

# Automatic Differential Locking System

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## Abstract:

The unit of differential we have designed is to lock it while moving on steep hills or slippery areas. By locking it the differential is separated from the axle. In this way the power is straightforwardly sent to the axle and thus to the wheels. It'll significantly decrease the power loss in an event when undesirable loss is going on because of the transmission on the off chance that influence from the shaft to the differential and, to the axle and thus to the wheels. So, in system the undesirable power loss in the proper way of transmission through the differential is decreased. There are a few downsides in the current instrument and we conquer it in the proposed project. The first is while moving in quite a while the differential isn't exactly required as the speed of the vehicle is low. And furthermore, there are some transmissions loses in the differential. So right now, the unit is locked and the loss is survived. Then, at that point, when a weighty truck is trapped in a pit or mud it is extremely challenging to recuperate the truck as the differential unit slices the power which is to be communicated to the wheel stuck. So, in this task the unit is separated and power is straightforwardly given to the axle by pneumatic means thus the recuperation is made simpler. This is even made use in the vehicle to be driven in the thick woods and, surprisingly, in dessert. Likewise, there will be a fastener component in the information shaft of the differential to forestall the opposite movement of the vehicle at the driver's will.

*Key Words* – Differential, Power loss, Transmission, Locking system, Torque.

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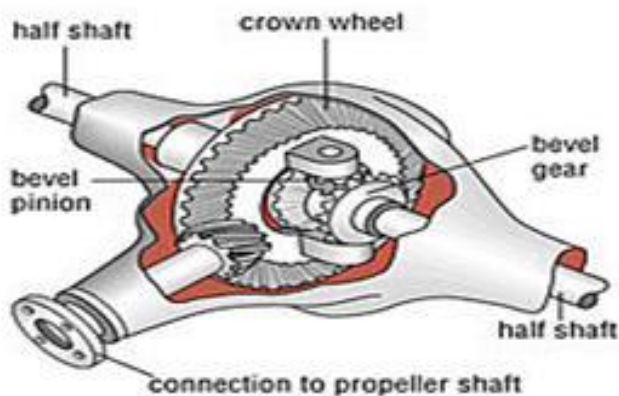
## I. INTRODUCTION

Whenever we try to turn our car or any vehicle we feel only the inertia, the jerk and for us the car simply turns towards the desired direction. We believe that

all the tires of the vehicle are turning at the same speed and that's how our vehicle is turned in the desired direction. But in actual while turning the inner tire rotates slowly while the outer tire rotates

Figure 1 [1]

faster to make the desired angle of turn and what



makes the turning of car more effective and effortless is the crucial part of automobile known as differential. The differential is that part which decide that how much torque and how much speed must be distributed in rear tires for the smooth running of vehicle. The power is produced by the engine but the power is not directly transferred to the tires, the power is passed through shafts and then the differential decides that how much power must be distributed in each for the tire for smooth running of the vehicles. Here is an image of the differential and its parts:

Now suppose if by any chance there is not such type of thing kike differential and its mechanism so what will happen to your vehicle? The answer is simple you would be unable to drive the vehicle properly because at that time all the power and torque will be distributed to the tires without considering the weight and inertia of the vehicle. The differential is not only needed in straight roads or plane areas, they are also required to perform in each type of terrain like offroad, racing track etc. [1]

Their some certain tasks or job we can say that a good differential should be able to do, these are as follows:

1. The differential should be dedicated to engine and it should try to collect all the power generated by the engine.

2. It must behave in such a way to reduce the final gear of the vehicle, which results in slowing down the rotational speed before it hits the wheels.
3. A good differential or suitable differential should transmit the power to the wheels while the wheels are still rotating at different speeds. This is one of the reasons behind the name of differential.

## II. TYPES OF DIFFERENTIALS:

1. Open Differential
2. Locked Differential
3. Limited Differential Slip
4. Torque Vectoring Differential

### Open Differential

An open differential is defined as one of the basic forms of differential which is attached to the two halves of the axle and has gear on both of its ends. They are both connected with the help of a 3<sup>rd</sup> gear which is able to make 3 sides of a square. These 3 differential gears are used with the 4<sup>th</sup> gear to make it work more properly and with more power. Furthermore, the entire system is linked with the ring gear in the differential case, whose main job is to keep the core gear in proper working order, and then the wheels are to be driven by the driven shaft via a pinion gear.[2]

### Locked Differential

We can find a locked differential on many off-road vehicles. Locking differential locks are activated by clutches and springs and provide the same amount of power to both wheels regardless of which requires more traction. The main advantage of a locking differential is that you get more traction by providing equal power to all four wheels as compared to an open differential. It's a big advantage while doing off-road driving or rock climbing.[3]

