AN INVESTIGATION AND ANALYSIS OF THE STEERING SYSTEM WITH THEIR CAPABALITIES

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Abstract

Steering system provides the directional change in the movement of an automobile and maintain in a position as per the driver's decision without much strain on him. This system converts rotary movement of the steering wheel into angular movement of the front wheels. It multiplies driver's effort by mechanical advantage, enabling him to turn the wheels easily.The steering system is a group of parts that transmit the movement of the steering wheel to the front and sometimes the rear wheels. The primary purpose of the steering system is to allow the driver to guide the vehicle.

1.Introduction

When a vehicle is being driven straight ahead, the steering system must keep it from wandering without requiring the driver to make constant corrections. The steering system must also allow the driver to have some road feel (feedback through the steering wheel about road surface conditions).

The steering system must help maintain proper tyre-to-road contact. For maximum tire life, the steering system should maintain the proper angle between the tires both during turns and straight-ahead driving. The driver should be able to turn the vehicle with little effort, but not so easily that it is hard to control.

It should not be confused with four-wheel drive in which all four wheels of a vehicle are powered. With the help of this system, the rear wheels also can be turned with respect to the direction of front wheels whenever required. Thus, the vehicle can be controlled more effectively especially during cornering, parking or when we get into a congested/narrow area.

This system finds application mainly in off-highway vehicles such as forklifts, agricultural and construction equipment and mining machineries. It is also useful in passenger cars, mainly SUVs. When both the front and rear wheels steer toward the same direction, they are said to be in-phase and this produces a kind of sideways movement of the car.

1.1 Requirement of a Good Steering System

For proper and smooth operation and performance of the system, the steering system of any vehicle should fulfill the following requirements:

- The steering mechanism should be very accurate and easy to handle.
- The effort required to steer should be minimum and must not be tiresome to the driver.
- The steering mechanism should also provide the directional stability. This implies that the vehicle should have tendency to return to its straight ahead position after turning.

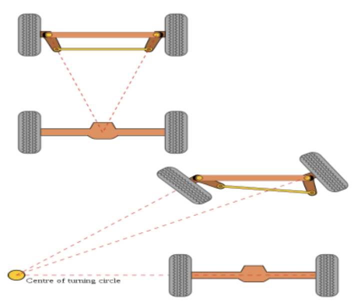
- It should provide pure rolling motion to wheel.
- It should be designed in such a manner that road shocks are not transmitted to driver.

1.2 Functions of a Good Steering System

- It helps in swinging the wheels to the left or right.
- It helps in turning the vehicle at the will of the driver.
- It provides directional stability.
- It helps in controlling wear and tear of tyres.
- It helps in achieving the self-rightening effect.
- It converts the rotary movement of the steering wheel into an angular turn of the front wheels.
- It multiplies the effort of the driver by leverage in order to make it fairly easy to turn the wheels.
- It absorbs a major part of the road shocks thereby preventing them to get transmitted to the hands of the driver.

2. Ackermann Steering Mechanism

With perfect Ackermann, at any angle of steering, the Centre point of all of the circles traced by all wheels will lie at a common point. But this may be difficult to arrange in practice with simple linkages. Hence, modern cars do not use pure Ackermann steering, partly because it ignores important dynamic and compliant effects, but the principle is sound for low speed maneuvers.



3.1 Steering Ratio

The steering ratio is the number of degrees that the steering wheel must be turned to pivot the front wheels 1 degree. E.g.: steering ratio 18:1 implies that the front wheels will turn by 1 degree when the steering wheel turns 18 degree.

The steering ratios generally used with present day steering gears vary from about 12: 1 for cars to about 35: 1 for heavy vehicles. An average overall ratio usually gives about one and half complete turns of the steering wheel each side of mid position to apply a full lock of 45 degrees each way on the wheels.

4. Calculation for Rack And Pinion

Pressure angle of rack and pinion (p) = 20˚ full depth system
Pitch of the rack and pinion (P) = 10 mm
Diameter of pinion (D) = 105 mm
Number of teeth on rack = 50
Number of teeth on pinion = 20
Addendum (a) = 1 / P
= 1 / 10
= 0.1 mm

Deddundum (d) = 1.25 / P
= 1.25 / 10
= 0.125 mm
$D_p = N_p / P_d$
$D_p = 50 / 10$
= 5.0 mm
$D_p = 20 / 10$
= 2.0 mm

$\sigma = F_t / (b_a . m. Y)$
Y = Lewis form factor = 0.352
Module of gear = m = 1 / D_p
= 1 / 5.0
= 0.2
Face width of gear(b_a) = 10 mm
Bending stress of gear= 110 Mpa 110 x 10^3
= F_t / 10 x 0.2 x 0.352
F_t = 156 x 10^^{3}N
W = Ft x v / 1000

