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Review on Recent Trends in Type of Lock used and Research Done on Differential Locking Systems

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Abstract: Differential gear locking systems have wide scope in all-terrain vehicles, automobiles, special purpose vehicles due to its feasibility to modify the RPM as per the demand. In present work, a review is made on manufacturing, experimental analysis and finite element analysis, and designing of automatic, semi-automatic and manual differential locking system.

Keywords: Differential Locking Mechanism, Semi- Automatic, Manual, Automatic

I. INTRODUCTION

In recent years there has been extensive research and development done on different types of locking system to be incorporated in differential gearbox. Many researchers designed, modelled, manufactured and analysed the manual, automatic and semi-automatic differential locking system and both manual and automatic systems introduced in the same system. One problem with an automotive differential is that if one wheel is held stationary, the counterpart wheel turns at twice its normal speed as can be seen by examining the complete scheme of automobile differential. This can be problematic when one wheel does not have enough traction, such as when it is in snow or mud and on undulating slippery surfaces. The wheel without traction will spin without providing traction and the opposite wheelwill stay still so that the car does not move. The above problem is solved by introducing a differential locking system which can be engaged or disengaged either manually or automatically, as per the conditions or a sensor based system can be developed that will sense the difference in speed or stalling of one wheel to lock the differential so that both wheels will have same traction. A locking differential, such as one using differential gears in normal condition but using mechanical systems, which when locked allows no difference in speed between wheels on the axle. This system employs a mechanism for allowing the axles to be locked relative to each other, causing both wheels to turn at the same speed regardless of which has more traction; this is equivalent to effectively by-pass the differential gears. Other locking systems may not use differential gears but instead drive one wheel or both depending on road conditions. Automatic mechanical lockers do allow for some differentiation under certain load conditions, while a selectable locker typically couples both axles with a solid mechanical connection like a spool when engaged.

II. LITERATURE REVIEWS

1. Subhadra Ghosh, E.Raja, P. Naveenchandran, and D. Mohankumar discussed on 'Design and Fabrication of Automatic Differential with Lock' in International Journal of Pure and Applied Mathematics in 2018. A differential locking framework presented can be locked in or withdrawn either physically or consequently, according to the conditions or a sensor based framework can be created that will sense the distinction in speed or slowing down of one wheel to bolt the differential by sliding a canine ring to get occupied with planetary apparatus spike shaft so that both wheels will have same footing. The set-up demonstrated programmed engagement of the differential when the loss of footing condition is experienced in this manner it approved the capacity of the programmed method of the differential locking framework. The set-up demonstrated them an ual abrogate utilizing push catch framework for self-loader method of differential locking.
2. ShashankVaidya, ChetanGurav, ShubhamRajore, Vishal Rokade, Prof. S.V. Raut discussed on design of dog ring for differential locking system purpose. In this project, Dog pins engage in the cage of thespike shaft and act as transmission elements. They can be designed similar to the bush pins in the bush pin type flexible flange coupling. It has been concluded that locking of wheel shafts with the help of spike shaft and dog ring is found very useful in

designing. It became very much useful in reducing a considerable amount of loss due the transmission through the differential. Results obtained from the experimentation predicted the effective locking.

3. Prof. A. S. Todkar and R. S. Kapare introduced a differential locking system that can be engaged or disengaged manually or automatically, as per the conditions or a sensor based system can be developed that will sense the difference in speed or stalling of one wheel to lock the differ by sliding a dog ring to get engaged in planetary gear spike shaft difference in the speed of driven and rolling wheels. The developed set-up has shown automatic engagement of the differential when the loss of traction condition is encountered there by validating the function of the automatic mode of the differential locking system. The set-up showed the manual override using push button system for semi-automatic mode of differential locking.

4. Ajinkya Shirsath*, Nehankit Nannaware, Shekhar Kale, SuchitChhajed and Shrikant Nimbalkar, designed a test rig for semi-automatic differential locking system. A Semi-automatic differential lock system introduced here can be engaged or disengaged manually as per conditions by stalling of one wheel to lock the differential by sliding a dog ring to get engaged in planetary gear spike shaft so that both the wheels have the same traction. If the difference in the speed of driven and rolling wheels is encountered then the differential is controlled to lock. The setup has been developed and the functioning has been checked successfully. It demonstrated the proper functioning of semi-automatic locking of the differential during the loss of traction condition is encountered and thereby validated the function of the semi-automatic mode of the differential locking mechanism by using push button system.

5. Vinod P. Sakhare, Ajinkya D.Wadatkar, Gaurav B. Lohakare, Nikhil G. Narad published a paper on advances in motion control of rear wheels of automobile differential using wheel locking system. A differential locking system introduced here can be locked or unlocked either by hand or automatically, as per the conditions of the road surface. The sensor based system can be very sensitive and hence signals to system even if there is no requirement for differential locking. Here in this system we will be incorporating manual based differential locking system. The dog ring will be engaged manually instead of sensor based system to avoid the actuation of sensor even if it is not required which senses even small variations on road surface which may sometimes cause accidents. The manual engagement of wheel stalls one wheel to lock the differential by sliding a dog ring to get engaged in planetary gear spike shaft so both the wheel have same traction and if the difference in speed of driven and rolling wheel is encountered then the differential is lock.

