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Review on Development of Automatic Ground Clearance Adjustment System in Cars using Pneumatic Lifting

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Abstract: Suspension and tyres are the two factors which lead to the height of the car. While designing a car both these factors are fixed to optimum ground clearance, ride and handling. Having taken these factors into consideration we can manage to make changes in ground clearance of the cars. Different techniques have been introduced to change the ground clearance of the cars and 'pneumatic lifting technique' is one them. Off road vehicles usually have higher ground clearance and this leads to reduction in speed and extra precaution is needed for handling these vehicles because of the higher centre of gravity. Since on road cars don't need higher ground clearance, these cars can run at great speeds with better stability. But in countries like India the condition of the roads in a very major issue since the road conditions are different every now and then and also the size of the speed breakers is also not constant. This leads to damaging the car chassis and front parts of the cars. Hence, designing a car with adjustable ground clearance is a good idea.

This paper introduces the prototype model of automatic ground clearance adjustable car using pneumatic lifting and Arduino programming.

Keywords- Ground Clearance adjustment, Centre of Gravity, Pneumatic lifting.

I. INTRODUCTION

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 increases the performance of car. This also reduces skidding of the cars while turning. But in passenger cars fixed ground clearance is provided. Since these cars have to run on rough roads with their fixed ground clearance which leads to damage the bottom portion of this cars and the chassis. To avoid these kinds of damages, we introduced the ground clearance adjustment system, in which driver can manually or automatically adjust the ground clearance by means of pneumatic lifting of the car according to the condition of the roads.

