International Journal For Recent Developments in Science & Technology
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A Peer Reviewed Research Journal
2581-4575

DESIGN OF MULTI DIRECTIONAL STEERING SYSTEM

P. Ravikanth Raju
Dept. of Mechanical Engineering, J. B. Institute of Engineering & Technology, Moinabad(Mdl) Hyderabad -75, India

***Abstract*- A Four Wheel steering (4WS) System is also known as ―Quadra Steering System‖. In this paper, both front as well as rear wheels can be steered according to speed of the vehicle and space available for turning. Quadra steer is system that gives full size vehicles greater ease while driving at low speed, and improves stability, handling and control at higher speed. Quadra steering system works in following three phases Negative phase, Neutral phase, Positive phase. It enables the car to be steered into tighter parking spaces. It makes the car more stable at speed (less body roll). It makes the car more efficient and stable on cornering, easier and safer lanes change when on motorways. The steering system allows the driver to guide the moving vehicle on the road and turn it right or left as desired. The main aim is that turning of the vehicle should not require greater efforts on the part of the driver.**

The Quadra steering system offers a 21% reduction in turning radius. So if a vehicle is capable of making a U-turn in a 25-foot space, Quadra steer allows the driver to do it in about 20 feet.

INTRODUCTION

Daimler-Benz had developed four-wheel drive, four-wheel steering vehicles for the Forest Service. Their rear wheels were designed to turn in the opposite direction to the front wheels so that the vehicle could make sharp turns along narrow mountain roads. However, the specification had yet to be adapted for use in mass-production units. Even though it was effective in mountain driving, manoeuvrability was less than perfect elsewhere. Consequently, these cars occasionally had stability problems while being driven on Germany's famed Autobahn.

A special committee under Japan's Ministry of Transport once examined the merits of a vehicle whose rear wheels could turn in the direction opposite that of the front wheels, as part of discussions regarding the safety of large trucks. There was mounting public concern at the time regarding the danger of transport vehicles, particularly in instances where wide left turns were called for. The committee, too, concluded that a vehicle with four-wheel steering would be less stable at high speeds. Furukawa's theoretical model substantiated these concerns, concurrently defining a direction as to how Honda should proceed. The fundamental principle identified by his model was that the front and rear wheels should turn in the same direction at high speeds and opposite directions at low speeds. "We used figures to express an ideal car," Furukawa said. "It was one that could make quick, sharp turns, for which we made the proper calculations. And this was the answer we came up with."The ideal control method for the four wheels was examined from a broader perspective, and those findings were then reflected in a concrete, theoretical model. This approach successfully outlined a 4WS system that was unlike anything before it. The principle mechanism won a basic patent in 1978, which further propelled Honda‗s development of the 4WS system.

HISTORY

As the four-wheel steering (4WS) system has great potentials, many researchers' attention was attracted

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to this technique and active research was made. As a result, passenger cars equipped with 4WS systems were put on the market a few years ago. This report tries to identify the essential elements of the 4WS technology in terms of vehicle dynamics and control techniques. Based on the findings of this investigation, the report gives an outline and perspective of the research areas involved.

TYPES OF 4WS:

There are three types of production of four-wheel steering systems:

Mechanical 4WS:

In a straight-mechanical type of 4WS, two steering gears are used-one for the front and the other for the rear wheels. A steel shaft connects the two steering gearboxes and terminates at an eccentric shaft that is fitted with an offset pin. This pin engages a second offset pin that fits into a planetary gear.

The planetary gear meshes with the matching teeth of an internal gear that is secured in a fixed position to the gearbox housing. This means that the planetary gear can rotate but the internal gear cannot. The eccentric pin of the planetary gear fits into a hole in a slider for the steering gear. A 120-degree turn of the steering wheel rotates the planetary gear to move the slider in the same direction that the front wheels are headed. Proportionately, the rear wheels turn the steering wheel about 1.5 to 10 degrees. Further rotation of the steering wheel, past the 120degree point, causes the rear wheels to start straightening out due to the double-crank action (two eccentric pins) and rotation of the planetary gear. Turning the steering wheel to a greater angle about 230 degrees, finds the rear wheels in a neutral position regarding the front wheels. Further rotation of the steering wheel results in the rear wheels going counter phase with regard to the front wheels. About5.3 degrees maximum counter phase rear steering is possible. Mechanical 4WS is steering angle sensitive. It is not sensitive to vehicle road speed.

