International Journal of Research in Engineering, Science and Management
Volume-2, Issue-4, April-2019
www.ijresm.com | ISSN (Online): 2581-5792

Design and Fabrication of Four Wheel Steering System

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***Abstract*: The cars that are designed in the industry tend to under steer or over steer. A car cannot automatically compensate for these problems, if this would have been the case ,the driver would enjoy neutral steering under different operating condition. With the help of 4 wheel steering system the automobile design engineers, would provide near neutral steering. In situations like low speed cornering, vehicle cornering and driving in heavy traffic, due to vehicles large wheel base, driving would not be feasible which gives rise to a requirement of the mechanism that reduces turning radius. This can be achieved by using 4 wheel steering mechanism, instead of the regular steering system. Four-wheel steering system is an effort on the part of automobile design engineers that aim to provide near-neutral steering. In situations like low speed cornering, parallel parking, driving in city conditions with heavy traffic. In tight spaces, driving would be difficult due to the larger vehicular wheelbase. Hence a mechanism is required which results in less turning radius. It can be achieved by implementing four wheel steering mechanism instead of the traditional regular two-wheel steering. The main aim of this project is to implement this system. In a 4 wheel steering system the rear wheels do not turn in a direction of the curve on the road and thus hamper the efficiency of the system. This system is not a preferred choice because the conventional mechanical Four wheel steering system is quite complex. However, a few cars like Honda Prelude, Nissan Skyline GT-R have been equipped with 4 wheel steering system in which the rear wheels are turned by an angle in order to help the front wheels in steering. 3 modes interchangeable 4-wheel steering is a modification of the present steering system. It is used for vehicular handling and it also assists the driver by controlling the steering angle, which makes the parking and handling easier in congested area. For meeting this application, the rear wheel would either steer in the same or in the opposite direction as the front wheel. This allows the reduction in the turning radius of the vehicle when sliding to the sideways. Our basic requirement of the project is to transmit the motion given on the steering wheels to the rear wheels to control it like the front wheels.**

After studying the actual design of the Four wheel steering mechanism, we have found that this system increases the efficiency of the traditional driving system. It makes the steering system more useful than it has ever been. We will even achieve greater vehicular stability and controllability. The steering will be quicker and easier as compared to the systems we have been using now.

***Keywords*: Efficiency, radius, vehicular, steering, mechanism, equipped, parking.**

1. Introduction

In the normal Two Wheel Steering system the rear wheels cannot turn as far the front wheels. The Four wheel steering system can enable the user to steer the vehicle according to his will i.e. only the front wheels or the rear wheels or all the wheels at the same time. This action is done with the help of an actuator. In most of the heavy duty vehicles with large wheelbase, they require large space for turning and moving. At low speed the rear wheels turn opposite to the front wheels which can be controlled electronically and also the turning degree of the rear wheels can be controlled. Especially in carrying large trailers this mechanism can be a very handy.

Four-wheel steering is a method developed for the effective turning of the vehicle and to increase the productivity of the traditional steering system. In a typical front wheel steering system, the rear wheels do not turn in the direction of the curve and thereby cause malfunctioning.

In four wheel steering the rear wheels turn with the front wheels thus increasing the efficiency of the steering system thereby, the vehicle. The direction of steering the rear wheels relative to the front wheels depends on the operating conditions of the system. 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 difficult, 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 the following: 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 quite confined due to the arrangement. Usually customers pick the vehicle with higher wheelbase and track width for comfort and face these problems, to overcome this problem a concept of four-wheel steering has to be adopted. This system reduces the turning radius of the vehicle which is effective in very confined spaces, in this project we have adopted a four wheel steering system prototype and shown the benefits of the steering system. The first vehicle to use this mechanism was a rally car Peugeot 405 during the 1988 Pikes Peak international hill climb. It is also popular in the large farm trucks and tractors.

2. Motivation

The most effective type of steering, the four wheel steering system type has all the four wheels of the vehicle used for

steering purpose unlike the traditional ones that make use of only two. Normally this system is not been the preferred choice due to complexity of manufacturing the steering systems. However, a few cars like the Honda Prelude, Nissan Skyline GT-R have been available with this system successfully. In these systems, the rear wheels turn by an angle to aid the front wheels in steering process. However, these systems steer the rear wheels by only 2-3 degrees, as their main aim was to assist the front wheels rather than steer by themselves completely. With technological advancements, modern four wheel steering systems boasts of overcoming the disadvantages of traditional steering system. Although such a complex four wheel steering model has not been created for production purposes for daily usage, a number of experimental concepts with some of these technologies have been built and tested successfully worldwide.