II. PROPOSED METHOD

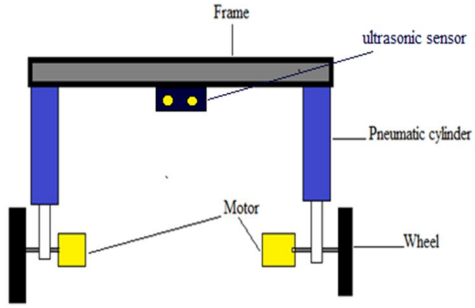


Figure 1. Block Diagram of Model

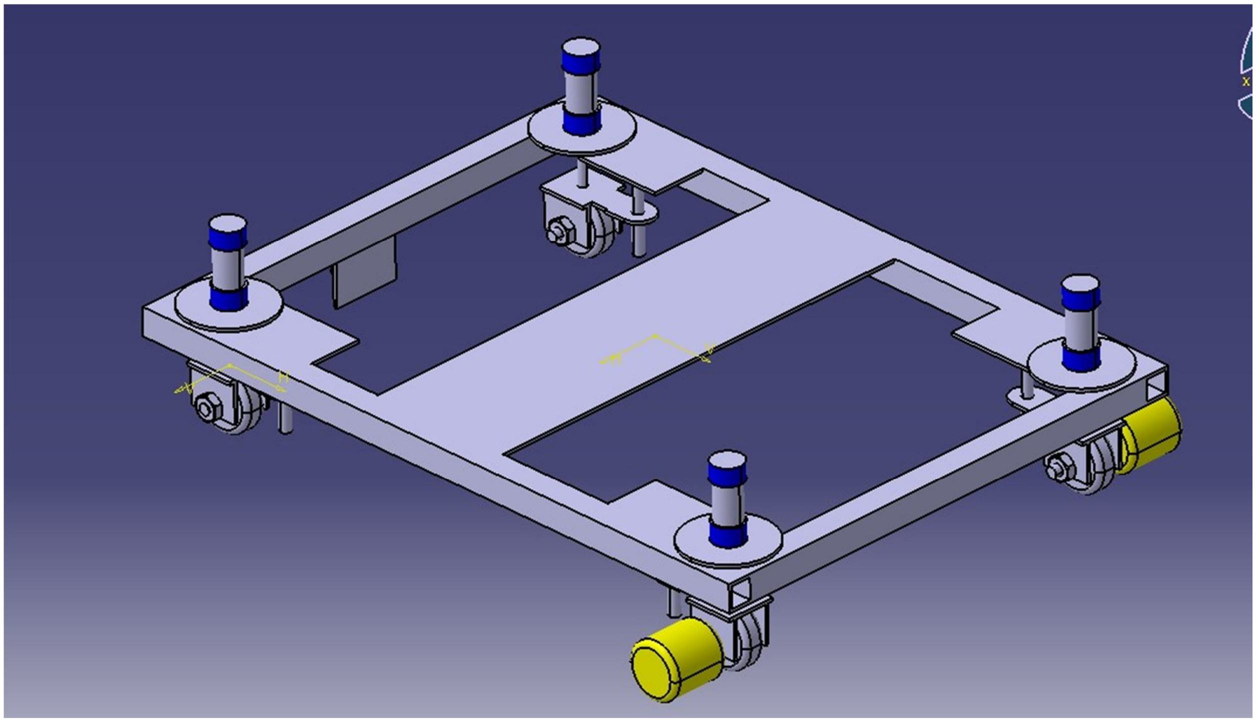


Figure 2. Cad Model

A. Specification of the Components Used

1) Specification of compressor

a) Type: Rotary air compressor

b) Input Voltage: 12volt 2.5amp, Output pressure: 3bar capacity, Discharge: 25 cm3 / s

2) Material used for Chassis: Square mild steel pipe of 20mm×20 mm

3) Battery: Output: 12volt 2.5amp dc supply.

4) Drive: Dc motor Input: 12volt 1amp, Speed: 10 rpm

5) Sensor: Ultrasonic sensor HC-04, Range: 2cm to 5m

III. CALCULATIONS

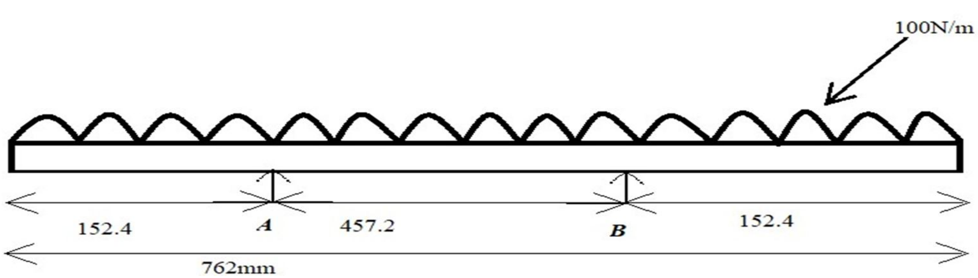
A. Basic Calculations for Frame Design

We have considered frame size as,
Length of frame=762 mm
Breadth of frame=610 mm

In our design, as overall weight of the system is placed on length of frame, the length part is considered as beam and design is done accordingly.

While designing, the beam is considered as overhang beam as two motors are placed between the ends of beam with uniformly distributed loading.

Hence UDL=100 N/m-------------Considering total mass of the prototype as 10kg.



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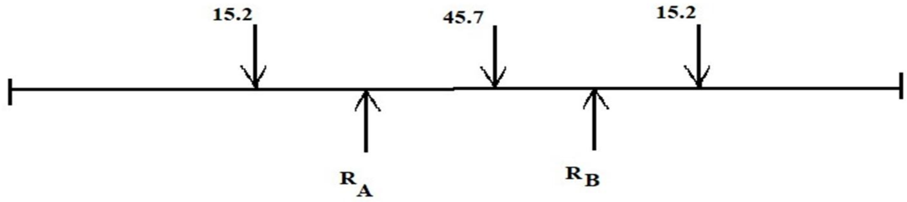
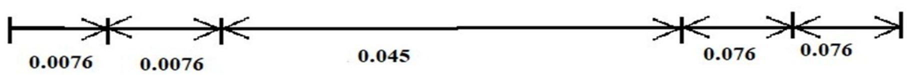
To calculate reactions, we need to simplify above diagram.





Now, to calculate reactions we need to simplify the load diagram. Considering equilibrium conditions, To find the reactions at A and B,

