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Comparative Study of Torsen Differential

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Abstract

The main objective of the study is to compare theTorsen differential with various other types of conventional differentials which are commonly used in automobiles. The comparison is based on various parameters like working mechanism, design, sensitivity etc.

Keywords

Invex Gearing, Elementary Gears, Side Gears, Differential Housing, Bias Ratio

I. Introduction

The differential is a common mechanical device preferred to be used in automobiles. The basic purpose of a differential is to transmit the power to the wheels while allowing them to rotate at different speeds.Though it seems a simple mechanism but still there are many of its types, each with its own specific property and mechanism.Torsen is also a type of differential invented and patented by Gleason in 1958, as shown in fig 1. Just like others it works on the principle of transmission of torque and power through meshing of gears but unlikely the mechanism of Torsen of controlling torque and traction differs technically.

II. The Working Principle

Every differential works on the simple principle of transfer of power and load from one gear to the other. Torsen also works on the same principal but what differentiates it with others is the use of worm and worm gear assembly in its operation. Its principle is simple i.e. a rotating worm gear can rotate the worm wheel but rotating worm wheel cannot spin the worm gear. This principle is the reason for its quick sensitivity to any change in torque output.

A. Invex Gearing

Invex gearing in a Torsen differential includes a gear train arrangement (refer to fig 2.) comprised of two or more pairs of satellite gears (called 'element gears') in mesh with central helical gears (called 'side gears').The pairs of element gears are connected with each other by means of two spur tooth engagement. Generally, to transmit and handle the torque coming from the engine, an overall set of 6 element gears is used but this number can vary depending upon the torque capacity and space requirement.

B. Torque Bias Ratio

Bias ratio is the maximum torque ratio which a particular differential design can support. It is expressed as quotient of higher torque (i.e. in the higher axle) to the lower torque (i.e. in the lower axle) proportioned to unity. A '4:1' TBR means the Torsen differential can deliver the wheel having better traction, four times the amount supported by lower traction wheel.

III. Comparision With Conventional Differentials

Even though all conventional differentials serves the same purpose of providing better traction and torque to the wheels at all allowable conditions still ,speaking technically, none of them can be pointed to be perfectly efficient for every condition

A. Comparison With Open Differential

In an open differential the drive axle connection is designed to deliver equal torque to both the wheels. This arrangement will not support any substantial torque difference between the drive axle and, as a consequence, offer very little resistance to differentiation. For example, if one of the wheel falls in poor traction region then this differential will transfer maximum torque to the other wheel resulting in 'spin up' of the wheel having poor traction. Thus the vehicle gets stuck and cannot overcome the traction difference problem. So, an open differential is limited to work when the car is approaching a turn in order to differentially distribute the torque to the two wheels. When comparing it with Torsen differential,the Torsen dominance over the open differential as it can easily come up the traction difference on the two wheels by its invex gearing mechanism, where if any of the wheel falls in a poor traction region the speed change will be transferred to the worm wheel, which in turn transfer the speed change to its adjacent worm wheel, since they are connected with spur gears (as explained in2.1 Invex gearing), this leads to locking of the whole drive mechanism into one system (as by the principle of worm and worm gear ,explained in section 2). Hence, the wheel with poor traction receives high torque and the vehicle can overcome the traction difference problem.

B. Comparision With Locking Differential

The locking differential is almost similar to open differential but with an inherent mechanism to lock the two axles when a traction difference occurs, just like the Torsen. When a wheel falls in a poor traction region, this differential locks both of the axle (as understood by its name "locking") into a single unit and the vehicle can overcome the traction difference problem. But as the Torsen also works on locking the axles then what is the difference in using it?. The answer lies in the design and reactiveness of the mechanism. The locking type has a clumsy and heavy design setup comprising of cam plate, friction discs and an engagement mechanism. Where the engagement mechanism is designed to work on an occurrence of a minimum traction difference, by engaging itself with the cam plate and friction discs. , resulting in axle locking.

When comparing the sensitivity of the differentials i.e. how quickly it responds to the change in traction between the wheels, Torsen leads over the locking type as the respond is quick whereas the locking differential takes time for its engagement mechanism to work. Thus when comparing it on an overall basis, the Torsenbeing compact in design, suits best for quick respond to traction difference.

C. Comparison With Limited-Slip Differential

Limited slip differential(refer to fig 3.) or LSD are provided with pre-loaded friction clutches to oppose the transfer of torque between the axles.The friction pre-load represents a minimum magnitude of resistance which must be overcome to permit any relative motion between the drive axles which may interfere with the operation of anti-lock braking system. Also, since frictional forces are continually active the friction clutches tends to wear, resulting in deterioration of intended differential performance. On the other hand the bias ratio characteristic of the Torsen differential instantly reacts to unequal traction conditions by delivering an increased amount of torque to the drive wheel having better traction before the other drive wheel exceeds the limit of traction available to that wheel. Hence, technically the Torsen shows better result in relation with the sensitivity and traction control of the wheels.

