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Adjustable Ground Clearance in Vehicles Using Pneumatic Lifting

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Abstract- The handling of vehicle depends upon the various parameters, centre of gravity of the vehicle is one of them. For better handling of the vehicle we need to keep centre of gravity as low as possible. For sport cars it is always kept low but for the passenger cars it compromises with its ground clearance. The designers prefer to maintain fixed ground clearance and design the system to acquire requisite suspension parameters. For different type of tracks, the ground clearance of vehicle is designed accordingly and that is why this is a subtle reason which also differentiates the vehicles as on-road (Sedan/Hatchback cars) and off-road (Sports utility vehicles (SUV)). Off-road vehicles have to face the rough terrain, where we need the high ground clearance of the vehicle, on the other hand we run the same vehicle on a road where high ground clearance is not necessary. Whereas a sedan car or hatchback has to run on smooth roads as well as on rough terrains sometime with its fixed lower ground clearance which tends to create dents on the bottom portion of the car. In both cases we need an adjustable ground clearance system in the vehicle to have optimum performance. Here this paper introduces the pneumatic lifting technique which is used to provide the higher ground clearance at the time of rough roads/breakers and lower the same to get proper ground clearance to maintain the stability at high speed on smooth roads.

Index Terms: Ground Clearance, Pneumatic lifting

I. INTRODUCTION

Road conditions are not similar at all places, it changes with application, environment and climate. In city at different sectors like school, hospital there are speed breakers of different dimensions. At certain condition road goes straight without any pits else we found irregularity. Most of the people buy only one four wheeler which they use that at all this condition. Hence it's necessary to give some standard ground clearance to the vehicle. But still there are some obstruction while driving the car on highway and in city.

It is not possible for the off-road vehicle to run at high speed on its standard ground clearance provided considering the city obstacles and on-road cars to run over the rough terrain with its lower ground clearance. To obtain the good performance at high speed and low speed it is necessary to build one system which can vary the ground clearance. This can achieved by changing the suspension height so that the chassis height can be adjusted with respect to the speed and the quality of roads.

Suspension systems plays vital role while designing the car for good stability and road holding ability. It is very difficult to achieve this ability at all road condition with passive suspension system only. This problem can be solved by active suspension system but this is not widely used because it required more external energy and additional controlling system which affects the cost of the vehicle. With a view to reduce the complexity and the cost while improving ride, handling and performance we can use the combination of active and passive suspension system.

In this paper various parameters are discussed which are related to the ground clearance and suspension system and its control. This gives the idea about the vehicle characteristics like ride control, height control, roll control, road holding etc. and its effect on vehicle performance.

Ground clearance is the position of the vehicle body (sprung mass) above the basic ground level. It is an important parameter in off-road vehicle. For a certain car's weight, there is a certain amount of mechanical down force which act on tires, and therefore the grip of tires is constantly changing during running condition. The whole weight of vehicle is concentrated at a point known as centre of gravity. At the lower ground clearance, we get the location of centre of gravity near the ground level. This reduces weight transfer during cornering, accelerating, and braking and increase the vehicle performance. Also, by lowering the front end and raising the rear end, we can improve high speed stability. Since the centre of gravity has an influence on most of the parameters during running of the vehicle. We need a location of centre of gravity at a high level as well as at lower level according to road conditions.

We have designed a simple pneumatic linkage mechanism for ground clearance adjustment. The adjustment is possible with the help of an active and a passive suspension which are linked together in series. Active suspension is placed below the passive suspension. With the help of this system we can vary ground clearance of the vehicle up to 200mm.

Pneumatic cylinders are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like in hydraulic cylinders, something forces a piston to move in the desired direction. Thus it produces a lift in desired direction.

Air compressor is utilised to produce a pneumatic lift to increase the ground clearance whenever required otherwise it brings the chassis down to its position to have standard ground clearance by acting as an active suspension system.