Usually when vehicles turn, the tires are subjected to the forces of grip, momentum, and steering input when making a movement rather than straight ahead driving. These compete with each other during steering maneuvers. With a front-steered vehicle, the rear end is always trying to catch up to the directional changes occurring in the front wheels. This causes the vehicle to sway drastically. When turning the vehicle, the driver applies a number of forces. Each of these unbalanced forces must be balanced against the other forces. The tires are subjected to calculated/uncalculated road grip and slip angle. Grip holds the vehicle's wheels to the road firmly. Input given to the steering, turns the vehicle. The car resists the motion of the turning given to it at first. This causes a tire slip angle to form. Once the vehicle begins to respond to this input given, forces generated at the corners are formed. The vehicle loses its balance as the rear wheels attempt to keep up with the forces already generated by the front tires. This is called as lag in the rear end due to the time delay between steering input and vehicle reaction.

3. Objectives

My project concentrates on the advancement in steering system of an automobile with the main objective of reducing the turning radius considerably up to 45-55%. It reduces the turning space required and provides a better sideways movement for easier parallel parking. Also it helps to reduce the driver's efforts in handling the vehicle. It aims at improving the turning efficiency of vehicle by reducing the load on the driver's hands. In a nutshell, the objectives include:

1. Parallel parking.
2. Easier turning at junctions.
3. Better handling on slippery roads.
4. High speed lane changing.
5. Improved stability of the vehicle.

4. Methodology

Design: The parts to be used in this design are as follows:
Linkages: A linkage is a mechanism formed by fastening two or more levers together. Linkages can also be designed to change the direction of a force or make two or more objects move at the same time together with the help of a specific linkage. Many different fasteners are used to connect linkages together yet allow them to move freely such as pins, end-threaded bolts with nuts, and loosely fitted rivets. There are only two general classes of linkages: simple planar linkages and complex specialized linkages. Both are capable of performing different tasks such as describing straight lines or curves and executing motions at differing required speeds. The names of the linkage mechanisms given here are varied but not universally accepted in all textbooks and references. The linkage associated with our project looks somewhat like below,

Fig. 1. Linkage

Linkages are classified according to the primary functions they serve:

- *Generation of a function:* the relative motion between the links that are connected to the frame.
- *Generation of the path:* the path of a tracer point that is made.
- *Motion generation:* the motion of the coupler link in the system

Reverse-Motion Linkage: Reverse motion linkage can make objects/force move in opposite directions relatively, this can be done by using the input link made as a lever. If the fixed pivot is at equal distance from the moving pivots, output link movement will equal the movement of the input link. Although, it will act in the opposite direction. If the fixed pivot is not bought to the center properly, the output link movement will not equal the input link movement. By selection of the position of the fixed pivot in the system, the linkage can be designed to produce a specific mechanical advantage. This linkage can also be rotated through 360°.

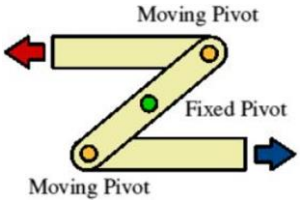

Fig. 2. Reverse-Motion Linkage

Push-Pull Linkage: Push-pull linkage, Fig. 3 (b), can make the objects or forces move in the same direction; the output link moves in the same direction of the input link. Technically a four-bar linkage can be rotated through 360° without changing its function.

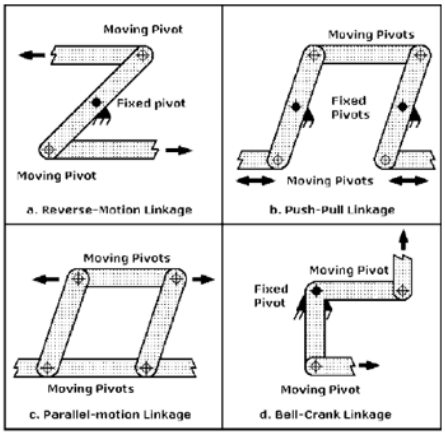

Fig. 3. Functions of four basic planar linkage mechanisms

Parallel-Motion Linkage: In figure 3 (c), can make objects or forces move in the same direction, but at a set distance apart. The moving and stationary pivots on the opposing links in the parallelogram must be equidistant for this linkage to work correctly. Technically differentiated as a four-bar linkage, this linkage can also be rotated through 360° without changing its function. Pantographs that contain power for electric trains from overhead cables are based on parallel-motion linkage. Drawing pantographs that permit original drawings to be manually copied without tracing or photocopying are also adaptations of this linkage; in its simplest form it can also keep tool trays in a plane/flat position when the toolbox covers are opened.