1.Moment about A is considered as 0. So,

R_b=37.54 N

2.Forces in Y direction=0. So,

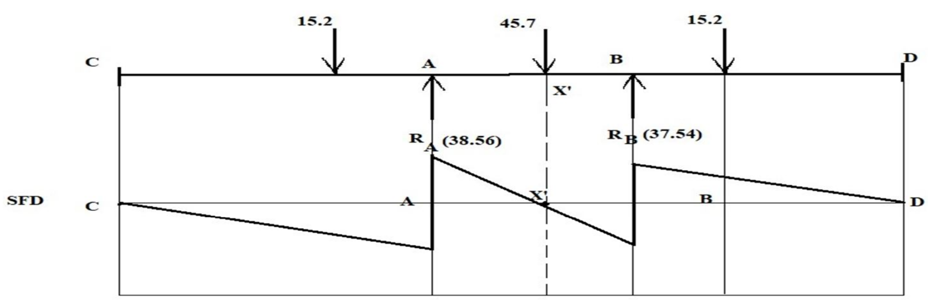
R_a=38.56 N

Now, calculations for shear force diagram (SFD),

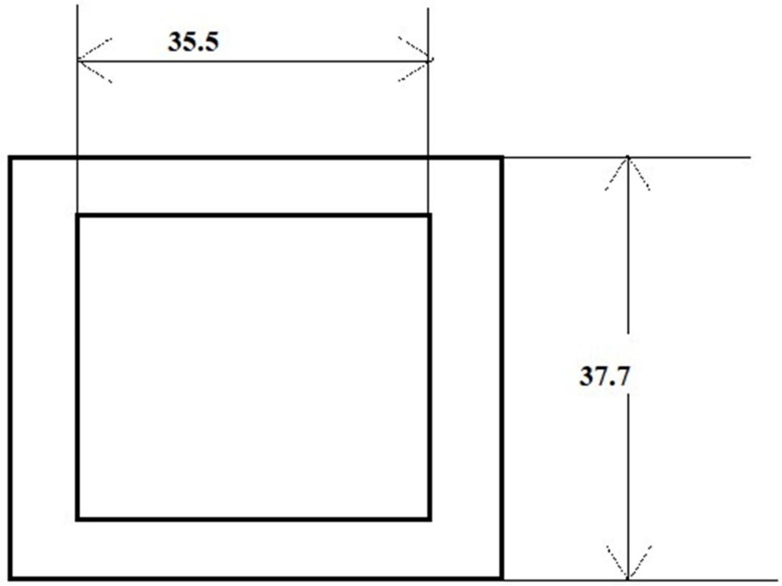
SFcl=0 SFcr=0
SFal=-15.2 N SFar=23.36 N
SFbl=-22.34 N SFbr=15.2 N
SFdl=0 Sfdr=0

Now we are doing calculations for bending moment diagram,

BMc=0
BMa=-1.15 N-m
BMb=0.23 N-m
BMd=0 N-m



We know that, point at which shear force is zero at that point maximum bending moment occurs.
X is the point at which maximum bending moment occurs.
BMx=4.30 N-m=0.0043 N-mm
The cross section of beam is square.



According to Flexure formula,
(M/I) = (σ/Y)
Now, we are using the square cross-sectional pipe with thickness as 2 mm.
So, according to flexure formula for bending stress,
(M/I) = (σ/Y)
Now, we know that,
M=0.0043 N-mm
Y=18.85 mm---------(distance of neutral axis)
By using the parallel axes theorem, we can calculate the moment of inertia (I)
I=IXX1-IXX2
I= (616.03-529.40) * 10^3 =86.62*10^3 mm^4
So, from above data we can calculate,
(0.004)/ (86.62*10^3) = (σ/18.85)
Hence σ =0.858 N/m2
This is the maximum permissible stress acting on frame.

B. Cylinder Piston Calculation

Cylinders are used to convert fluid power into mechanical action. It consists of a cylindrical body, closures at each end, movable piston, and a rod attached to the piston. When fluid pressure acts on the piston, the pressure is transmitted to the piston rod and it results in linear motion. The piston rod thrust force developed by the fluid pressure acting on the piston is easily determined by multiplying the line pressure by the piston area.

