International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Manufacturing of Air Braking System Using Suspension

Shantanu Pawar*

[a]*UG Student, Savitribai Phule Pune University, Pune,Maharashtra, India.*

Abstract

In this braking system, exhaust gas from IC engines is used to operate air brakes in automobiles. The most common braking system in automobiles is the air brake. Instead of an air brake, the proposed model uses exhaust gas to operate the brake lever. The exhaust gas from the engine is stored in a specially designed pneumatic tank. This exhaust gas pressure is used to power the pneumatic cylinder and brake lever. The secondary system will be a thermoelectric generator used to charge a 12 volt battery and a DC compressor used to further pressure rise the exhaust air tank, resulting in a dual mode operation, hence the term hybrid. This study can be expanded to include diesel and gasoline engines. The primary goal of this project is to reduce the workloads of the engine drive in order to operate the air compressor. In this project, pressurised air from the DC compressor will be used to operate the pneumatic brake.

Keywords- Braking system, Exhaust gas, thermoelectric generator, Compressor.

1 Introduction

An air brake, also known as a compressed air brake system, is a type of friction brake for vehicles that uses compressed air pressing on a piston to apply the necessary pressure to the brake pad to stop the vehicle. Air brakes are used in large heavy vehicles, especially those with multiple trailers that must be linked into the braking system.

Trucks, buses, trailers, and semi-trailers, as well as railroad trains, are examples of their applications.

extended for diesel and gasoline engines The primary goal of this project is to reduce the workloads placed on the engine drive in order to operate the air compressor. The pneumati will be operated in this project using pressurised air from the DC compressor.Air brakes were invented by George Westinghouse for use in railway service. On March 5, 1872, he patented a safer air brake. Westinghouse made numerous changes to his air-pressured brake invention, which resulted in various types of automatic brakes. After its benefits in railway use were demonstrated, it was adopted by truck and heavy road vehicle manufacturers in the early twentieth century.

Exhaust gas from IC engines is used in this braking system to operate air brakes in automobiles. The most common type of braking system in automobiles is the air brake. Instead of using an air brake, the proposed model uses exhaust gas to operate the brake lever. The engine's exhaust gas is stored in a specially designed pneumatic tank. This exhaust gas pressure powers the pneumatic cylinder and brake lever. The secondary system will be a thermoelectric generator used to charge a 12 volt battery and a DC compressor used to further pressurise the exhaust air tank, resulting in a dual mode operation, hence the term hybrid. This research can be expanded to include diesel and gasoline engines. The primary goal of this project is to reduce the workloads placed on the engine drive in order to operate the air compressor. The pneumatic brake in this project will be operated by pressurised air from the DC compressor.

Literature Gap

From careful study of the literature pertaining to the problem of air brake by application of the compressed air from the suspension has been studied how ever various researchers have studied the problem no research points towards the direct application of the suspension motion to charge the air tanks. Thus, there is scope and possibility to experiment with and prove the use of suspension motion to charge the air tank for use in the air brake. As a result, the purpose of this paper is to propose an alternative technology and the system components that will be used as a result.

Problem Statement

The conventional exhaust brake is only suitable for heavy vehicles, whereas the pneumatic brakes require to compress air that in turn uses the compressor that runs on the engine power. Thus to run the pneumatic brake we are consuming engine power and more over the energy of the exhaust gases is discharged to the atmosphere which will increase pollution and so also energy is wasted.

Solution

The proposed solution is to make use of the high pressure air generated by the suspension motion and compress it further to make pressure energy useful to operate the pneumatic brake.

.

Objectives

The objective of our project is to design and development of Air braking using vehicle suspension system and avoids the drawback of old braking system. The purpose is to avoid energy crisis in India and reduces the human efforts, operating cost and maintenance cost. Also this system keeps the environment clean and healthy. Also avoid loss of engine power.

Chapter No 2

Working of conventional air brakes

An air brake, also known as a compressed air brake system, is a type of friction brake for vehicles that uses compressed air pressing on a piston to apply the necessary pressure to the brake pad to stop the vehicle. In addition to railroad trains, air brakes are used in large heavy vehicles, particularly those with multiple trailers that must be linked into the brake system, such as trucks, buses, trailers, and semi-trailers. Air brakes were invented by George Westinghouse for use in railway service.On March 5, 1872, he patented a safer air brake. Westinghouse made numerous changes to his air-pressured brake invention, which resulted in various types of automatic brakes. After its benefits in railway use were demonstrated, it was adopted by truck and heavy road vehicle manufacturers in the early twentieth century.

Air brake systems are commonly found on large trucks and buses. The system is made up of service and parking brakes, a control pedal, and an air storage tank. There is a disc or drum arrangement for the parking brake that is designed to be held in the 'applied' position by spring pressure. To release these "spring brake" parking brakes, air pressure must be produced. To use the service brakes (the ones used while driving for slowing or stopping), press the brake pedal, which sends air under pressure (approx. 100–120 psi or 690–830 kPa or 6.89–8.27 bar) to the brake chamber, causing the brake to engage.The majority of truck air brakes are drum brakes, though disc brakes are becoming more popular. The air compressor draws filtered air from the atmosphere and forces it at 120 psi into high-pressure reservoirs (830 kPa; 8.3 bar). Most heavy vehicles have a gauge in the driver's line of sight that indicates the availability of air pressure for safe vehicle operation, and it frequently includes warning tones or lights. A mechanical "wig wag" that drops into the driver's field of vision when the pressure falls below a certain point is also common.When the parking/emergency brake is depressed, the pressurised air in the lines between the compressed air storage tank and the brakes is released, allowing the spring-actuated parking brake to engage. A sudden loss of air pressure would immediately result in full spring brake pressure. A compressed air brake system is divided into two components: the supply system and the control system. The supply system compresses, stores, and distributes high-pressure air to the control system as well as additional air-powered auxiliary truck systems (gearbox shift control, clutch pedal air assistanceservo,etc.).

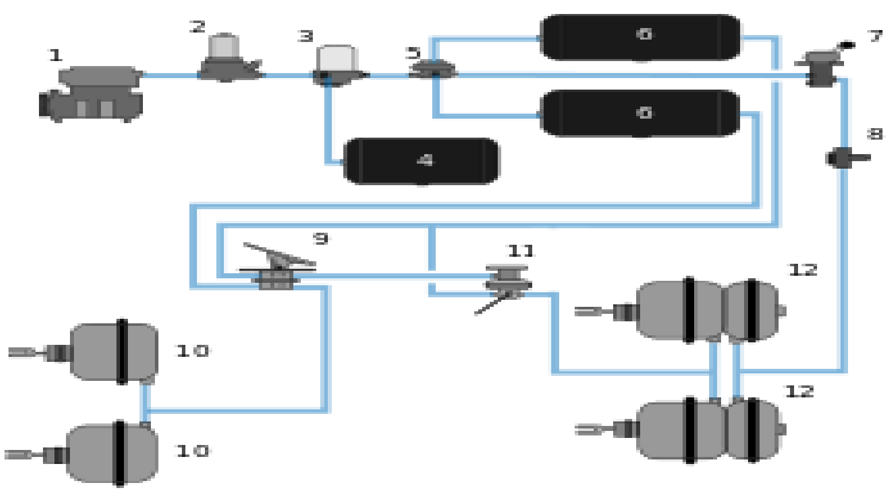


Figure 1 Control System of Conventional Air Brake Systems

The engine either drives the air compressor through a crankshaft pulley via a belt or directly through the engine timing gears. The engine lubrication and cooling systems lubricate and cool it. Compressed air is routed first through a cooling coil and into an air dryer, which removes moisture and oil impurities and may also include a pressure regulator, safety valve, and a smaller purge reservoir. In addition to the air dryer, the supply system can include an anti-freeze device and an oil separator.The compressed air is then stored in a supply reservoir (also known as a wet tank), from which it is distributed via a four-way protection valve to the primary reservoir (rear brake reservoir) and secondary reservoir (front/trailer brake reservoir), as well as a parking brake reservoir and an auxiliary air supply distribution point. A variety of check, pressure limiting, drain, and safety valves are also included in the system. A wig wag device, which deploys to warn the driver if the system air pressure drops too low, may be included in air brake systems.