Fig. 1 Pneumatic cylinder

II. LITERATURE REVIEW

Hrishikesh V Deo& Nam P Suh[1] introduced that how the comfort and handling are interrelated with centre of gravity of the vehicle. They designed the suspension system which varies its height and stiffness according to speed. The researchers used short long arm suspension system which is widely used in front wheel suspension. For controlling the height and stiffness, it can be achieved by making the lower spring pivot movable along the lower control arm. For moving the pivoted point and achieve desired position electric motor is used to actuate the actuator. But there are some limitation which we come across, that is about less quick response. In this paper they also described about active and semi-active suspensions limitations and how it can be overcome with adaptive control with variable height.

P.E. Uys, P.S. Els, M. Thoresson[2] presented the suspension settings for optimal ride comfort of off-road vehicles travelling on roads with different roughness and speeds. In this they vary the suspension settings for different roads roughness and vehicle speeds and results achieved for comfort level. Simulation is performed on a Land Rover Defender 110 model in MSC.ADAMS software for speeds ranging from 10 to 50 km/hr. Tests were performed on 100m Belgian paving and also ISO 2631-1, BS 6841 and VDI 2057 at different speeds. Correlation between measured and simulated results is very good, especially with respect to vertical acceleration. There are number of applications related to ground clearance and their consideration is designer need. To give the information about vital role of ground clearance.

DebojyotiMitra[3] presented design optimization of ground clearance of domestic cars. Stability and performance is also parameter of ground clearance. If we allow the vehicle for the low ground clearance then it helps to give less drag force simultaneously it consumes less fuel resulting less pollution. The experiment is carried out in wind tunnel with the help of notch back car model. The result shows that the positive lift force reduces with increasing height of ground clearance. Hence the optimized value of h/b ratio has to be taken in to consideration of clearance design. With the help of spoiler the lift force problem can be solve.

The active suspension system is very essential for handling and giving comfort. These days this system is used in different type of vehicles like hybrid vehicles.

Morteza and Mahdi[4] presented active suspension system in parallel hybrid electric vehicles. In this they compare the conventional and hybrid vehicle with active suspension. For conventional the power is taken from the IC engine hence gives little lag in actuation while in hybrid electric vehicle it is direct, resulting less fuel consumption and less emission.

Guangqiang Wu, Guodong Fan, and JianboGuo[5] presented ride comfort evaluation for road vehicle based on rigid-flexible coupling multibody dynamics. Spectrum of vibrations occurs in the vehicle due to various speeds. There are different road profiles and roughness therefore occupants are subjected to accelerations in different directions, which caused discomfort. With the help of ADAMS-CAR they built rigid and rigid flexible coupling multi-body vehicle models. As speed increases the relative difference goes increases, at 80 km/hr it becomes 8%. It is better to build the variable suspension with rigid flexible coupling.

Mohammad, Mahir and Iyad[6] gives new control strategy for active suspension using modified fuzzy and PID controllers. In this they proposed controlled strategy to control the suspension system by means of electro-hydraulic actuator. The passive suspension is replaced by low frequency active suspension. The quarter car model tested under rolling effect, cornering and pitching effect at different speeds and road profiles. The reduction in body acceleration by 60% gives better road holding and car stability. There are two types of active suspensions which are commonly recognized that are low bandwidth and high bandwidth. Non-linear controllers are more capable to handle high bandwidth active suspension because they show good capability at worst road condition. Researchers give the linear controller over active suspension of low bandwidth new PID with fuzzy switch which improve the performance of suspension.

The design of suspension is concern with three main parameter; car body acceleration for ride comfort, the tire deflection for road holding and the suspension travel. The ideal suspension system would minimize these three quantities for any road and operating condition, which is not achievable for suspension having constant spring stiffness and damping. This can be achieved by active suspension system. But this needed high external energy. Hence it is not widely used. The alternative solution is to use of semi-active suspension. It reduces car body resonance without compromising road holding. But this solution gives disturbance like jerk, rattling noise etc. Hence C. Collette, A. Preumont[7] presented paper on energy transfer in semi-active suspension that the energy transfer phenomenon may be bearable up to certain extent by filtering the control signal or providing suitable mounting.

