Automatic Ground Clearance Using Speed and Detection Sensing Mechanism

[1]Vignesh.S, [1]Tanikonda Surendra,[1]Vijay.G, [1]Uttlapalli Jithendra, [2]Hemanth.K
[1]Students, [2]Associate Professor
School of Mechanical Engineering
REVA University

Abstract- This research paper mainly focuses on the design, development and evaluation of an automatic adjustable ground clearance system. This system is aimed to improve vehicle performance on all terrain conditions from rough to flat surfaces. The proposed design is done by using pneumatic cylinder which is placed between wheel assembly and body of vehicle. Two technology is been used, one is that vehicle will lift automatically based on speed of the vehicle and other one is that vehicle will detect the bumps on the road. This technology can be adopted for all type four wheeler cars. By utilizing the concept of Adjustable Ground Clearance Mechanism which will prove beneficial effect to the off-road vehicles to adjust the ground clearance according to terrain. Here this paper tells how automatic lift is achieved through pneumatics with the help of sensors.
Keywords: Pneumatics, Pneumatic Cylinder, Spring, 5/2solenoid Valve, Ground Clearance, Spur Gear, IR Sensors, Relay Switches.

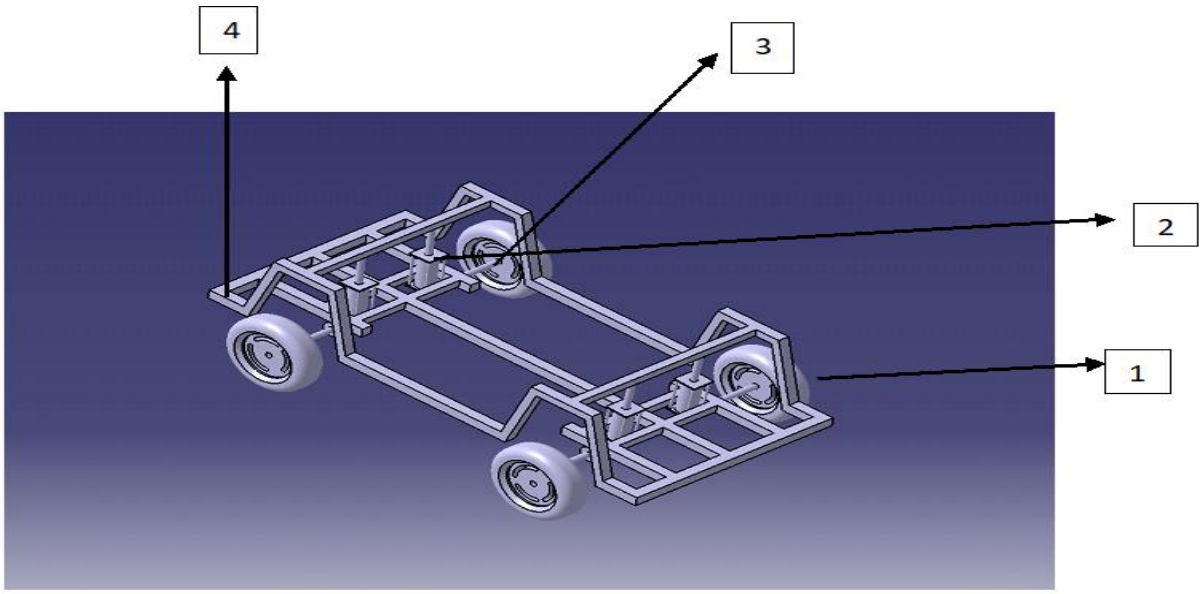
I. INTRODUCTION

Ground clearance is the position of the vehicle body above the basic ground level. It's an important parameter in off-road vehicle. For a certain car's weight, there is a certain amount of mechanical down force 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 a centre of gravity point. Hence it's necessary to give some standard ground clearance to the vehicle. But still there are some restrictions to drive the car on highway and in the city.

