iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** V **Month of publication:** May 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Study on Differential for Optimum Utilization in Automobile

Prakash Kumar Sen[1], Shailendra Kumar Bohidar[2], Narayan Prasad Sahu[3]
[1,2]Faculty,[3]Student Mechanical Engg. Department,
Kirodimal Institute of Technology, Raigarh, Chhattisgarh, INDIA 496001

Abstract: This paper introduce about differential. Differential is the mechanical device which is used for balancing the automobile. Differential differentiate the motion of inner and outer wheel of automobiles. It has different types in which different elements are included. These elements have working principle which is utilized in automobile. Many gears are used in differential like bevel gear, helical gear and spur gear. In automobiles and other wheeled vehicles, the differential allows each of the driving road wheels to rotate at different speeds, while for most vehicles supplying equal torque to each of them. A differential is a device, usually but not necessarily employing gears, capable of transmitting torque and rotation through three shafts, almost always used in one of two ways: in one way, it receives one input and provides two outputs--this is found in most automobiles--and in the other way, it combines two inputs to create an output that is the sum, difference, or average, of the inputs.
Keyword: Differential, Traction device, Automobile

I. INTRODUCTION TO DIFFERENTIAL

When the car is taking a turn, the outer wheels will have to travel greater distance as compared to inner wheels in the same time. If therefore, the car has a solid rear axle only and no other device; there will be tendency for the wheel to skid. Hence if the wheel is skidding is to be avoided, some mechanism must be incorporated in the rear axle, which should reduce the speed of inner wheels and increase the speed of outer wheels when taking turns; it should at the same time keeps the speeds of all the wheels same when going straight ahead. Such a device serves the above function is called differential.[1] A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels with equal torque while allowing them to rotate at different speeds. In vehicles without a Differential, such as karts, both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain-drive mechanism. When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the entire drive train.

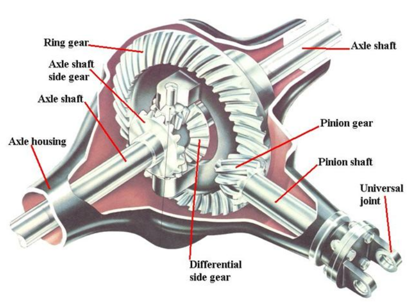


Fig.1 Schematic diagram of Differential

II. CLASSIFICATION

A. Open Differential

Open differentials (Fig.2) make use of a planetary gear set mechanism which distributes torque equally between the drive axles while allowing the wheels to rotate at different rates [2]. The input shaft transmits torque from the driveline to a large ring gear

Volume 3 Issue V, May 2015
ISSN: 2321-9653

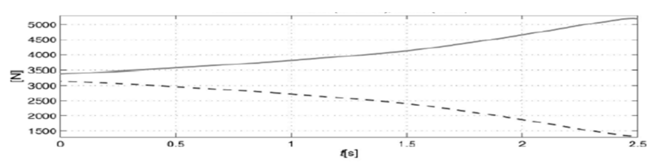
outside the differential carrier. When the vehicle is travelling in straight line the mechanism remains disengaged and the differential casing rotates at same rate as the drive axles. As the vehicle enters the turn the gear set engages and the meshing of the pinion gears allow the drive axle to rotate at different speeds.

Fig 2: Open Differential

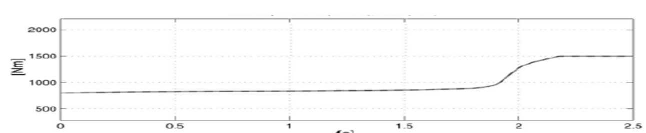
B. Dynamic Model of Cornering

A model of the forces on the tires of the driving wheel has been presented by . The forces transmitted by a tire to the ground are separated into longitudinal and lateral components. The longitudinal force is responsible for forward motion. When torque applied to the wheel exceeds the maximum longitudinal force the tire can transmit, slippage results, the maximum force transmittable by the tire is a function of the normal force acting against the bottom surface of the tire and thus also a function of the amount of load above the tire. During high speed cornering, the weight of a vehicle shifts away from the turning direction due to inertia creating a higher load on the outer wheel and a smaller load on the inner. The maximum transmittable longitudinal force is therefore reduced for the inner tire and increased for the outer tire, thus the outer tire becomes capable of handling more torque and the inner tire, less (Fig.3).[3] As torque is divided equally between both drive axles in an open differential, the inner wheel soon experiences more torque than its tire can transmit causing slippage and loss of control. In high performance conditions, this instability can pose a significant risk to the occupants safety.

