International Journal of Applied Research in Mechanical Engineering

Volume 2 | Issue 3 Article 13

January 2013

USAGE OF TUMBLER GEAR MECHANISM IN FOUR WHEEL STEERING

T. SARAN RAJ
t.saranraj@gmail.com

USAGE OF TUMBLER GEAR MECHANISM IN FOUR WHEEL STEERING

T.SARAN RAJ

Student, Mechanical Engineering, 2008-2012

Abstract- Maneuverability is been one of the key things which people look for in their automobiles. This lead to the implementation of "Four wheel Steering "in vehicles. Four wheel steering is a system that allows the rear wheels to turn, rather than just following the front wheel. It is a system with two phases, a negative phase for slow speeds and a positive phase for the high speeds. Turning the rear wheels in the opposite direction to the front is the negative phases, which enhances faster maneuvering and a much tighter turning radius. Turning the rear wheels in the same direction as those at the front is the positive phase, which enhances sudden lane changes with much greater stability At present, there are three mechanisms used for steering the rear wheel. They are mechanical (using hypocycloidal gear set up), hydraulic and electro-hydraulic. The reason for the system not being implemented in the commercial vehicle was its expensive nature. To overcome the above statement, a study was made on four wheel steering using tumbler gear mechanism. The result shows the decrease in the cost of implementation of the system and turning radius compared to two wheel steering respectively.

Keywords- *Four Wheel Steering, Tumbler Gears, Maneuverability, Turning radius*

I. INTRODUCTION

A. Steering Mechanism

The Steering is a collection of linkages that helps the driver to guide the moving vehicle on the road and control the direction of the vehicle according to his wishes. The steering system converts the rotary motion of the steering wheel into the angular turning of the front wheels and also provides multiple drivers' effort with leverage or mechanical advantage while turning the wheels. The type of mechanism used to transfer the rotary motion of the steering wheel to the wheels of the vehicle is referred to as Steering mechanism. There are several different types of steering mechanism, out of which we consider Rack and Pinion steering mechanism in this study.

B. Four Wheel Steering

Four-wheel steering, 4WS, also called rear-wheel steering or all-wheel steering, provides a means to actively steer the rear wheels during turning maneuvers. It improves handling and helps the vehicle make tighter turns. When both the front and rear wheels steer toward the same direction, they are said to be in phase or positive phase and this produces a kind of sideways movement of the car at high speeds. When the front and rear wheels are steered in opposite direction, this is called anti-phase, counter-phase or opposite-phase and it produces a sharper, tighter turn and parking.

C. Importance of Four Wheel Steering

The importance of four wheel steering can be studied in comparison with front wheel steering. With a front-steered vehicle, the rear end is always trying to catch up to the directional changes of the front wheels. This causes the vehicle to sway. As a normal part of operating a vehicle, the driver learns to adjust to these forces without thinking about them. The idea behind four-wheel steering is that a vehicle requires less driver input for any steering maneuver if all four wheels are steering the vehicle. As with two-wheel steer vehicles, tire grip holds the four wheels on the road. However, when the driver turns the wheel slightly, all four wheels react to the steering input, causing slip angles to form at all four wheels. The entire vehicle moves in one direction rather than the rear half attempting to catch up to the front. There is also less sway when the wheels are turned back to a straight-ahead position.

The vehicle responds more quickly to steering input because rear wheel lag is eliminated.

D. Phases of Four Wheel Steering

The Four Wheel Steering system has two phases, namely [1] Positive Phase and [2] Negative phase. In the Positive phase, the rear wheels tend to turn in the same direction to that of the front wheels. This phase is used in highways during high speeds for easy lane changes without losing the vehicle stability.

This also reduces slippage of the vehicle. In Negative phase or Opposite phase, the rear wheels tend to turn in the opposite direction to that of the front wheels. This phase is used in U-turns, sharp bends during the low speeds for getting a reduced turning radius.

E. Existing Four Wheel Steering Mechanism

The existing Four Wheel Steering mechanism which are used in commercial cars are [1]Mechanical type [2] Hydraulic Type , [3] Electro-hydraulic type.

The main disadvantages of these existing systems are its cost and complicated designs. The study is based on the above two factors and the ways to improve it.

F. Tumbler Gear Mechanism

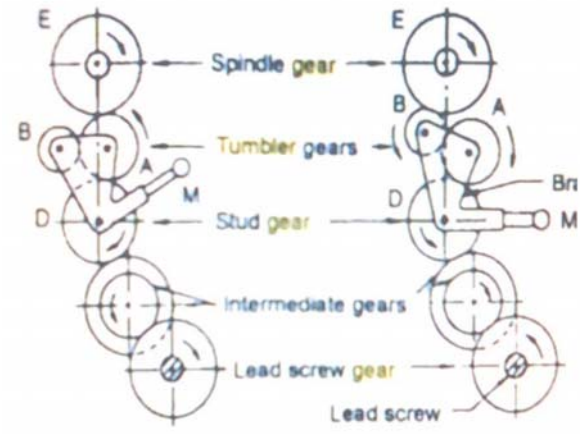

Figure1 Tumbler gear mechanism.

