VEHICLE HANDLING IMPROVING BY ACTIVE STEERING

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REFERENCE

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"I admitted that I have read this paper and in my opinion this paper is enough in terms of scope and quality for granting of Bachelor of Mechanical Engineering (Automotive)"

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ABSTRAK

Projek PSM ini menceritakan bagaimana untuk meningkatkan tahap kecekapan kawalan sesebuah kereta dengan menggunakan aktif stereng hadapan. *Active Front Steering* (AFS) adalah teknologi baru yang dicipta untuk kereta penumpang. Ia mengandungi elektronik kawalan yang dapat mengawal sudut stereng yang digerakkan oleh tangan, di mana sudut stereng tersebut ditentukan oleh pemandu. Penambahan sudut bebas berlaku berterusan dan bergantung pada situasi pemanduan dan ciri-ciri tambahan stereng. Di dalam teknologi Active Steering terdapat satu set sistem gear yang bercantum dengan tiang stereng. Elekrik motor dalam sambungan akan membetulkan sudut roda hadapan stereng dalam kedudukan semasa kelajuan kenderaan. Aktif stereng ini dinilai dengan menggunakan sistem penyerupaan perbezaan input stereng. Penyelesaian masalah akan dilakukan dalam Matlab/Simulink. Model kenderaan juga dilakukan dalam Matlab/Simulink. Di akhir projek ini, system stereng akan dapat diketahui dengan lebih mendalam dalam meningkatkan kestabilan kenderaan daripada tergelincir.

ABSTRACT

This PSM project is about improving handling behavior of car by using active front steering. *Active Front Steering* (AFS) is a newly developed technology for passenger cars. It provides an electronically controlled superposition of an angle to the hand steering wheel angle that is prescribed by the driver. This additional degree of freedom enables a continuous and driving-situation dependent adaptation of the steering characteristics. At the heart of the new Active Steering system is the planetary gear set integrated into the steering column. An electric motor in the joint adjusts the front wheels' steering angle in proportion to the vehicle current speed. This active steering is evaluated by simulating different steering inputs. The active steering solution has been implemented in Matlab/Simulink. A vehicle model is also implemented in Matlab/Simulink. This paper focuses on comparison both two systems: a conventional vehicle and a controlled vehicle. Simulation is made for a constant speed and a specific changeable road adhesion coefficient. The motivation for this work is to understand and characterize the response of a vehicle with a complementary steering system. Improved stability is obtained for the vehicle during slippery road driving.

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CHAPTER 1

INTRODUCTION

This chapter describes a general overview of this research. Background information related to the topic of active steering and modeling along with project objectives. Brief literature is reviewed in this section, linking relevant topics to the research presented here. Finally an objective of the thesis and a brief description in problem statement are also presented.

1.1 Project overview

An active steering system is a complementary system for a front-steered vehicle that adds or subtracts a component to the steering signal performed by the driver. The steering signal from the driver is an angular movement on the steering wheel. The resulting steering angle is thus composed by the component performed by the driver and the component contributed by the steering system. The main reason for this is the aim to improve safety and handling. However it is still difficult to value the improvements. In this paper one solution is implemented and analyses.

1.2 Objective

1) Characteristic the difference of the response between the controlled and the uncontrolled vehicle steering for nominal driving and at the limit driving.
2) Have a system with steady state distribution rejection.
3) Stability of the vehicle due to side wind force by reduces yaw rate and lateral acceleration phase difference.
4) Improve the vehicle handling performance in terms of lateral and yaw motion.

1.3 Scope

The scope for this project is shown below:

- Development of Vehicle Handling Model
- Develop Active Front Steering Model
- Performance evaluation

1.4 Problem statement

Usually for currently car without active front steering (AFS) will hard to control the car especially when driving with side wind force disturbance. This situation gives the unwanted yaw to the car. The driver will overcome the unwanted yaw by controlling the steering angle. This situation was reducing the car comfortable. The new dimension in steering comfort; active steering offers precision, agility and comfort in every driving situation.