Hydraulic 4WS:

The hydraulically operated four-wheel-steering system is a simple design, both in components and operation. The rear wheels turn only in the same direction as the frontwheels. They also turn no more than 11/2degrees. The system only activates at speeds above 30 mph (50km/h) and does not operate when the vehicle moves in reverse. A two-way hydraulic cylinder mounted on the rear stub frame turn the wheels. Fluid for this cylinder is supplied by a rear steering pump that is driven by the differential. The pump only operates when the front wheels are turning. A tank in the engine compartment supplies the rear steering pump with fluid.

When the steering wheel is turned, the front steering pump sends fluid under pressure to the rotary valve in the front rack and pinion unit. This forces fluid into the front power cylinder, and the front wheels turn in the direction steered. The fluid pressure varies with the turning of the steering wheel. The faster and farther the steering wheel is turned, the greater the fluid pressure. The fluid is also fed under the same pressure to the control valve where it opens a spool valve in the control valve housing. As the spool valve moves, it allows fluid from the rear steering pump to move through and operate the rear power cylinder. The higher the pressure on the spool, the farther it moves. The farther it moves, the more fluid it allows through to move the rear wheels. As mentioned earlier, this system limits rear wheel movement to 11/2 degrees in either the left or right direction.

Electro-hydraulic 4WS:

Several 4WS systems combine computer electronic controls with hydraulics to make the system sensitive to both steering angle and road speeds. In this design, a speed sensor and steering wheel angle sensor feed information to the electronic control unit (ECU). By processing the information received, the ECU commands the hydraulic system steer the rearwheels. At low road speed, the rear wheels of this system are not considered a dynamic factor in the steering process. At moderate road speeds, the rear wheels are steered momentarily counterphase, through neutral, then in phase with the front wheels. At high road speeds, the rear wheels turns only in phase with the front wheels. The ECU must know not only road speed, but also how much and quickly the steering wheel is turned. These three factors - road speed, amount of steering wheel turn, and the quickness of the steering wheel turn - are interpreted by the ECU to maintain continuous and desired steer angle of the rear wheels.

The basic working elements of the design of an electro-hydraulic 4WS are control unit, a stepper motor, a swing arm, a set of bevelled gears, a control rod, and a control valve with an output rod. Two electronic sensors tell the ECU how fast the car is going. The yoke is a major mechanical component of this electro-hydraulic design. The position of the control yoke varies with vehicle road speed. For example, at speeds below 33 mph (53 km/h),the yoke is in its downward position, which results in the rear wheels steering in the counter phase(opposite front wheels) direction. As road speeds approach and exceed 33 mph (53 km/h), the control yoke swings up through a neutral (horizontal) position to an up position. In the neutral position, the rear wheels steer in phase with the front wheels.

The stepper motor moves the control yoke. A swing arm is attached to the control yoke.

The position of the yoke determines the arc of the swing rod. The arc of the swing arm is transmitted through a control arm that passes through a large bevel gear. Stepper motor action eventually causes a push-or-pull movement of its output shaft to steer the rear wheels up to a maximum of 5 degrees in either direction.