G. N. Reizina[8] carried out experiments to Investigation of the Vibrations of an Automobile Suspension Using the Theory of Experiment Design Professor Jonathan S et al .[9] carried out A form verification system for the conceptual design of complex mechanical systems MehranKhalaj et al .[10] carried out a novel risk-based analysis for the production system under epistemic uncertainty Risk analysis of production system, while the actual and appropriate data is not available, will cause wrong system parameters prediction and wrong decision making. The research has presented a hopeful concept for the calculation of production system's risk, and its results show that in uncertainty condition Sy-Wei Lo et al .[11] carried out Monitoring the Displacement of a Blank in a Deep Drawing Process by Using a New Embedded-Type Sensor.

Murray Mackay[12] carried out A Review of the Biomechanics of Impacts in Road Accidents The real world characteristics of road accidents relevant to biomechanical considerations will be outlined P. L. Ardoino and F. Ioppolo[13] carried out Kinematics and Dynamics of the Vehicle/Seat/Occupant System Regarding Whiplash Injuries Whiplash injuries continue to have significant societal cost; however, the mechanism and location of whiplash injury is still under investigation. Predicting neck response and injury resulting from motor vehicle. J Latchford et al .[14] carried out Development of a third generation mechanically inflated airbag head restraint system and its characterization under impact loading. The function of the head restraint system is to prevent injurious hyperextension of the neck following a vehicle rear end

impact. The nature and severity of the head and neck injuries attributed to rear end.

Eun-Mi Lee et al .[15] carried out Study on design of progressive dies for manufacture of automobile structural member using DP980 advanced high strength steel Advanced high-strength steel (AHSS) is widely used in automobile manufacturing to reduce the weight of vehicles, thereby improving fuel efficiency. PingJun Xia et al.[16] carried out a new type haptics-based virtual environment system for assembly training of complex products. Virtual reality (VR) - based assembly training has been an interesting topic for the last decades. Generally, there are two shortcomings for nowadays virtual assembly training systems

Hongshen Zhang and Ming Chen[17] carried out Theoretical Analysis and Experimental Study on the Coating Removal from Passenger-Vehicle Plastics for Recycling by Using Water Jet Technology The recovery and utilization of automotive plastics are a global concern because of the increasing number of end-of-life vehicles. Kenneth A et al.[18] carried out Improving Automotive Safety: The Role of Industry, the Government, and the Driver This paper identifies three groups that can improve automotive safety. The three groups are the automotive industry by designing into cars such safety devices as seat belts, roll bars, or air bags. Xiaoxuan Zhang et al.[19] carried out Application Research of Statistical Energy Analysis on Vehicle Sound Package A whole vehicle SEA model is established by hybrid method combining body structure and sound package. Modal density, damping loss factor and sound package material parameters are obtained by testing Lin Hu et al .[20] carried out Vehicle ride comfort is one of the most important performances of vehicle; the research of automotive ride comfort is getting more and more important. In this paper, the subsystems dynamics analysis models arguably, the first attempt to develop such a design technique was on the 1922 Lancia Lambda to provide structural stiffness and a lower body height for its car body. The next application of an effective structural integration of body and chassis using spot welded deep stamped steel sheets into a structural cage, including sills, pillars and roof beams was on the 1934 Citroën Traction Avant. The streamlined 1936 Lincoln-Zephyr with conventional front-engine, rear-wheel-drive layout utilized a unibody structure. By 1941, unit construction was no longer a new idea for cars, "but it was unheard of in the low-price field [and] Nash wanted a bigger share of that market." The single unit body construction of the Nash 600 provided weight savings and Nash's Chairman and CEO, George W. Mason was convinced "that unibody was the wave of the future." Nash became the first automaker to develop this type of construction for a mass-produced, low-priced car.

S. Madhavarao, Ch. RamabhadriRaju, Anil Kumar and P. Ravi verma[21] have worked on automati ground clearance adjustment system.