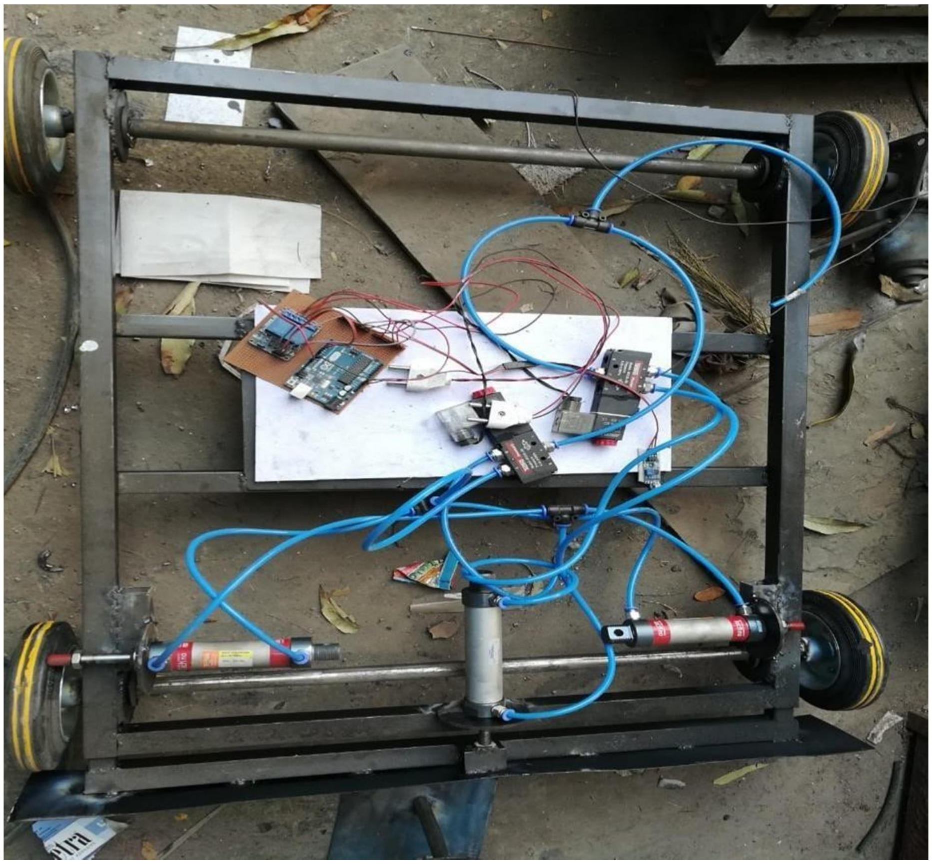
FORCE = PRESSURE x AREA

We selected the air compressor which has capacity of 3bar pressure. For this model according to factor of safety we should design the piston cylinder which can apply pull force according to the weight of our prototype i.e.15kg (approximate weight). So, we select 25mm diameter piston with 25 mm stroke. Further calculations as follows: First, we should find piston area. The area of a circular surface is πr*r, where "r" is the radius. For a 25 mm diameter piston, the area is 490.87 square mm(πr*r). Pressure acting is 3bar on each square mm. The total thrust force will be = 490.87*10-6 * 3*105 =147.361 N. To convert it into kg divide by 9.81 147.361/9.81= 15.01 kg. Thus, the piston cylinder can lift up 15 kg load at 3bar for 25 mm stroke length.
Hence, we select Piston cylinder specification as, Stroke length: 25 mm diameter Diameter: 25 mm, Pull force capacity: up-to 15 kg.

IV. WORKING OF THE SYSTEM AND EXPERIMENTAL RESULTS

The whole system is mounted on frame which will move with the help of wheels. On the front end of the system there is an ultrasonic sensor. This sensor senses the object in front of frame. Ultrasonic sensor uses transducer and receiver to send and receive single. Here, the program in the Arduino starts to execute. Whenever the sensor detects any object in front of the system, our system starts working and the vehicle is lifted. This lift makes use of the of pneumatic cylinders mounted in the vehicle. Ultrasonic sensor gives signal to pneumatic cylinder and frame lift in upward direction. As the object passes away pneumatic cylinder goes down in accordance with the installed program in Arduino.
We took number of readings of the working model and following results were obtained:

A. The time required by the system to vary the ground clearance is 5 seconds.
B. The ground clearance of the vehicle is increased by 20mm along the obstacles and it saves the vehicle from getting damaged.
C. This system can withstand a weight of 10-15kg with the air tank.