### Limited Differential Slip

This differential is known for having the advantage of both open and locked differentials, which is supposed to be put simply rather than complicated. Under simple road conditions, the slip differential works like an open differential to provide torque independently to each wheel, but when the road is difficult to drive or heavy load vehicles, the wheel can slip easily. At this phase, the limited slip differential comes on and provides less torque so that the wheel doesn't slip off. It does work with the help of plates and clutches in the differential. Different sports cars or race cars use this type of differential.[4]

### **Torque Vectoring Differential**

Torque The vectoring differential is considered the most advanced electronic form of differential because it can provide more torque only to limited or special wheels at different angles and vector quantities. It obtains data from the sensors and, according to that, provides torque and activates electronic actuated clutches. They are also known as active differentials, and they provide the best driving experiences among differentials. It can be easily found in some high-driven vehicles and all-drive vehicles.[5]

### **III. WORKING OF DIFFERENTIAL:**

Let's first define what a locked differential unit or system is. As the name suggests it is opposite to the open differential. The main purpose of the locked differential is to maintain equal speed among both the wheels.

Locked differential is mostly under use in rough terrain compared to the open differential, which is used 90 percent of the time, usually on straight roads. When a vehicle executes a curve or a corner, the inner wheel covers a shorter distance compared to the inner wheel. This is so, just to avoid dragging,

spinning or unpredictable handling or prevent uneven wear of the wheels of the vehicle.

A differential is basically a device which allows the wheels to be driven at different speeds to execute a curve or a turn properly without causing any problem or damage to the vehicle.

The drive shaft transmits the torque to the differential unit. After this, the torque is used further by the spiral bevel pinion, which is mounted in the housing in the differential unit. The pinion meshes with the spiral bevel ring gear, further connected to the differential cage. This cage has four bevel gears and each of them is meshed with two neighbouring gears in perpendicular plane. The two sun wheel gears are adjusted on a similar pivot as the crown wheel gear, and drive the hub shafts associated with the determined wheel. The other two planet gears are adjusted on an opposite pivot which changes direction with the ring gear's rotation. There is no differential development of the planetary arrangement of gears when the vehicle is moving in straight line.

If the vehicle with the open differential is lifted off the ground with the help of a hydraulic lift and provided that the engine is turned off, and if we manually rotate one wheel which is connected to the differential, the other wheel will rotate in the opposite direction to the wheel being rotated to the same extent.

The disadvantage of an open differential is that it limits the traction. It means that if a vehicle with an open differential is stuck, which means that if one of the wheels connected to the differential is stuck, all the power will be transmitted to the other wheel, making that wheel to either spin freely or slip and cause wheel damage. The load on vehicle at a specific position chooses the foothold expected to push the vehicle additionally there are different

factors like inclination of the street, drag and friction too as the vehicle's momentum which influences the traction prerequisites.

The advantages of locking differential system can be:

- (a) Speed or rotary motion of all the wheels will be equal.
- (b) A locked differential will make sure that equal amount of torque/power is transmitted to both the wheels of the wheels at any given condition.
- (c) For rough terrain use, one does not have to depend entirely on the tire or worry about the tire wear, as the equal power is transmitted to the wheels with very less or no slippage.

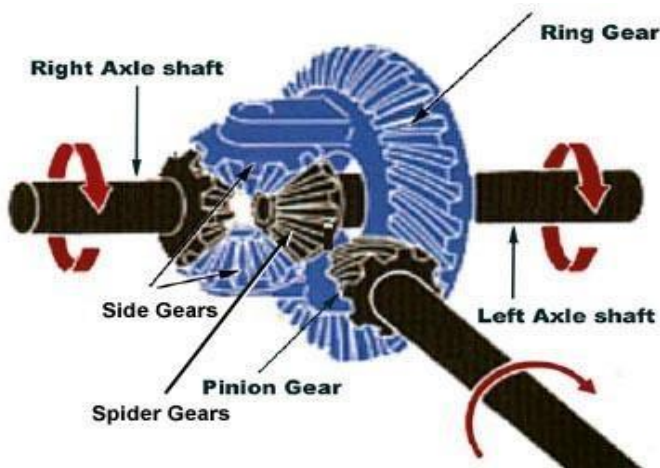


Figure 2 [1]

#### IV. AUTOMATIC DIFFERENTIAL LOCKING MECHANISM:

Now the working of differential is a different thing and the locking of differential is a whole new thing for the automobile scenario. The working of differential is not same in every terrain, it depends and vary on the basis of what type of vehicle is to be used and where it going to be used. What are the conditions of the terrain? What type of work is going to be done by the vehicle? There are so many things

that are took under considerations for the working and designing of differential. And the one kind that supports all of the above questions is Automatic Differential Locking System. It is a type of system by which a driver or vehicle automatically senses the terrain and lock the differential to simple transmit all of the power and the speed to the vehicle. Basically, the vehicles which consist this type of mechanism is known as all-wheel drive vehicles.[7]

