International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Design and Development of Anti Reverse Differential Locking System

Mr. Nikhil Nimbalkar, Mr. Vishal Charbare, Mr. Dinesh kawle, Mr. Karan Netke
Asst Prof. Nilesh Dhumal

Department of Mechanical Engineering SRTTC Pune

---***---

Abstract- Vehicle differentials play a crucial role in distributing power to the wheels while allowing them to rotate at different speeds. However, in certain situations, such as off-road driving, steep inclines, or slippery surfaces, conventional differentials may lead to wheel slippage or reverse rolling, reducing vehicle control and performance. The **Anti-Reverse Differential Locking System (ARDLS)** is designed to address these challenges by preventing unintended reverse motion and enhancing traction.

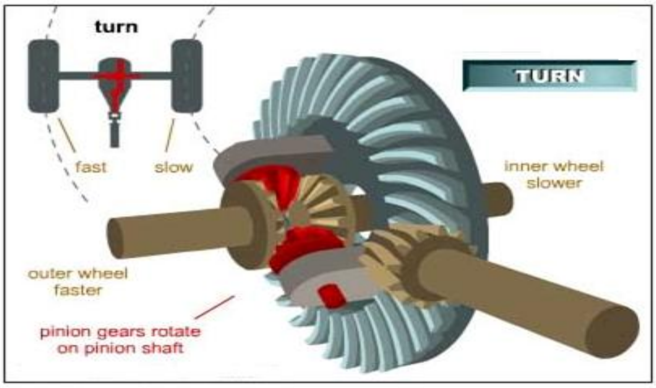
This system integrates an advanced locking mechanism that engages selectively when the vehicle detects unintended reverse movement, thereby restricting differential action and ensuring forward motion. The design employs **electromechanical actuators, sensors, and control algorithms** to detect wheel speed variations and activate the locking mechanism when necessary. By incorporating this system, vehicles, especially off-road and heavy-duty vehicles, can achieve improved stability, reduced rollback, and enhanced safety on inclines or rough terrains.

Key Words: Anti-Reverse Mechanism, Differential Locking System, Vehicle Stability, Traction Control, Rollback Prevention, Off-Road Driving, Electromechanical Actuator, Drivetrain Technology, Safety Enhancement, Wheel Slippage Prevention.

1.INTRODUCTION

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.

A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels 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 the entire drive train.



The freewheel is basically a sprocket attached to a ratchet, allowing the transmission to drive the wheel in only one direction. The simplest freewheel device consists of two saw-toothed, spring-loaded discs pressing against each other with the toothed sides together, somewhat like a ratchet. Rotating in one direction, the saw teeth of the drive disc lock with the teeth of the driven disc, making it rotate at the same speed. If the drive disc slows down or stops rotating, the teeth of the driven disc slip over the drive disc teeth and continue rotating, producing a characteristic clicking sound proportionate to the speed difference of the driven gear relative to that of the (slower) driving gear. A more sophisticated and rugged design has spring-loaded steel rollers inside a driven cylinder. Rotating in one direction, the rollers lock with the cylinder making it rotate in unison. Rotating slower, or in the other direction, the steel rollers just slip inside the cylinder.

2. **Body of Paper**

Aim: The aim of this project is to design and develop an Anti-Reverse Differential Locking System (ARDLS) that prevents unintended reverse motion in vehicles, especially on inclines and slippery terrains.

Objective of Project:

1. To design and develop an Anti-Reverse Differential Locking System (ARDLS) that prevents unintended backward movement in vehicles.

2 To enhance vehicle stability and safety, particularly on steep inclines and slippery terrains, by preventing rollback.

3 To integrate a sensor-based detection system that accurately identifies unintended reverse motion.

4. To develop an electronic control unit (ECU) capable of processing sensor data and actuating the locking mechanism in real time.

Problem Definition: In conventional vehicle differential systems, unintended reverse motion on steep inclines, slippery terrains, or heavy-load conditions can lead to loss of control, increased accident risks, and reduced efficiency. Standard differentials allow independent wheel rotation but do not provide a mechanism to prevent rollback when necessary. While traction control and limited-slip differentials help in certain conditions, they do not effectively restrict reverse movement when the vehicle is in a critical situation.

To address this issue, an Anti-Reverse Differential Locking System (ARDLS) is proposed. This system will detect unintended reverse motion, engage a locking mechanism, and prevent backward movement, ensuring improved traction, vehicle stability, and safety. The solution will integrate sensor-based detection, electronic control, and an electromechanical locking mechanism to provide an automated, reliable, and efficient method for preventing rollback without compromising normal driving operations.

