ADVANCEMENT OF PNEUMATIC BRAKING SYSTEM

Durgasi Mahesh, Pothuri Nageswara Rao,Madakala Chandra Obul Reddy,
Miriyala Ujwal, Shivam Singh
Department of Mechanical Engineering,
Lovely Professional University, Punjab, India.

Abstract:-Most of the accidents in four wheeled vehicles occurs due to failure of braking systems. Manual method of applying brakes as it leads to accidents the linkages of braking systems, road conditions, uncontrollable speed of the vehicle and manual operation of braking systems are the reason of accidents. It is necessary to control brakes automatically through electronics devices to reduce accident problems. In this research paper we design an effective methodology for automatic control of braking system to avoid accidents. We used Arduino, relays, IR transmitter, and IR receiver for the effective function of braking control system. This complete system can be fixed on the dashboard of a vehicle and effectively used for automatic control of braking system. Vehicle accidents are everywhere in recent years. This is because of increase in population of vehicles, due to its high demand. A system must be designed to reduce the accidents.. The technology of pneumatics plays a main role in the field of automation and modern machine shops.. IR sensor fixed on the front end of the vehicle detects the presence of the obstacle. The use of pneumatic system can be useful in automation due to its simplicity and ease of operation. The past experiment results show that the control method can be improve the braking performance of a vehicle. So, the objective is to develops a system based on automatic control of vehicle. So design "Pneumatic Braking System". Generally, we see a pneumatic controlled braking system within the heavy loaded vehicles. In today's world technology is upgraded day by day with the assistance of advance braking system in pneumatic controlled braking systems we will make it work more effectively. Generally, we see heavy loaded vehicles travels long distance So as to induce safe driving, braking system should be advance, braking distance are minimum. Automatic controlled air braking system of ABS is advancement in air braking system Although improvements like high bandwidth is additionally required Bioactivated valves gives accuracy to the brakes and also work on heavy reservoir to form it less heavy are to be improvement also driver cannot control the air which is triggered at the time of applying brakes to form systems more advance a special style of drain valve called as drain cock can augment to the reservoir tank. Within the air braking system, we see that brakes are not frequently used as compressor takes power from the engine so at that time high pressurized air is release to atmosphere so by stopping the compressor the power can be reduced and energy can be conserved this mechanism can be achieved with the help of engaging and disengaging of the air brakes. Braking by wire with multifunction's used in the commercial vehicles under the name of electro pneumatic braking system. advancement in braking systems required so there will be less accidents and this advancement are often done by improvements. And a braking are advance given that it gives effectively good response.

Keywords:- Emergency Braking systems, Brake Valve, Pneumatic Actuators, Solenoid Valve, Brake Valve, Sensors (IR, proximity), Compressors, ABS, Reservoir, Slip Control, Electro Pneumatic Braking System (EBS).

INTRODUCTION: -

Brake plays important role within the vehicle as engine. An engine requires to run the engine it also needs brakes since we used hydraulic brakes but what about heavy vehicles, in heavy vehicles we use Pneumatic air brakes for the effective braking. Generally, a pneumatic brake or air brake is a kind of mechanical System in which compressed liquid fluid from hydraulic brake is replaced from compressed air which applying pressure to the master piston cylinder connected to the brake pads for the deceleration of vehicle.

In this paper, we are studying about the advancement in the pneumatic braking system. In the present study about pneumatics breaks the breaks are used to avoid collision between two vehicles and reduce accidents and reduce the damage of vehicles from collisions and also protect the people from injury. the vehicle accidents mainly depend upon the driver inability to press the brake pedal at the right time and rash driving etc. for this type of accidents can be controlled and somehow we can reduce by attaching the sensors to the breaks and the break will be automatically done is known as the automatic pneumatic braking system. An automated collision avoidance system is one such system that is reducing accidents. This pneumatic break can be controlled electrically. The main objective of this system is to avoid the collisions of the vehicles. The main purpose was designed to develop of a command system based on the electronically controlled automotive bumper activation system is called "automatic pneumatic braking system". The automatic pneumatic braking consists of IR transmitter, Receiver circuit, command unit, solenoid valve, pneumatic bumper system. The IR sensor senses the obstacle. When the obstacle is come closer the vehicle wheels the control signal is given to the bumper and break activation system. this bumper activation system is activated when the speed 30-50 km per hour. Speed was sensed by proximity sensor and that can be transfer to the control unit and the pneumatic bumper activation system. In collision mitigation system, the sensors detect the possibility of collision but will not take the immediate action.

Road accidents are the most unwanted thing that happens to road user. Sometimes this accident proves to be fatal. The major source of vehicle accidents are occurred due to the human error. These accidents are mostly caused due to the delay of driver

to press the brakes pedal. The main purpose of this paper is to design the system which will resolve such accidents by the continuously keeping the record of the distance between two vehicles. In Intelligent Battery Sensor (IBS), ultrasonic sensor senses the imminent collision with another vehicle, person or the IR Sensor is detect the obstacle and the microprocessor in the system start the brakes can be applied to the wheel and it will slow down the vehicle or bring it to stop if needed. The main reason for writing this paper is to implement a braking system using IR sensor and to proposal a vehicle with less human attention to the driving.