Peripheral velocity of gear = v = π x D x N / 60 x 1000
= π x 90 x 250 / 60 x 1000
= 1.178 m / s
W = F_tx v / 1000
= 156 x 10^^{3} x 1.178 / 1000
= 184 watts
Pressure angle of gear = 20˚
Normal force (Fn) = F_t x tanϴ
= 156 x 10^^{3}x tan 20
= 56780 N
Radial load (Fr) = F_t / tanϴ
= 156 x 10^^{3} / tan 20
= 429752N

4.1 Calculation for Bevel Gear
No. of teeth, T = 18
Diameter of the pitch circle, D = 40 mm
Circular pitch, Pc =πD/T,
= 3.14*40/18
= 6.98
Diameter of the pitch,
Pd =T/D
=18/40
=0.45 mm
Module m = D/T
= 40/18
= 2.22

4.2 Calculation for Spur Gear

4.2.1 Gear 1:

Diameter of gear = Ø60mm
No. of teeth =48 no
Thickness of the gear =10mm
Module: (M)

This is the standard term used in S.I units.It can be defined as the length on the pitch circle diameter per tooth. It is the reverse of the diameter pitch.

m = D/T
m = 60/48
m = 1.25 mm

Addendum: (a)

The radial distance between the pitch circle and the tip circle is known as Addendum.

a = 1 m
a = 1 x 1.25
a = 1.25 mm
Dedendum: (D)

The radial distance between the pitch circle and the root circle is known as Dedendum (d).

d=1.25m
d = 1.25 x 1.25
d = 1.562 mm

Circular pitch (pc):

`The distance between the corresponding sides of two adjacent of a gear measured on the pitch circle is known as circular pitch.

Pc =□D/T
Pc = □ (60)/ 48
Pc = 3.926 mm

Diametral pitch (pd):

It is the ratio of the number of teeth per unit pitch diameter. This is mostly used in F.P.S. system.

Pd=T/D
Pd = 48/60
Pd = 0.8 mm

4.2.2 Gear 2:

Diameter of gear = Ø33mm
No of teeth =24 no
Thickness of the gear =10mm
Module:

M = d/t
M = 33/24
M = 1.375 mm

Addendum:

A = 1 m
A = 1 x 1.375

A = 1.375 mm

Dedendum:

D=1.25m
D = 1.25 x 1.375
D = 1.718 mm

Circular pitch:

Pc =□d/t
Pc = □ (33)/ 24
Pc = 4.319 mm

Diametrial pitch:

Pd=t/d
Pd = 24/33
Pd = 0.727 mm

4.3 Calcaultion for Dc Motor

Speed = 30 rpm
Voltage = 12 volt
Watts = 18 watt

Electrical (electric) power equation:

Power P = I × V

Where,

V = 12 W = 18
I=18/12=1.5 A
H.P= .02414

Torque of the motor:

Torque = (P x 60) / (2 x 3.14 x N)
Torque = (18x 60) / (2 x 3.14 x 30)
Torque = 5.72 Nm
Torque = 5.72 x 10^3 Nmm

The shaft is made of MS and its allowable shear stress = 42 MPa

Torque = 3.14 x fs x d ^{3} / 16
5.72 x 10^3 = 3.14 x 42 x d ^{3} / 16
D = 8.85 mm

The nearest standard size is

d = 9 mm.

5. Conclusion

Thus the four-wheel steering system has got cornering capability, steering response, straight-line stability. It is advantageous over the conventional two-wheel steering system.

Currently the fabrication cost of a vehicle with 3 mode operation of steering is more than that for a vehicle with the conventional two wheel steering. On large scale industrial production we can reduce the cost of this system. The rapid increasing in number of vehicles on road day by day, demands an exploration of such mechanism to reduce driver’s effort and get rid of from the huge traffic. If an electronic and hydraulic assistance is given to the system, it will reduce the complexity and helps in better handling.

Introduction of sensors and hydraulic actuators instead of the pure mechanical system will make the vehicle more stable and efficient. Also the introduction of 90 degree turn to the front and rear wheels helps the vehicle to move in a horizontal direction will make the marking easier, by this method vehicle can be moved easily from the parking easily.

All the modes i.e. reducing radius mode, sliding mode, normal mode and turning of the vehicle can be more accurate and efficient with the help of hydraulic/pneumatic actuators and sensors. The above mentioned modes will help to control the vehicle more easily in every situation.

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