Figure 1.1: Without AFS

Figure 1.2: With AFS

More features:

- AFS actually changes the steering ratio (the number of turns of the steering wheel required to turn the road wheels from lock to lock) while you drive.
- AFS can intervene in an instant to provide a correction if the rear end starts to break away.
- AFS is different than variable assist power steering, which only varies the amount of effort, not the actual steering ratio.
- AFS works with Dynamic Stability Control (DSC) to prevent a skid. When the yaw sensors detect an oversteer situation (the back end beginning to step out), it clicks in a few degrees of opposite lock.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic steering components

The steering system can be one of several designs, which we'll go into further down the page, but all the designs essentially move the track rod left-to-right across the car. The tie rods connect to the ends of the track rod with ball and socket joints, and then to the ends of the steering arms, also with ball and socket joints. The purpose of the tie rods is to allow suspension movement as well as an element of adjustability in the steering geometry. The tie rod lengths can normally be changed to achieve these different geometries.

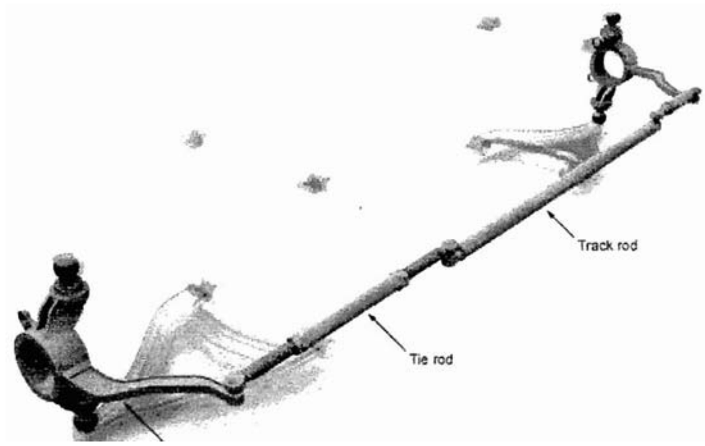

Figure 2.1: Steering component

Source: www.carbibles.com

2.2 Steering ratios

Every vehicle has a steering ratio inherent in the design. If it didn't you'd never be able to turn the wheels. Steering ratio gives mechanical advantage to the driver, allowing driver to turn the tires with the weight of the whole car sitting on them, but more importantly, it means driver don't have to turn the steering wheel a ridiculous number of times to get the wheels to move. Steering ratio is the ratio of the number of degrees turned at the steering wheel vs. the number of degrees the front wheels are deflected. So for example, if driver turn the steering wheel 20° and the front wheels only turn 1° that gives a steering ratio of 20:1. For most modern cars, the steering ratio is between 12:1 and 20:1. This coupled with the maximum angle of deflection of the wheels gives the lock-to-lock turns for the steering wheel. For example, if a car has a steering ratio of 18:1 and the front wheels have a maximum deflection of 25°, then at 25°, the steering wheel has turned 25°x18, which is 450°. That's only to one side, so the entire steering goes from -25° to plus 25° giving a lock-to-lock angle at the steering wheel of 900°, or 2.5 turns (900° / 360). This works the other way around too of course. For example if a car is advertised as having a 16:1 steering ratio and 3 turns lock-to-lock, then the steering wheel can turn 1.5x360° (540°) each way. At a ratio of 16:1 that means the front wheels deflect by 33.75° each way. For racing cars, the steering ratio is normally much smaller than for passenger cars - i.e. closer to 1:1 - as the racing drivers need to get fuller deflection into the steering as quickly as possible.

2.3 Turning circles

The turning circle of a car is the diameter of the circle described by the outside wheels when turning on full lock. There is no hard and fast formula to calculate the turning circle but can get close by using this; turning circle radius = (track/2) + (wheelbase/sin(average steer angle)) The numbers required to calculate the turning circle explain why a classic black London taxi has a tiny 8m turning circle to allow it to do U-turns in the narrow London streets. In this case, the wheelbase and track aren't radically different to any other car, but the average steering angle is huge. For comparison, a typical passenger car turning circle is normally between 11m and 13m with SUV turning circles going out as much as 15m to 17m.

2.4 Steering System designs:

2.4.1 Pitman arm types

There really are only two basic categories of steering system today; those that have pitman arms with a steering 'box' and those that don't. Older cars and some current trucks use pitman arms. Newer cars and unibody light-duty trucks typically all use some derivative of rack and pinion steering.