VERTICAL LOAD: INNER (DASHED), OUTER (SOLID)



AXIS TORQUES: INNER (DASHED), OUTER (SOLID)



WHEELS SPEED: INNER (DASHED), OUTER (SOLID)

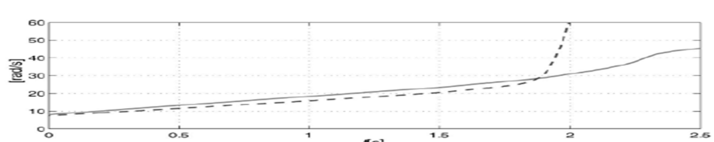


Fig 3: Graphical representation of the vertical loads, axial torques, and rotation speed of the inner & outer wheel [3]

Volume 3 Issue V, May 2015
ISSN: 2321-9653

1) Redistributing Torque Appropriately: Ideally the outer wheel ought to receive a progressively larger amount of torque over time as the load shifts. Several disparate solutions have been developed to mitigate the problems experienced by open differentials during the negotiation of turns at high speed.

2) Clutch Plate Limited Slip Differentials: One of the earliest solutions to the problem of inappropriate torque distribution between axles is the clutch plate differential. This unit functions by making use of the difference in speed of the inner and outer wheels during a turn to improve traction. They employ a set of friction plates on either side of the differential case. Half of these plates are meshed with the profile of the case whilst the other half is meshed with each of the drive axles. In straight line driving the carrier and the axles turn at the same rate as the differential gearing remains disengaged. At the beginning of a turn, the outer wheel begins to spin faster than the inner wheel resulting in the engagement of the differential and initially the driveshaft torque is still equally distributed between the two axles. The differentiation causes the friction plates to turn in opposite directions and produce a restraining force on the mechanism to keep each of the axles spinning at the same rate. As mentioned above, the speed of the inner wheel begins to increase due to the initial excess torque transfer and once it has become equal to that of the outer wheel, the friction plates ensure that it does not rise any further. As a result, more torque is gradually transmitted to the outer wheel as its vertical load increases. The torque and axle speed characteristics are outlined below (Fig. 4).

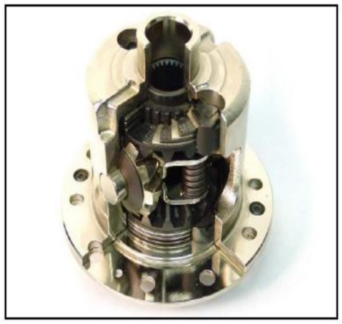


Fig 4: Clutch plate limited slip differential

3) Viscous Limited Slip Differential: Similar in many ways to the clutch plate design, these mechanisms employ viscous couplings joined to an open differential. A set of friction surfaces is surrounded by one of several viscous fluids which have the property of solidifying at high temperatures. As the two axles begin to spin at different rates, the friction surfaces rotate in the fluid performing work and thus generating heat. The increasing viscosity of the fluid provides the resistance to differentiation. Engagement is slightly delayed as the fluid cannot heat up instantaneously. If the situation becomes so extreme that one wheel has almost no traction at all (either due to a very high speed while cornering or as a result of being on a nearly frictionless surface like ice), the resistance provided by the fluid may not be applied quickly enough. One of the shortcomings of this type of differential is that the work g enervated in the fluid can eventually exceed a critical limit that it can tolerate. The result is a partial or complete loss of its mechanical properties. These differentials are difficult and expensive to repair since a unique fluid is used. (Fig.5).

Fig 5: Viscous limited slip differential

III. WORKING PRINCIPAL

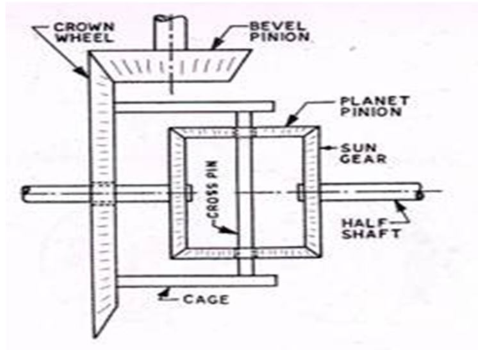


Fig 6: Principal of Differential [4]

To understand the principal on which differential works, consider fig. to the crown wheel of the final drive is attached a cage, which carried a cross pin (in case two planet pinions are employed) or a spider (in case four planet pinions are used). Two sun gear mesh with the two or four planet pinions. Axle half shafts are splined to each of these sun gears. The crown wheel is free to rotate on the half shaft. The main components of the differential mechanism are as follows.

Crown wheel
Cage
Sun gears
Planet pinions

The power from the propeller shaft bevel pinion goes to the crown wheel. Along with the crown, rotates the assembly of four bevel pinions (planet pinions and sun gears). Two bevel gears are carried on individual half axles which are connected to the rear wheels. When stationary, if one wheel is made to rotate in anticlockwise direction then the other wheel through the bevel gear assembly rotates in the clockwise direction.If on a straight road the both the wheels are rotating at N rpm, and now if negotiating a curved path, if the inner wheel rotates at N-a rpm the outer wheel will rotate at N+a rpm.[5]