Chapter No 3

Suspension System

The primary function of a vehicle's suspension system is to absorb or dampen all vibration transmitted from the road to the vehicle's body via the vertical movement of the wheels. The suspension system is made up of four major parts: sprung mass, or one-quarter of the car body, unsprang mass (wheels), springs, and dampers. Road irregularities act on the wheels, causing displacement input on the wheel level. Vibration motions are transmitted from the wheels to the car body at a specific frequency.The suspension system components, such as the springs and dampers, filter the vibrations between the wheels and the car body to prevent the motion from acting on the car body and to keep the wheels in contact with the road for an optimal driving experience.
suspension systems. The passive suspension is widely used for the majority of commercial cars since it has a high market value. The damping force in this case is tuned to a constant value. The semi-active suspension relies on the road input to calculate a better isolation value for the vibration of the wheels by linking the change of the damping force to the road profile. As for the active suspension system, the components apply an opposite force from There are three types of suspension systems that are classified as passive, semi-active, and active the actuator to negate the force applied by the road through the oscillation of the wheels.

Passive Suspension System

Passive suspension system is commonly used in the majority of today's car industry. The system is designed to diminish car vibration energy by a mechanical damping through fluid or absorption of motion. The system consists of springs and single-tube or twin-tube dampers. The dampers are the suspension system components that control the ride comfort and vehicle stability. Soft dampers generate a smoother motion on the level of the suspension which results in a more comfortable ride for the driver, while stiffer dampers maintain an optimal stability of the car by maximizing reduction the oscillations on the level of the suspension. Using the previous knowledge, the damping force in the passive suspension system then gets tuned to a chosen value or condition that is optimal for most of the road's irregularities. Thus, this system only operates on roads in which the road condition does not shift constantly.

Semi-Active Suspension System

Different to the condition stated in the passive suspension system, the semi-active suspension system has the advantage of altering the damping force in respect to the external power exerted on the wheels when the vehicle experiences different road irregularities. This system consists of sensors and micro-controllers that receive an input signal from the road and change the damper characteristics to match the road profile. The dampers then eliminate all the vibrations in the shortest period of time for a better driving experience. Thus, the performance of the semi-active suspension system proves superior to that of the passive suspension system especially when responding to a sudden effect of hitting an acute road irregularity. The semi-active suspension system relies on an electronic controller, and it is electrically powered by the car, but even if the controller fails the system still automatically operates as a passive suspension system for that period, which is still optimal as using a passive suspension system vehicle.

Active Suspension System

The active suspension system is a fully electric system that relies on both the power provided by the car's battery and the external power exerted by the ground on the wheels. The performance of the system uses feedback control by mounting an actuator that acts as an external force that diminishes and suppresses the vibrations. However, the active suspension system can only be implemented for large vehicles due to its immense size, weight and electricity consumption.Moreover, since the system totally relied on the car electric power to operate, if the power is down, the vehicle will have zero damping force, thus, the system safety 16 remains questionable.

Dampers in Vehicle Suspension System

The dampers or the shock absorbers in a vehicle's suspension system are considered majorcomponents of the system. They are designed to suppress vibration energy through fluid, air, ordry frictions. There are two types of dampers, the passive dampers that are commonly used incars and that use mono-tube or twin-tube oil damping, while the semi-active dampers use a widervariety of damping strategies in the vehicle's suspension system such as Solenoid-valves, ER-fluid, MR-fluid, Eddy current and electromagnetic dampers [4]. The last type is an active damperthat works on reaching the best suppression performance in return of power consumption, priceandweight.

Passive Dampers

The passive damper is commonly referred to as hydraulic damper. This system is conventionalfor the use in most automobiles du e to its market value and simplicity. The hydraulic damperworks on the mechanical movements on the level of the piston valve in the oil chamber to absorbthe vehicle vibration due to the viscosity of the oil that helps absorb the oscillation inside thedamper

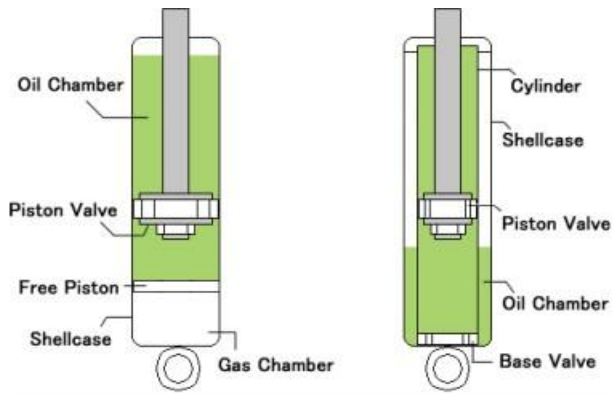


Figure2HydraulicDamperDiagram

Ground Vehicle Dynamics

When talking about reality, the road is not totally flat. Vehicles always experience various typesof disturbances, which act on the car as a form of vibration. Road roughness differ from a road
to another resulting in a variation in the energy dissipated by shock absorbers. Thus, it is highly recommended to understand the possible flow of energy suppressed by dampers when the vehicle experiences different speeds on a high oscillation road. Thus, studying the road roughness helps know and predict the multiple roads the vehicle can be experiencing.[7]

Road Roughness

When the vehicle is traveling on the road, the wheels move in respect to the trajectory of the imperfections of road surface. Thus, as stated before, the road imperfections can be referred to as ground displacement input. This displacement input is a space variable working on a space domain, therefore, it is needed to convert it into time domain for future calculations for the suspension velocity.

10.2. Suspension Displacement and Velocity

The modeling of road disturbance works as a displacement input from the ground to the wheels. The process of the transition consists of transforming the vehicle's speed into an increase in the root mean square value of displacement (RMS). When driving with a speed of 96kmh on an average road, the RMS suspension velocity can reach 0.25 m/s. The following figures show respectively both the suspension displacement and suspension velocity of a car traveling at 96kmh on an average road.[5]

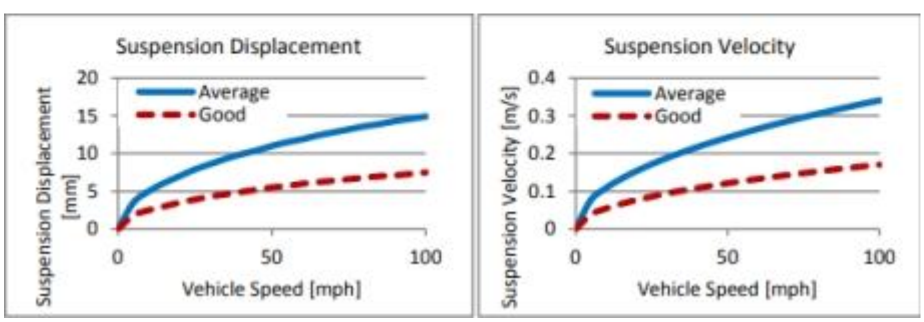


Figure 3 Suspension Displacement and Velocity

Chapter No 4

Overview on compressors functioning

An air compressor is a device used to condense air into a storing device that later will contain compressed air. The process varies from an air compressor to another. There are three distinctive types of air compressors working up to date. The first type is the rotary-screw compressor, it is mainly used to generate high pressure compressed air, and relies on a mechanical function of rotation to produce condense air. The latter is often used to replace reciprocating compressors when high pressured air is needed.