They are certain problems or issues that are sfaced in the existing normal differential and these are as follows:

1. A normal differential usually performs two functions that are transmitting power to the to the wheels and other is to permit the wheels to rotate at different speed regarding the terrain condition.
2. It has standard gear ratios for the different terrain and suitable for them at all.
3. The design allows the wheel to spin more freely with less traction which is not good at all.
4. Even in LSD (limited slip differential) it does not provide the traction as necessary regarding the offroad or plane conditions of the track.

The mechanism that helps to solve all these problems with the introduction in automatic locking system is LOKKA mechanism.[8]s

#### LOKKA Mechanism:

This mechanism promotes differential action that is, allowing the wheel to run faster that the differential and it does not let them to turn slower than the differential which in result gives more traction to the wheels to keep them in contact witch the surface. And it also allows the wheel run at different speed.[9]



### 100% positive locking with LOKKA:

Now what it means by saying that it is 100% positive locking is that there is no slippage of the parts when the differential is fully locked as desired. There is no spin in the wheel and no play or slippage in the gears also. Indirectly it also means that 100% torque and power is transmitted to the wheels ideally. The all-wheel drive vehicle will run more effortlessly and effectively.[10]

### Dynamic Locking Principal:

Now the meaning of dynamic locking principal is the LOKKA mechanism provides the feature of locking and unlocking of the differential without stopping the car that means in dynamic motion. And also, it means the after locking if more power is applied to the differential, then it will be locked more tightly and with more force. This mechanism is most effective in the slippery roads or areas because more traction is also gained by wheels due to the locking of differential.[11]

## V. ADVANTAGES OF AUTOMATIC DIFFERENTIAL LOCKING SYSTEM:

1. The manual force required to lock the differential is negligible.
2. Most of the locking system are pneumatic which has its own benefits like being cheap and safe than the hydraulics.
3. Utilisation of time in locking the differential is reduced.
4. Very much effective and more efficient than normal differential as discussed above.

## VI. DESIGN CONSIDERATION FOR THE STUDY:

For the study purpose we had two approaches to design the differential and that are:

1. Mechanical Design or Fabrication
2. System Design or 3-D modelling.

By considering the present situation of covid-19 and doing the cost analysis we chose to design 3-D differential model with simulation for better understanding of the working and design.

The steps followed to design the differential are:

**Step 1:** To give dimensions to the gears.

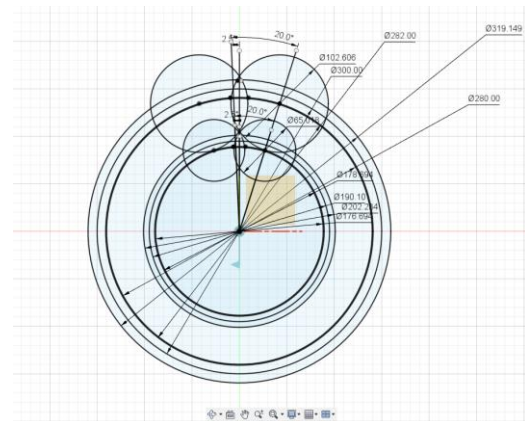


Figure 3 Step-1

**Step 2:** To check the view of the sketch and to check the elevation of gears.

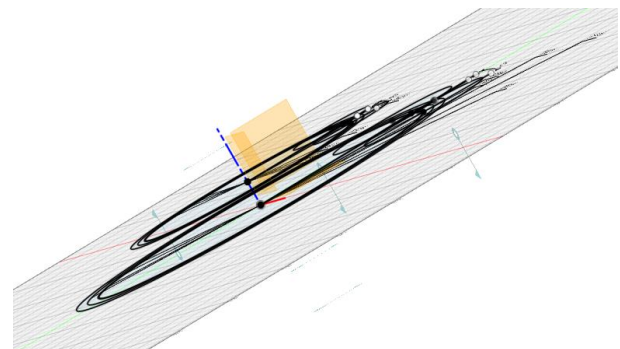


Figure 4 Step-2

**Step 3:** Creating the models of each gear.

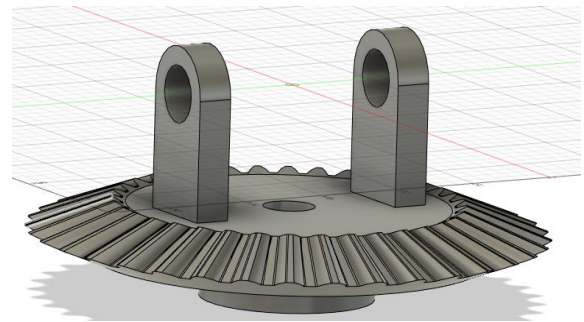
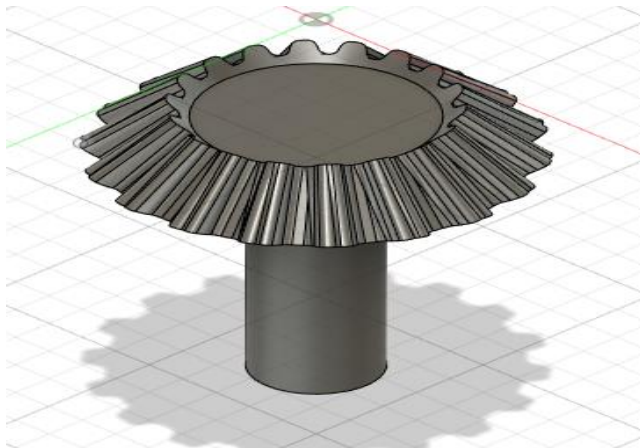


Figure 5\*4 Step-3

**Step 4:** Now Assemble all the gears in one and done.

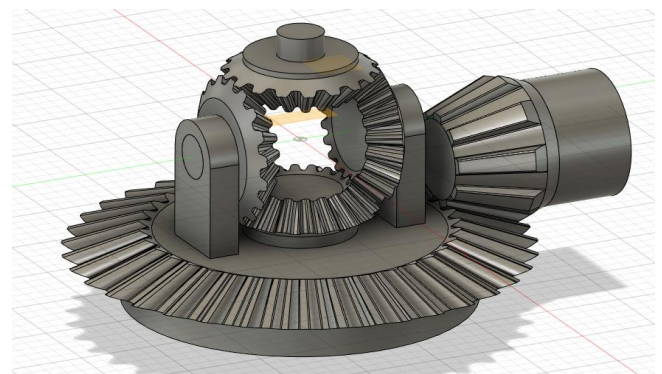
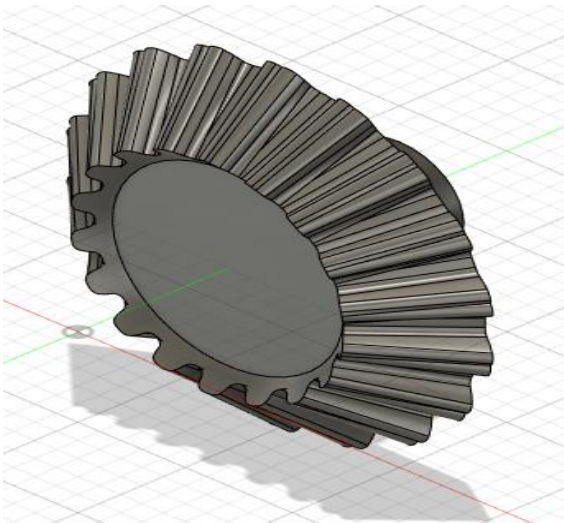
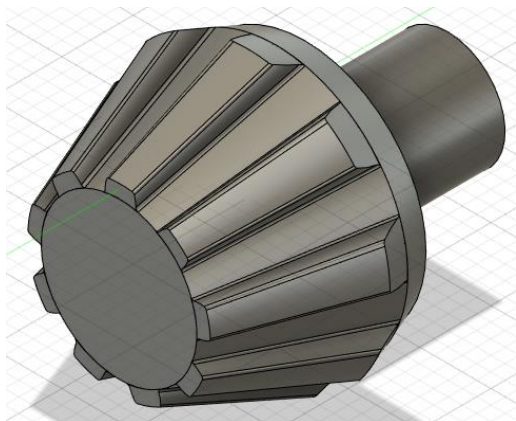


Figure 6 Step-4



## VII. CONCLUSION:

During this research we attend a vast knowledge about the different parts of the automobile especially Differential. We get to know about the working of differential and different types of it and how they are used in vehicles and what are their specific functions and conditions to use them.

And after analysing the data we came to conclusion that Automatic Differential Locking System is the need of hour and has many advantages over normal differential which makes it stronger to use in today's cars.

The advantages of LOKKA mechanism just increase the efficiency of the differential tremendously. The

advantages of this mechanism is just next level and make the working of differential more effective by providing other advantages like more traction control and good control at speed of different wheels.

We also designed the 3-D model of the differential and simulated it for better understanding.

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