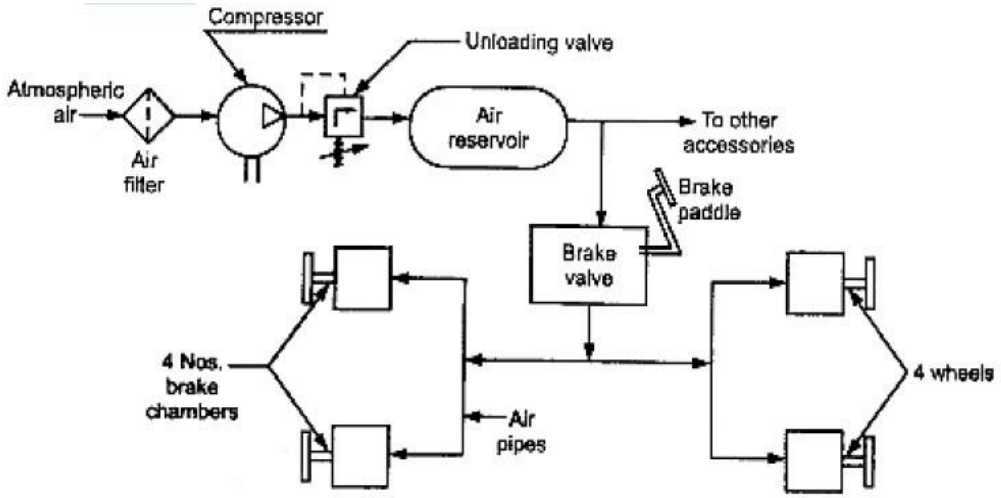


Figure -1

Whenever the vehicle is moving in a highway or traffic less area the application of brake is not that much frequent, in that time the compressor send high pressure to the atmosphere as required amount volume of air is already available in the reservoir. As a result, sound of releasing air come from the heavy loaded vehicles. Brakes are applied by pushing down the brake pedal which is also known as foot valve more pressure can apply by pushing harder the vehicle. Release the breaks let some air get out from the system so that the air pressure can be reduced from the system. There are also large vehicles which have emergency braking system in which compressed air holds back with the help of spring.so, if pressure lost brakes will engage itself and vehicle will stop.

OBJECTIVES: -

- To improve the brake efficiency
- To reduce the accidents

BRAKE:-A brake is a mechanical device that prevents motion of the wheel by absorbing energy from a moving system. Break used for reducing the speed of vehicle or stopping a moving vehicle, wheel, axle, or to stop its motion. most often accomplished by means of friction. Most of the brakes commonly use friction between the two surfaces pressed together kinetic energy of a moving object it can be converted into heat. however other methods of energy conversion may be employed.

PNEUMATIC BRAKE SYSREM: -

Pneumatics:-Basically, pneumatics word comes from Greek word in Greek pneuma means wind. The pneumatics systems are used in the all type of industry like automobile, machining, etc. The pneumatics normally run by the compressed air or some compressed inert gases.

George Westinghouse was first developed pneumatic brakes for use in railway service. He patented a harmless air brake on March 5, 1872. Westinghouse made numerous alterations to improve his air pressured brake invention, which led to various forms of the automatic brake used in modern vehicles for safer and more advance braking system.

Pneumatic brake uses air as a working fluid. The system actuated to apply this phenomenon is called as Pneumatic Brake System.

A pneumatic brake or a compressed air braking system, is a type of friction brake for vehicles in which compressed air on a piston is used to apply the pressure to the brake pad is needed to stop the vehicle.

