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Developing a System for Reducing the Turning Radius of a Car

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Abstract*—This paper aims for development of a system to reduce the turning radius of a car. The indigenously developed system consists of screw jack, gears and mechanism with arrangement of the various kinematics links. The developed system was electric motor driven. In this system at first car is lifted and then turned in the required direction. The mechanism was found sufficiently capable in turning the car in any direction without steering and has turning radius equal to the half of the length of car itself. The car can be turned back in 40 second. This system can be useful in better parking, traffic jam, back turning on narrow roads, changing of punctured wheels etc.

***Index Terms*- Turning radius, turning system, parking problem, lifting of car, back turning.**

I. INTRODUCTION

Automobiles have become a basic necessity in present world of industrialization and fast growing population. An automobile is a self propelled vehicle, which is used for road transportation of passengers and goods. The self propelled vehicle is that contains its own source of power for the propulsion, e.g., car, jeep, bus, truck etc. World's first automobile was produced in 1892. General Motors India Ltd. started their factory in Mumbai in 1928 for assembling cars and trucks. In 1930, Ford Motor Corporation of India Limited started assembly shop in Madras and in 1931 at Mumbai and Calcutta [1]. The first Indian owned motor vehicle plant started working in 1947 when Premier Automobiles Ltd. under the management of Aero Auto brought out Dodge, De Soto and Forgo trucks and buses. Soon thereafter, Hindustan Motors Ltd. managed by Birlas started assembly of CKD parts of Studebaker trucks and buses. Maruti Udyog Limited (MUL) was incorporated as a public sector company in 1981. Agreement with Suzuki Motor Corporation of Japan was signed in 1982 to make it a joint venture of Govt. of India and Suzuki and produced many new models of cars [2].

Automobile giants in India like Tata, Maruti, Hyundai, Honda, Ford, Mahindra and Mahindra etc. are manufacturing more than 3 million vehicles per year. 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, centre 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, Volks Wagon, 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. Fig. 1 shows the problem at parking and traffic jam.

Fig. 1: Problem at parking and traffic jam

In this work, main emphasis was given on developing a system for minimum turning space or turning radius of the vehicle. Cho (2009) [3] developed analytical model for

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vehicle steering returnability with maximum steering wheel angle at low speeds suggested the suspension geometry changes according to road wheel steering angle. The turning radius of an automotive vehicle is the radius of arc described by the centre of curved track made by the outside front wheel of the vehicle while making its shortest turn, as shown in Fig. 2.

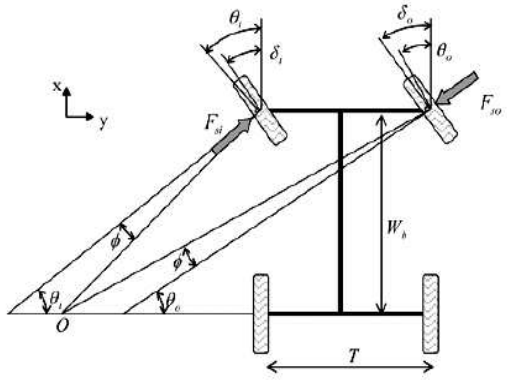

Fig. 2: Center of turning circle [3]

When a vehicle is turned, it describes a circular path and turning radius is half of the amount of space a vehicle needs in order to go round in a complete circle.

A. Zero Turning Radius Vehicles

Zero turning radius of a vehicle implies the vehicle rotating about an axis passing through the centre 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. Zero turning radiuses exists in heavy earth mover, like excavator, as shown in Fig. 3, which consists of two parts, i.e. the upper part, cabin and boom/jaw and lower part, crawler chain.

The upper part of excavator can rotate about its center, so that direction of the boom along with cabin can be changed without changing direction of lower part. It requires space equal to its length for turning, hence turning radius of the excavator, JCB is zero. But, it has some limitations, like no tyres. Another car of zero turning radius, the Jeep Hurricane [5], which has multiple steering modes using four-wheel independent steering. That means that each wheel can turn independently from the others. The vehicle has two modes of four wheel steering.

Fig. 3: Excavator from JCB with boom turning mechanism [4]

Fig. 4: Jeep Hurricane [5]

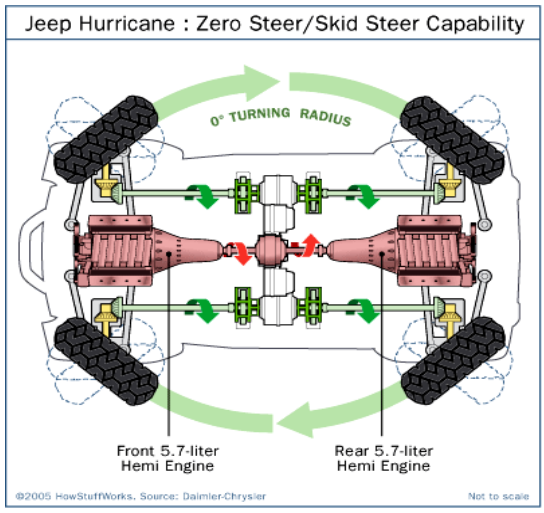

Fig. 5 Zero turning radius mechanism in zeep hurican [5]

The first traditional (standard) mode in which rear tires turns in opposite direction of the front tires, which reduces the turning circle. In the second mode, all the four wheels turns in the same direction for crab steering, causing the vehicle to move sideways without changing the direction it is pointing, thus facilitating parking in a narrow space. A third mode, utilizing the 'T-Box Zero Steer' mechanism, allows all four wheels to "toe-in" and changes the drive direction to each wheel so that they alternate. The jeep hurricane can actually rotate in place, as shown in Fig. 4 and 5. But, this car has some limitations, like steering system is very complex, skilled driver is required to operate it, two engines and two propeller shaft is used and hence more expensive and wear of tires is more.