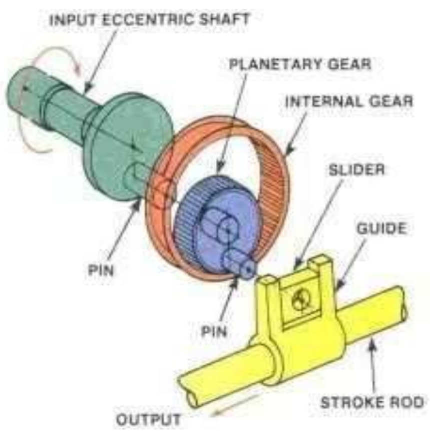

Fig-1 Mechanical 4WS

PARTS AND CALUCLATIONS:

A. CHASIS:

A chassis is the physical frame or structure of an automobile, an airplane, a desktop computer, or other multi-component device. *Case* is very similar in meaning, but tends to connote the protective aspect of the frame rather than its structure. People tend to choose one term or the other. The rest of this definition uses *chassis* but applies as well to the term *case*. Both terms are derived from the Vulgate Latin for *box*. The plural form is also *chassis*. In a computer, the chassis houses the main electronic components, including the motherboard (with places to insert or replace microchips for the main and possibly specialized processors and random access memory (RAM) and places for adding optional adapters (for example, for audio or video capabilities). Typically, room is provided for a hard disk drive and a CD-ROM drive.

The IBM PC chassis for its XT computers set an early de facto standard for a chassis configuration (sometimes referred to as the form factor). The desktop computer has since evolved through the AT model, the mini-AT, and the small-footprint PC. A later development was the vertical or tower chassis configuration, designed to be placed under a desk. The outer dimensions of a chassis are said to form its footprint. The term is not usually applied to mobile and notebook computers perhaps because the hardware components have to be more tightly integrated. Some communications devices such as terminal servers have a chassis especially designed to handle many combinations of hardware add-ons. Such a chassis is described as *modular*.

Number of square rods used to make chassis: 5 Nos.

Length of the square rods used in chassis: 39 cm

Width of chassis: 24 cm

Thickness of square rods used in chassis: 2 cm
L-angle rods:4 Nos.

Length of the L-angles: 7 cm

Width of the L-angles: 4 cm

Thickness of the L-angles: 4 mm

B. BATTERY:

The convention rack pinion steering with pitman arms are not suitable, as if the zero steering is used, the front two wheels steer in opposite direction.

Number of idler gears as well as the weight of the vehicle will increase if the distance between front and rear wheel is increased.

Relative rapid wear of wheels. Could not implement in tracked vehicles, Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge.

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Common examples are the alkaline battery used for flashlights and a multitude of portable devices. Secondary (rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current.

Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics. Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centres. According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales each year, [4] with 6% annual growth. Batteries have much lower specific energy (energy per unit mass) than common fuels such as gasoline. This is somewhat offset by the higher efficiency of electric motors in producing mechanical work, compared to combustion engines.

Battery specifications: 12 volts, 7amps.

Total battery capacity: 14 hours.

C. MOTORS:

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills.

The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Number of driving motors used: 4 Nos.

Driving motors specifications: 12 volts, 3 watts, and 30 rpm.

Number of steering motors used: 1 Nos.

Steering motor specifications: 12 volts, 6 watts, 30 rpm.

WHEELS:

A wheel is a circular component that is intended to rotate on an axle bearing. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labour in machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel, potter's wheel and flywheel.

Common examples are found in transport applications. A wheel greatly reduces friction by facilitating motion by rolling together with the use of axles. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by the application of another external force or torque.

Number of wheels: 4 Nos.

Wheel outer diameter: 10 cm

Wheel inner diameter: 8 cm

Wheel centre whole diameter: 8 mm

E. GEARS:

A gear or cogwheel is a rotating machine part having cut *teeth*, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape.[1] Two or more meshing gears, working in a sequence, are called a gear train or a *transmission*. A gear can mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a crossed belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage. When two gears mesh, ifone gear is bigger than the other, a mechanical advantage is produced, with the rotational speeds, and the torques, of the two gears differing in proportion to their diameters. In transmissions with multiple gear ratios—such as bicycles, motorcycles, and cars— the term "gear" as in "first gear" refers to a gear ratio rather than an actual physical gear. The term describes similar devices, even when the gear ratio is continuous rather than discrete, or when the device does not actually contain gears, as in a continuously variable Transmission.[2]

