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Design and Development of Anti-Roll Back Mechanism

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Abstract: ***The purpose of the paper is to analysis and reviews the already developed anti-roll back mechanisms for vehicles and other mechanisms of the same kind, to find the shortcomings of each of them, which hindered its general use in the vehicles, and to propose a mechanism overcoming all those shortcomings. Anti-roll Back Mechanisms or Unidirectional Motion Mechanisms are the mechanisms which may be added to the conventional gear box of a vehicle, to provide the remedy for the issue of descending of the vehicle under the influence of self-weight, faced while starting a vehicle to move uphill. Technically, this mechanism encounters the issue free motion of the shafts of the gearbox as the vehicle tries to roll downhill when the clutch is pressed (disengaged) for the moments in which driver shifts his foot from the brake pedal to accelerator pedal to accelerate the engine. Such mechanisms restrict one or the other shaft(s) of the gearbox to rotate opposite under the influence of wheels, thereby restricting vehicle to roll back in opposite direction. In this work the mechanism has been developed to stop the vehicle from rolling backwards when the vehicle is moving in the hill roads. Ratchet and Pawl mechanism has been identified to arrest the motion to the front axle. Anti-Roll Back mechanism has been fabricated and tested on the front axle assembly. The mechanism works well.***

Keywords: Anti-roll back mechanism, unidirectional motion mechanisms, Ratchet and Pawl mechanism, etc.

1. Introduction

Ratchet and pawl mechanism is used in many applications effectively where the one side power transmission is required for example in (i) Giant wheel- It is the large wheel used in the amusement parks to rotate along the horizontal axis to rotate in one direction while carrying the number of passengers. (ii) Clocks- where the hands rotate in clockwise directions only. (iii) Baffle gates- in the entrances of many buildings which rotate about vertical axis in one direction. In the hill station, the most common problem to the drivers is to park their cars in the slope and to start up the car. While waiting in the traffic, the cars have to move on step by step very slowly this situation is a difficult one for the drivers to make their car not to roll back in the slope. So the mechanism has to be developed to stop the vehicle from rolling back and it should not stop the vehicle in accelerating forwards. This function can be achieved by using the ratchet and pawl mechanism.

For conventional trucks in India, moving uphill is often a very risky proposition, particularly with a full payload. The vehicle risks rolling back if the driver lets go the clutch with not enough power on the gas. In high-end commercial vehicles though, technologies like the Electronic Braking Systems (EBS) helps pull away the vehicle from a standstill on steep gradients with no risk of rolling back. As a common practice in the country, the parking brake is usually engaged, when loading or unloading a vehicle or on inclines to avoid roll back. This is never a full-proof option, and requires adequate driving skills to ensure operation. That was the challenge that the engineering team at KBI took up, that of developing a technically suitable and commercially viable system for the Indian market that predominantly runs on vehicles with manual transmissions. When the vehicle is stationary and inclined, the releasing of brakes activates the flow control means, which releases the air from the rear brake actuator at a slow rate. That enables the vehicle to remain stationary even after the brakes are released. The slow release of air provides the time needed for the driver to feel and accelerate the vehicle, either to drive up the hill or reverse it.

The present invention in a preferred embodiment provides systems and methods for preventing a vehicle from reverse movement on a slope. The system comprising of

a) A heavy commercial vehicle.
b) A ratchet and pawl device connected to at least one wheel of the vehicle.
c) A connecting or fastening component which connects the ratchet and pawl device such that the wheel shall rotate only if the ratchet and pawl device rotates.
d) And electronic mechanism i.e. Actuator which will control the movement of the pawl while engaging or disengaging the mechanism Where in the system may be engaged using an engaging mechanism when reverse motion is undesirable or to be restricted, and may be disengaged when the reverse motion is desirable and is to be.

2. Literature Review

A. Arunkumar, T. Muthumani et.al has Studied to stop the vehicle from rolling backwards when the vehicle is moving in the hill roads. Ratchet and Pawl mechanism has been identified to arrest the motion to the front axle. Anti-Roll Back mechanism has been fabricated and tested on the front axle assembly. The mechanism works well. In this work, Ratchet and Pawl mechanism is identified to arrest the backward motion to the car. The ratchet is placed in the front drive shaft and the Pawl is fitted with the frame. When the vehicle is moved in the hill road, the lever has to make the pawl to touch the ratchet [1].