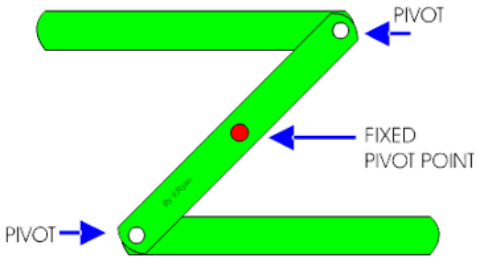

Fig. 4. Linkage

Bell-Crank Linkage: Bell-crank linkage can change the direction of objects or force by right angle. Taken linkage rang doorbells before electric clappers were invented. Lately this mechanism has been adapted for bicycle brakes. This was done by pinning two bell cranks bent right angle in opposite directions together to form tongs. By squeezing the two handlebar levers linked to the input ends of the crank, the output ends will move together. Rubber blocks on the output ends of the cranks press against the wheel rim, stopping the bicycle. If the pins which form a fixed pivot are at the center points of the cranks, link movement will be same. However, if those distances changes, mechanical advantage can be gained.

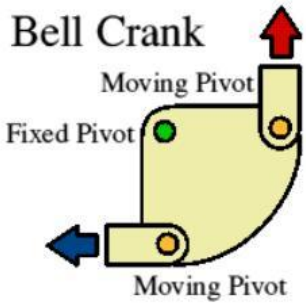

Fig. 5. Bell-Crank Linkage

Crank Rocker Mechanism: The 4 bar linkage is the simplest and often times, the most useful mechanism. As we mentioned previously, a mechanism composed of rigid bodies and lower pairs is called a linkage. In planar mechanisms, there are only 2 kinds of lower pairs -revolute pairs and prismatic pairs.

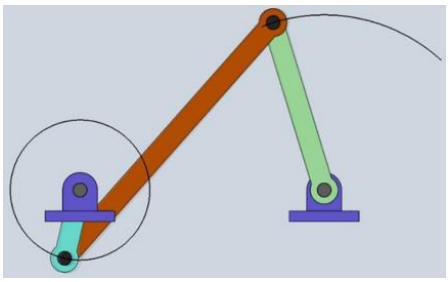

Fig. 6. Crank Rocker Mechanism

This mechanism has four moving links. Two of the links are pinned to the frame which is not shown in this picture.

Tyres: A Tire is a ring of material that covers the rim of a wheel. Most commonly used is the rubber tire. They help a vehicle to move smoothly. In this design, we will require four rubber tires. Driving with worn out tires is very dangerous. Hence, one should take proper care about the health of his tires. It causes the tire to explode and cause serious driving issues, there are many types of tires. They come in all shapes and sizes.

Eg: 225/60R16
Tire size; 225/60R16
Tire width: 225mm
Sidewall height: 225*60=135mm
Wheel diameter: 16”

Fig. 7. Tyres

Nuts and Bolts: A nut is a fastener with threaded hole. They are used in conjugation with a mating bolt to fasten many parts together. The two are kept together by combining their threads together.

A bolt is a thread fastener type with an external male thread.

Fig. 8. Nuts and Bolts

DC motor: It is a device that converts direct electrical current into useful mechanical energy.

In our project, we have used a simple DC motor of 60RPM which is enough to demonstrate the working of the four wheel steering system.

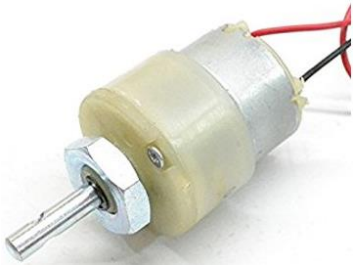

Fig. 9. DC motor

Steering: It is the assembly of various components (linkages) fastened together to allow the vehicle to pursue a desired course of path. Its primary use is to help the driver to guide the vehicle efficiently. Four wheel steering system is sued to improve steering response and give less effort to the driver's hands while driving. It is also used to decrease the turning radius of the vehicle. Also, it helps in easing the high speed lane changing.