V. CONCLUSION AND FUTURE SCOPE

Considering the condition of the roads in India, we can surely give a try to introduce this technique while designing passenger cars in India. This technique will be very useful for riding in such tough terrain conditions for stability and for damage reduction of car chassis. Pneumatics has lots of applications in the field of automobile industry as well. Therefore, it is important for all engineers to have adequate and in-depth knowledge of pneumatic cylinders, pneumatic valves and other technique. This pneumatic adjustment works well in the prototype we have designed for our project using the Arduino programming. But there might be some limitations of the system in other real-life automobile models. And with proper designing of the mechanism and study of aerodynamics along with pneumatics, one will surely be able to achieve to apply this system in future automobiles.

VI. ACKNOWLEDGEMENT

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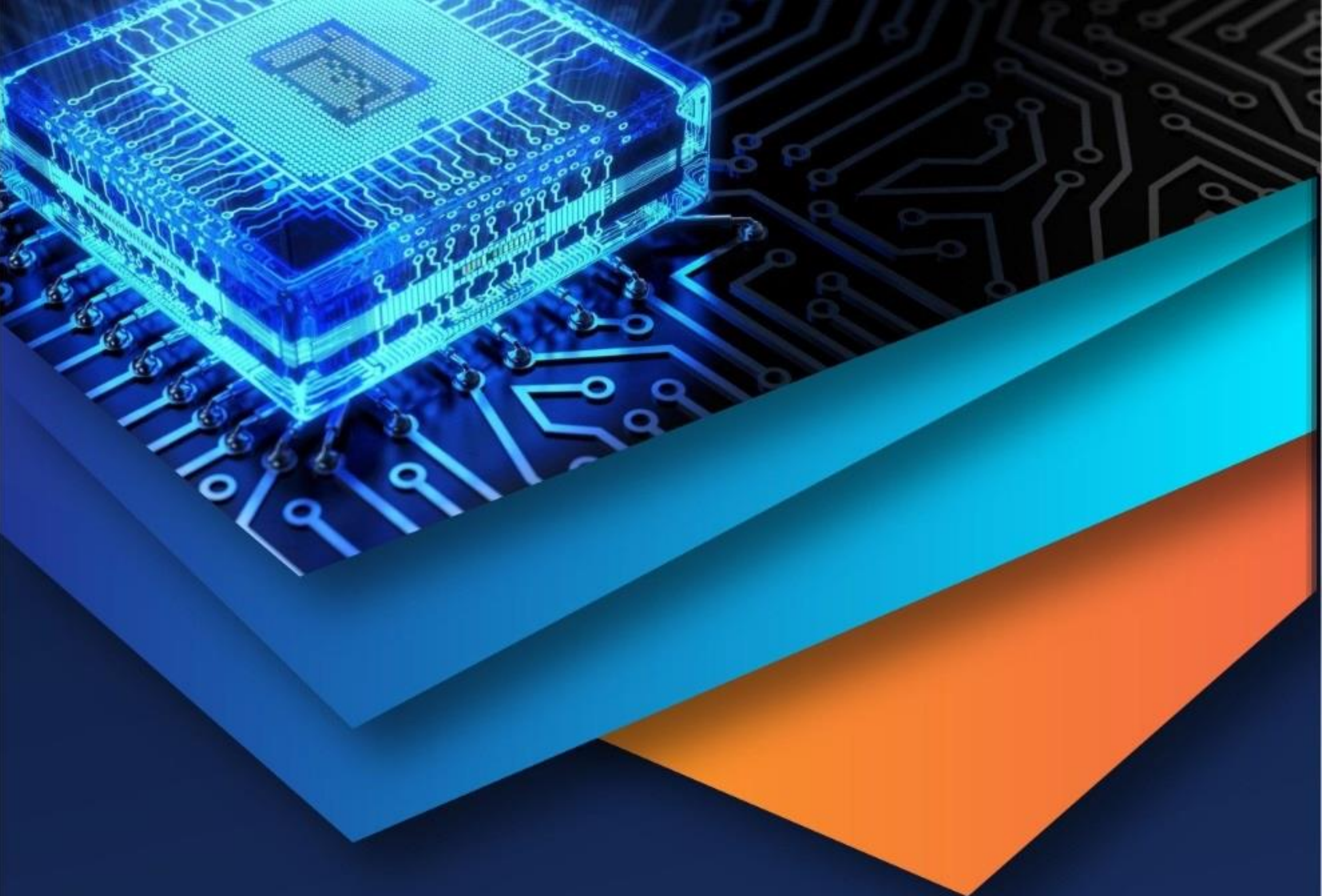

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