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Electro-pneumatic braking system

Ketan H. Mhatre
ketanmhatre4443@gmail.com
VIVA Institute of Technology, Virar, Maharashtra

ABSTRACT

"Electro-Pneumatic braking system" uses laws of pneumatics to apply the brakes. When any hurdle is sensed in the path by the sensors, it will apply the instant brake in seconds, So that it will reduce the accidents which are caused by human unawareness's. So basically whenever the Bike senses any object ahead, it will apply automatic brakes by determining the distance, which we put in sensors. We have used Pneumatic breaking circuit and IR sensors to perform these operations.

The circuit can break the vehicle within seconds running at a high speed. Automatic brake with the electro-pneumatic system will provide extra safety to the two-wheelers. This project has been made to perform the required task in shortest time and to add some innovation in the automobile industry.

Keywords: *Compressor, IR transmitter/receiver, Pneumatic cylinder, Solenoid valve.*

1. INTRODUCTION

In today's world, everyone wants speed and rapidity in each and every field. Therefore the essential part is rapidity and quickness. But sometime in this rapidness, we forget about the safety of human life. We see many people losing their life due to over speediness of vehicles on roads. Therefore bring new innovations and designs became very essential for engineers. Our Electro-pneumatic braking system and arrangement for emergency braking of a vehicle consist of a recognition system on the vehicle. Hence whenever any obstacle will come ahead of the vehicle, the sensors located ahead of the vehicle will generate a data, which determines the condition of vehicle i.e. speed, distance from the obstacle etc. that data will be compared with target values for controlling the motion of the vehicle. After determining that collision of the vehicle is not preventable by doing any movement like steering movement or braking, it will activate the emergency braking to slow down the vehicle or to stop it.

As material and most of the equipment needed to make this project, we got easily. By making this project we got very good knowledge, experience about automobile industry and we also developed some good skills like coding of Arduino. As this project is cheap and very reliable and is very good for the safety of human life. This project can be used in the industrial sector, for minimizing damage to the man, machine and material of the organization as it uses sensors to stop the high rotating objects or translational objects.

2. PROBLEM DEFINITION AND OBJECTIVE

The Technologies has increased in our daily life and we are using modern technologies. Now a day's safety is great important aspects of automobile industries and automation is the key which keeps the safety at our fingers. The goal of using modern technologies is to reduce the human efforts applied by human i.e. to reduce work done by human beings.
As our motive concern is to reduce the accidents which are led by human unawareness for example, if the driver is new and doesn't have awareness of his surroundings it would definitely lead to the accident and damage the car or in a worst case scenario a huge damage caused to the human life. So we like to introduce our design for reducing the accident which is caused by unawareness of human carelessness. With our design, we can definitely reduce from small accidents to big distasteful accidents.

The main objective of introducing is this system is to eradicate the human error from the root level and reduce the accidents which take place due to human unawareness and carelessness.

3. PROPOSED METHODOLOGY

The below block diagram shows the basic components of the Pneumatic Braking system. there are Power supply, Control unit, IR sensors – IR Transmitter and IR Receiver, Solenoid valve, Flow control valve, Compressor, Pneumatic Cylinder and Mechanical Brake. When the vehicle gets too close, the sensor transmits the signal which is received by the receiver and then air starts to flow from the compressor and the brake is applied mechanically by Pneumatic cylinder.