Block Diagram :-

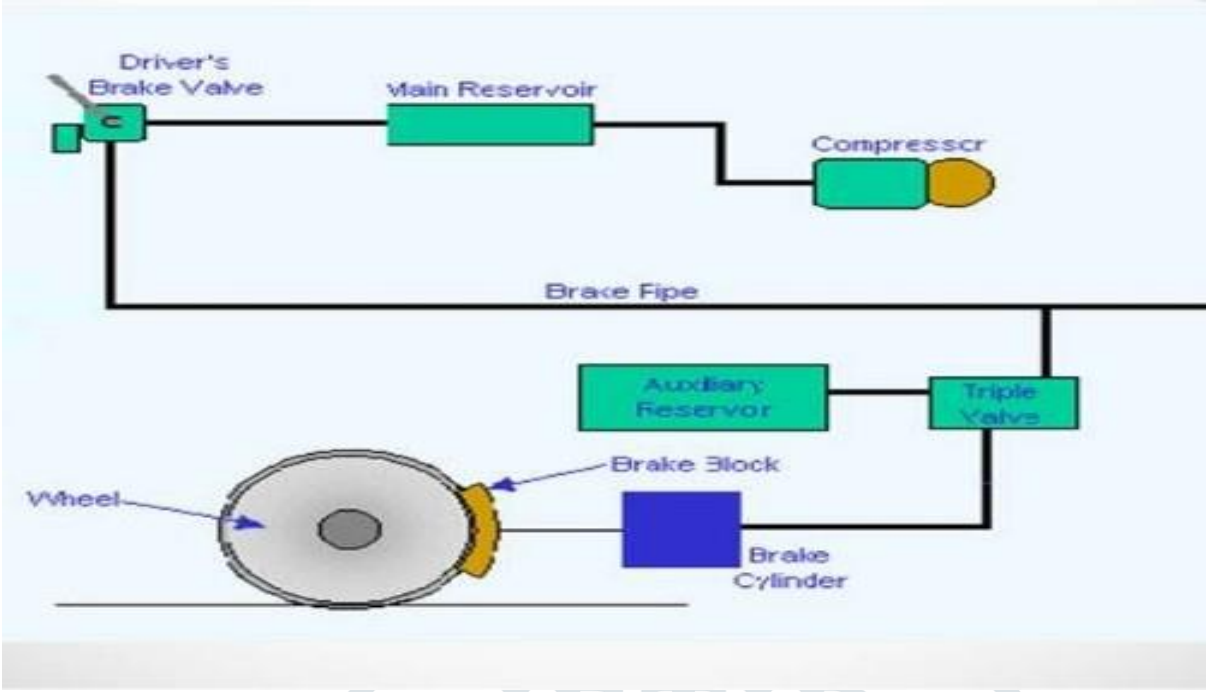
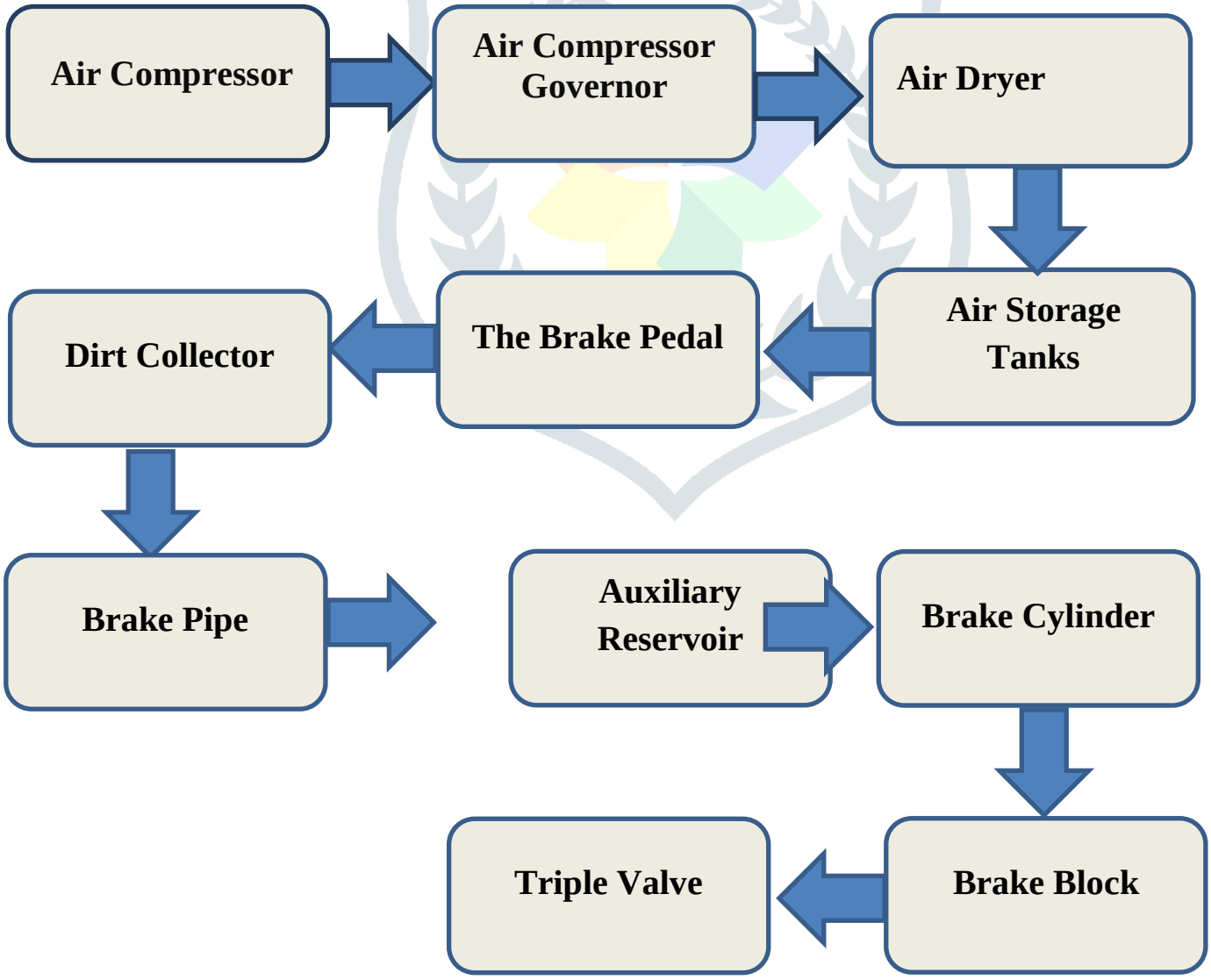