6. Utkarsh A. Patil1, Vishal J. Savant, Rohit S. Bharamgonda, Prof. P. N. Gore published a research paper on 'Recent Advances in Differential Drive Systems for Automobile Propulsion'. A comparative study among all of these differentials becomes essential. It is hoped, this paper will help us to know various differentials available. This paper focused on types of differential with several operational methods, so it is possible to create an idea to solve the limitations by combining two or more methods of differential drive system. Also for studies related to available differentials, this paper will help to conduct surveys related to differentials.

7. K. Dinesh Babu, M. Siva Nagendra, Ch. Phanideep, J. Sai Trinadh presented a research paper on 'Design and Analysis of Differential Gear Box in Automobiles'. The main objective of this paper was to perform mechanical design of differential gearbox and analysis of gears in gear box. In this paper they checked as the aluminium can be the other material for the differential gear box for light utility vehicles in order to reduce the weight.

8. Shashank Pandey, Nikhilesh N. Singh & Dr. Prabhat Kumar Sinha discussed on modelling, design & analysis of differential gear box and its housing through fem, solid work & ansys bench work 14.0.The differential gears assembly and its housing have been analysed for the vibration effect on a system in which the life of the gears is determined within different frequency range in the platform of Ansys-14.0 by importing part modelled in Solid works. It has been observed thatthe gear housing is also affected by vibration in casing that surrounds the gear box. The results were in good congruence with the theoretical values, which suggest that the model designed was correct.

III. WORKING PRINCIPLE AND MODEL DESIGN

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3.1 Working of Differential gears: -The conventional differential is used in transmission in which difference in speed of both the rear wheels and allows taking a fix turn rotation .The major principal of the differential is to permit each of the driven wheels must rotate at different speed. The wheels move at different speeds, at the time of turning. The conventional differential is designed to run both of the wheels with same torque while allowing them to rotate at variation in speed. At the time of cornering, the inside wheel needs to travel a smaller distance than the outside wheel so, in case of open differential the inside wheel spins, sometimes it may cause slipping, and this result in difficulty in handling the vehicle. Skilled drivers can tackle this situation based on their driving experience. But major problem is that when the vehicle travels on the rough and muddy surface having pits, at stationary condition, the opposite wheel turns at twice its normal speed. This condition creates major problem in when wheel cannot generate enough traction. And due to loss of traction it will spin and the counter wheel will stay stationary so the vehicle won't be able to cover the distance.

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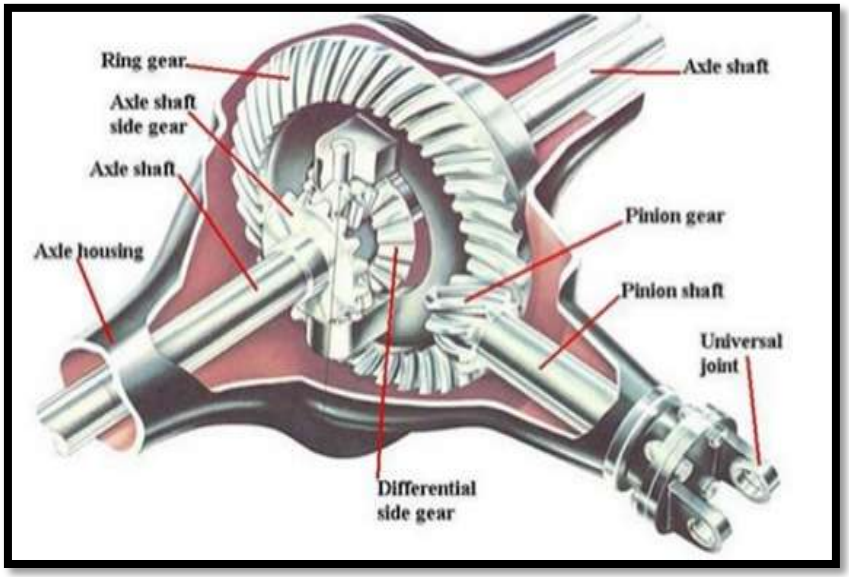

Figure 1: Functioning of Conventional differential gear

3.2 Working of differential with lock-

A locking differential is designed to overcome the main limitation of a standard open differential by locking both wheels on an axle together as those are mounted on a common shaft. This causes both wheels to turn in unison, regardless of the traction available to either wheel individually.