Tumbler gear mechanism is used to change the direction of lead screw and feed rod in lathe machines. By Engaging tumbler gear, the carriage can be moved automatically from tailstock end to headstock. End or moved from headstock end to tail stock end. E is the gear attached to the spindle. It always rotates in the clockwise direction. A & B are tumbler gears. These gears are fitted in a bracket. The lever M of the bracket can be shifted upwards or downwards. D is the stud gear. The stud gear D is connected to the lead screw gear through a set of intermediate gears. Two positions of the tumbler gears are shown. In position 1, the lever M is in upward position. Now gear A connects spindle gear E and stud gear D. so the lead screw rotates in the same direction of the spindle. In position 2, the shift lever is in the horizontal position. Now E is connected to gear B, B is connected to gear A, and A is connected to D. so the lead screw rotates in anti-clockwise direction to the spindle. When the lever M is in middle position, tumbler gears are not engaged.

Methodology

A. Outline of the Methodology

The methodology consists of three sections [1] Steering box Modification [2] Tumbler Gear Setup [3] Lever Actuation.

B. Steering box modification

As in the normal rack and pinion steering system, the steering wheel rotates the pinion which transfers a linear motion to the rack which in turn moves the front wheel. In this study we consider two steering boxes, each of which works on rack and pinion mechanism. The rack and pinion for the front wheels is connected to a series of gears which is connected to another rack and pinion for the turning of the rear wheels. The front steering boxes has been modified in such a way that there is a rack at the bottom section. A rack has been cut in the bottom portion of the original rack. This additional rack is connected to a gear which in turn is connecting to the rear steering boxes through a shaft.

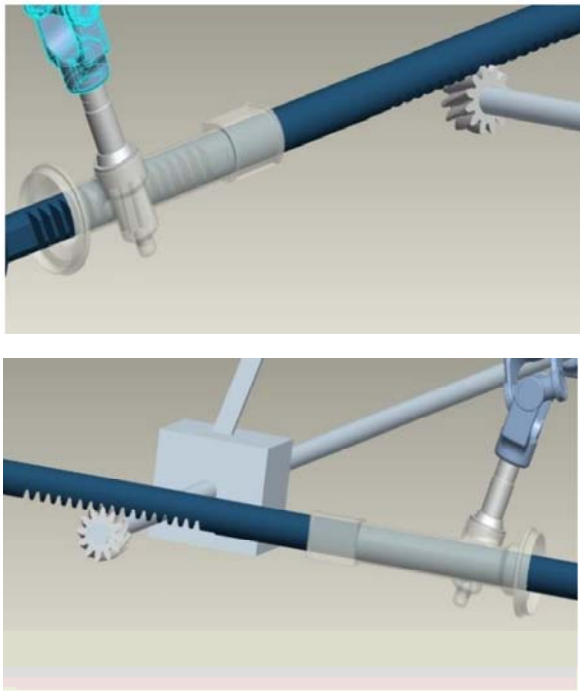

Figure 2 Steering gear box setup

C. Tumbler Gear Setup

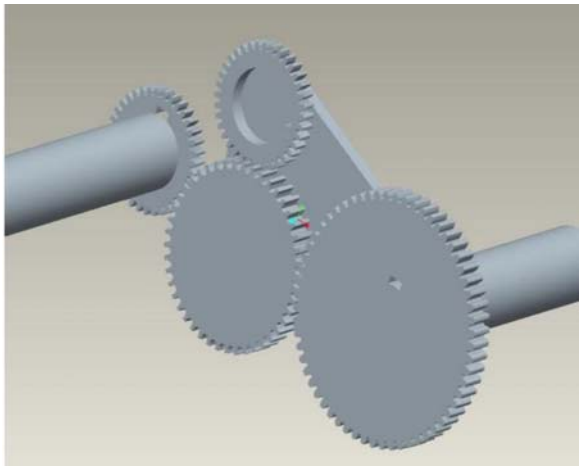

Figure 3 Three gear meshed

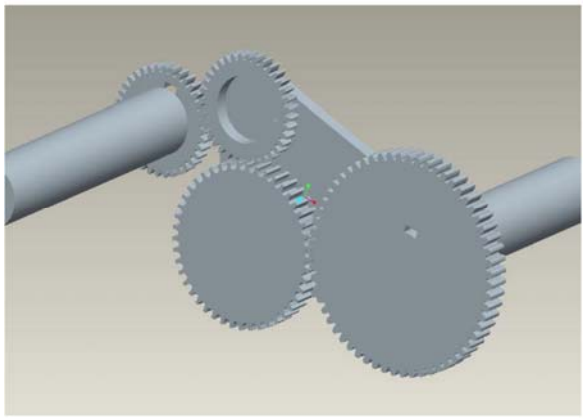

Figure 4 Four gear meshed

The above figure shows the tumbler gear setup. The above diagram in which three gears are meshed is the

opposite phase and the four gears are meshed is the positive phase. Out of the two shafts shown in the figure, one comes from front rack and another goes to the rack at the rear. The main consideration for the selection of these gears are done in such way that the front wheels have to turn twice the angle of rear wheels. So the gear4 has twice the diameter of gear1.