Pitman arm mechanisms have a steering 'box' where the shaft from the steering wheel comes in and a lever arm comes out - the pitman arm. This pitman arm is linked to the track rod or centre link, which is supported by idler arms. The tie rods connect to the track rod. There are a large number of variations of the actual mechanical linkage from direct-link where the pitman arm is connected directly to the track rod, to compound linkages where it is connected to one end of the steering system or the track rod via other rods. The example below shows a compound link.

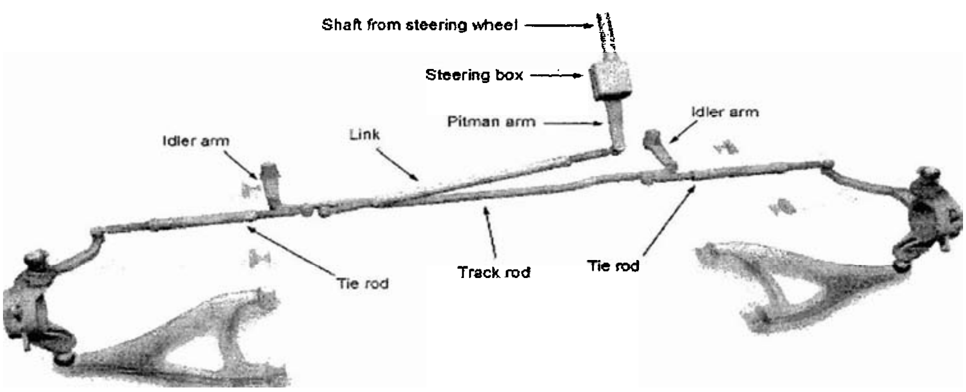

Figure 2.2: Compound link

Source: www.carbibles.com

Most of the steering box mechanisms that drive the pitman arm have a 'dead spot' in the centre of the steering where can turn the steering wheel a slight amount before the front wheels start to turn. This slack can normally be adjusted with a screw mechanism but it can't ever be eliminated. The traditional advantage of these systems is that they give bigger mechanical advantage and thus work well on heavier vehicles. With the advent of power steering, that has become a moot point and the steering system design is now more to do with mechanical design, price and weight. The following are the four basic types of steering box used in pitman arm systems.

2.4.2 Worm and sector

In this type of steering box, the end of the shaft from the steering wheel has a worm gear attached to it. It meshes directly with a sector gear (so called because it's a section of a full gear wheel). When the steering wheel is turned, the shaft turns the worm gear, and the sector gear pivots around its axis as its teeth are moved along the worm gear. The sector gear is mounted on the cross shaft which passes through the steering box and out the bottom where it is splined, and the pitman arm is attached to the splines. When the sector gear turns, it turns the cross shaft, which turns the pitman arm, giving the output motion that is fed into the mechanical linkage on the track rod. The following diagram shows the active components that are present inside the worm and sector steering box. The box itself is sealed and filled with grease.

