Advanced Steering System for Reduction of Bump Steering Phenomenon

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Abstract- *In this paper we have focused on improvement and designing of custom rack and pinion steering assembly for an automobile for minimizing the bump steering phenomenon. By some amendments in design, we produced a new design of assembly using the principle of variable gear ratio.*

Keywords- Bump steering phenomenon, Variable Gear Ratio Mechanism, Off-road vehicle, Rack and Pinion steering

I. INTRODUCTION

In our design we have provided two set of teeth on rack which meshes individually with two respective set of teeth on pinion. For this we have taken into consideration of ackerman steering geometry for the designing procedure. This new arrangement of the steering system lead to decrement in bump steering and also better manoeuvrability. This system proves to be very efficient for Off-roading vehicles where bump steer frequently occurs.

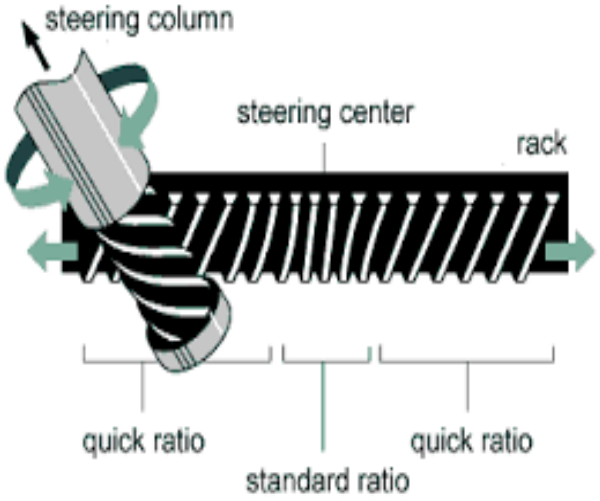

Fig. 1. Conventional Variable steering gear ration mechanism

A normal steering system has a rack and pinion to steer the wheels, we have introduced a new mechanism in it to avoid bump steer. In our mechanism the rack is divided into two parts, and each part have a separate pinion. When the bump is encountered by the wheels, the reaction will be transferred to the rack through tie rods. This force experienced by the driver on his steering wheels, known as bump steering, disturbs the driver and leads to poor maneuverability often. But, due to our different design, such jerks/reactions onto the pinion (in meshing) will not be in direct meshing with the Rack on which the jerk(reaction) is encountered, rather it would be on the other rack. This arrangement will help to improve the steering system by reducing the bump steer.

The application of variable gear ratio helps to obtain different gear ratio at different position of the pinion, helping to get the desired the maneuverable. To provide this benefit, it consists of rack teeth with different pitch and respective pinion teeth for proper meshing and provide smooth transition.

II. CALCULATIONS

Considering force (F) on steering wheel by an adult equal to 150 Newtons. Also, taking steering wheel diameter (D) equal to 25.4 cm.

Let us assume we want 5 turns for lock to lock of the steering wheel. (All this values have been assumed within the possible values and assumption is made because this information focuses more designing rack and pinion)

A. Design of middle pinion and side rack:

Let the diameter of middle pinion = 51mm
So, Radius (R_p) = 25.5 mm

Now, the length of rack covered by 1 turn of the pinion = $2\pi R_p$
$= 2 * \pi * 25.5$
= 160.14 mm

Distance covered in one rotation of pinion, is 160.14 mm, then length covered in lock to lock turns (5 turns) will be,

= 5 * 160.14
= 800 mm
= 31.52 inch

Hence, length of rack =31.52 inch

We know that, $\text{module} = \frac{\text{Diameter}}{\text{Number Of Teeth}}$

$M_p = \frac{Dp}{Tp}$

Teeth on middle pinion (T_P) = 51 / 1.5
(Module = 1.5 mm) = 34 teethes

Teeth on side rack = rack length / pitch

But Pitch = $\pi * M_p$

$= \pi * 1.5$

$= 4.71$ mm

So, Teeth on side rack = 800.7 / 4.71

= 170 teethes

B. Design side pinion and middle rack:

Taking module of side pinion (M_{p2}) = 4 mm

Diameter of side pinion (D_{p2}) = 52 mm

We know, $\text{module} = \frac{\text{Diameter}}{\text{Number Of Teeth}}$

$M_{p2} = D_{p2} / T_{p2}$

So, $T_{p2} = D_{p2} / M_{p2}$

= 52 / 4 = 13 teethes

Hence, number of teethes on side pinion is 13 teethes.