ShivrajChandrakantPatil[22] has also given the thesis on the adjustable ground clearance mechanism by working on the model which involves the use of a small gear as a tool to move toothed bracket which holds the shock absorber. This toothed bracket is in the shape of a circular arc.

SmayantakHokale[23] has worked on the adoptive control on ground clearance of vehicle with variable speed.

III. PROPOSED METHOD

Pneumatic lift in a vehicle can be achieved by pneumatic cylinder employing a reciprocating compressor. Compressor compresses the gas to a high pressure. This high pressurized gas then send to pneumatic cylinders to exert force against the piston head inside it to have the piston movement to create a linear motion outwards. By lowering the pressure of gas the piston movement can be reversed. And with this mechanism ground clearance of the vehicle can be increased or decreased.

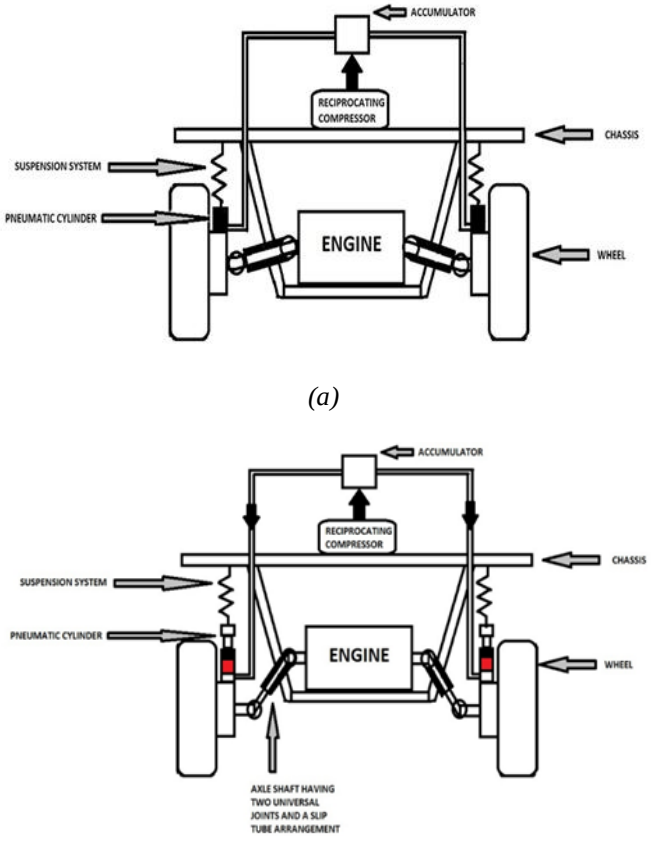
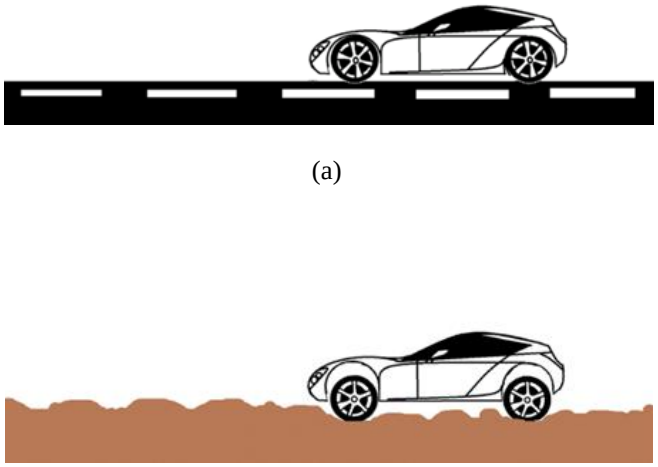