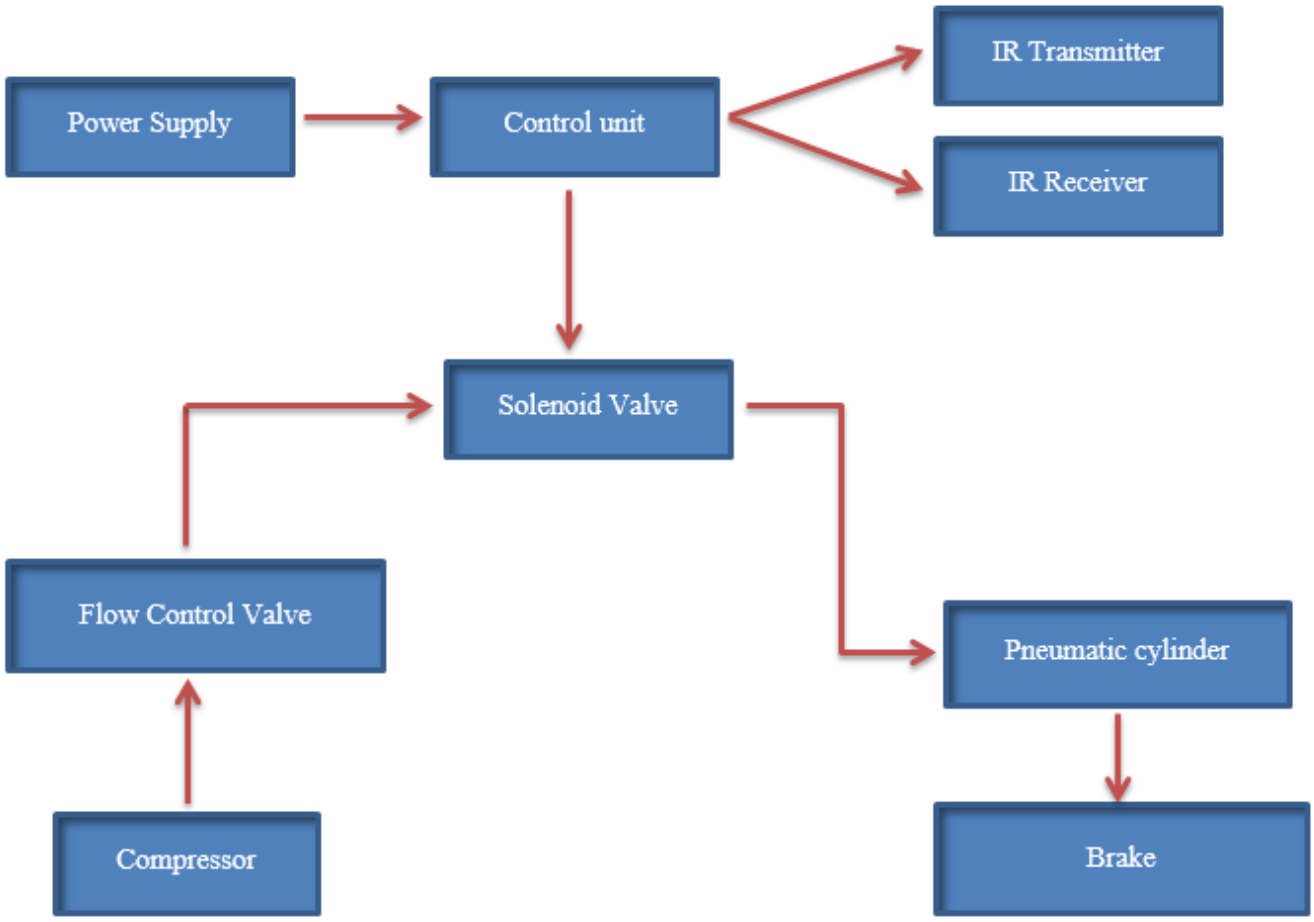

Fig.1 Methodology

A. Components and description

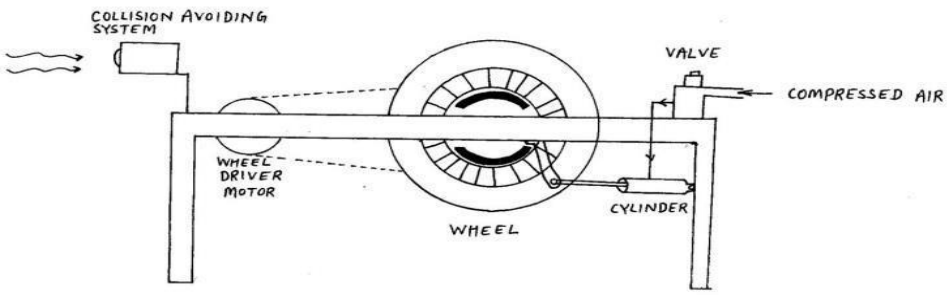

Fig.2 Electro-Pneumatic Braking System

This is how our prototype will look like; it consists of a wheel driver motor which is required to rotate the wheel which is coupled with the motor with a chain drive mechanism

There is also an IR sensor which is attached to the control unit, which controls the switching ON, OFF of the air from the compressor. From the compressor, the air is passed to the pneumatic cylinder by passing through the solenoid valve which controls the flow of air from the compressor. And in the end, the pneumatic cylinder hits the lever of the brake and the brake is applied.