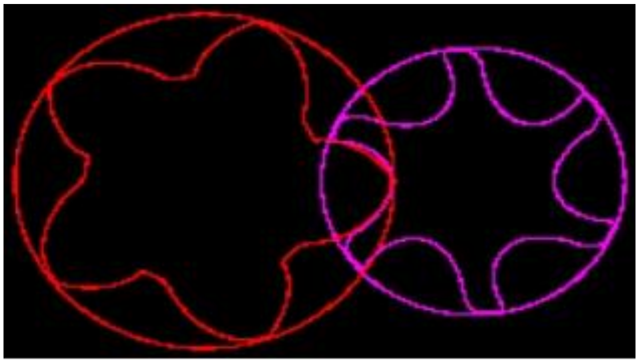


Figure 4 Rotary compressor

The rotation creates a pressure on the air between the two threads of the cylinders, which results in producing compressed air at the bottom of the compressor that gets stored instantlyThe second type of compressors is the centrifugal or radial compressor. This type works by increasing the entering velocity of the air that gets converted into static pressure through a rotating motion on the level of the diffuser that reduces the air flow, thus, resulting in a more compressed air when exiting the diffuser.The third type of air compressors, which is the tool we're using in our model, is the reciprocating air compressor. The latter uses the mechanical movements of a piston inside a cylinder to compress air. There are two sub-types of reciprocating air compressor: the first typeis the single-stage compressor, which compresses air only once for each complete movement of the piston. The second type is the two-stage compressor that compresses air twice for one movement of the piston. The two-stage compressors are used to create medium pressure air up 22 to 200 psi, while the single-stage compressors are considered a low pressure air compressors as it produces a compressed air for less than 150 psi.

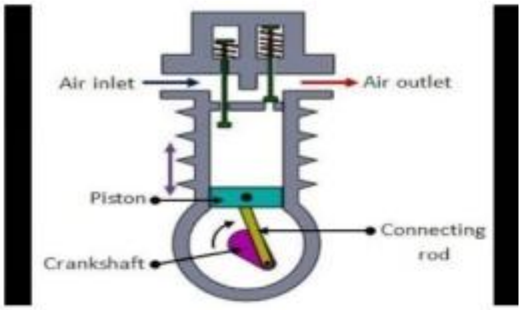


Figure 5 Resiprocating Compressor

We chose to use the reciprocating air compressor because it only relies on the mechanical movements of the wheel. Without any need for electricity or energy, we will reduce the materialsused for the product, along with the space taken. Also, we chose the single-stage air compressor over the double-stage one because it only consists of one piston which is optimal for placing it above the tire.

Vehicle suspension

A vehicle's suspension is a system linkage between the tires and the body of the vehicle that allows a movement between the two. The whole system works as an oscillation nullifier while the vehicle goes through any of the vehicle dynamics principles (Road isolation, Road handling and cornering). The job of a suspension system is fundamental to the vehicle's movement since it keeps the tires at constant friction with the horizontal road. There are three types of suspension that can be used in a vehicle. The first one is the active suspension that uses electronic monitoring of the vehicle and tire's placement in respect to the ground. That way it automaticallyresets to the road level to keep the tire in friction with the road.

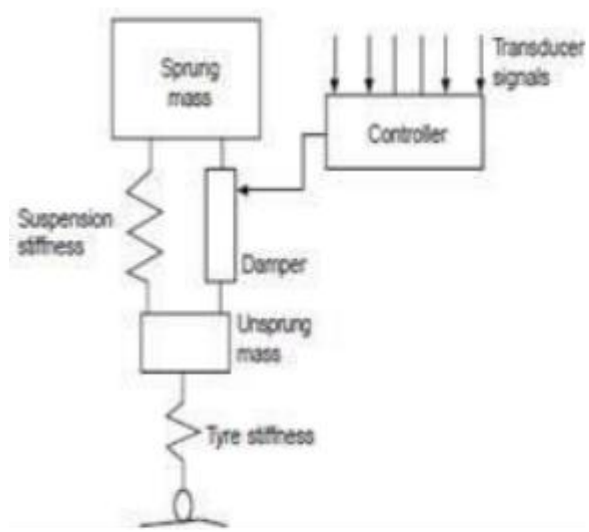


Figure 6 Quarter Car Model of Active Suspension

The semi-active suspension is another type that consists using multiple electronic based devices such as air springs that consist of an electrically powered compressor. This type of suspension is often used in buses, trucks and trains.The passive suspension is the third type of suspension which relies only on the mechanical movements of its parts to absorb the vertical movements of the tire

.

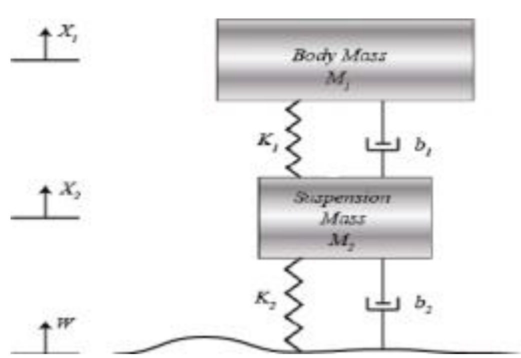


Figure 7 Quarter Car Model of Passive Suspension

This system appears to be optimal for our product designed since it only relies on a mechanicalmovement which suits our product's mechanism.

Analysis

System prerequisites

The system needs to constantly keep the compressed air tank full in order to ensure reliability of the overall design. The car tires need to be at a pressure of about 2.5 bars. Since, the transfer occurs twice: from the pneumatic cylinder to the tank and from the tank to the tires. Therefore, the tank needs to at least provide air at a pressure around 4 bars, so the air can move to the tire. The tank chosen needs to operate at a maximum pressure higher than 4 bars, and the pneumatic cylinder needs to provide air at 4 bars or higher.

Dynamic flow

Pneumatic cylinder specifications

The most crucial component of this project is without any doubt the pneumatic cylinder incorporated in the suspension. In order to simplify the calculations, an industrial pneumatic cylinder was chosen with compliance to space restrictions. The cylinder chosen is a double acting pneumatic cylinder from ASCO having a bore of 63 mm and a stroke of 100 mm. Additional information can be found in the cylinder's datasheet in the appendix.

Energy efficiency

Generally, pneumatic cylinders have a efficiency factor from 50% up to 90%. In order to ensure a valid pressure output transmitted to the tank, the minimum efficiency of the system needs to be calculated.
First of all, the force applied by the piston needs to be calculated using the following formula.

$$F = P_{atm}A_{out} + m_s g cos\theta$$

Having Patm=101.325kPa, outstroke are Aout=0.0027m2, ms300kg, and an angle of inclination of 45 degrees, we obtain a force F=2354.59N.
Now, the input power to the distance is needed:

$$P_{in} = F\dot{x}_{max}$$

Having F already calculated above, and a max velocity of the piston with respect to the road profile of 0.15 m/s according to [4], the input power is 353.19W.
The desired output power is known through the formula:

$$P_{out} = PQ$$

Where, P is the output pressure and Q is the air flow entering the system. The tank needs at least to be at a pressure of 4 bars in order to inflate the tires; therefore, Pmin needs to be used if we are to calculate the minimum efficiency for the system to work properly. The entering air flow is proportional the maximum velocity of the piston.

$$Q = A_{in}\dot{x}_{max}$$

Having the instroke area Ain=0.0031m2 and the maximum velocity of the piston same as used before, the intake air flow equals 0.000467m3/s. Therefore, the minimum output desired would be 186.8W.