Fig. 10. Connections

5. Importance of the project

The four wheel steering system is an important adaptation of the conventional steering system. It provides a means to actively steer the rear wheels during turning maneuvers. It should not be confused with four-wheel drive in which all four wheels of the vehicle are powered. It improves handling and helps make the vehicle tighter turns without affecting the effort required to turn the steering. Production cars that are build tend to under steer or over steer whereas the 4WS does not.

This project aims at developing a Four Wheel Steering System which would cater to the needs of the people. This system is employed to improve steering response, increase vehicle stability while maneuvering at high speed or to decrease turning radius at low speeds. The applications are varied: The ways in which the system can work is shown in the below figure.

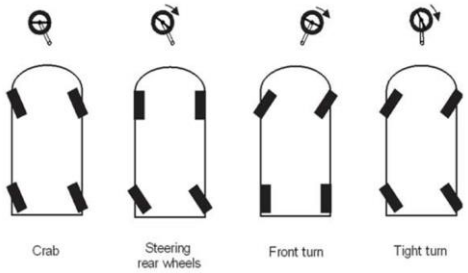

Fig. 11. Steering mechanism

6. Results and discussion

The design is expected to work better than the traditional two wheel and four wheel steering systems. It is expected to deliver better results at low speed as well as at high speed conditions. The traditional steering system impacts a great load on the driver's hands. But this design will aim at decreasing this effect and make the steering operation quite easy.

This is a special design as the conventional steering systems are already in use.

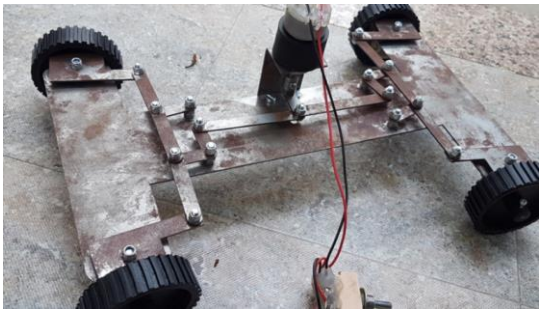

Fig. 12. Hardware setup

We expect this design to be commonly used in today's world as it has many advantages over the steering system being used today. It can be a boom to the society and can lead to an increase in the market. For countries like India, which is one of the fastest growing economy in the world this can be a very good option as it may help also on the economic front. On one side where we use the normal steering system, this four-wheel system can last more as compared. It has the ability to fulfill the demands of the customers which is the prime aim of any industry.

In India, where there is such shortage of space and so many people. Car parking is a very serious problem. With the use of four wheel steering system we can also make use of its many advantages like Parallel Parking. It takes lesser space and can easily accommodate anywhere. It increases the efficiency of the parking space. This project is based on how to deliver more output than the 2 wheel steering system which is quite obvious. The final model is as shown in fig. 12.

7. Conclusion

In today's advancing world as there are new designs being produced every day, we look forward to this project being one of the successful ones. As this project has been created before too, we expect it to work better than the others. We need to make use of this alternative design as it has so many advantages over the traditional two wheel steering system. This idea is to give light towards the better future prospects and can be used for replacing the whole obsolete design which is present in today's market.

By the analytical and experimental analysis and results we conclude that;

- Four wheel steering concept was generated.
- The four-wheel concept was simulated in SOLIDWORKS to check for functionality of mechanism.
- Working prototype was built to check if the mechanism works or not and to find the reduction in turning radius with four wheel steering when compared to two-wheel steering

Now-a-days most of the vehicles on road use the two wheel steering mechanism as their main handling system. But the efficiency of two wheel steering system is proven to be low compared to the four wheel steering vehicles. This has been employed in some vehicles to improve steering response, increase vehicle stability while moving at a certain speed, or to decrease turning radius at low speed.

In situations like low speed cornering, vehicle parking and driving in city conditions with heavy traffic in tight spaces, high speed lane changing would be very difficult due to vehicle's larger wheelbase and track with which it brings high inertia and friction into consideration. Thus, this system can now be very successful as a remedy in the above situations mentioned.

Acknowledgement

We sincerely thank our guide Dr. Jayat Patil for his guidance and constant support and also for the stick to our backs. We also thank the project coordinators for arranging the necessary facilities to carry out project work. We thank the HOD, Dr. Siddhesh Sidappa Dean Academic, and Dr. R. R. Sedamkar, Vice Principal, Dr. Deven Shah, The Principal, and Dr. B. K. Mishra and the college management for their support.

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