B. The major building blocks

1) Power supply: The electric potential is required to run the control unit and infra-red sensors. Power supply of DC (direct current) voltage is required which can be taken from the battery of the car, which is charged before the running condition.

2) Control unit: Control unit is an electrical network for infra-red sensors to operate when the obstacle is not very far and of course power required to do the work is given by the Power supply of DC (direct current) voltage.
3) Sensor unit: Sensor unit has two infra-red sensors i.e. infra-red transmitter and an infra-red receiver. To receive ultrasonic rays when they are reflected back from the obstacles which are transmitted by the transmitter and it is sent to the control unit, then the distance is determined of the obstacle from the car and if the distance is within the range then the signal is sent to the solenoid valve and then the brakes are applied.

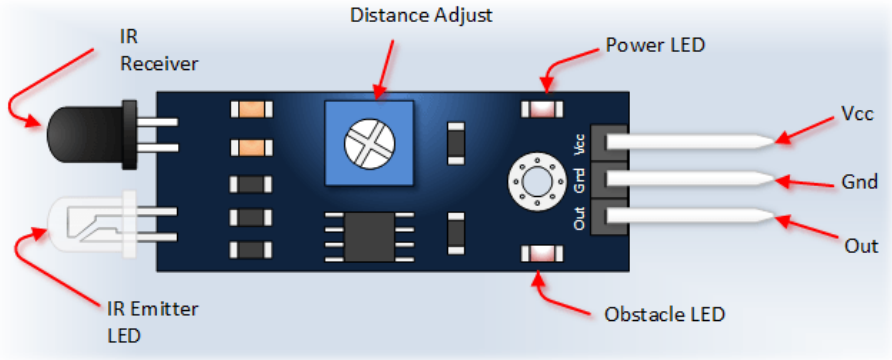

Fig.3 IR Sensors [8]

4) Compressor: A continuous supply of compressed air is required to the solenoid valve to operate the brakes whenever needed. A compressor can compress air to the required pressures. It converts the mechanical energy from motors and engines into the potential energy in compressed air. A single central compressor can supply various pneumatic components with compressed air, which is transported through pipes from cylinder to the pneumatic components.
5) Pneumatic cylinder: Pneumatic cylinder consists of Piston and Cylinder. A single acting cylinder consists of a simple piston arrangement in which a spring is loaded in opposite side if the working area of the fluid.

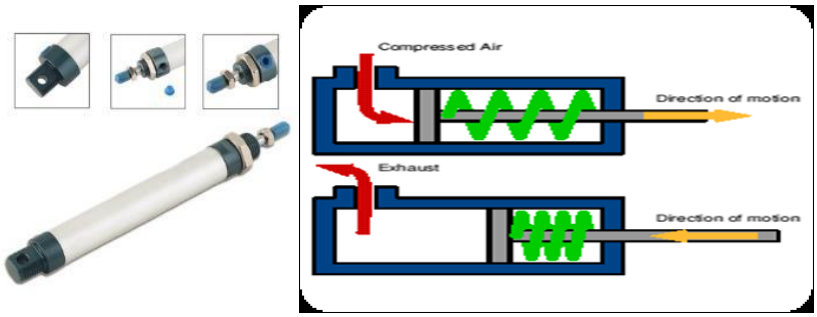

Fig.4 Pneumatic Cylinder [9]

6) Solenoid valve: The solenoid valve is the valve which controls the flow of pneumatic by an electrical signal. A solenoid valve used here is 3/2 spring return pilot solenoid valve. 3/2 valve means it has three ports that are we can give three connection to the valve and it has two positions which mean there are two positions that this valve can be operated.