Reizina [1] carried out experiments to Investigation of the Vibrations of an Automobile Suspension Using the Theory of Experiment Design Professor. Jonathan et al [2] presented A form verification system for the conceptual design of complex mechanical systems. Mehran et al [3] described 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 et al [4] carried out Monitoring the Displacement of a Blank in a Deep Drawing Process by Using a New Embedded-Type Sensor. Mackay [5] presented A Review of the Biomechanics of Impacts in Road Accidents The real world characteristics of road accidents relevant to biomechanical considerations will be outlined. Arduino and Ioppolo [6] developed 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. Latchford et al [7] 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. Lee et al [8] presented an 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 et al [9] 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. Zhang and Chen [10] carried out Theoretical Analysis and Experimental Study on the Coating Removal from Passenger-Vehicle Plastics for Recycling by Using Water Jet Technology. Zhang et al [11] 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. Morteza and Mahdi [12] 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.

In the present study the design of prototype model for automated ground clearance by using two mechanisms in order to avoid damages to lower part of the vehicle and air force acting on the vehicle opposite to the motion, one is by using dump detecting and other by using speed sensing mechanism. With the help of this system the ground clearance of the vehicle can be varied. It is an electrically controlled by an ardunio circuit, which aims to provide ground clearance according to the requirements of road conditions.

II. DESIGN AND CALCULATIONS:-



1. WHEELS
2. PNUMATIC CYLINDER
3. CONNECTING ROD
4. CHASIS FRAME (MS MATERIAL)

Figure.1 Draft image from Catia

Abbreviations and Acronyms:

- d_c = Diameter of cylinders =40mm
- d_p = Diameter of piston=15mm
- p = Pressure acting=6bar
- r_c = Radius of cylinder=20mm
- r_p = Radius of piston=7.5mm
- A = Area of cylinder=1256mm^2
- B = Area of piston=176.625mm^2

i . Calculations for Force applied on the cylinder

1. **Area Of Cylinder(A)** $= 3.14 * r^2_c$
   $= 3.14 * 20^2$
   $=$ **1256mm^2**

2. **Area of piston rod(B)** $= 3.14*r_p^2$
   $= 3.14*7.5^2$
   $=$ **176.625mm^2**

3. **Effective area(A-B)** $= 1256-176.625$
   $=$ **1079.375mm^2**

4. **Outward stroke force** $= p*A = 0.5*1256$
   $=$ **738.527N**

5. **Inward stroke force** $=p*$effective area
   $=0.553*1079.375$
   $=$ **596.894N**

6. **Length of piston rod:**
   Approach stroke = 160 mm
   Length of threads = 2 x 20=40mm
   Extra length due to front cover = 12 mm
   Extra length of accommodate head = 20 mm
   Total length of the piston rod = 160 + 40 + 12 + 20 = 232 mm
   By standardizing, length of the piston rod = **230 mm**

Technical Data of cylinder:

Table No.1 Cylinder specifications

Stroke length: Cylinder stoker length	160 mm = 0.16 m
Quantity	4
Seals	Nitride (Buna-N) Elastomer
End cones	Cast iron
Piston	EN – 8
Media	Air
Temperature	0-80 º C
Pressure range	6-8 N/m²
Yield stress	850 megapascal =86.67587810312kilogramforce/millimeter²
Action	Double
Max Operating Pressure	12bar
Rods	Single
Port Function	G ¼
Min Operating Temperature	-20^0c
Barrel	It is made of cold drawn aluminum honed to 25mm

ii. Design for Spring

Rates & Loads:

Spring Rate (Spring Constant), k =**7.715N/mm**
True Maximum Load, True F_{max} =**374.564N**
Maximum Load Considering Solid Height, *Solid Height* F_{max} =**374.564N**
Potential True Maximum Travel w/ Longer Free Length, *True* $Travel_{max}$ =**48.553mm**
Maximum Travel Considering Solid Height, *Solid Height* $Travel_{max}$ = **48.553mm**
Minimum Loaded Height = **55.447mm**