FIGURE -2

COMPONENTS OF PNEUMATIC BRAKING SYSTEM: -



COMPONENTS DISCERPTION : -

- **Air Compressor: -**Air compressor is a device which converts compressed air into power. By using gear or belts compressor is connected to the engine
- **Air Compressor Governor**: -The governor is a device maintain required compressed air in required limits.
- **Air Dryer**: -Air dryer is used to take the moisture out from the air, so the water moisture will not be in the air storage tanks. if moisture in the air that will caused to brake failure.
- **Air Storage**: -The function of the air reservoir is to store the compressed air so that there will always be an ample supply available for immediate use in brake operation. It stores and provides the sufficient compressed air to permit brake applications even after the engine has stopped and just restarted. It also provides a space when the air is heated during compression might cool, and oil and water vapours condense.
- **Brake Pedal**: -brake pedal is used to apply the brakes , applying by pushing down the brake pedal. How much harder you push down on the pedal; the more air pressure is applied from the storage tanks into the brake chambers.
- **Dirt collector: -**It is placed in the brake pipeline at a point from where a branch is taken off to the triple valve.
- **Brake cylinder: -**the brake cylinder which is provided to actuate the brake rigging for application and release of the brakes.
- **Triple valve:-**Application and release of brakes where brake pipe pressure has to be reduced and increased respectively with the help of driver's brake valve .during these operations the triple valve is used.

WORKING OF PNEUMATIC BRAKING SYSTEM: -

The Brake system is based upon a design Air patented by George Westinghouse on March -5 year1872. The Westinghouse Air Brake Company (WABCO) was systematic organized to manufacture and sell Westinghouse invention which has been universally adopted.

The air compressor operated by the engine forces air at a pressure of 9-10 km/sec, through the water and oil separator to the air reservoir. The air pressure in the reservoir is indicated by the pressure gauge. The reservoir contains required compressed air for several braking operations. From the reservoir the air is enter into the brake valve. As long as brake pedal is not pressed, brake valves stop the passage of air to brake chambers and there is no braking effect.

When the brake pedal is depressed, the brake valves change its position and compressed air is admitted into the wheel brake chambers. In the chambers the air acts upon flexible diaphragms, and then the pushes out the rods connected with the levers of the brake gear cams. The cams move and separate the shoes then breaking the wheels.

When the brake pedal is released, the supply of compressed air is stop to the brake chambers and which connected to the atmosphere. The pressure in the chambers drops, then brake shoes are returned to their initial position and the wheels run free. The brake valve is connected with a servo mechanism and which maintain the braking force on the shoes is proportional to the force applied on the pedal. the valve imparts a relative reaction to the movement of the pedal so that the driver can knowns the degree of the brake application.

LITERATURE REVIEW

Electro Pneumatic Braking system –In Electro-pneumatic braking system law of pneumatic used for apply the brakes. When any obstacle sensed in the path by sensors. it will apply instant brake in seconds so driver can protect from the major accidents. So, there is a pneumatic braking circuit with IR sensors perform these operations. Automatic braking systems in two wheelers is very useful and provide extra safety to the two wheelers, So the purpose of the project is to perform required task in small time with adding some in automobiles. The circuit can stop the vehicle within seconds running at a high speed. Automatic brake with the electro-pneumatic system will provide more safety to the two-wheelers. The main aim of the project is made to perform the required task in shortest time and to add some innovation in the automobile Industry. There are some calculations for designs are as follows:

DESIGN OF BRAKE SHOE:

μ' = coefficient of friction .

r = radius of the drum.

brake drum material is C 45 = 340N/mm². With f.o.s of 1.5

Frictional force = $\mu' F$

Frictional force = 0.5×1081.73

The Bearing pressure applied on brake shoe ≤ 8 bar

Let Pb = 6 bar,

Pb = F/r×2×Φ×b

b = 0.0036794 m

Using,

sinθ = half length/radius of drum

sin45×0.25 = half length

half-length = 0.2127 m

Total length = 2×0.2127

= 0.4254 m

Therefore, stress = F/a

Stress = 540.865/ (3.6794×425.4)

= 0.345528 N/mm².

The design stress in 266.6667 N/mm².So, induced stress is lesser than design

stress, so the design is safe.

D. CODING FOR ARDUINO:

```
int LED = 13; // Use the onboard Uno LED

int isObstacle Pin = 7; // This is our input pin
int isObstacle = HIGH; // HIGH MEANS NO OBSTACLE

void setup () {

pinMode (LED, OUTPUT);

pinMode (isObstaclePin, INPUT);
```

Arduino is the source hardware and also the software company which is used as a micro controller. which is intended in an exceedingly way which will repeat the designed coded program for the air flow through the solenoid valve.