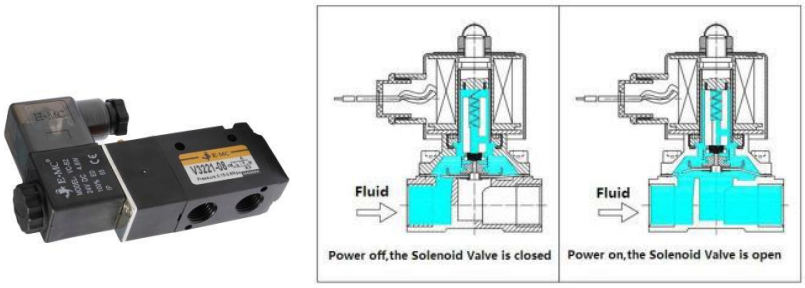

Fig.5 Pneumatic Solenoid Valve [10]

7) Flow control valve: A flow control valve is used to control the amount of flow of air in one direction only. This is used to avoid any disturbances to the compressor. A flow control valve is formed by non-return valve and a variable throttle. A flow control valve is connected to between solenoid valve and compressor. But most of the time flow control valve is already attached to the cylinder. By using the time consumption is reduced because of the faster movement of the piston.
8) Arduino: **Arduino** is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world [7]. In this system, program will be given to Arduino which will be set in the computer. By that coding, the whole system will work. Purpose of Arduino board is that it is used for the repetitive work, in this project, sensing of obstacle and then allowing the air to flow through the solenoid valve.

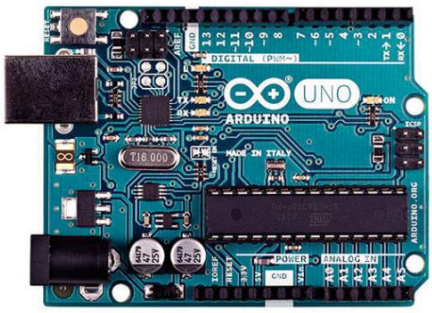

Fig.6 Arduino [11]

C. Calculation and design

1) Design of storage tank walls:

Considering the tank to be cylindrical with hemispherical ends

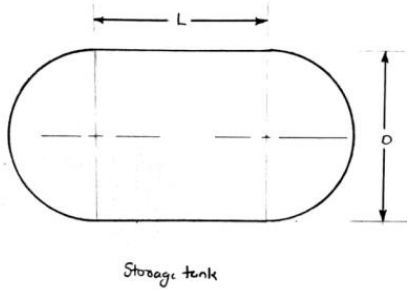

Fig.7 Storage tank

Assuming diameter of the hemispherical end equal to the length between to hemispherical ends
i.e D = L
The volume of the storage tank

$V = \left(\frac{\pi}{4} D^2 L\right) + (\frac{4}{3}\pi R^3)$

Where D = 2R

$V = \left(\frac{\pi}{4} D^2 L\right) + (\frac{4}{3}\pi(\frac{D^3}{8}))$

$24 \times 10^{-3} = \left(\frac{\pi}{4} D^3\right) + (\frac{4}{3}\pi(\frac{D^3}{8}))$

D = 0.2637 m.
Since, D = L = 0.2637 m
Maximum pressure inside tank Pmax= 8bar = 8×10 N/m².
And the material of tank is selected as carbon steel C-45 from PSG.
Syt = 340 N/mm2.
Factor of safety for steel is 1.5 i.e. f.o.s. = 1.5

$\sigma_{yt} = \frac{Syt}{f.o.s}$

$\sigma_{yt} = \frac{340}{1.5}$

$\sigma_{yt} = 226.6667\ N/mm^2$

We know the stress induced in a cylindrical shell.

$\sigma_{ind} = \frac{PD}{2t}$

$\sigma_{ind} = (\frac{8 \times 10^5 \times 0.2637}{2 \times t})$

For safety,

$\sigma_{ind} \leq \sigma_{yt}$

$(\frac{8 \times 10^5 \times 0.2637}{2 \times t}) \leq 226.667 \times 10^6$

$t \geq 6.6921 \times 10^6$

Now checking for hemispherical shape
We know the stress induced in a hemispherical shell

$\sigma_{ind} = \frac{PD}{4t}$

For safety

$\sigma_{ind} \leq \sigma_{yt}$

$(\frac{8 \times 10^5 \times 0.2637}{4 \times 6.6921 \times 10^{-3}}) \leq \sigma_{yt}$

$\sigma_{yt} \geq 7.8809\ N/mm^2$

Since σ_{yt} is greater than σ_{ind} so the design is safe for a storage tank.

2) Design of pipes/ hoses:

Assuming pipe to be a small cylinder of diameter d having fluid as air having pressure Pmax = 8 bar

$\sigma_{ind} = \frac{PD}{2t1}$

Where t1 is the thickness of the pipe

For safety

$\sigma_{ind} \leq \sigma_{yt}$

Where, Material for pipe is selected as PVC, Syt = 56 N/mm^2 from PSG.