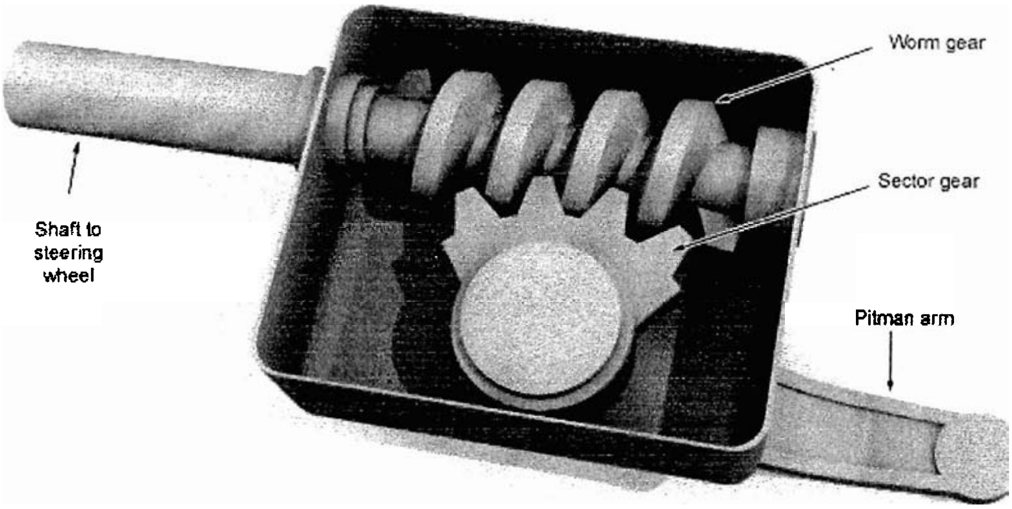

Figure 2.3: Worm sector

Source: www.carbibles.com

2.4.3 Worm and roller

The worm and roller steering box is similar in design to the worm and sector box. The difference here is that instead of having a sector gear that meshes with the worm gear, there is a roller instead. The roller is mounted on a roller bearing shaft and is held captive on the end of the cross shaft. As the worm gear turns, the roller is forced to move along it but because it is held captive on the cross shaft, it twists the cross shaft. Typically in these designs, the worm gear is actually an hourglass shape so that it is wider at the ends. Without the hourglass shape, the roller might disengage from it at the extents of its travel.

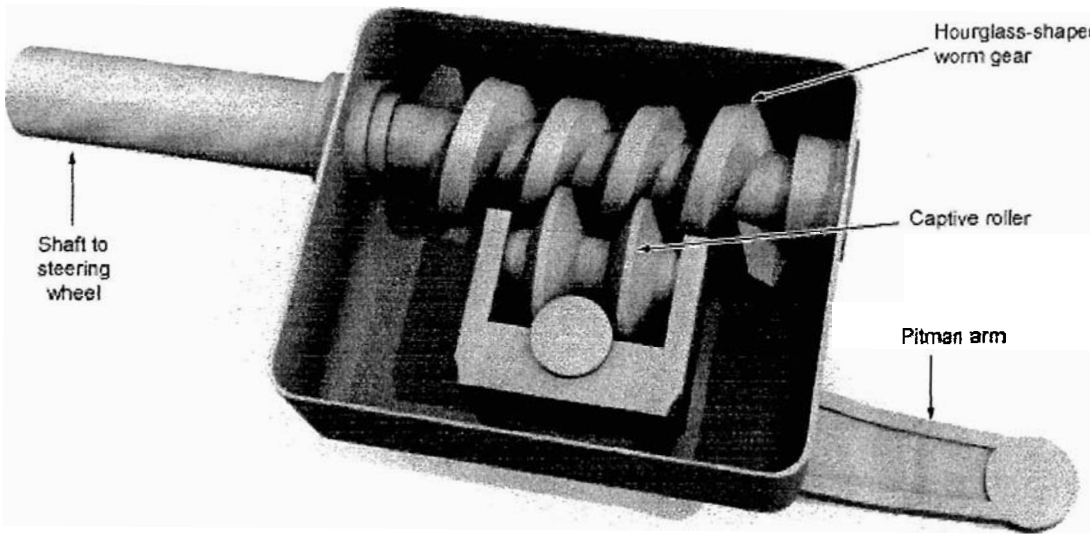

Figure 2.4: Worm and roller

Source: www.carbibles.com

2.4.4 Worm and nut or recirculating ball

This is by far the most common type of steering box for pitman arm systems. In a recirculating ball steering box, the worm drive has many more turns on it with a finer pitch. A box or nut is clamped over the worm drive that contains dozens of ball bearings. These loop around the worm drive and then out into a recirculating channel within the nut where they are fed back into the worm drive again. As the steering wheel is turned, the worms drive turns and forces the ball bearings to press against the channel inside the nut. This forces the nut to move along the worm drive. The nut itself has a couple of gear teeth cast into the outside of it and these mesh with the teeth on a sector gear which is attached to the cross shaft just like in the worm and sector mechanism. This system has much less free play or slack in it than the other designs, hence why it's used the most. The example below shows a recirculating ball mechanism with the nut shown in cutaway so can see the ball bearings and the recirculation channel.