Physical Dimensions:

Table.2 Dimension of spring

Diameter of spring wire, d	**3.000 mm**
Outer diameter of spring, D_{outer}	**23.000 mm**
Inner diameter of spring, D_{inner}	**17.000 mm**
Mean diameter of spring, D_{mean}	**20.000 mm**
Free length of spring, L_{free}:	**104.000 mm**
Number of active coils, n_a:	**13**
Number of total coils, n_T:	**15**
Solid height, L_{solid}:	**48.000 mm**
Type of ends:	**closed & squared**
Spring index, C :	**6.667**
Distance between coils, $Coil_{pitch}$:	**7.308 mm**
Rise angle of coils:	**6.63 Degrees**
Material type	**Music Wire ASTM A228**

iii. Design of Spur Gear:

Two motor of 300 RPM and 85 RPM is used and Spur gear is designed on the basis of speed ration 1:3.5

GEAR (1)

NUMBER OF TEETH (N) =30
OTTER DIAMETER (OD) = 30mm
DIAMETRICAL PITCH (DP) = (N+2)/OD
= (30+2)/30
= **1.06mm**

PITCH DIAMETER (PD) =N/DP
= 30 / 1.06
= **28.301 mm**

CIRCULAR PITCH = 3.147 / DP
= 3.147 / 1.06
= **2.96 mm**

WHOLE DEPTH = 2.157 / DP
= 2.157 / 1.06
= **2.03 mm**

TOOTH RADIUS (r) = (3 / 4) * CP
= (3 / 4) * 2.96
= **2.22 mm**

CORDIAL THICKNESS (CT) = PD * Sin (90 / N)
= 28.301 * Sin (90/30)
= **1.48 mm**

GEAR (2)

NUMBER OF TEETH (N) = 100
OTTER DIAMETER (OD) = 100mm
DIAMETRICAL PITCH (DP) = (N+2)/OD
= (100+2)/100
= **1.02 mm**

PITCH DIAMETER (PD) = N/DP
= 100 / 1.02
= **98.03 mm**

CIRCULAR PITCH = 3.147 / DP
= 3.147 / 1.02
= **3.08 mm**

WHOLE DEPTH = 2.157 / DP
= 2.157 / 1.02
= **2.11 mm**

TOOTH RADIUS (r) = (3 / 4) * CP
= (3 / 4) * 3.08
= **2.31 mm**

CORDIAL THICKNESS (CT) = PD * Sin (90 / N)
= 98.03 * Sin (90/100)
= **1.539 mm**

III. FABRICATION PROCESS:

STEP 1: Back Set Up

By considering motor specifications of 12v 7.5 amps, the speed ratio required is 1:3 so two spur gears of diameter 30mm and 100mm. These spur gears are connected by using connecting shaft of 15mm diameter MS material and ball bearings of inner diameter of 15mm and outer diameter 40mm and a lever is connected to the gear assembly for speed conversions as require. This is the complete procedure of back set up.

STEP 2: Chassis Setup

In this process Activa wheels of 228mm size are selected, depending on wheel size frame of size of 965mm length and 508mm width is built. The material used to build this frame is MS Square Pipe 18 Gauge. The total weight of chassis is 15kg .

STEP 3: Spring Setup

Spring is designed depending upon load it can withstand and the material of spring is music wire ASTM A228 whose total length is 104mm and means diameter 20mm and inner diameter where this spring is connected to pneumatic cylinder. Hence this diameter is selected because to match with the 15mm diameter piston rod.