IV. Conclusion

The Torsen differential exhibits a torque biasing characteristic,compact design and high sensitivity of reacting instantlyto traction problems. The TBR property of the Torsen makes it possible to distribute the torque unevenly between the wheels. Thus it is found to be better than any other conventional differential that are discussed in this paper.

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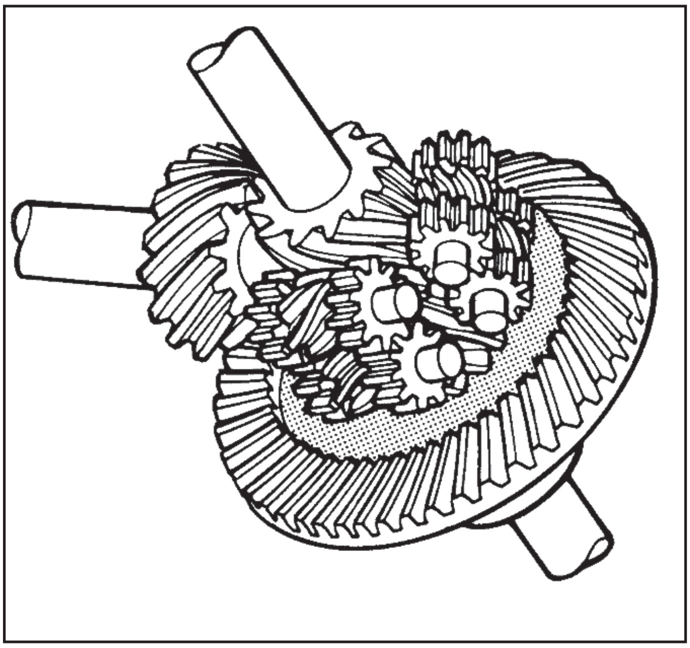

Fig. 1:

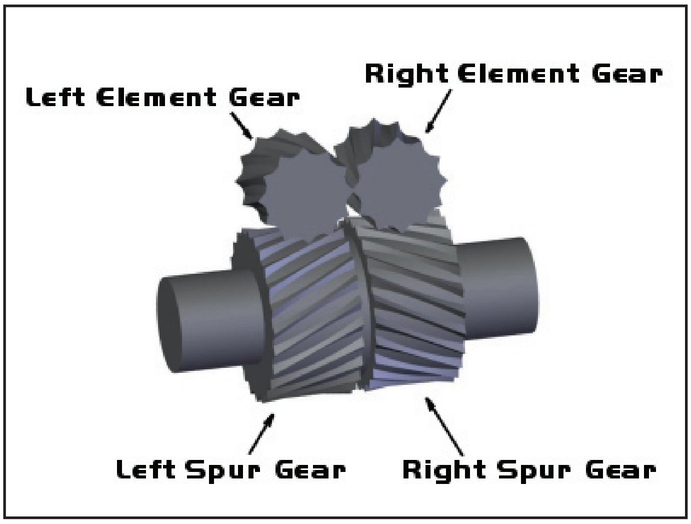

Fig. 2:

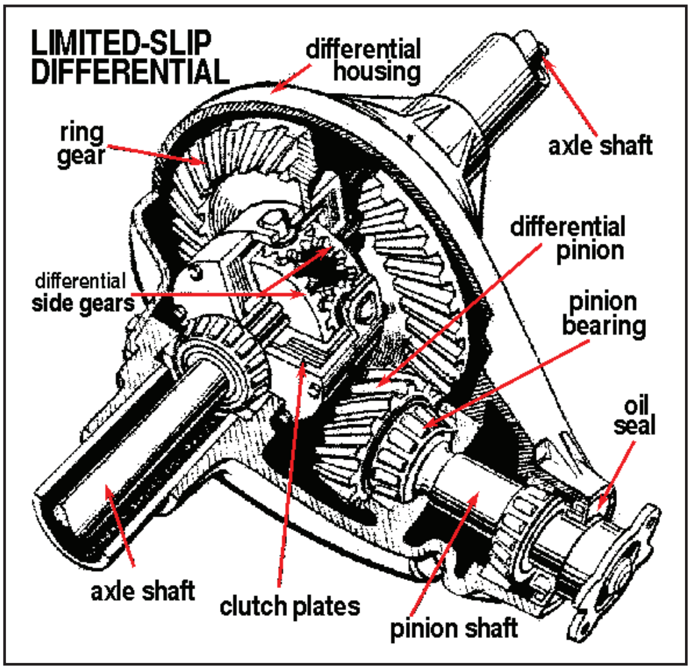

Fig. 3:

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