Fig. 2 (a) Original position and (b) position after pneumatic lifting

The whole lifting mechanism act as active suspension system consisting of four pneumatic cylinders which are mounted between each wheel assembly and passive suspension system in such a way so that the outer dead centre of cylinder faces upwards and inner dead centre faces downwards. The inlet of each cylinder is connected to the accumulator via air tubes. Accumulator is attached to the outlet of reciprocating compressor through air tubes which is mounted over the chassis at the fixed position. An electric motor drives the reciprocating compressor using the battery power which is charged by the engine. There are two button system on the dashboard, one to turn on the motor and one to open the outlet of pneumatic cylinders to release the high pressurized gas. A person driving a car on a smooth road when sees rough bumpy road or rough terrain in front of the vehicle, he can choose to increase the ground clearance just

by pressing the button which is assigned to start the motor by connecting it with the battery.
And as the rough terrain ends driver of vehicle can decrease the chassis height by pressing another button assigned to open the exhaust valve of the pneumatic cylinders to release the high pressurized air to the atmosphere which makes all the lifted pistons of pneumatic cylinders to get down to the position of inner dead centre. Releasing the pressed button ensures the closing of outlet valve of pneumatic cylinders. And again driver can have the standard ground clearance of the car to have a proper centre of gravity so to utilize the full potential of acceleration.



(a)

(b)

Fig. 3 Vehicle during (a) on-road and (b) off-road

Prototype of this project consists of one chassis with four wheels with their axle shafts attached to it, one reciprocating compressor, four motors, a DPDT controller and rest of the design accessories. The prototype vehicle runs by the electric motors and compressor which runs on the battery power is employed to produce the pneumatic lift at each vehicle to increase the ground clearance of the vehicle. A controller is used to operate the compressor and motors to run the mechanism.

Fig. 4 Prototype design

IV. RESULT AND DISCUSSION

The pneumatic lift mechanism applied in prototype to increase the ground clearance works successfully. It is able to lift the weight of chassis up to 3-4kg with a compressor of capacity 350psi, which is good enough for a lower scale work. The mechanisms takes maximum 5 seconds to lift the chassis after providing input to the controller and then can have a fixed higher ground clearance up to required period of time to protect the chassis of prototype. And later can lower the chassis using controller to have fixed lower ground clearance within 5 second. And the performance can be optimized.
The results can be arranged as:
•The average time required by the system to vary the ground clearance of the vehicle is 5 seconds.
•The ground clearance of the vehicle is increased by 3cm along the obstacles. Car chassis is prevented from being damaged
•The system can withstand a weight of 3 to 4 kg with the compressor of 350psi capacity.

The project works well in case of prototype but there might be a chance that the result can vary with the real time application of the pneumatic system. But with proper design and mechanism with having accurate measurement in real time application the performance can be optimized.

V. CONCLUSION

This innovation can help driver to choose the ground clearance with his comfort of driving according to terrain. Riding off-road becomes easier and vehicle can fuel efficient by lowering ground clearance while driving on-road. For the off-road tracks, one can have highest clearance and move along the course of the road with better handling. On other hand for on road tracks, by lowering ground clearance we can enjoy the pleasure of being in an on-road vehicle. This system help in under steering of the vehicle. The system is very user friendly. This system will increase the economy of a vehicle. The results in increased complexity.
The system proves that the Adjustable Ground Clearance Mechanism is a good innovative system for better performance of off-road vehicles. Since the system is more user friendly and at the same time increase the performance, this will have good market potential. The ground clearance can be easily adjusted by the driver itself at any place. The system is very much reliable in operation. This system is cheaper in initial as well as running costs. It does not require

an external energy to run the system and no moving parts in the system so maintenance is also very low. This system allow to overcome uneven territory without damaging lower body and reduce unnecessary burden caused by such damage. In case of vehicle with high clearance they are good to go when travelling in bumpy and uneven territory but create fuel economy problem when travelling in even territory, which can be overcome by reducing the clearance of the vehicle which ultimately give better fuel economy & aerodynamic structure. With a better aerodynamic structure vehicle is able to overcome vibration problem associated with high speed. The sole purpose is to protect vehicle from damage and at the same time increase fuel economy. To fulfil these purpose we need a system which is capable of lifting our vehicle and then coming back to its original position. Thus for the lifting purpose we can utilize different mechanism For example instead of using pneumatic cylinder we can utilize screw with square threading as square thread is best for lifting heavy loads.

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