Mohamed Krid, Faiz Benamar et.al has studied integrated approach of an active anti-roll system has been presented. An innovative kinematics which can be easily added on existent

off-road chassis is proposed. A model predictive controller based on minimization of load transfer and energy consumption is designed. Simulation results show that this system improves the performance and the stability of the robot when cornering. An important advantage of the proposed solution is its easy integration as new part, without any transformation of the original chassis. This system can be controlled independently and is demonstrated to have no effect on the dynamics of path controller. A new rover based on an existent commercial chassis is currently under construction to equip it with electric actuators, sensors, and the active anti-roll system detailed in this paper. The next steps will focus on the experimental validation of this promising new system. Another challenge for increasing off-road performance, would be the design and development of innovative systems for preventing tip-over instability along both roll and pitch axes. [2].

J. A. Kennedy & L. L. Howell et.al has studied a ratchet and pawl ring mechanism that has advantages for mechanical safety mechanisms, particularly when the design envelops is too small to allow for traditional mechanical components. The mechanism constraints are outlined and the mechanism and its modeling are defined. A series of three scaled prototypes and their testing are described [3].

William K. Messer smith & Keith H. Fulmer et.al has studied booster connected to a control circuit provides a system for the continued braking of a vehicle when the vehicle is situated on an incline and the brake pedal is released by the operator. Continued brake application is accomplished by utilizing a control circuit responsive to vehicular attitude, clutch pedal position, and vehicular direction. The control circuit is connected to the combination of a check valve and two-way solenoid valve connected to a movable wall brake booster. The combination valve is connected to a flexible hose disposed interiorly of the booster, and the other end of the flexible hose connected to the input opening of a three-way poppet valve located at the central hub of the booster. When the control circuit senses that the vehicle is on an incline, the clutch pedal depressed, the ignition "on", and the vehicle not backing up, it actuates the two-way solenoid of valve which continues to supply a first fluid pressure to the front booster chamber while closing to prevent the supply of the first fluid pressure to the rear booster chamber, via the flexible hose and poppet valve [4].
Cook George et.al invented relates to an anti-creep and hill holder brake system and more particularly to a brake system which prevents the creeping or rolling of automobiles equipped with either automatic fluid transmissions or friction clutches. Presently known types of anti-creep or anti-roll systems incorporate a circuit having a number of switches with one switch being operated by the ignition key, another by the accelerator pedal and another by the movement of the vehicle. Because of the slow actuation provided for these switches, present systems do not operate satisfactorily since the systems do not respond properly to the actions of the driver and interfere with the actions of the driver [5].

3. Research Methodology

- Literature review
  Collection of data from different international journals and studied on them.
- Data collection
  Collection of data for design and components to be used.
- Design of parts and selection of standard components
  Studying the collected data, designing is done analytically.
- 3D Modeling
  A 3D model is designed by using software so as to ease the study of model.
- FE Analysis
  Analysis of components was done for different forces acting on them so as to check its working capacity under different loads or forces.
- Production and manufacturing.
  Manufacturing of components is done and standard components were bought.
- Result and Discussion
  Working of model is checked and charts are plotted under different conditions showing its capacity.

4. Problem Statement

In the hill station, the most common problem to the drivers is to park their cars in the slope and to start up the car. While waiting in the traffic, the cars have to move on step by step very slowly; this situation is a difficult one for the drivers to make their car not to roll back in the slope. So the mechanism has to be developed to stop the vehicle from rolling back and it should not stop the vehicle in accelerating forwards.

5. Objective

- To overcome problem of sliding in reverse direction of a vehicle while on hill or any inclined surface.
- To replace the electrical component in design of hill assist braking system by ratchet & pawl for cost consideration

6. FE Analysis of Anti Roll Back Mechanism

A) **Analysis of Shaft:**
Load is acting on middle of the shaft. Then the moment is considered one side of the shaft is **1.5 N-m**. Red color is indicating the moment and blue color indicate fixed support as shown in figure 1.

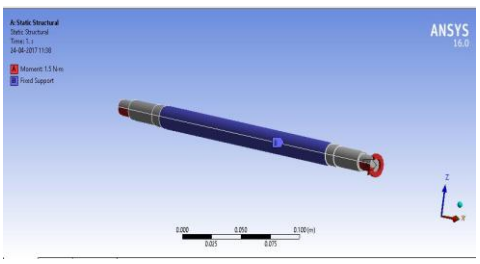


Figure 1: Boundary conditions of shaft in Anti-roll back mechanism

Static structural Analysis for Equivalent stress in shaft is shown in figure 2. In this figure red color indicates the maximum stress 5.1474e^{6} Pa and blue color indicate the minimum stress 1.3406e^{-6} Pa. It is seen from the FE Analysis, that the number of element formed are 1141 with 2202 Nodes by triangle surface Mesher. The color in the image indicates the forces acting i.e. red color indicates the maximum forces acting on the component and blue color indicates the safe force acting on the shaft.