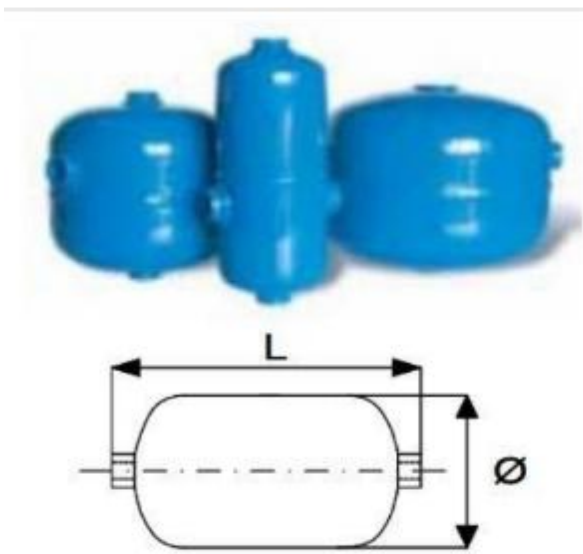
Now, the minimum efficiency required for a normal functioning of the system is about 53%using the formula

$$\eta = \frac{P_{out}}{P_{in}}$$

Clearly, the system has a wide margin of efficiency drop in the system since cylinders operate above an efficiency of 50% unless there are leaks or parts wear.

Air tank specifications

The air tank used for the design project needs to comply with various constraints; it has to be relatively light, have a decent capacity and working pressure. There are industrial tanks that conform to our specifications



.

Figure 8 compressed air tank

The figure above shows compressed air tanks from Pneumatiek that have characteristics perfectly fitted for our requirements. They have different configurations to choose from; the tank chosen has a maximum working pressure of 7 bars, a capacity of 7 liters. Their dimensions are suited for a car application having a length of 300 mm, a diameter of 150 mm and a weight of 3.2 Kg. Additional information can be found in the appendix.

Flow Control of the System

Once the air tank reaches its maximum capacity, the pneumatic actuator should no longer provide it with compressed air. In order to achieve this task, a solenoid control valve is used to control the system. The control valve used is a 3/2 valve, which translates to 3 ports and 2 positions. Switching from a position to another in a solenoid valve is performed using a solenoid as the name states. One port is always connected to the outlet of the pneumatic actuator; the two remaining ports interchange based on the position of the valve. The left position connects the outlet of the pneumatic cylinder to the tank; while the second one acts as an exhaust for the unused compressed air. Additional processing elements should be implemented in the pneumatic circuit like air regulators; however, they are omitted in this 27 circuit for the sake of simplicity since we are mainly focusing on the performance of the design. The figure # shows the simplified pneumatic circuit used for the design drawn using PneuDraw tool.

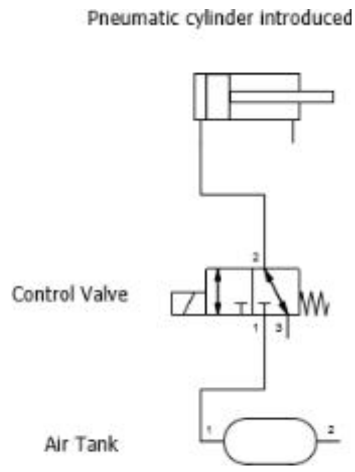


Figure 9 Pneumatic Circuit

The control valve changes positions to connect with the tank whenever a pressure sensor inside the tank indicates that the pressure is below the minimum pressure required

Suspension analysis

In this subsection, an analysis of the normal passive suspension system of a car is to be performed to later be compared to the system proposed by this project. This analysis is targeting the dampening effect of the solution and how it is in no way affecting the normal functioning of the suspension. The approach used in this analysis is the quarter car model employed in many studies targeting vehicle suspension. The quarter vehicle model is a simplification used to study vehicle suspension. There are many variations of the model. The model used in this paper is based on the assumptions that the tire is modelled as a linear spring with damping as opposed to other similar models; also, no rotational behavior neither in the wheel nor the body is considered, the motion of the damper and spring are linear and the tire never loses contact with the surface ofthe road. [5]

Normal Passive SuspensionForce Analysis

A basic free body diagram of the suspension is drawn and used for the analysis

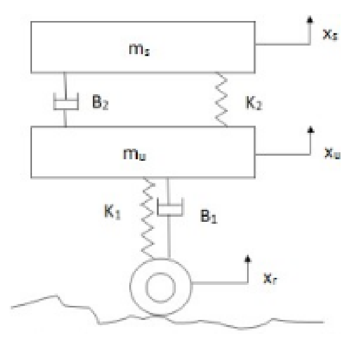


Figure 10 Quarter Car Model of Passive Suspension

The figure above shows the forces applied on both the sprung and unsprung mass. The sprung mass defines the fraction of the vehicle's total mass supported by the car's suspension; the unsprung mass is simply what remains of the mass, which is the mass of the suspension and wheel.
Separate free body diagrams of both the sprung and unsprung mass are made to analyze theforces applied on them.

Figure 11 Sprung Mass FBD

$$\sum F = F_{B2} + F_{K2} = -m_s \ddot{x}_s$$

The forces applied on the sprung mass are the spring force FK2 and the dampening force FB2. Replacing the above equation with its respective definitions, we obtain:.

$$\leftrightarrow m_s \ddot{x}_s + B_2(\dot{x}_s - \dot{x_u}) + K_2(x_s - x_u) = 0$$

Where, K2 = the suspension stiffness
B2 = the dampening coefficient of the suspension

Applying the same analysis on the unsprung mass while considering the reaction forces of theforces applied on the sprung mass, we obtain:

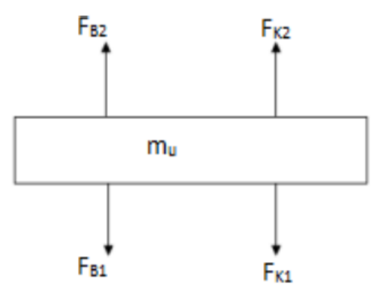


Figure 12 Unsprung Mass FBD

$$\sum F = F_{B2} + F_{K2} - F_{B1} - F_{K1} = m_u \ddot{x_u}$$

$$\leftrightarrow m_u \ddot{x_u} - B_2(\dot{x_s} - \dot{x_u}) - K_2(x_s - x_u) + B_1(\dot{x_u} - \dot{x_r}) + K_1(x_u - x_r) = 0$$

Where, K2 = the suspension stiffness
B2 = the dampening coefficient of the suspensionK1 = the tire stiffness
B1 = the dampening coefficient of the tire

Those two equations obtained constitute a system of second order differential equations describing the positional behavior of the sprung and unsprung mass with respect to the road profile.

Suspension with incorporated pneumatic cylinderForces analysis

Similarly, the same force analysis is performed on the suspension including now the pneumaticcylinder.