IV. LOSS OF TRACTION

One undesirable side effect of a conventional differential is that it can limit traction under less than ideal conditions. The amount of traction required to propel the vehicle at any given moment depends on the load at that instant—how 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 drive train can *supply* as much torque as necessary, so the limiting factor becomes the traction heavy the vehicle is, how much drag and friction there is, the gradient of the road, the vehicle's momentum, and so on.The torque applied to each driving wheel is a result of the engine, transmission and drive axles applying a twisting force against 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 one of the drive wheels exceeds the threshold of traction, then that wheel will spin, and thus only provide torque at each other driven wheel limited by the sliding friction at the slipping wheel. The reduced net traction may still be enough to propel the vehicle. A conventional "open" (non-locked or otherwise traction-aided) differential always supplies close to equal (because of limited internal friction) torque to each side [6]. To illustrate how this can limit torque applied to the driving wheels; imagine a simple drive vehicle, with one rear road wheel on asphalt with good grip, and the other on a patch of slippery ice. It takes very little torque to spin the side on slippery ice, and because a differential splits torque equally to each side, the torque that is applied to the side that is on asphalt is limited to this amount [7, 8].

V. TRACTION AIDING DEVICE

In a four-wheel drive vehicle, a viscous coupling unit can replace a centre differential entirely, or be used to limit slip in a conventional 'open' differential. It works on the principle of allowing the two output shafts to counter-rotate relative to each other, by way of a system of slotted plates that operate within a viscous fluid, often silicone. The fluid allows slow relative movements of the shafts; such as those caused by cornering, but will strongly resist high-speed movements, such as those caused by a single wheel spinning. This system is similar to a limited slip differential.Centrifugal weights can be used in conjunction with, or in place of the preload spring(s) to force the side gears into the carrier. The EatonG80 (sold by General Motors under the Gov-Lok name) is one example of this. In theory the centrifugal action should offer a more progressive application of torque bias, and therefore fewer undesirable side-effects. The added complexity can cause premature failure under heavy use. [9] A locking differential typified by the Detroit Locker (now an Eaton brand) is not a differential at all. In place of the differential is a pair of dog and preload springs that force the two drive axles to "lock up" with the case (typically this type uses the case of a standard open differential, replacing the differential gears) while driving in a straight line. During cornering, one of the dog clutches should disengage, causing one side to freewheel. In practice the unlocking can be problematic and erratic.

VI. ACTIVE DIFFERENTIAL

A relatively new technology is the electronically controlled 'active differential'. An electronic control unit (ECU) uses inputs from multiple sensors, including yaw rate, steering input angle, and lateral acceleration—and adjusts the distribution of torque to compensate for undesirable handling behaviours like understeer. Active differentials used to play a large role in the World Rally Championship, but in the 2006 season the FIA has limited the use of active differentials only to those drivers who have not competed in the World Rally Championship in the last five years. Fully integrated active differentials are used on the Ferrari F430, Mitsubishi Lancer Evolution, and on the rear wheels in the Acura RL. A version manufactured by ZF is also being offered on the B8 chassis Audi S4 and Audi A4[10].The Volkswagen Golf GTI Mk7 in Performance trim also has an electronically controlled front-axle transverse differential lock, also known as VAQ[11]. The second constraint of the differential is passive—it is actuated by the friction kinematics chain through the ground. The difference in torque on the road wheels and tires (caused by turns or bumpy ground) drives the second degree of freedom, (overcoming the torque of inner friction) to equalise the driving torque on the tires. The sensitivity of the differential depends on the inner friction through the second degree of freedom. All of the differentials (so called "active" and "passive") use clutches and brakes for restricting the second degree of freedom, so all suffer from the same disadvantage—decreased sensitivity to a dynamically changing environment. The sensitivity of the ECU controlled differential is also limited by the time delay caused by sensors and the response time of the actuators.

VII. CONCLUSION

Differential is so important for automobile. It provide balance. In any turning moment of automobile, automobile occures slip if differential is not used. Differential used many gears such as helical, bevel, spur gear according to use. All parts have worth in differential. Differential results that it is used for controlling the vehicles and it is also used for safety purpose.

REFERENCES

[1] Dr. Kripal Singh, automobile engineering vol. 1, pp: 139-140.
[2] S. H. Gawande et al, ‘design, manufacturing and analysis of differential crown gear and pinion for MFWD axle, iosr-jmce, ISSN (e): 2278-1684, ISSN (P): 2320 334X, PP: 59-66
[3] S. H. Gawande et al, ‘design, manufacturing and analysis of differential crown gear and pinion for MFWD axle, iosr-jmce, ISSN (e): 2278-1684, ISSN (P): 2320-334X, PP: 59-66
[4] Dr. Kripal Singh, automobile engineering vol. 1, pp: 139-140.
[5] http://scholarexpress.com/differential-of-an-automobile/
[6] Chocholek, S. E. (1988) "The development of a differential for the improvement of traction control"
[7] Bonnick, Allan. (2001) "Automotive Computer Controlled Systems p. 22
[8] Bonnick, Allan. (2008). "Automotive Science and Mathematics p. 123
[9] From Wikipedia
[10] "ZF Press release". Zf.com. Retrieved 2011-01-09.
[11] "Golf VII GTI". Pistonheads.com. Retrieved 2013-06-24.