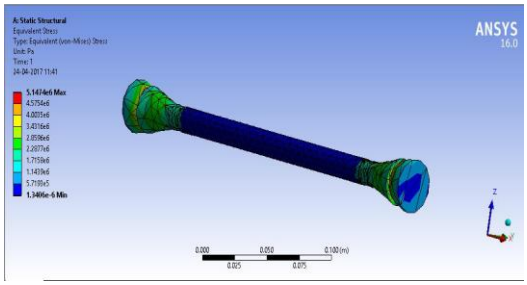
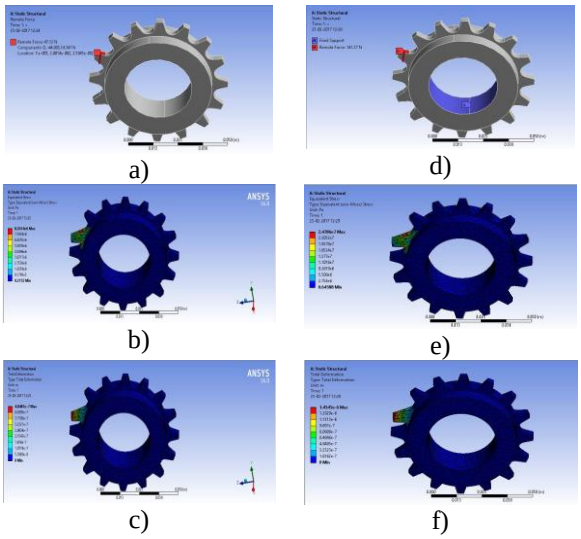


Figure 2: Static structural analysis of shaft in Anti-roll back mechanism

B) **Analysis of Ratchet:**

For static structural analysis of ratchet, first applied force on teeth is 47.12N. The applied this force indicated by red color as shown in figure 3 a). The maximum equivalent stress is 8.2614e^{6} Pa and minimum equivalent stress 0.2152 Pa as shown in figure 3 b). Total maximum deformation is 4.8481e^{-7} m and minimum deformation is 0 m as shown in figure 3 c).

For static structural analysis of ratchet, second applied force on teeth is 141.37N. The applied this force indicated by red color as shown in figure 3 d). The maximum equivalent stress is 2.4786e^{7}and minimum equivalent stress 0.6458 as shown in figure 3 e). Total maximum deformation is .4545e^{-6} and minimum deformation is 0 as shown in figure 3 f).

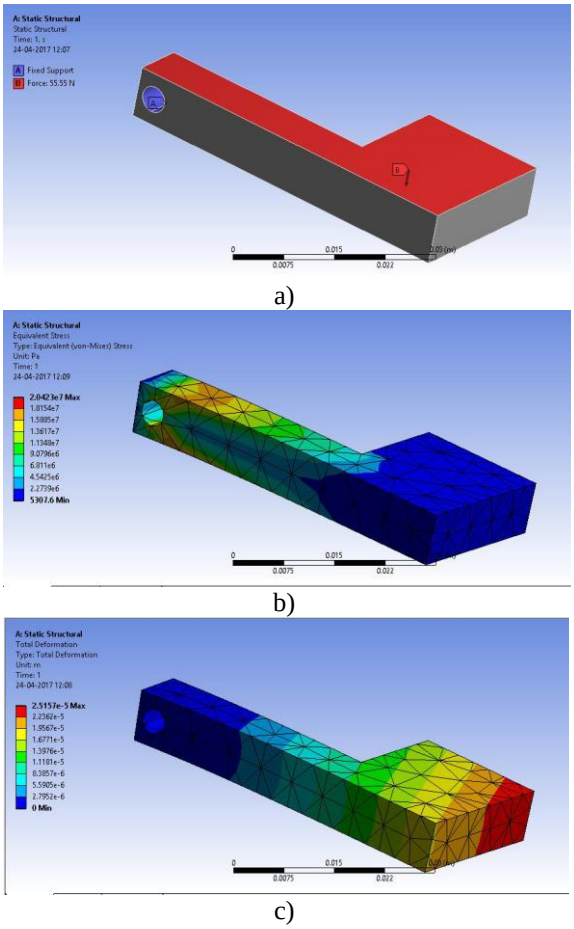


a) d) b) e) c) f)

Figure 3: Static structural analysis of Ratchet in Anti-roll back mechanism for force 47.12 N and 147.37 N.

C) Analysis of Pawl:

For static structural analysis of Pawl, first applied force on teeth is 55.55N. The applied this force indicated by red color as shown in figure 4 a). The maximum equivalent stress is 2.0423 e^{7} Pa and minimum equivalent stress 0.5307 Pa as shown in figure 4 b). Total maximum deformation is 4.8481e^{-7} m and minimum deformation is 0 m as shown in figure 4 c).



a) b) c)

Figure 4: Static structural analysis of Pawl in Anti-roll back mechanism

After FEA analysis we have developed and manufacture a model of Anti-roll back mechanism as shown in figure 5.