Designing and testing an advanced pneumatic Braking System for Heavy Vehicles -Generally we see poor braking systems in heavy vehicles at time of emergency compare to other vehicles and generally problems created in pneumatic brake actuators which limits the control bandwidth of their ABS And also the algorithm that used do not achieve the max braking force throughout the stop. So according to the research paper the pneumatic air braking system which used for heavy vehicles will be improve by placing high band width brake actuators the braking control algorithm is change with wheel slip regulator with little change of mode with the help of combined actuator and slip controlled surface friction can be reduced from 10% to 27%

Several slip control algorithms have been derived for passenger cars,19–22 but only a few works have focused on heavy vehicles. Akey23 simulated a fuzzy logic wheel slip controller specifically for commercial vehicles. The algorithm produced 15% better braking distances than finite-state ABS in a Monte-Carlo simulation analysis. However, details of the simulation were sparse, and no indication of experimental validation was given. A sliding mode slip controller was designed for a rigid commercial vehicle with conventional air-over-hydraulic brakes by Kawabe et al.24 Full-scale vehicle tests showed that the control error was relatively small, but because the focus on the reducing chattering, the sliding controller was not compared to conventional ABS'

The binary-actuated valves and sliding mode controller were tested on a HiL rig that included the ECU, pneumatic brake system and prototype valves, along with a simulation model of the rest of the vehicle. These tests showed reductions in stopping distance of 10% and 27% over conventional ABS on smooth and rough, high friction surfaces, respectively. Reductions in stopping distance of 23% and 25% were also observed on low friction, smooth and rough roads, respectively.

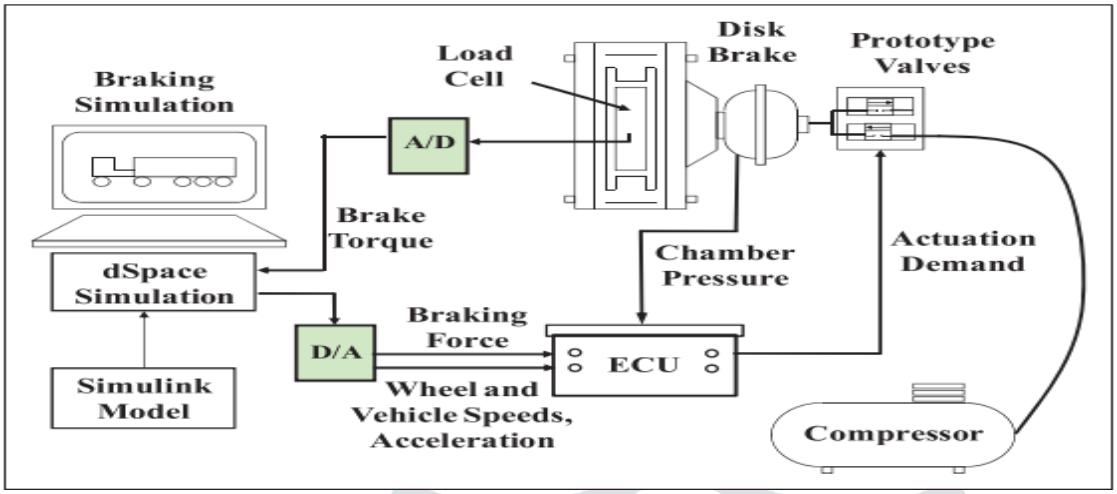
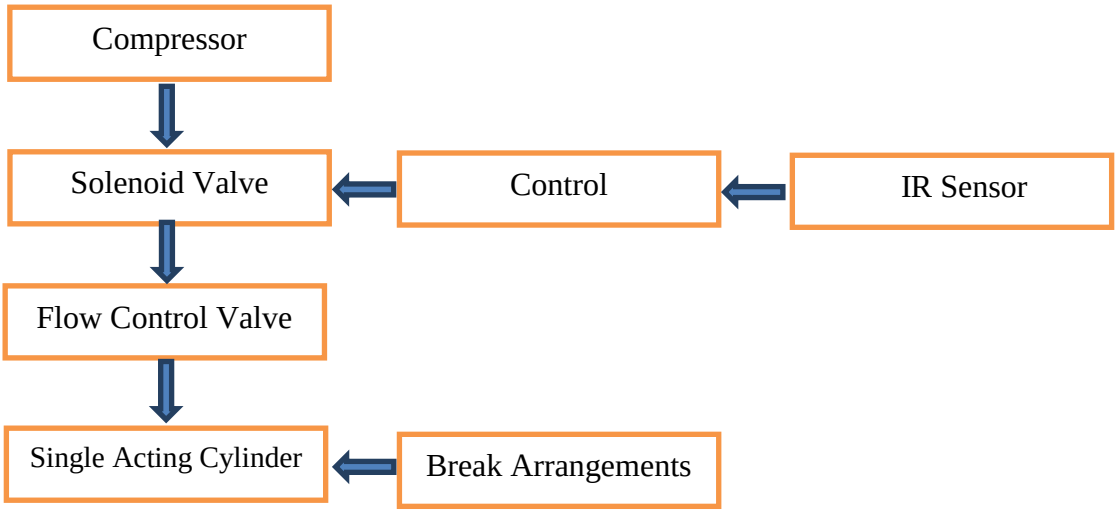