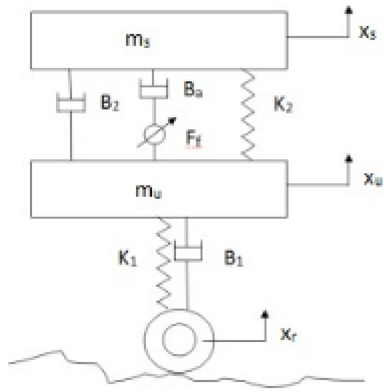


Figure 13 Quarter Car Model for Suspension including Pneumatic Cylinder

$$\sum F = F_{B2} + F_p + F_{K2} = m_s \ddot{x}_s$$

Again, splitting the sprung and unsprung mass into two separate free body diagrams:

The forces applied on the sprung mass are the spring force FK2, the dampening force FB2 and the dampening force of the pneumatic cylinder Fp. Replacing the above equation with itsrespective definitions, we obtain:

$$\leftrightarrow m_s \ddot{x}_s + B_2(\dot{x}_s - \dot{x}_u) + c(\dot{x}_s - \dot{x}_u) + K_2(x_s - x_u) = 0$$

Where, K2 = the suspension stiffness

B2 = the dampening coefficient of the suspension

Applying the same analysis on the unsprung mass while considering the reaction forces of theforces applied on the sprung mass, we obtain:

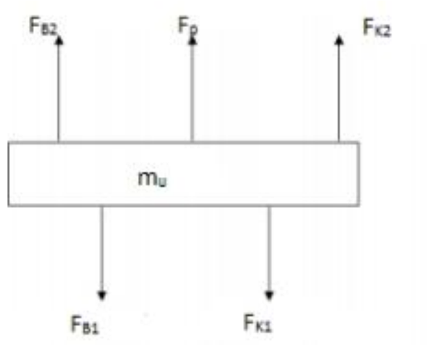


Figure 14 Unsprung Mass FBD

$$\sum F = F_{B2} + F_p + F_{K2} - F_{B1} - F_{K1} = m_u \ddot{x}_u$$

$$\leftrightarrow m_u \ddot{x}_u - B_2(\dot{x}_s - \dot{x}_u) - c(\dot{x}_s - \dot{x}_u) - K_2(x_s - x_u) + K_1(x_u - x_r) + B_1(x_u - x_r) = 0$$

Where, K_2 = the suspension stiffness
B_2 = the dampening coefficient of the suspensionK_1 = the tire stiffness
B_1 = the dampening coefficient of the tire
C = the dampening coefficient of the cylinder

Identically to the analysis done previously, these two equations resulted describe the positional behavior of the sprung and unsprung mass with respect to the road profile.

Steeple Analysis

The STEEPLE analysis is a model that identifies-in the same order- the major social, technological, economic, environmental, political, legal and ethical factors in a certain process that would affect, either positively or negatively, the targeted audience.

Social Factors

The product between hands is mainly targeting the big social issue of deaths caused by car accidents. This project will directly help reduce the numbers of deceases in the highways by preventing any failure of vehicle tires.

Technological Factors

The whole project is relying on a technological basis; the use of the mechanical movements of the shock absorbers and the electronic materials to define the air pressure of the tire are both major components in the calculations to regulate the air pressure inside the under-inflated tire.

Economic Factors

The designed product is an included part in the making of the new issued vehicles, thus, the price will be included in the vehicle's price in the selling process. Also, under-inflated tires directly cause over- consumption of the vehicle's fuel. This product will prevent the engine from consuming more, therefore, minimizing the cost of fuel per distance traveled. In other hands, when minimizing tire damage risks, the consumer will avoid the extra fees for tires' replacement each year.

Environmental Factors

As stated above, the product will minimize fuel consumption and fuel combustion per distance traveled. This will automatically reduce the toxic emissions of the vehic

Legal Factors

Our product provides the car with an internal operating system that helps the user have access to compressed air at any time. Thus, the product is legally approved since it will not push the vehicle exceed the weight limit.

Ethical Factors

The project remains side to side with the ethical rules of engineering since it provides the public with an easier way of life. It also helps simplify their daily tasks and reduces the public's concerns regarding the inconveniences of under-inflated tires.

Chapter 5

Braking system

Brakes are one of the most important control components of the vehicle. They are required to stop the vehicle within the smallest possible distance and this is done by converting the kinetic energy of the wheels into the heat energy which is dissipated into the atmosphere.

Types of brakes based on method of actuation:

- Mechanical brakes
- Hydraulic brakes
- Electric and electronic brakes
- Vacuum brakes
- Air brakes

Types of brakes based on application

- Drum brakes
- Disc brakes
- Parking Brakes

Drum brakes

The modern automobile drum brake was invented in 1902 by Louis Renault, though a less - sophisticated drum brake had been used byMaybach a year earlier. The shoes in the first drum brakes were mechanically operated by levers, rods, or cables. The shoes were operated by oil pressure in a small wheel cylinder and pistons beginning in the mid-1930s, though some vehicles continued to use purely mechanical systems for decades. Two wheel cylinders are used in some designs. The shoes in drum brakes are subject to wear and the brakes needed to be adjusted regularly until the introduction of self adjusting drum brakes in the 1950s. In the 1960s and 1970s brake drums on the front wheel of cars were gradually replaced with disc brakes and now practically all cars use disc brakes on the front wheels, with many offering disc brakes on all wheels. However, drum brakes are still commonly used for handbrakes because designing a disc brake suitable for holding a car when it is not in use has proven extremely difficult. Furthermore, it is very simple to install a drum handbrake inside a disc brake so that one unit serves as both the footbrake and the handbrake. Asbestos was used in early brake shoes. When working on the brake systems of older vehicles, take care not to inhale any dust that may be present in the brake assembly. As the Federal Government of the United States began to regulate asbestos production, brake manufacturers were forced to switch to non-asbestos linings. Owners initially complained of poorbraking with the replacements; however, technology eventually advanced to compensate. A majority of daily-driven older vehicles have been fitted with asbestos freeinings. Many other countries restrict the use of asbestos in brakes as well. Drum brakes are made up of a backing plate, brake shoes, a brake drum, a wheel cylinder, return springs, and a self-adjusting system. When you apply the brakes, brake fluid is pushed under pressure into the wheel cylinder, causing the brake shoes to come into contact with the machined surface on the inside of the drum. Return springs pull the shoes back to their rest position when the pressure is released. The shoes must travel a greater distance to reach the drum as the brake linings wear. When the distance reaches a certain point, a self-adjusting mechanism adjusts the rest position of the shoes to bring them closer to the drum.

Brake shoes

Brake shoes, like disc pads, are made of steel with the friction material or lining riveted or bonded to it. Linings, like disc pads, eventually wear out and must be replaced. If the linings are allowed to wear through to the bare metal shoe, they will cause severe damage to the brake drum.

Backing plate

The backing plate is what holds everything together. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes and assorted hardware. It rarely causes any problems.

Brake drum

Brake drums are made of iron and have a machined surface on the inside where the shoes come into contact with them. Brake drums, like disc rotors, will show signs of wear as the brake linings seat against the machined surface of the drum. The brake drum should be machined smooth after new shoes are installed. The maximum diameter of a brake drum is stamped on the outside of the drum. When machining a drum, it must never exceed that measurement. If the surface cannot be machined within that limit, the drum must be replaced.

Wheel cylinder

The wheel cylinder consists of a cylinder that has two pistons, one on each side Each piston is equipped with a rubber seal and a shaft that connects the piston to a brake shoe. When the brakes are applied, the pistons are forced out, causing the shoes to make contact with the drum. If the wheel cylinders show signs of leaking, they must be rebuilt or replaced. The major components of the drum brake assembly is shown in the following figure the detailed exploded view of drum brake components.

Return springs

Return springs pull the brake shoes back to their rest position after the pressure is released from the wheel cylinder. If the springs are weak and do not fully return the shoes, the linings will wear prematurely because they will remain in contact with the drum. During a brake job, a good technician will inspect the springs and recommend replacement if they show signs of fatigue. On certain vehicles, the technician may recommend replacing them even if they look good as inexpensive insurance.