Outer Diameter = 100mm

Inner Diameter = 80mm

No. of Teeth= 72

Module = m

Addendum Circle Diameter (OD) = d+2m........... (1)

Dedendum Circle Diameter (ID) = d-2.314m....... (2)

100 = d+2m

80 = d-2.314m

4.314m = 20

M = 4.636

Pitch Circle Diameter = 100-2m = 90.127mm

F. PINION:

A pinion is a round gear used in several applications: usually the smaller gear in a geardrive train, although in the case of John Blenkinsopp‘s *Salamanca*, the *pinion* was rather large.[1] In many cases, such as remote controlled toys, the pinion is also the drive gear. The smaller geardrives in a 90-degree angle towards a crown and the small front sprocket on a chain driven motorcycle. The round gear that engages and drives a rack in a rack and pinion mechanism and against a rack in a rack railway In the case of radio car controlled cars with an engine (i.e. nitro) this pinion gear can be referred to as a clutch bell when it is paired with a centrifugal clutch.[2]

Outer Diameter = 70mm

Inner Diameter = 50mm

No. of Teeth= 54

Module = m

Addendum Circle Diameter (OD) = d+2m;

Duodenum Circle Diameter (ID) = d-2.314m;

70 = d+2m

50 = d-2.314m

4.314m = 20

M = 4.636

Pitch Circle Diameter = 70-2m = 60.727mm

GEAR RATIO = (No. of Teeth Gear)/ (No. of Teeth of Pinion) = TG/Tp = 72/54 = 1.33

Power, P = 2*(3.14)*N*T/60

Torque, T = P*(60)/2*(3.14)*N = 1.91 Tangential Load

(WT),

For Gear = T/(DG/2)= 1.91/(90.127*10-3) = 21.19N

For Pinion = T/(DP/2)= 1.91/(60.727*10-3) = 31.45N

I. CONCLUSION:

Even though it is advantageous over the conventional two-wheel steering system, 4WS is complex and expensive. Currently the cost of a vehicle with four wheel steering is more. Thus the four-wheel steering system has got cornering capability, steering at for a vehicle with the conventional two wheel steering. Four wheel steering is growing in popularity and it is likely to come in more and more new vehicles. As the systems become more commonplace the cost of fourwheel steering will drop. 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 neutering 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

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been introduced together in a locomotive and its performance has been simulated and shown.

From this research, we found that the multi–mode 4WS system provided robust, repeatable results. In particular, it can be concluded that:

1. In headland turning manoeuvres, coordinated 4WS showed performance advantages over conventional 2WS through increased aligning distance, decreased headland width, and reduced rear–wheel tracking area.

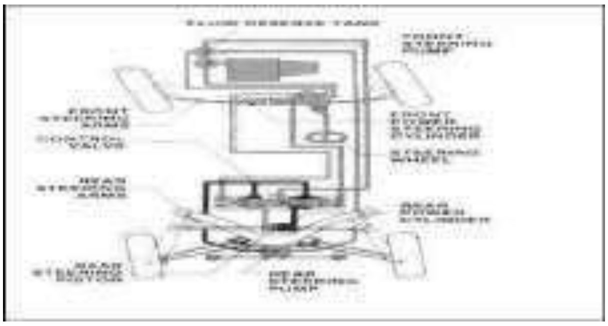

Fig-2 Hydraulic 4WS

In lateral shifts during chemical application, crab 4WS resulted in substantial reductions of all application error metrics over conventional 2WS. Coordinated 4WS resulted in increased error but revealed an inverse relationship between turning radius and application error.

Increased vehicle manoeuvrability was observed with 4WS, as demonstrated by the reduced turning radii. This manoeuvrability can be used by operators to achieve improved machine performance metrics under controlled test conditions that are related to real–world functional tasks. These results provide evidence that 4WS can lead to improved machine performance in typical field operations. A 4WS system with several fixed modes, however, unnecessarily burdens the operator to select a steering mode most appropriate for a particular operation. Being constrained to a fixed number of steering modes will achieve sub–optimal results compared with what may be possible if these constraints we removed

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