FIGURE- 3
DIAGRAM OF HARDWARE IN THE LOOP

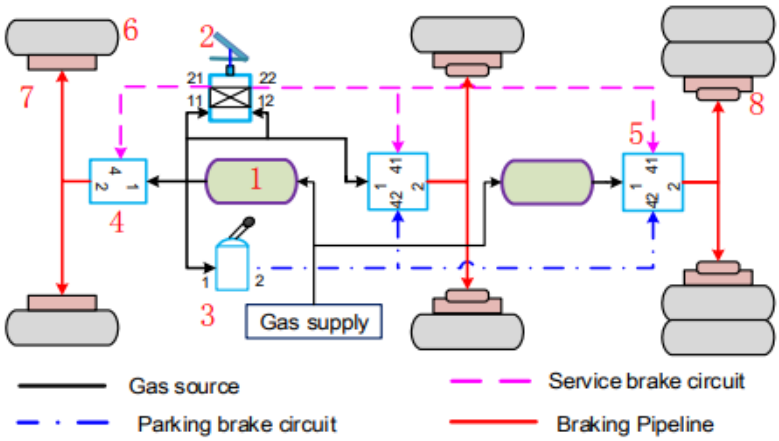
A study on automatic bumper system–During this system controlling is completed by IR sensor with the assistance of IR sensor pneumatic bumper actuate brake will applied. When the obstacle is available in front of sensor the IR sensor sense and it'll be actuate the solenoid valve which having a two output and one input. Input is connected from compressor and the output is connected to the pneumatic cylinder by which the bumper will go further and comes back by the gas. When the obstacle comes before of car the IR sensor unit will command to the control unit and control unit will cut the facility off motor by this rotation of wheel decreases and brake will applied. In aim of the project is to overcome the accident problem by means of providing the sensor arrangement in bumper. The aim is to style and develop a bearing system based an intelligent. electronically controlled automotive bumper activation system is named automatic pneumatic bumper. This technique is consisting of IR transmitter and receiver circuit, control unit, pneumatic bumper system. The IR sensor is employed to detect the obstacle

Automatic Pneumatic Braking System –Aim of the Automatic pneumatic braking system is to shield the life, property of car and driver with the assistance of the advance bumper circuit, connected with the solenoid valve, IR sensors and proximity sensors a vehicle can be protected by the collision of any obstacle. A threshold safe distance is already calculated if supposed that driver fails to response A symbol of warming is announce for the motive force and after crossing the edge distance brakes will apply automatically.



An experimental study on hysteresis characteristic of a pneumatic braking system for the multi axle heavy vehicle in emergency braking situations-Hysteresis is a inherent property of the PBS, which with little question encompasses a significant impact on braking performance. The hysteresis characteristics can be divided into two types they are one is system level and component level. Most of the literatures are focused on the trade valves, brake pipelines, and other sub-assemblies. However, subassemblies in a very loop are connected to every other and affect each other; analysis of individual subassembly seems to be insufficient. In terms of the system level, Selvaraj and He established simulation models of the PBS on two-axle vehicles using AMEsim (Advanced Modelling Environment for performing Simulation of engineering systems) and MWorks, respectively. Additionally, sensors aren't easily placed or replaced on subassemblies after the vehicle is totally assembled. Hence, a test bench for studying hysteresis characteristics of PBS for MHV is critical.

In the below figure PBS in an MHV are showed. The system consists of service brake circuit and emergency brake circuit. Usually, double circuits are employed within the service brake circuit, only for avoiding the braking failure just in case one amongst the 2 circuits has stochastic fault. Each circuit within the system mainly consists of gas reservoirs, control valves, brake chambers and brakes. The gas source of the entire vehicle is provided by compressor and stored during a main reservoir with large capacity additionally as several normal ones with relatively small capacity. Control valves mainly comprise a emergency valve and a treadle valve located within the cab, several relay valves, and delay relay valves arranged within the rear axle of the chassis. Drum brakes, which might offer more powerful braking force compared to disc brakes, are widely utilized in MHVs.