STEP 4: Double Acting Pneumatic Cylinder Setup

The dimensions of cylinder depending on the weight of the chassis. Depending on the weight pressure required is 6 bar. This pressure is enough to lift the chassis. Specifications of cylinder is given below in the Table No.1

STEP 5: Making Of Electronic Circuit

Using Arduino board controller an electronic circuit is build using relay board, ultrasonic sensor, and IR sensor and suitable program is written and dumped to Arduino board in order to automate the whole process.

STEP 6: Assembly Process

By using Arc welding the back setup is welded to the chassis, then the pneumatic cylinder with spring is connected to the wheel assembly and chassis, and cylinder of capacity 10L is placed upon the chassis, by using hoses 5/2 Solenoid valve connections are given to pneumatic cylinder and electronic circuit . This is total fabrication process which was done to our prototype which took 25 days to complete the fabrication process where number of parts are listed above in the Table No:3.

Table No.3 List of parts

Sl. No	Parts	Quantity
1	DOUBLE ACTING CYLINDER	4
2	FLOW CONTROL VALVES	1
3	5/2 SOLONOID VALVES	2
4	WHEELS	4
5	SPRINGS	4
6	INDUTION MOTOR	2
7	SPUR GEAR	2
8	BATTERY	2
9	SENSOR UNIT CIRCUIT	1
10	IR SENSOR	1
11	UV SENSOR	1

IV. WORKING PRINCIPLE

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 vice versa. It is able to lift the weight of chassis up to 25kg with a compressor of capacity 6bar, which is good enough for a lower scale work. The mechanisms takes maximum 2 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 2 second. And the performance can be optimized.

The automatic lift mechanism is achieved by using two technologies. First method is by using UV sensors give a proximity range within that range the prototype will detect presence of bumps which comes on the way and the chassis of the prototype vehicle will raise and after it overcomes the bumps it lowers and other second method is which unique one designed by us, here speed controller mechanism is used to lift the vehicle which is achieved i.e. when vehicle is moving from low speed to high speed gear lever position will change. This change is position of lever is detected by using IR sensors where for high speed vehicles chassis position is lowered to help vehicle to move more faster and for low speed position of chassis is raised up to prevent damage. The complete working is shown in form of block diagram in Figure.2 .Hence by using this study future characteristics of vehicles will be improved.

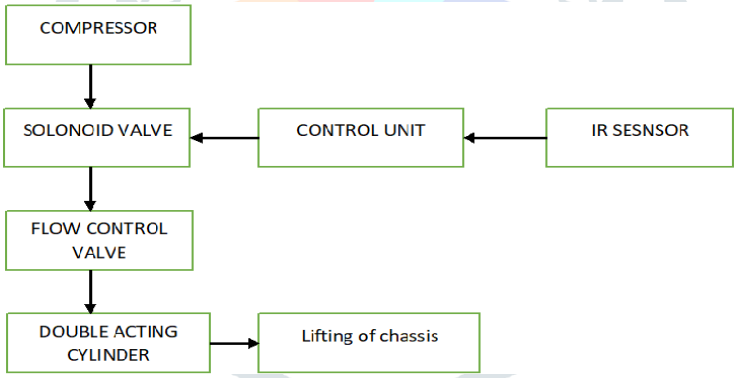


Figure.2 Block diagram

V. COMPONENTS USED AND ITS DESCRIPTIONS

i. PNEUMATIC DOUBLE ACTING CYLINDER:

Pneumatic cylinder consist of A) PISTON B) CYLINDER which is shown in Figure.3 The cylinder is a Double acting cylinder one, which means that the air pressure operates where high force is required in both directions of travel. The air from the compressor is passed through the regulator which controls the pressure to required amount by adjusting its knob. A pressure gauge is attached to the regulator for showing the line pressure. Then the compressed air is passed through the single acting 5/2 solenoid valve for supplying the air to one side of the cylinder.