For finding number of teethes on middle rack we will use the formula,

Gear ratio = $\frac{Teeth\ on\ rack}{Teeth\ on\ piniom}$

Teeth on rack = Gear ratio * teeth on pinion

= 0.538 * 13 = 7 teethes

For obtaining length of middle rack,

Teethes on middle rack = $\frac{Rack\ length}{Pitch}$

Rack length = Teeth on middle rack * Pitch

= 7 * (π * 4) [pitch = π * module]

= 87.92 mm = 3.21 inch

TABLE I. Value of the quantities derived from calculations

Quantity	Value
Middle Rack length	3.21”
Side Rack length	31.25”
Diameter of Side Pinion	52 mm
Diameter of Middle pinion	51 mm
Number of teeth on Middle Rack	7
Number of teeth on Side Pinion	13
Number of teeth on Side Rack	170
Number of teeth on Middle Pinion	34

III. CAD Model

We designed the components using software called SOLIDWORKS, below are the design of all components and the whole assembly as well.

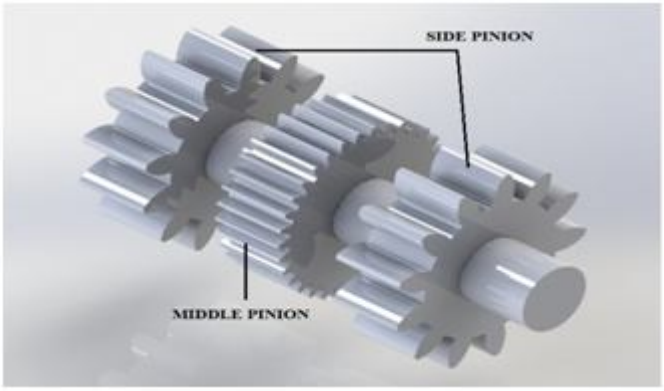

Fig. 1. Side Pinion and Middle Pinion Gear Design

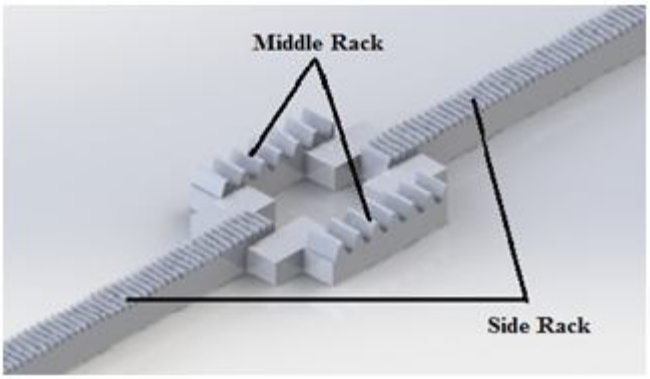

Fig. 2. Middle Rack and Side Rack Design

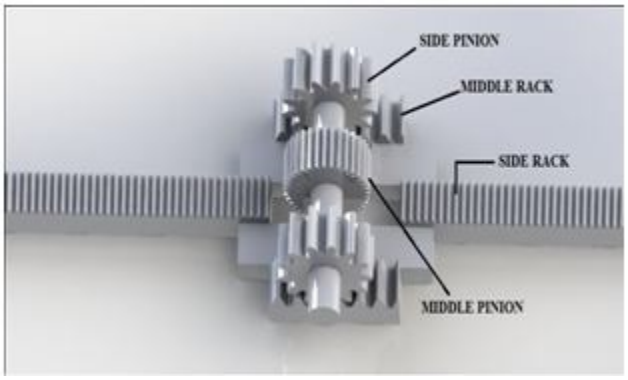

Fig. 3. Assembly Design

Fig. 4. Assembly Design (Top View)

IV. CONCLUSION

With the use of this custom rack and pinion steering system, significant enhancement can be achieved in the steering response. Moreover, this system can find potential application in All Terrain Vehicle (ATV) or Off-roading vehicle where the path encounters extreme condition and leads to significant bump steering. These values are calculated considering some assumption and might differ in practical use. This paper helps to design such special rack and pinion for the particular requirements.Fig. 3. Assembly Design

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