Design of Dog Ring for Differential Locking System Purpose

Shashank Vaidya\textsuperscript{1}, Chetan Gurav\textsuperscript{2}, Shubham Rajore\textsuperscript{3}, Vishal Rokade\textsuperscript{4}, Prof. S.V. Raut\textsuperscript{5}

‘ABMSP’S Anantrao Pawar College of Engineering & Research, Savitribai Phule Pune University, Pune – 411007
Maharashtra State, India’

Abstract: The differential locking system used in automobiles is defined as a system that provides increased traction as compared to standard or open differential by restricting each of the two wheels on the same rotational speed without regard to available traction or differences in resistance seen at each wheel. The differential locking system (DLS) is the important element in automobile used for traction movement of the 4 wheeler vehicle under ideal condition. This traction movement dominates the wheel motion and speed at the time when wheel(s) are trapped on the pit/slippery road. In this project, Dog pins engage in the cage of the spike shaft and act as transmission elements. They can be designed similar to the bush pins in the bush pin type flexible flange coupling.

1. Introduction

A differential is a gear train with three shafts that has the property that the angular velocity of one shaft is the average of the angular velocities of the others, or a fixed multiple of that average. In automobiles and other wheeled vehicles, the differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve roll farther and faster than the other. The average of the rotational speed of the two driving wheels equals the input rotational speed of the drive shaft. An increase in the speed of one wheel is balanced by a decrease in the speed of the other.

When used in this way, differential couples the input shaft (or prop shaft) to the pinion, which in turn runs on the crown wheel of the differential. This also works as reduction gearing to give the ratio. On rear wheel drive vehicles the differential may connect to half-shafts inside an axle casing or drive shafts that connect to the rear driving wheels. Front wheel drive vehicles tend to have the pinion on the end of the main-shaft of the gearbox and the differential is enclosed in the same casing as the gearbox. They have individual drive-shafts to each wheel. Older 4x4 vehicles and tractors usually have a solid front axle; the modern way can be a separate differential and drive shaft arrangement for the front.

A differential consists of one input, the drive shaft, and two outputs which are the two drive wheels, however the rotation of the drive wheels are coupled by their connection to the roadway. Under normal conditions, with small tire slip, the ratio of the speeds of the two driving wheels is defined by the ratio of the radii of the paths around which the two wheels are rolling, which in turn is determined by the track-width of the vehicle (the distance between the driving wheels) and the radius of the turn.

1.1 Objective

a. To prevent the unexpected reverse motion of an Automobile under gradients and mountain roads.

b. To prevent the loss of traction while vehicle driving on the slippery road.

c. To lock and unlock differential locking system according to driver’s willed.

d. To ensure the safety of the driver and vehicle on inclined grounds.

2. Problem Definition

Loss of Traction

The torque applied to each driving wheel is a result of the engine, transmission and drive axles applying a twisting force against the resistance of the traction at that road wheel. In lower gears and thus at lower speeds, and unless the load is exceptionally high, the drivetrain can supply as much torque as necessary, so the limiting factor
becomes the traction under each wheel. It is therefore convenient to define traction as the amount of torque that can be generated between the tire and the road surface, before the wheel starts to slip. If the torque applied to drive wheels does not exceed the threshold of traction, the vehicle will be propelled in the desired direction; if not, then one or more wheels will simply spin.

3. Design Methodology

In our attempt to design a special purpose machine we have adopted a very a very careful approach, the total design work has been divided into two parts mainly:

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine no of controls position of these controls ease of maintenance scope of further improvement; height of m/c from ground etc.

In Mechanical design the components are categorized in two parts:-

- Design parts
- Parts to be purchased

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work.

3.1 Working

When one of the wheels (e.g. RH wheel) goes in a pit or slippery condition due to loss in traction (friction between road and wheel) wheel shaft stops turning.

- As a result the LH wheel shaft speeds up to twice, transmission speed vehicle tiers cannot generate enough traction to come out of the pit.
- The proximity sensor senses this drop in speed or motion and through the electronic relay operated the DC motor.
- DC motor pinion drives the rack shifter mechanism to the right.
- Shifter mechanism moves the dog ring toward right and the dog teeth engage in the spike shaft slot.
- Engagement will lock the spike shaft thereby the conventional differential actions stops and both the wheel shafts get engaged in drive and thus equal power is given to either wheels.

- Wheels after receiving the power will pull/push the vehicle out of pit. Operator moves the reversing switch to bring the dog ring back out of engagement thus conventional differential action is restored.

3.2 Mechanics of Differential Locking System

The differential is shown in the rear axle housing. The rear axle housing includes a flange supporting the bearing retainer. The bearing retainer supports the differential bearing assembly and a rear axle bearing assembly and the differential bearing assembly.

4. Design and Manufacturing Process of Dog Ring

The dog ring is provided with a single spike for engagement. Shifter mechanism moves the dog ring toward right and the dog teeth engage in the spike shaft slot. Presently the dog ring is provided with a single spike for engagement.
4.1 Material Selection

Ref :- (PSG 1.10, 1.12 & 1.17)

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>TENSILE STRENGTH N/mm²</th>
<th>YIELD STRENGTH N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 24</td>
<td>850</td>
<td>680</td>
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</table>

‘Dog is located on PCD 72 mm. These pins engage in the cage of the spike shaft and act as transmission elements.’

They can be designed similar to the bush pins in the bush pin type flexible flange coupling.

‘Three pins’ transmit the entire torque;

These pins are located at PCD (D_p) = 72 mm

\[
\text{Tangential force on each bolt (F_b) } = \frac{\tau}{D_p \pi / 2} 
\]

\[
\Rightarrow T = N \times F_b \times D_p
\]

4.2 Material Procurement

Material is procured as per raw material specification and part quantity. Part process planning is done to decide the process of manufacture and appropriate machine for the same.

General material used :-

EN24 - Alloy Steel
EN9 - Plain Carbon Steel
MS - Mild Steel
STD - Standard Parts Selected From PSG Design ; Data/Manufacturer Catalogue

5. Conclusion

On comparing conventional and our new modified differential locking system, we came to conclusion that locking of wheel shafts with the help of spike shaft and dog ring is found very useful in designing. In concluding the words of our project, since the locking of the differential is very much useful in reducing a considerable amount of loss due the transmission through the differential.
Results obtained from the experimentation predict the effective locking which is required by the differential when the vehicle wheel stucked in to any obstacle like mud.

6. References