Self adjusting system

To ensure that the brakes maintain their adjustment over the life of the linings, the parts of a self-adjusting system should be clean and free to move. If the self-adjusting mechanisms fail, you will notice that you must step down further and further on the brake pedal before you feel the brakes engage. Disc brakes are self-adjusting and do not require any kind of mechanism.When a technician performs a brake job, aside from checking the return springs, he will also clean and lubricates the self adjusting parts where necessary.

Disc brakes

Disc brakes consist of a metal disc attached to the wheel hub that rotates with the wheel. Calipers are attached to the frame or fork, and pads on the disc squeeze together. For decades, such brakes have been used successfully and as the primary choice on motorcycles. The disc brake is similar to the brakes on a bicycle. A calliper squeezes the brake pads against the wheel on bicycle brakes. The brake pads in a disc brake squeeze the rotor rather than the wheel, and the force is transmitted hydraulically rather than via a cable. Friction between the pads and the disc slows the disc down.

Construction

THEORY OF CONVENTIONAL HYDRAULIC DISC BRAKE

A Disc brake uses a flat, round disc or rotor, attached to the wheel hub instead of a drum. Brake pads are positioned on the opposite sides of the rotor and are mounted in the brake caliperThe hydraulic piston used to apply the shoes and transmit braking forces from the shoes to the suspension members is housed in the calliper. All disc brakes are non-energized, non-servo brakes, with lining pressure proportional to brake pedal pressure. The contaminants will be thrown off the rotor by centrifugal force. Because of the increased area exposed to the air flowing past it, disc brakes operate much cooler than drum brakes. To transmit application forces from the brake pedal to the brake shoes, all modern automotive brake systems use a hydraulic system. The master cylinder is the starting point for the hydraulic system of the brakes. The master cylinder is essentially a piston-type hydraulic pump that is controlled by the brake pedal. When you press the brake pedal, brake fluid is pumped to the calliper or wheel cylinder piston. This fluid pushes on the pistons, which push the brake shoes against the rotor.

Chapter 6

Overview

Block Diagram

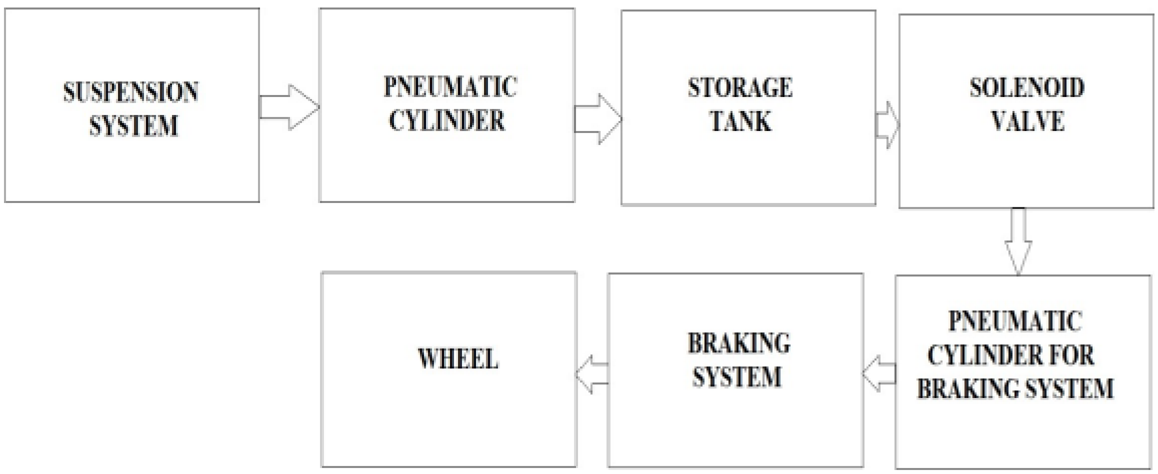


Figure 15 Block Diagram

Methodology

Literature Survey

We started the work of this project with literature survey. We gathered many research papers which are relevant to this topic. After going through these papers, we learnt about braking system using suspension system .

The components which are required for my project are decided

The testing will be carried out and then the result and conclusion will be drawn.

Software Analysis

In this the model of existing air brake components and its analysis using suitable software will be done. Then according to the results of existing components , modifications will be made to the components to obtain the best braking performance.

Phase I

We started our work with literature survey.Search many research papers from various articles and published journal papers. Worked on diff. Mechanisms that can be useful for our project.We tried for a rough model After getting rough model we selected standard components.

Phase II

Purchasing of standard components and parts Prepared drafting and catia models

Final calculation and analysisDesign and assembly

Testing

Description of pneumatic components

Double acting air cylinder with piston arrangement:

It consists of a piston inside a cylindrical housing called a barrel. A rod is attached to one end of the piston, and the rod end has one port. This rod end port, which extends outside one end of the cylinder, is used for air entry. A port for air exit is located at the opposite end. The double acting cylinder can be pneumatically extended and retracted. A double acting cylinder's smallest bore size is 1 1/8 inch. The piston, made of ductile iron, has u-cup packing to prevent leakage between the piston and barrel. The ports are located in the end caps, which are bolted and nutted to the barrel.

Figure 16 Pneumatic cylinder

DIRECTING CONTROL VALVES:

A direction control valve is used to reverse machine tool devices by changing the direction of airflow as needed by the system. A direction control valve can be classified based on the design of its internal moving parts, as

Rotary spool Type.

Sliding Spool Type.

Solenoid operated valves

Figure 17 non return valve

SOLENOID OPERATED VALVES:

Solenoid valves are electromechanical devices like relays and contractors. A solenoid valve is a device that uses fluid or air pressure to generate mechanical movement in machinery. A valve controlled by a cylindrical electrical coil applies fluid or air pressure to the cylinder piston. The electrical coil, along with

its frame and plunger, is referred to as a solenoid, and the assembly of a solenoid and a mechanical valve is referred to as a solenoid valve. As a result, the solenoid valve is yet another important electromechanical device used in machine control. There are two kinds of solenoid valves.
Single solenoid spring return operating valve,(5/2)

Double solenoid operating valve

Figure 18 Solenoid valve

A single solenoid spring return valve in its de-energized condition. The symbol for the solenoid and the return are also shown. The solenoid valve is shown connected to the cylinder to help readers understand the solenoid valve action. In the de energized condition, the plunger and the valve spool position as In this position of spool, port P is connected to port A and port B is connected to tank or exhaust (i.e. atmosphere) if air is used. Spring pressure (S) keeps the spool in this condition as long as the coil energized. Fluid pressure is applied to the left side of the cylinder piston via ports P and A. As a result, the cylinder piston moves in the correct direction. When the solenoid coil is activated, the plunger is drawn in and pushes the spool against spring pressure. In this spool position, port A is connected to the tank, and port P is connected to port B. As a result, pressure is applied to the cylinder piston from the right, causing the piston rod to move to the left. Simultaneously, fluid from the other side is drained into the tank. When the solenoid coil is de-energized, the spring (S) returns the spool to its original position, as illustrated in Figure 1.Thus, normally when the solenoid coil is de energized the piston rod remains extended.

NEUMATIC FITTINGS:

There are no nuts to tighten the tube to the fittings as in the conventional type of metallic fittings. The tube is connected to the fitting by a simple push ensuring leak proof connection and can be released by pressing the cap and does not require any special tooling like spanner to connect (or) disconnect the tube from the fitting.

SPECIFICATION OF THE FITTING:

Body Material - Plastic Collect/Thread Nipple - BrassSeal - Nitrate Rubber
Fluid Used - Air
Max. Operating Pressure - 7 Bar
Tolerance on OD of the tubes - mm

Min. Wall thickness of tubes - 1 mm.

