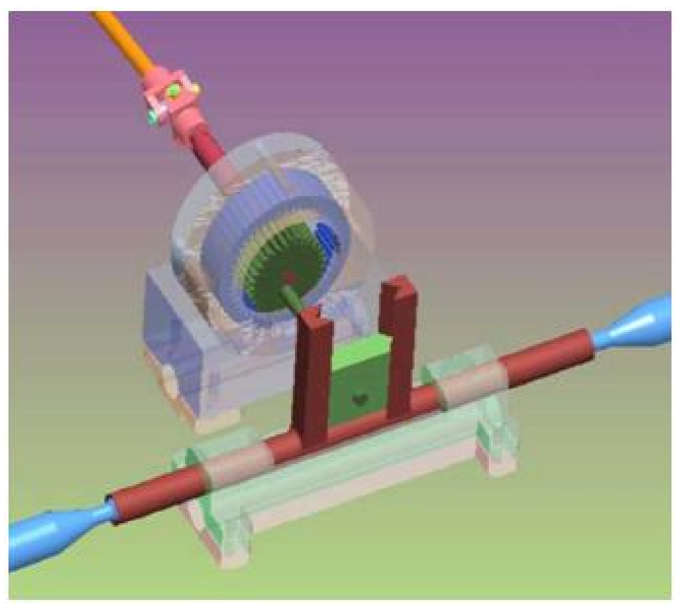
IV. ASSEMBLY DRAWING

4.1 Front gearbox assembly:



For the perfect working of planetary gear box, the required revolutins of the shaft must be 2 i.e. 720°, but in the front the required revolution is 1 i.e. 360°(for 360° lock to lock steering). Therefore front to rear gear ratio is 1:2. This ratio is achieved with a simple gear train in the front gear box with a driving pinion of PCD 56 mm and a driven pinion of PCD 28 mm, with two idle gears of PCD 28 mm. The idle gears are used to get a sufficient gap between the two shaft of the front gear box so that the Universal couplings coupled with the shafts are free to rotate without hitting each other.

4.2 Rear Assembly:



The rear steering box is basically formed from an epicyclic gear set consisting of a fixed internally toothed annular ring gear in which a planetary gear driven by an eccentric shaft revolves. Motion is transferred fron the input eccentric shaft to the planetary gear through an offset peg attatched to a disc which is mounted centrally on the eccentric shaft. Rotation of the input eccentric shaft imparts movement to the planetary gear which is forced to orbit around the inside of the annular gear. At the same time motion is conveyed to the guide fork via a second peg mounted eccentrically on the face of the planetary gear and the slider plate which fits over the peg. Since the slider plate is located between the fork fingers, the rotation of the planetary gear and peg causes the slider plate to move in both a vertical and horizontal direction. Due to the construction of the guide fork, the slider plate is free to move vertically up an down but is constrained in the horizontal direction so that the stroke rod is compelled to move transversely to and fro according to the angular position of the planetary gear and peg.

Adopting this combined epicyclic gear set with a slider fork mechanism enables a small same direction steer movement of the rear wheels to take place for small deviation of the steering wheel from the straight ahead position. The rear wheels then progressively change from a same direction steer movement into an opposite steer displacement with a large steering angles.

VI. CONCLUSION

There are three modes in 4-wheel steering each of which is individually implemented in most of the 4 wheel steering cars. Each one has its own disadvantage like use of crab mode increases the turning radius which is turn decreases the ease of maneuvering the vehicle at sharp bends, similarly rear steer mode decreases the turning radius to a greater extent, thus increases the risk of toppling of the vehicle at high speed.

Hence to overcome these problems, both the modes have been introduced together in a locomotive and its performance has been simulated and shown.

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