Figure.3 Double acting cylinder

ii. SOLENOID VALVE WITH CONTROL UNIT:

The directional valve is one of the important parts of a pneumatic system. These are also used to operate a mechanical operation which in turn operates the valve mechanism as shown in Figure.4

Figure.4 Solenoid valve

iii. HOSES:

Hoses used in this pneumatic system are made up of polyurethane. These hoses can with stand at a maximums pressure level of 10 kg/cm2 which is shown in below Figure.5

Figure.5 Hoses

iv. CHASSIS FRAME:

This is a frame which is made up of mild steel whose shape is shown in Figure.6

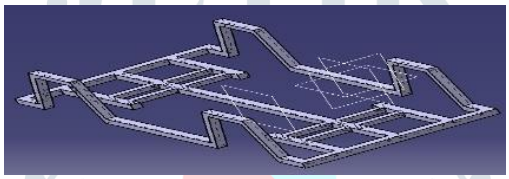


Figure.6 Chassis frame

v. IR SENSOR UNIT:

The IR transmitter and IR receiver circuit is used to sense the obstacle.

A) Normal Condition: The IR transmitter sensor is transmitting the infrared rays with the help of 555 IC timer circuit.

B) Obstacle Condition: At Obstacle conditions the IR transmitter and IR receiver, the resistance across the transmitter and receiver is high due to the non-conductivity of the IR waves.

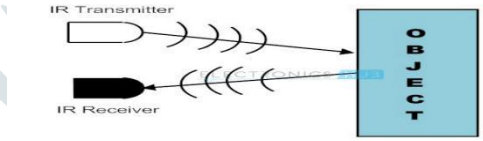


Figure.7 IR working

vi. ARDUINO UNO BOARD WITH CIRCUIT :

The Arduino Uno is a microcontroller board based on theATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Simply connect it to a computer with a USB cable or power it with AC to Dc adapter or battery and a suitable program is embedded in the micro controller of the board. Below is the circuit diagram of Arduino board whose diagram is shown below in Figure.8.

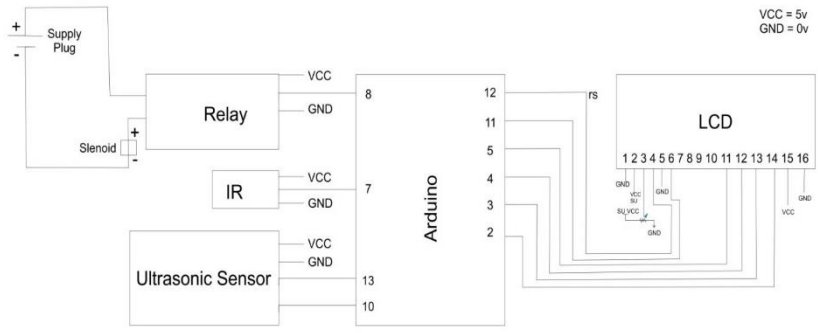


Figure.8 Circuit diagram

VIII. RESULTS AND DISCUSSIONS

1. A suitable program is developed for measuring high or low speed and detecting the presence of bumps for automation process.
2. The average time required by the system to vary the ground clearance of the vehicle is two seconds.
3. The ground clearance of the vehicle is increased by 7.5cm along the obstacles.

IX. CONCLUSION

In automobile industry there are always research is going on to provide maximum comfort to the passenger. While considering this situation it's difficult for vehicles to maintain its ground clearance at low and for the highway application to get more speed and stability to the vehicle and is not possible to achieve with high ground clearance. Aspect of this paper is implementing the Automatic ground clearance adjustment system to prevent number of damages to the car chassis are greatly reduced.

X. APPLICATION

1. This technology used can be used in all types of cars and also in buses.
2. This innovation would help in garage for mechanics to work under body without any additional jack
3. It would save time of installing a manual jack and washing of the lower body of the car as it would raise the car.
4. Hence a suitable Design has been designed such that the vehicle can be lifted from the floor land without application of any impact force.
5. This mechanism prevents damage for lower body of vehicle. Hence it can be used in low range cars.

XI. REFERENCES

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