FLEXIBLE HOSES:

The Pneumatic hoses, which is used when pneumatic components such asactuators are subjected to movement. Hose is fabricated in layer of Elastomer or synthetic rubber, which permitsoperation at high pressure. The standard outside diameter of tubing is 1/16 inch. If the hose is subjected to rubbing, it should be encased in a protective sleeve.

Air tank

The compressor air tank is a reservoir of air that builds up pressure as the compressor pump runs until the pressure switch cut out pressure is reached. At that point, the compressor shuts down due to a high pressure cut out. Even if the compressor is turned off to allow it to cool, you can still work with compressed air by using the reservoir of air in the compressor air tank.

Figure 19 compressed air tank

Disc Brake

A disc brake is a type of brake that uses the calipers to squeeze pairs of pads against a disc or "rotor" to create friction. This action slows the rotation of a shaft, such as a vehicle axle,either to reduce its rotational speed or to hold it stationary.

Figure 20 Disk Brake

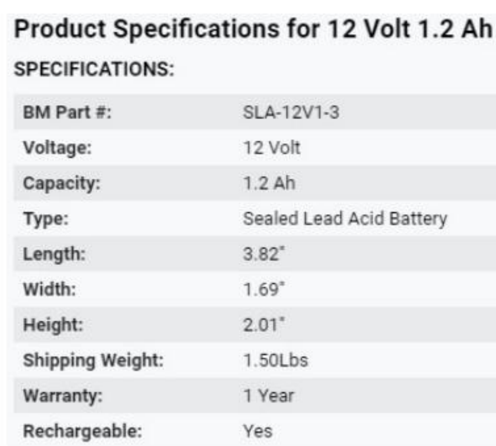
DC Motor

The working of DC motor is based on the principle that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force. The direction of the mechanical force is given by Fleming's Left-hand Rule and its magnitude is given by F = BIL Newton.

Figure 21 AC Motor

Battery

In our project we are using secondary type battery. It is rechargeable type. A battery is made up of one or more electrochemical cells that store chemical energy and convert it into electric current. Batteries are classified into two types: primary (disposable) and secondary (rechargeable), and both convert chemical energy to electrical energy.



Product Specifications for 12 Volt 1.2 Ah

SPECIFICATIONS:

BM Part #:	SLA-12V1-3
Voltage:	12 Volt
Capacity:	1.2 Ah
Type:	Sealed Lead Acid Battery
Length:	3.82"
Width:	1.69"
Height:	2.01"
Shipping Weight:	1.50Lbs
Warranty:	1 Year
Rechargeable:	Yes

Figure 22 Battery

PARTS ESTIMATE

Table 1 Parts estimate

SR NO.	DESCRIPTION	QTY	COST
1.	MOTOR	02	1600
2.	BELT	01	200
3.	GRUB SCREW	09	36
4.	BEARINGS	02	680
5.	NRV	02	380
6.	CYLINDER 40 X50	01	900
7.	5/2 D C VALVE	01	350
8.	DISK BRAKE SET	01	700
9.	PNEUMATIC CYLINDER 20X15	01	440

ACHINING ESTIMATE

Table 2 Machining estimate

OPERATION	RATE Rs /HR
LATHE	80
MILLING	90
DRILLING	60
ASSEMBLY	-

Chapter no 7

Work done:-

Indian Road Survey-

According to a survey there are approx. 36 speed breakers per 11km length Moreover in India the roads condition are not good and on an average 2 to 3 potholes are also found. And there are more curves on Indian roads compared to other countries.In these condition suspension are used heavily which is beneficial for our project.

Figure 23 Road conditions

Calculations:-

Pneumatic Cylinder

- According to the pressure requirement and condition we have selected the suitablepneumatic cylinder
- We have selected the standard cylinder.
- The dimensions of this cylinder are as followsDouble acting cylinder
  Stroke=80Piston dia. =32Pressure=0.3 to 12 bar

Volume of air exhaust through the cylinder

=stroke*area of piston

$=80*pi/4*D^2$

$=64339.8175mm^2$

Volume of compressed air storage tank

=Pi/4d^2*L

=300*150

=5301.437*10^3

Strokes of piston required to fill the tank

=volume of tank /volume of air exhaust

=5301.437*10^3/64339.8175

=83

- If double acting pneumatic cylinder is used then 42 stroke will be enough to fill the tankcompletely
- According to the previous survey a 11 km stretch will be enough to fill the tank accordingto Indian road conditions.
- The dimensions of pneumatic cylinder will be selected according to our needs.

Design of Spring

The spring is mounted on frame to make initial position of rack. The outer diameter of spring isrestricted which is 22mm. For avg service life 422N/mm². Wire diameter range is 4.5 to 8 mm
We get wire diameter d = 5 mm from range

Calculating the load bearing capacity of spring,

Spring index = C = D/d = 22/5= 4.4 664 C = 4.4 K = [4C – 1 / 4C-4] - 0.615 / CFor C =4.4 K= 1.08

We know,

Shear stress = (8KPD/3.14*d^3) P = (422*3.14*5^3) / (8*1.08*22)P = 870.74 N

Applied load is limited to 200NSo the design of spring is safe.

As we required deflection of spring in the range of 125 to 150 mm

Spring rate = P/δ = 870.74 / 150 = 5.8 N /mmK = 5.8 N/mm.

Calculation of number of turn of Spring,We know

δ = (8*P*Do^3*N) / (Gd^4)

150 = (8*870.74*22^3*N) / (0.007845*10^6*5^4)

N = 10.68 TurnsN = 11 Turns

Solid length of springLs = N x d = 11 x 5 = 55 mm

Free length of spring = Ls + δmax + 0.015 x δ = 55 + 150 + 0.15 x 150

Lf = 227.5 mm

Pitch of spring = free length / N

Pitch = 20 mm

Summary of Spring

Wire dia. d = 5 mmCoil dia. D =2mm

Solid length = Ls = 55 mm

Free length = Lf = 227.5 mm

Pitch = P = 20 mm

No of turns = 11 Deflection δ = 150 N / mm

Motor selection :

Compressed air created by using cylinder. 8 kg force required to rotate the wheel8*9.81*0.050= 5.886nm

Our motor is 0.5 hpP=2*Π*N*T/60

T= 10.17 Nm

Design of angles:-

Due to the load of flywheel, machine structure and tortional force, and the angle-link may bucklein two planes at right angle to each other. For buckling in the vertical plane, the links are assumed as fixed at the middles and for buckling in a plane perpendicular to the vertical plane, then this are assumed to be fixed at the both the ends.

Therefore , The maximum load due factors = 20 kgf= 20kg = 20 x 9.81 =

196 N.

We know that he load on each link, F1 = 196/4 = 49N.

Assuming a factor of safety as 2, the links must be designed for a buckling load ofWcr = 49 x 2 = 98 N

Let t1= Thickness of the linkb1= width of the link

So, cross sectional area of the link = A = width X breadth.Let we assume that width is

thrice that of link thickness.

Therefore

A= t1x 3 t1 = 3 t12

And M.I. of the cross section of the link,I = 1/12 t1b13

= 2.25 t14I = A

x K2

K2 = I/A = 2.25t14 / 3 t12 = 0.75 t12

Since for the buckling of the link in the vertical plane, the ends are considered as hinged,therefore, the equivalent length of the link

L = l = 610 mm.

And Rankin's constant, a = 1/ 7500Now using the relation,

$$WC = \frac{F * A}{(1 + A\left(\frac{L}{K}\right)^2}$$

$$98 = 1 + \frac{100 * 3 * t1\text{^}2}{(1 + \frac{1}{7500}) \quad (610^2/0.75t1^2)}$$

$$98 = \frac{300t1\text{^}2}{1 + \frac{66}{t1^2}}$$

300 t14 – 98t12 –64680 = 0

t12 – 3.26 t12 –215.6 = 0

t1^2 $= \frac{3.26 \pm \sqrt{(3.26)^2 + 4 * 215.6}}{2}$

t1 = 4 mm

b1 = 3 x t1 = 3 x 4 = 12 mm.