$\sigma_{yt} = \frac{Syt}{f.o.s}$

$\sigma_{yt} = \frac{56}{2}$

$\sigma_{yt} = 28$ N/mm^2

$\left(\frac{8 \times 10^5 \times 0.2637}{2 \times t1}\right) \leq 28 \times 10^6$

$t1 \geq 0.2857 \times 10^{-3}$ m

So assuming hose thickness as, t1= 2 mm.

3) Design of Pneumatic cylinder:

i) Design Piston rod:

Diameter of the Piston (d) = 40 mm

Pressure acting (p) = 8 bar

Material used for rod = C 45

Yield stress (S_{yt}) = 340 N/mm²

Assuming factor of safety =1.5

Force acting on the rod, F = P×A

F = 1081.73 N

Design Stress (σ_{yt}) = S_{yt} / 1.5

= 340/ 1.5 = 226.6667 N/mm²

= 1081.73/ (Π d² / 4)

∴ d = √ 4 F/ Π [σ_{yt}]

= √ 4 x 1081.73 / {Π x 226.6667}

= √ 6.02794 = 2.45518 mm

∴ Minimum diameter of rod required for the load=2.45518 mm

Design of rod is safe since diameter of design is lesser than real diameter.

So we assume rod diameter = 8mm.

4) Design of Brake shoe:

μ′ = coefficient of friction between the brake shoe and drum (0.5).

r = radius of the drum.

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

Frictional force = μ′F

Frictional force = 0.5×1081.73

= 540.865 N.

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.

Since 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 isObstaclePin = 7; // This is our input pin
int isObstacle = HIGH; // HIGH MEANS NO OBSTACLE
void setup() {
pinMode(LED, OUTPUT);
pinMode(isObstaclePin, INPUT);
```

```
Serial.begin(9600);
}
void loop() {
isObstacle = digitalRead(isObstaclePin);
if (isObstacle == LOW)
{
Serial.println("OBSTACLE!!, OBSTACLE!!");
digitalWrite(LED, HIGH);
}
else
{
Serial.println("clear");
digitalWrite(LED, LOW);
}
delay(200);
```

4. RESULT AND CONCLUSION

These are some records of road accidents occur in India. More than 135 thousand people loosed there lives in road accidents in 2017 alone, which is more than the number of people killed in all our wars put together. Approximately 15-18 children die on Indian roads daily. 4-6 lives end on Delhi's roads every day. In India due to road accident, one death occurs in every four minute. Drunken driving is one of the leading causes of road fatalities. One serious road accident in the country occurs every minute and 16 die on Indian roads every hour.1200-1250 road crashes happen every day in India. Two wheelers account for 20%-40% of total road crash deaths. 20 children under the age of 14 die every day due to road crashes in in the country. 370-400 people die every day, equivalent to a jumbo jet crashing every day. In Utter Pradesh two to three people die every hour, that makes them State with maximum number of road crash deaths. In Tamilnadu maximum number of road crash injuries happens.

Top 10 Cities with the highest number of Road Crash Deaths (Rank –Wise):

Delhi (City), Chennai, Jaipur, Bengaluru, Mumbai, Kanpur, Lucknow, Agra, Hyderabad, Pune.

So with the help of our project, Electro-Pneumatic Braking System, Accidents can be reduced further with great extent as it allows the braking system to come in action when the obstacle is sensed at certain distance and the moving vehicle can come to halt, even the person who is unaware of the surrounding will not become the case of accidents so the accidents can be reduced with the help of this project.

The ELECTRO-PNEUMATIC BRAKING SYSTEM, if executed in automobile sector it can spare human lives and property. Implementation of such system can be made compulsory like wearing of safety belts with the goal that misfortunes can be deflected to some degree. Our ELECTRO-PNEUMATIC BRAKING SYSTEM operates for the car wellbeing and because of this vehicle can be for staying away from miss-chances. The outcome of car security is more than simply constructing up another innovation; it is moving the way to deal with safety. ELECTRO-PNEUMATIC BRAKING SYSTEM approach states to a huge movement from the conventional way to deal with safety, yet it is crucial to accomplishing the momentous benefits.

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