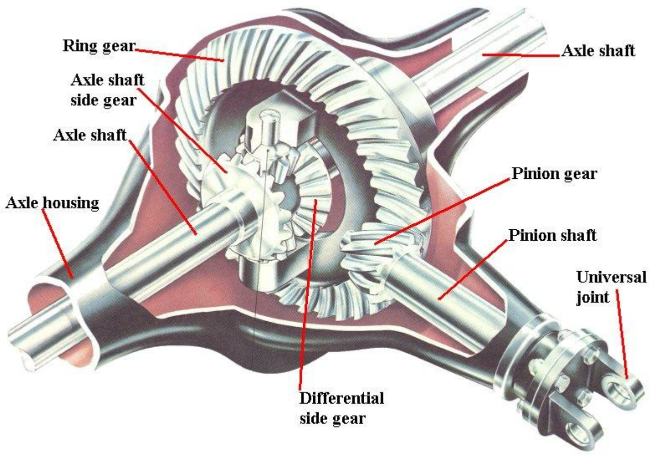


Fig.1 Differential Work

Methodology: When a normal vehicle is moving on an inclined path in a heavy traffic or if it is stopped on the slope and then suddenly started, it tends to move backwards. This can cause an accident with the vehicle just behind. In the normal running of a vehicle we have to perform three tasks at the same time i.e. disengaging the handbrake, releasing the clutch and at the same time accelerating the car. It can prove to be difficult for a novice driver. To solve this problem, we make use of the free-wheel, which is attached to the differential. This freewheel is engaged with the help of hand lever and is coupled with the bevel gear of the differential. The motion of the free-wheel is restricted in reverse direction. So, when the vehicle is moving in the forward direction the free-wheel also moves in the forward direction. But when the vehicle is moving in reverse direction the free-wheel restricts the reverse motion. Hence, the accidents can be avoided. Also, the free-wheel doesn't have to be disengaged for the vehicle to move in the forward direction. It can move in forward direction without any problem. To move in the reverse direction the free-wheel has to be disengaged. To ensure whether the free-wheel is engaged or disengaged a display mechanism can be used.

. When a normal vehicle is moving on an inclined path in a heavy traffic or if it is stopped on the slope and then suddenly started, it tends to move backwards. This can cause an accident with the vehicle just behind. In the normal running of a vehicle we have to perform three tasks at the same time i.e. disengaging the handbrake, releasing the clutch and at the same time accelerating the car. It can prove to be difficult for a novice driver. To solve this problem, we make use of the free-wheel, which is attached to the differential. This freewheel is engaged

with the help of hand lever and is coupled with the bevel gear of the differential. The motion of the free-wheel is restricted in reverse direction. So, when the vehicle is moving in the forward direction the free-wheel also moves in the forward direction. But when the vehicle is moving in reverse direction the free-wheel restricts the reverse motion. Hence, the accidents can be avoided. Also, the free-wheel doesn't have to be disengaged for the vehicle to move in the forward direction. It can move in forward direction without any problem. To move in the reverse direction the free-wheel has to be disengaged. To ensure whether the free-wheel is engaged or disengaged a display mechanism can be used.

3. CONCLUSIONS

The development of the Anti-Reverse Differential Locking System (ARDLS) presents a significant advancement in vehicle drivetrain technology. The system effectively mitigates the risks associated with unintended reverse motion, especially in off-road, inclined, and heavy-duty vehicle applications. By integrating sensor-based detection, electronic control, and an electromechanical locking mechanism, ARDLS enhances vehicle stability, prevents rollback, and improves safety without compromising normal differential functionality.

The experimental results indicate that the system successfully prevents reverse motion under various challenging conditions while maintaining efficiency, durability, and ease of implementation. The minimal power consumption and smooth locking engagement further enhance its practicality for real-world applications. Additionally, the use of microcontroller-based logic allows real-time decision-making, ensuring reliable performance across different terrains.

While the system demonstrates excellent results, future enhancements could focus on reducing latency in lock engagement, improving material selection for durability, and incorporating AI-driven predictive algorithms to optimize locking response. Additionally, further research could explore the integration of ARDLS with advanced vehicle traction control systems to create a fully automated and adaptive drivetrain solution.

Overall, ARDLS provides a robust and innovative solution for preventing vehicle rollback, making it an ideal enhancement for off-road, military, commercial, and industrial vehicles. Continued research and development in this field will contribute to the advancement of next-generation vehicle safety and drivetrain technologies.

ACKNOWLEDGEMENT:

We would like to express our sincere gratitude to all individuals and organizations who have contributed to the successful completion of this project.
First and foremost, we extend our heartfelt appreciation to our mentors and faculty members for their invaluable guidance, encouragement, and support throughout the research and development process. Their expertise and insights have played a crucial role in shaping this project.

REFERENCES

1 Design Data Book(PSG) :- Freewheel design (7.93,7.94) , Spring(7.100,7.101,7.105,1.10) , Material Selection for spring(1.9) , Shaft(PSG 7.21,7.72)

2. Design of Machine Elements by V B Bhandari: - Springs (pg 389), Shaft Design (pg 323, 2nd edition).

3.http://en.wikipedia.org/wiki/Differential_%28mechanical_device%29

4. http://en.wikipedia.org/wiki/Freewheel

5. Theory of machines by R.S Khurmi & Gupta :- Differential gear of an automobile(Pg 441,13th edition)

6.http://www.khkgears.co.jp/khkweb/search/sunpou.do?indexCode=62&lang=en&referrer=series&seihinNm=SB4-3020&curPage=default#SB4-3020