When the differential is unlocked operates as an open differential, it allows each wheel to rotate at different speeds (such as when negotiating a turn). An open (or unlocked) differential always provides the same torque (rotational force) to each of the wheels, on that axle. So although the wheels will rotate at different speeds, they apply the same rotational force, even if one is entirely stationary, and the other spinning.

By contrast, a locked differential forces both left and right wheels on the same axle will rotate at the same speed under nearly all circumstances, without regard to traction differences seen at either wheel. Therefore, each wheel can apply as much rotational force as the traction under it will allow, and the torques on each side-shaft will be unequal and rotational speed will be same. Exceptions apply to automatic lockers, discussed below.

In the locked position when you are driving straight ahead and unlocked when you turn a corner when the outer wheel is turning faster than the inner wheel. This wheel overrun is then re-locked when both wheels are rotating at the same speed again. So now you have a locked diff for those hairy situations plus a diff that's effectively open for on-road use and ease of steering, all rolled into one [4].

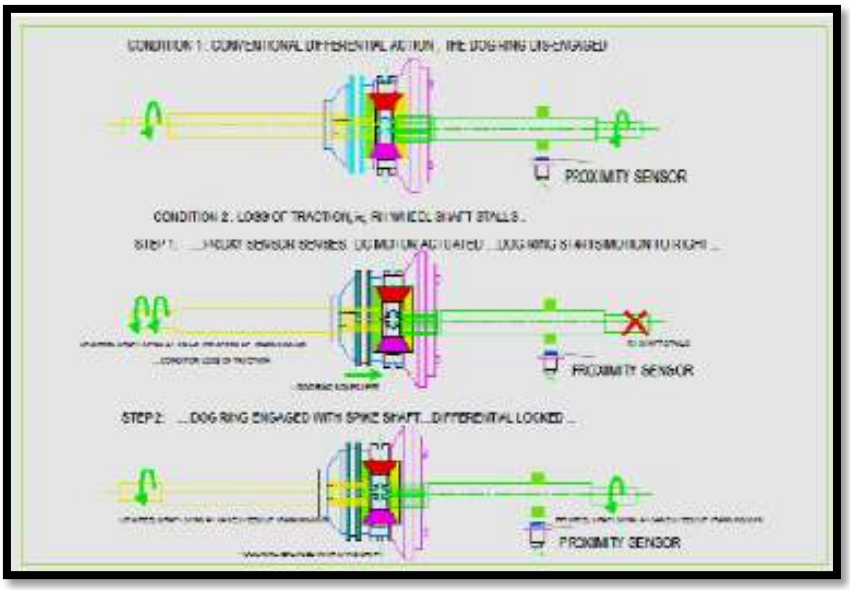

Figure 2-Working of proposed differential automatic locking [3]

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A locked differential can provide a significant traction advantage over an open differential, but only when the traction under each wheel differs significantly. An electronic locking differential typically has two parts. Part 1-Sensors at each wheel that measure the turning speed. The computer in the car uses this measurement to detect if the wheel is slipping. If it is, it engages the second part. Part 2- A clutch or gear system is used to make both wheels rotate at the same speed, i.e. a locked differential. Once locked both or all wheels turn at the same speed. The advantage of an electronic locking system is that the wheels are locked only while one of more wheels are slipping.

IV. CONCLUSION

- It has been the major conclusion that, various types of lock systems are available. Manual locking, automatic locking.
- Automatic locking has been found to be the user friendly system. The vehicle, in which automatic locking system is incorporated, it manages to provide proper speed of rotation and traction to one wheel or both wheels. The locking can be enacted and turned back off in a fraction of a second. Older purely mechanical systems are not as flexible or as fast as this one. Auto lockers require no driver input, but they also help the inexperienced off-roader to get further down a difficult track than his or her ability might otherwise allow. These are more suitable for front differential drive as they offer easier steering compared to the (almost) non-existent steering you have with an engaged manual locker. When tackling tight turns and roundabouts, you may feel a slight resistance to the steering input and your turning circle may be larger as the locker cuts in and out. The main advantage is smooth and automatic operation and positive locking for 100 percentage traction. [9]. Automatic system is featured with extremely sensitive unlocking (finger touch). Doubles your 4WD's off-road abilities [10].
- It is likely to get a little higher tyre wear with automatic type of lock for on-road use.
- Manual locking will yield the advantage of same traction to be transmitted to both wheels. But it can be used by skilled and experienced drivers or vehicle users. The user will be able to decide when to lock and unlock after getting a good command on manoeuvring the vehicle. Locking can be used only when vehicle is at its lowest speed. Driver must disengage the lever to unlock the differential on a uniform or plane road.
- Manual system or mechanically operated system will result in much lesser unsafe driving conditions as compared to automatic locking.
- Locking system is suitable for 4 wheel drive. It is used to free the vehicle from the muddy road.
- The system increases off road capability and control in difficult off road driving condition.
- Locking can be used only when speed is below 8 km/h.[11]

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