Schematic diagram of a pneumatic braking system (PBS) on a multi-axle heavy vehicle (MHV) (1—gas reservoir; 2—Treadle valve; 3—Hand brake valve; 4—Relay valve; 5—Delay relay valve;6—Wheel; 7—Brake chamber; 8—Spring break chamber).
FIGURE -4

Vehicle braking force distribution with electronic pneumatic braking and hierarchical structure for commercial vehicle-You will be seen wire braking system within the commercial vehicles that allow no. of multifunction works, which can improve braking comfort and safety of business vehicle. The design of braking force distribution control method has drawn rather more attention. Considering structure characteristics of electronic pneumatic braking system, control method with a three-layer hierarchical data structure is proposed. The primary layer presents an estimation method towards vehicle mass and Centre of gravity combining Kalman filter with recursive least square. The second layer is developed by designing a hard and fast relationship between the foot pedal displacement and vehicle brakingdeceleration.Whereas the third layer decides the braking force between front and rear axles. In line with the strategy of deceleration control which might be achieved with the graceful axle load transfer during a way of linear matrix inequality. The research shows that control method can enhance the performance of electronic pneumatic braking system.

A study on automatic bumper system–During this system controlling is completed by IR sensor with the assistance of IR sensor pneumatic bumper actuate brake will applied. When the obstacle is there in front of vehicle then the IR sensor sense and that signal transfer to the solenoid valve is actuated. solenoid valve having a two output and one input. Input is connected to the compressor and the output is connected to the pneumatic cylinder and the bumper will go further which comes back by the gas. When the obstacle comes before of car the IR sensor unit will command to the control unit and control unit will cut the facility off motor by this rotation of wheel decreases and brake will applied. In this project they are mainly focused on the reduce accident problem by means of providing the sensor arrangement in bumper. The aim is to style and develop a bearing system based an intelligent. Electronically controlled automotive bumper activation system is named automatic pneumatic bumper. This technique is consisting of IR transmitter and receiver circuit, control unit, pneumatic bumper system. The IR sensor is employed to detect the obstacle.

MERITS: -

- low in cost as compared to other systems
- Storage of compressed air is easy
- Simple in design and control
- Easy to control
- Can apply a lot of force from a small and light package
- The speeds and forces are infinitely variable
- Force is limited by air pressure and cylinder diameter
- Simple
- Free resources so no refilling or changing required
- Air pressure is quick to act and hence air brakes are immediate
- Air brakes can effectively stop loads of over 14 tons
- A little feather would apply the same pressure
- Air does not corrode the metals, so the life of pneumatic brake is more
- Air is available everywhere in atmosphere so the brake can never run out of its operating

APPLICATIONS: -

- Air brakes on busses and trucks
- Air compressors
- Air engines for pneumatically powered vehicles
- Compressed air engine and compressed air vehicles
- Air brakes on trains
- Lego pneumatics can be used to build pneumatics models
- Pneumatics actuator
- Pneumatics bladder
- Pneumatics cylinder
- Pneumatics tools
- Pneumatics tire
- Pneumatics motor

ADVANCEMENT IN PNEUMATIC BRAKING SYSTEM: -

Pneumatic braking system is used in heavy vehicles earlier but our innovation is pneumatic braking system is used in mini cars and auto and vehicles and with IR Sensor which will sense the object near by the vehicle and pneumatic brake will activate and vehicle will be come to rest position and IR sensor works on program and reduce the cause of accident and improve the safety to the passenger. Pneumatic braking system is using in heavy vehicles and not used in mini vehicles so our innovation is using a Pneumatic braking system in mini vehicles by connecting of IR sensor to the bumper of the vehicle and pneumatic brake system is fixed to vehicle in place of hydraulic or another brake system and reduce size of components of pneumatic braking system and coding was stored in board and air will take from the environment and air filter will filter the air and send it to the compressor and then to reservoir than when we apply brake in very short period of time the brake will work and vehicle will stop and when any obstacles come suddenly and sensor will detect and pneumatic brakes activation take place and vehicle will stop and reduce the number of accident .

DESIGN &CALCULATION :-

Abbreviations and Acronyms

$D_{Breaking}$ =Breaking distance
μ=Coefficient of friction
g = acceleration due to gravity
V = Velocity before applying brakes
v = final velocity
u = initial velocity
a = acceleration
s = braking distance
F= Force

UNITS :-

$D_{Braking}$= m = Meters
v = final velocity = m/sec =meter/sec
u = initial velocity= m/sec =meter/sec
a = acceleration = m/ =meter/sec2
s = braking distance = m= meter
F= Force = N = Newton

FORMULAS :-

$$D_{braking} = \frac{v^2}{2 * \mu * g}$$

Where,
V = Velocity before applying brakes
μ = coefficient of friction
g = acceleration due to gravity