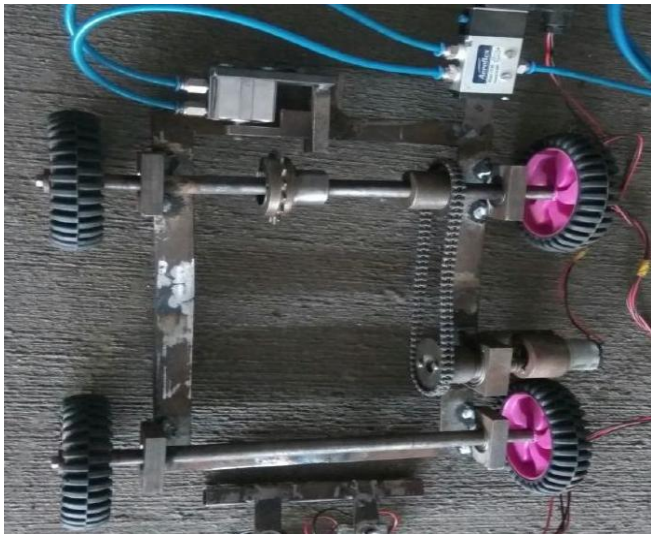


Figure 5: Developed model of Anti-roll back mechanism

7. Working Principle

In this work, Ratchet and Pawl mechanism is identified to arrest the backward motion to the car. The ratchet is placed

in the rear drive shaft and the Pawl is fitted with the frame. When the vehicle is moved in the hill road, the lever has to make the pawl to touch the ratchet. If the vehicle tends to move backward direction, the pawl would stop the ratchet to move Counter Clock-wise direction with respect to front wheel.

As the vehicle is in neutral position, the pawl engaged the ratchet and the vehicle did not move in backward direction. So the hand brakes need not to be applied. When the vehicle is in moving condition, the engagement between the ratchet and pawl is detached.

We also introducing the Push button operated Single acting cylinder. The single acting cylinder is useful when a driver wants to drive vehicle in the reverse direction. The pneumatic cylinder will move in forward direction and the linkages will move for predetermined direction. This will provide to ride in reverse direction too as shown in figure 6.

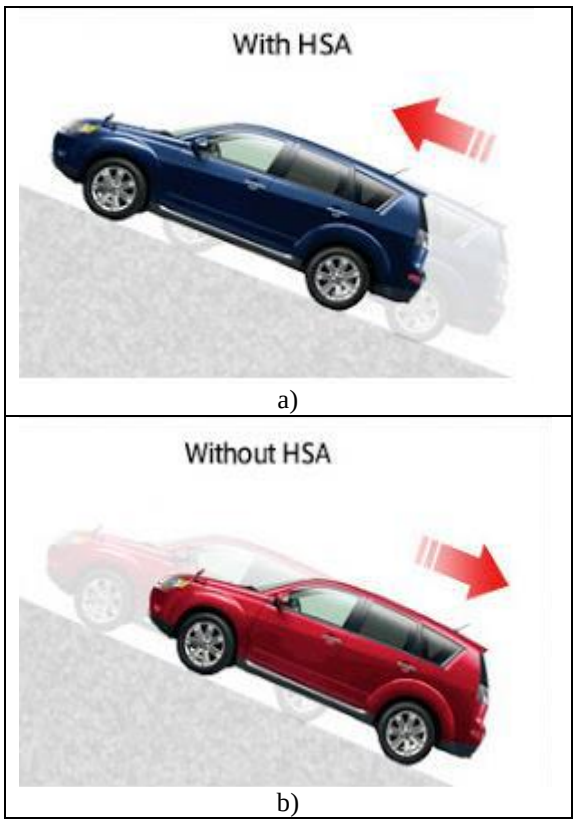


Figure 6: Vehicle with and without Anti-roll back mechanism

8. Conclusion

- Thus the mechanism can stop the vehicle from rolling back in hill roads.
- This would be more helpful for the driver to drive their car comfortably in hilly roads and he can take off the car in the uphill without rolling back the car.
- The cost of the project is not much more that's why we can use comfortably in four wheelers. The installment and mounting is easy.
- There is no any need of the major changes in the vehicle design so it is easy and to designer. For new drivers it is very easy to drive in hill station in traffic or any inclined road surface when climbing. So it is possible to implement this mechanism in the car.
- Indian roads have a mixed pattern of traffic, with all modes of transportation coexisting in bumper-to-bumper traffic.
- A roll back of a vehicle could mean serious injuries, sometimes fatal, to fellow occupants on roads. The Anti-Roll Back system developed by KBI is a solution that reduces that risk significantly.

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