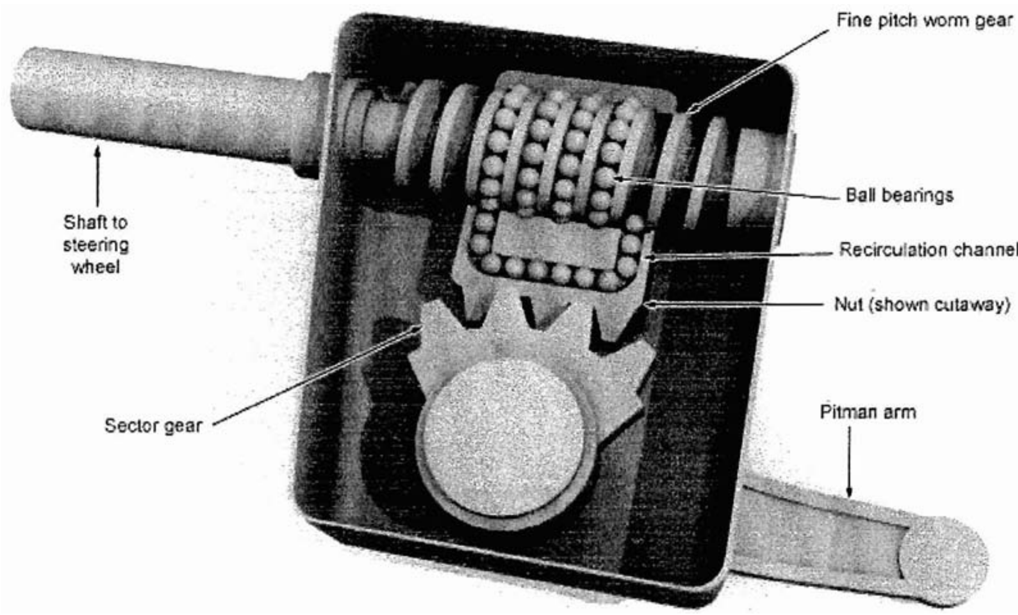

Figure 2.5: Worm and nut or recirculating ball

Source: www.carbibles.com

2.4.5 Cam and lever

Cam and lever steering boxes are very similar to worm and sector steering boxes. The worm drive is known as a cam and has a much shallower pitch and the sector gear is replaced with two studs that sit in the cam channels. As the worm gear is turned, the studs slide along the cam channels which forces the cross shaft to rotate, turning the pitman arm. One of the design features of this style is that it turns the cross shaft 90° to the normal so it exits through the side of the steering box instead of the bottom. This can result in a very compact design when necessary.

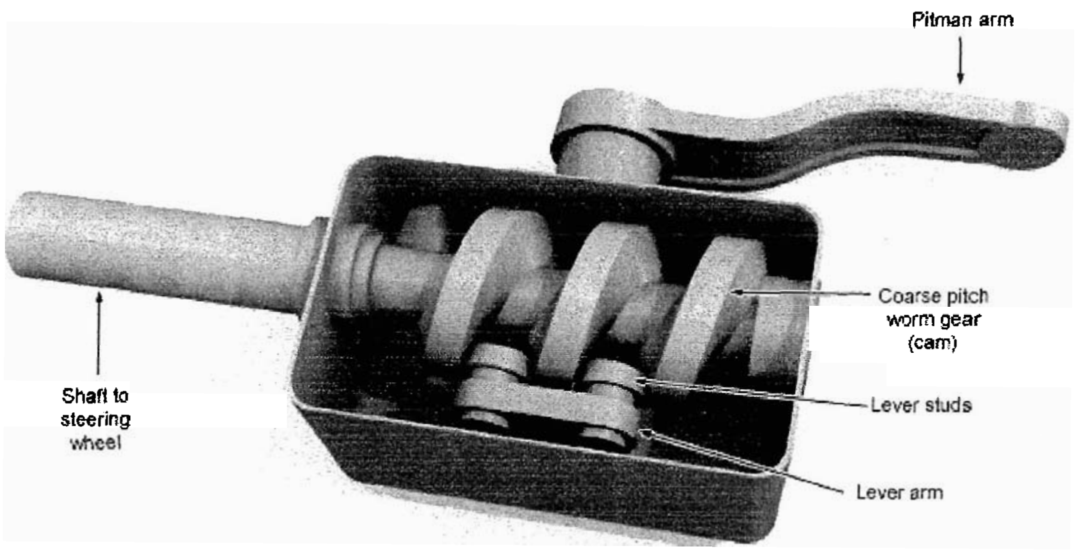

Figure 2.6: Cam and lever

Source: www.carbibles.com