CONCLUSION: -

After reading the above research paper I found that timing for the braking systems for various vehicles is different. ABS play major role within the controlling of car ABS can protect vehicles from the slippery road. The simplicity of pneumatic braking systems prove that its operation is straightforward and also IR sensors perform well with this. Centrally located and electrically powered compressors that powers cylinders and other pneumatic devices through solenoid valves can provide power during a cheaper way with more safety and more flexibility. There's a negligible maintenance and even have long lifetime of pneumatic actuators throughout the life cycle. Since heavy vehicles carries huge load with its pneumatic systems provide spring effect with it so when brakes applied there'll be a less jamming of disc within the vehicle. Supported pure pneumatic ABS control and optimum control theory, the optimization of the control strategy for regenerative braking with ABS is proposed. The optimization is devised to create better use of electrical motor torque when the frictional braking system comes under ABS control. The difference within the supply pressure and also the steady state pressure within the brake chamber is strongly associated with the severity of the leak. Behind the designing of this method, our main aim is to boost the technique of prevention of accidents and also reducing the hazard from accidents like damage of auto, injury of humans, etc. The appliances of pneumatics produce smooth operation. By using more techniques, they'll be modified and developed per the applications. By implementing this project, we will reduce cost of high-end cars by giving similar reasonably safety. A pneumatic braking system for an eight-axle vehicle is introduced. So as to accurately study the hysteresis effect of the system in emergency braking situation, a test bench is made. Not only the delay time of every loop such as each axle but also the interval of every subassembly during a single loop is detected in real time.

REFERENCES:

1. Ketan H. Mhatre "Electro-pneumatic braking system "VIVA Institute of Technology, Virar, Maharashtra International Journal of Emerging Research & Development ISSN: 2454-132X Impact factor: 4.295 (Volume 4, Issue 3).
2. Quantifying the potential impacts of regenerative braking on a vehicle's tractive-fuel consumption for the U.S., European, and Japanese driving schedules. SAE paper 2006-01- 0664, 2006.
3. Miller J and Cebon D. A high performance pneumatic braking system for heavy vehicles. Vehicle SystDyn 2010; 48(1): 373–392.
   Salaani M, Rao S, Every J, et al. Hardware-in-the-loop pneumatic braking system for heavy truck testing of advanced electronic safety interventions. SAE Int J Passeng Cars: Mech Syst 2016; 9(2): 912–923.
4. R. B. GmbH., Automotive Brake Systems. Society of Automotive Engineers (SAE), Warrendale, PA, 1995.S. Williams and R. Knippling, "Automatic slack adjusters for heavy vehicle air brake systems," Research Report DOT HS, vol. 807, p. 724, 1991.
5. 5. R. C. Kull, "WABTEC ECP system update," in Proc. IEEE Veh.Technol. Soc. Land Transport. Div. ASME Rail Transport. Div. JointRailroad Conf., 2001, pp. 129–134.
   Air Brake Association, Chicago, IL, "Management of train operation and train handling," 1972.
   P. Howlett, "Optimal strategies for the control of a train," Automatica, vol. 32, no. 4, pp. 519–532, Apr. 1996.
6. J. Werde and H. Decker, Brake by wire for commercial vehicles, Trans. SAE 922489 (1992), pp. 849–859.
   Anon, Traffic Safety Facts, 2005, National Highway Traffic and Safety Administration, US Department of Transportation, Washington, DC, 2006.

J. Miller, F. Kienhofer, and D. Cebon, the look and evaluation of another heavy vehicle braking system, 9th International Symposium on Advanced Vehicle Control, Kobe, Japan, 2008.
Miller, J.; Cebon, D. An investigation of the consequences of pneumatic actuator design on slip control for heavy vehicles. Veh. Syst. Dyn. 2013, 51, 139–164. [CrossRef]

7. Sovran, G. and Blaser, D. Quantifying the potential impacts of regenerative braking on a vehicle's tractive-fuel consumption for the U.S., European, and Japanese driving schedules. SAE paper 2006-01- 0664, 2006.
Tanaka, Y., Nakaoka, H., Mizutani, Y., and Nakamura, E. Brake control device and brake control method. US Patent, 2009.
Tagata, K., Sakai, K., and Aoki, Y. Vehicle brake device. US Patent, 2007.
Jiang, F.; Gao, Z. An application of nonlinear PID control to a category of truck ABS problems. In Proceedings of the 40th IEEE Conference on Decision and Control (CDC), Orlando, FL, USA, December 2001; Volume 1, pp. 516–521
8. Mr. Kushal V. Gawande, Mr. Bharat A. Shende, Mr. Vipul B. Meshram "Automatic Pneumatic Braking System" March 2017, Volume 4, Issue 03 JETIR (ISSN-2349-5162).
9. Shubham Wasnik, Ketan Gedam, Aamir Sayed et al., "Automatic Pneumatic Bumper," International Research Journal of Engineering and Technology, vol. 4, no. 2, Feb. 2017. M. B. Bankar, S. K. Pawar, R. V. Lalge, et al., "Design and Development of Automatic Pneumatic Bumper System," 2017.
10. V. B Bhandari, Design of machine elements, Mc-Graw Hill Education 2010.
Satoshi Kozai, Yoshihiko Takahashi, Akihiro Kida, Takayuki Hiromitsu, Shinji Kitaura, Sadamasa Sawada, Gladys Acervo, Marius Ichim "Development of Automatic Braking System to assist Reduce Rear Impacts," SAE Technical Paper 2017-01-1408, 2017.
AmardeepSathyanarayana ; Sandhya Nageswaren ; Hassan Ghasemzadeh ; Roozbeh Jafari ; John H.L. Hansen , " Body sensor networks for driver distraction identification", Vehicular Electronics and Safety, 2008.