D. Four Wheel Steering Phase Control

Phase control of four wheel steering means the direction in which the rear wheels must turn with respect to the front wheels. The working is mainly based on the position of the tumbler gears. The tumbler gears are set in different positions by using the lever which is welded to the bush. The lever can be positioned in two different places. According to its positioning; the meshing of the gears takes place. It has two positions [1] Three gears are meshed.[2] Four gears are meshed By the above mentioned positions, the following conditions of the steering system can be achieved.[1]Opposite Phase [2] Positive phase.

1) Opposite Phase

In this phase when the steering wheel is steered in clockwise direction, the steering shaft rotates and this rotation is transferred to the pinion. The rotary motion of the pinion is converted into linear motion by the rack. So, the tie rods move with the rack and the front wheels turns right. As the rack moves, the rack at the bottom which meshes with a gear rotates it in anti-clockwise direction. This rotation is transferred to the input gear through the center shaft. Now, the input gear is meshed with the idler gear and the idler gear in turn is meshed with the output gear. So, the output gear rotates in same direction of the input gear (i.e. anticlockwise direction). This rotation is transferred to the pinion of the rear steering gear box.

2) Positive Phase

In this phase when the steering wheel is steered in clockwise direction, the steering shaft rotates and this rotation is transferred to the pinion. The rotary motion of the pinion is converted into linear motion by the rack. So, the tie rods move with the rack and the front wheels turns right. As the rack moves, the rack at the bottom which meshes with a gear rotates it in anti-clockwise direction. This rotation is transferred to the input gear through the center shaft. Now, the input gear is meshed with the idler gear and the idler gear to the reverse gear and the reverse gear to the output gear. So, the output gear rotates in clockwise direction.

This rotation is transferred to the pinion of the rear steering gear box. The clockwise rotation of the pinion moves the rack. Thus the rear wheel turns right. In this way, the positive phase condition is achieved

E. Lever Actuation

The tumbler gears are switched from three gear meshing to four gear meshing using a lever. This lever actuation is done automatically using sensors and a hydraulic setup. The lever actuation depends upon two criteria [1] position of the wheels and [2] speed of the engine. The actuation of the lever is done using the 4/3 solenoid valve. Solenoid valves are actuated using electrical signals.

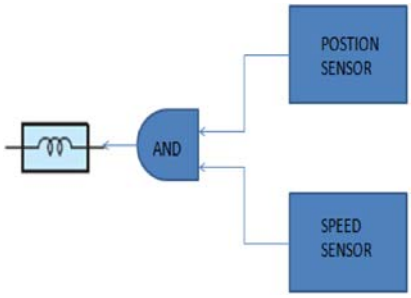

Figure 5 Electronic Circuit

The electrical signal to actuate solenoid comes from the position sensor and speed sensors. The position sensor is used to find whether the position of the wheels is in stable position i.e. without any turn. If it is so, the sensor gives a HIGH signal or else a LOW signal. As the meshing of gears depends upon speed of the vehicle, there is a use to measure the vehicle speed. This is done by the speed sensor. If both the sensors give a HIGH signal, then the AND gate is opened and the signal is send to solenoids. In this way the lever actuation is done 4/3 solenoid valves and thus the meshing of tumbler gears.

RESULT AND DISCUSSION

The study gave a less expensive and less design complicated way of implementing four wheel steering in an automobile using Tumbler gears. It also gave a result of 24.8% decrease in turning radius rather than a two- wheel steered vehicle. It can also be implemented in the conventional and off-road vehicles with few modifications in the rear axle.

Table 1 Cost report

MATERIALS	COST
STEERING GEAR BOX (2 NOS)	4000/-
GEARS (5NOS)	500/-
COUPLINGS (2 NOS.)	500/-
DOUBLE ACTING CYLINDER	1000/-
HYDRAULIC VALVE	3000/-
POSITION SENSOR	300/-
SPEED SENSOR	600/-
HYDRAULIC OILS& HOSES	500/
FABRICATION &MISCELLANEOUS	2000/-
TOTAL	**13,400/-**

The above table shows the cost report of implementing tumbler gear mechanism in achieving four wheel steering.

The cost of implementation turns to be less expensive than other existing mechanism. So, implementing this mechanism in commercial vehicle on mass production could decrease its cost still more with being effective.

REFERENCES

[1]. 'Automobile Engineering' by Kirpal Singh.

[2]. 'Fundamentals of Vehicle dynamics' by Thomas D. Gillespie.

[3]. 'A text book of Production Technology' by P.C. Sharma.

[4]. 'A text book of MACHINE DESIGN' by S. Md. Jalaludeen.

[5]. 'Vehicle Dynamics: Theory and Applications 'by Reza.N. Jaza