But the standard angle available of 25x25x4 hence for safer side we have selected it. Which can bear the impact load. Hence our design is safe.

Design of welded joint:-

Checking the strength of the welded joints for safety purpose.Transverse fillet welds all edges with all sides,

P = 0.707 x S x L x ft.

Where, S = weld size, L = length of contact = 35mm(10 mm at the start and end of weld)The shear load considering the friction is 200 kg = 1962N

Hence, 1962 = 0.707 x 5 x 35 x ft. Hence we have to find the safe value of

ft.$therefore\ ft = \frac{1962}{0.7075 * 5 * 35}$

ft = 15.85 N/mm^2

hence calculated tensile load is very less than The permissible value as ft=56 N/mm2. Hence welded joint is safe.

Drafting

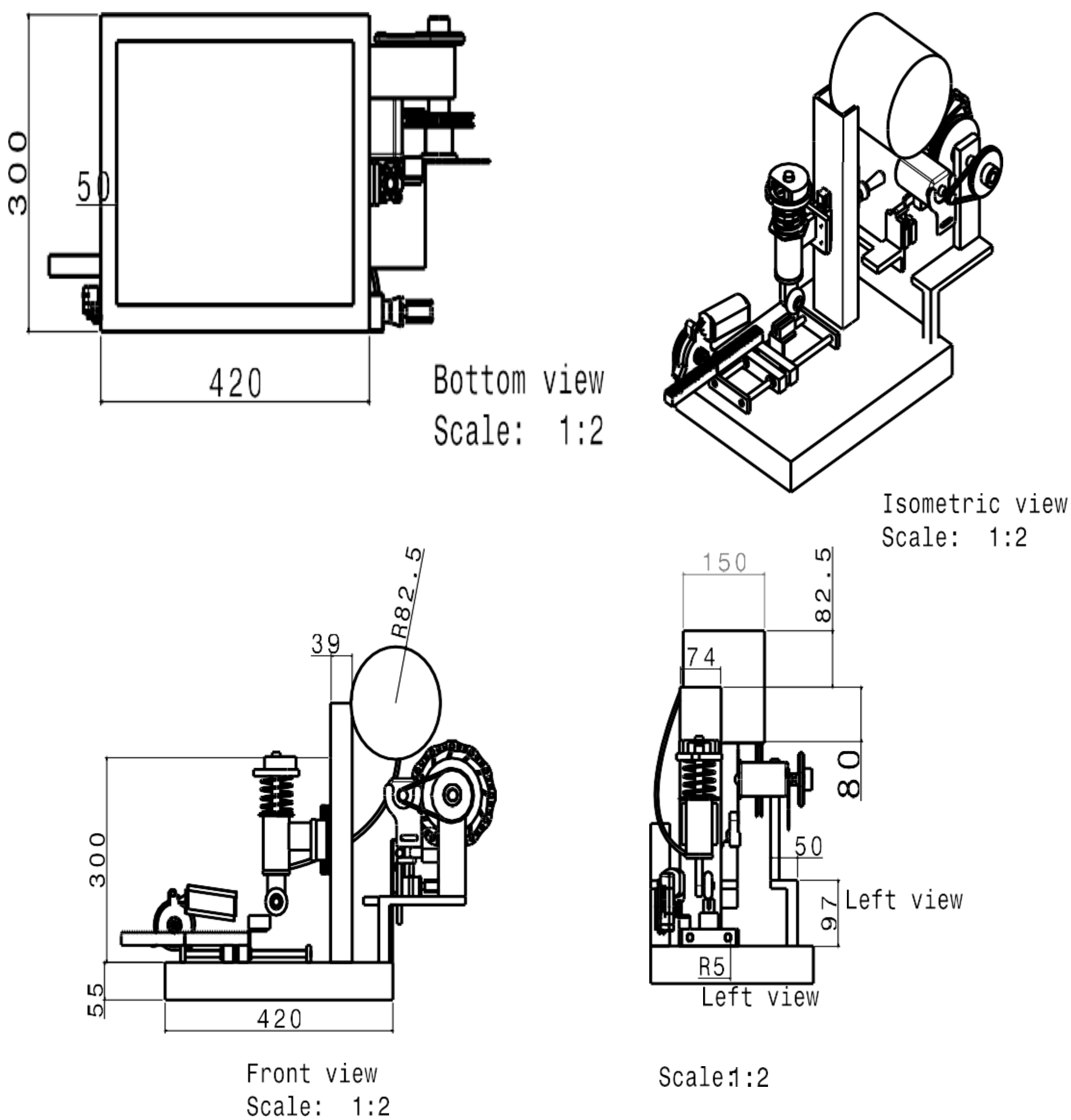


Figure Drafting

Catia model

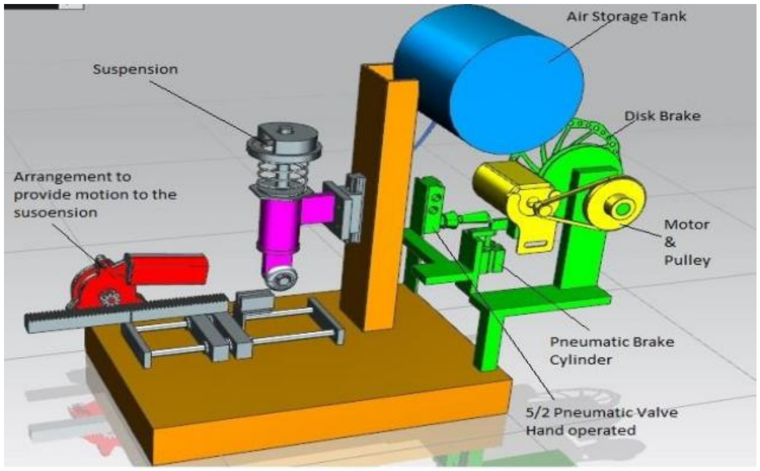


Figure 25 Catia model

Result and Conclusion: -

After careful review of literature it was found that no specific solution to apply air brake using suspension was available. The project makes a proposal to use one of these systems, and the components required to develop the unit are discussed. Thus the schematic is prepared and the future work will be to design and develop the unit and selection of standard components and In the following project work, the design analysis of the system components to sustain the given system of forces will be discussed and completed. Thus 'DESIGN AND MANUFACTURING OF AIR BRAKING SYSTEM USING SUSPENSION' can utilize the wasted energy of the suspension system which can increase efficiency and can also reduce load on engine. This system would be more economical and practical if used on heavy vehicles

References: -

[1] GaurangTiwari, Dr. R.K. Saxena, "The Regenerative Energy Suspension System",International Journal of Scientific & Engineering Research, Volume 6, Issue 4, April-2015 1249.

[2] AbhijitLendhe, Nikhil Mangvade, Prasad Naik, Pratik Jadhav, "Regenerative Suspension System", International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS) Vol. 2, Issue 2, pp: (30-33), Month: April 2015 - June 2015.

[3] NinadMalpure, SanketBhansali, "Compressed Air Production Using Vehicle Suspension",

[4] IJSTR, Volume-4, Issue-11, Nov.2015

[5] Li He, Xiaolong Wang, Yunqing Zhang, Jinglai Wu, Liping Chen CAD Center,Modeling andSimulation Vehicle Air Brake System,Huazhong University of Science and Technology, China

[6] Pneumatic Brake Control for Precision Stopping of Heavy-Duty Vehicles Fanping Bu+