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. Section II describes the methodology of developing the system. Section III explains the working of the developed system.

II. MATERIALS AND METHODS

A. Lifting and Turning Mechanism

In order to develop the new system for car, a model of small electric car was used. The selected model was 910 mm long, 360 mm wide and 195 mm height. Some modifications were done in the existing car by incorporating the screw jack,

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spur gears, electric motor, capacitor etc. The power screws [6] are used to convert rotary motion into translatory motion. For lifting and turning of car, two methods were proposed, the mechanical system and the hydraulic system. In this model, mechanical system was developed. A screw jack (Fig. 6) was used to develop the rising mechanism for car. At one end of the screw jack, a gear-1, which acts as the nut of the screw jack and which is free to rotate over the body of screw jack, was placed and meshed with another gear-2, which was placed on the shaft of reversible motor-2. Another end of the screw jack was attached with frame of the car by foot step bearing.

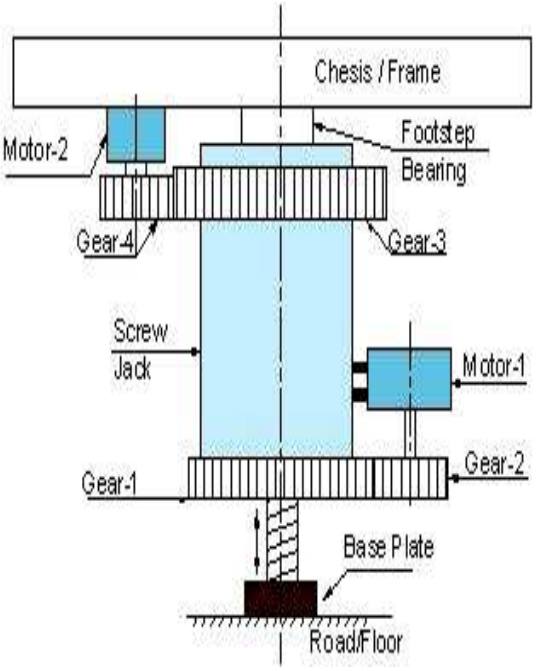

Fig. 6: Lifting and turning system

For the turning mechanism, gear-3 was fixed on the body of screw jack at another end i.e., opposite to that of gear-1. A gear-4, which mounted on the shaft of reversible motor-2, was meshed with the gear-3. The motor-2 is fixed with frame of the car. To drive the mechanism and the car, two electric motors were used.

B. Balancing Mechanism

During the lifting and turning, balancing of the car is required. There are two methods for the balancing of the car. In first method base plate (Fig. 6) is made sufficient larger for the balancing and in another method two balancing wheels are provided which are attached with the levers, operated by power of the car and balance the car. In the present work, former was used.

III. Working Of The Developed System

In the developed system, as shown in Fig. 7, when the motor-1 rotated the gear-2, meshed with gear-1, then the screw comes out and the car was lifted by 18 cm in 10 seconds. For turning, when the motor-2 was operated, then the gear-4, meshed with gear-3 rotated on its axis and around the gear-3; hence the whole car body was rotated at the required angle. Again the motor-1 was operated in reverse direction and whole car was lowered in 10 seconds.

Fig. 7: Developed system for lifting and turning

IV. Results And Discussion

The developed model of car was tested in various conditions for different applications. It was lifted by 18 cm in 10 seconds, turned back in 20 seconds and lowered in 10 seconds. So in all, it required 40 seconds in lifting, turning back and lowering. The developed system is most suitable in parking at home and multiplexes. Car can be easily removed from the tight parking of the vehicles, on the crowded roadside and in the traffic jams (Figs. 8 and 9).

Fig. 8: Parking at home [7]

Fig. 9: Nearest parking region

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Fig. 10: A woman in trouble during the wheel changing on road [8]

The automatic lifting system of the car is very helpful in changing the punctured wheel of car on road, as shown in Fig. 10. In hilly areas, where roads are very narrow and reversing of the vehicle is very dangerous, so it can be turned back using the developed system. In the developed system, lifting and lowering time is fixed, while turning time depends on the angle of turning.

V. Conclusion And Recommendations

Automobile industry is very fast growing industry and day-by-days developing the new technologies/systems that are mainly related to safety, ergonomics and efficient drive. The developed model was tested in various conditions and effectively reduced the turning radius to its minimum in the developed model. The reduced turning circle diameter (nearly about zero) has lots of advantages in daily life, such as-

- Better parking at home in narrow space and at multiplexes
- Easy removal of vehicle from the traffic jams
- Easy changing the punctured tyre,
- Turning back at narrow roads
- Use in service and maintenance etc.

The system can be developed using the hydraulic system. This can give fast response and less space is required. The developed model is recommended for inclusion in the cars.

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