INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue3)
Available online at www.ijariit.com

Pneumatic Based Automatic Railway Gate Control System

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Abstract*: There are many railway crossings which are unmanned due to lack of manpower and unavailability of electricity needed to fulfill the demands. Hence, many accidents occur at such crossings, since there is no one to take care of the functioning of the railway gate when a train approaches the crossing. This paper describes the automatic railway gate control system using a pneumatic cylinder with sensor assistance for saving precious human lives and preventing major disasters in railway track. Here pneumatic power is used so that it can be efficient in the remote area also. This system can be divided into two parts. The first part is a concern on the hardware development where all electronic components have been included. Ultrasonic sensors are used to sense the rail and these sensors are controlled by the controller circuit. The microcontroller and the pneumatic compressor forms the main unit of the system. It receives an input signal from the sensors and sends information to the gate pneumatic actuator for opening and closing the gate. Besides, the input signal will also activate LCD display and alarm. The first ultrasonic sensor is fixed at a certain distance before the gate and the second sensor is fixed at the same distance after the gate. We call the sensor along the train direction as 'foreside sensor' and the other as 'after side sensor'. When foreside sensor gets activated, the sensed signal is sent to the microcontroller and the gate is opened by the pneumatic actuator and the gate is closed and stays closed until the train crosses the gate and reaches after side sensors. This system is one of the efficient methods to avoid train accidents. The second part is based on software programming to operate the hardware structure. Program for railway gate control system is based on PIC microcontroller with PIC Basic Pro language.

Keywords: PIC Basic Pro Language.

1. INTRODUCTION

The railways are the most commonly used transportation mode in India. It is also one of those modes of transport where a minor human error can cause multiple fatalities as in level cross accidents, collisions, etc. A level cross, an intersection of a road and a railway line, requires human coordination, the lack of which leads to accidents. Level crosses are mostly controlled by manually operated gates. In order to avoid the human errors that could occur during the operation of gates, the proposed paper introduces the concept of railway gate automation.

1.1 Present technology in India

Level crossings are managed by the gatekeeper and the gatekeeper is instructed by means of the telephone at most of the level crossings, from the control room. But the rate of manual error that could occur at these level crosses are high because they are unsafe to perform without actual knowledge about the train timetable , obstacle stuck in the level cross etc. leads to the increasing rate of accidents at the level cross. Thus the railway gate automation system aims to deal with two things. It reduces the total time taken for the gate operation at the level cross and also ensures the safety of the passengers at the level cross during when the train passes. The reduction in the direct human intervention during the gate operation, in turn, helps to reduce the collision and accidents at the level cross. Since the gate operations are based on the sensors, the gates are closed and opened when the train is at an optimum distance away. The paper thus intends to develop an automatic railway gate control system which is more reliable and secured than the existing manual systems.It proposes a unique and economical method for improving the safety of the level crossings.

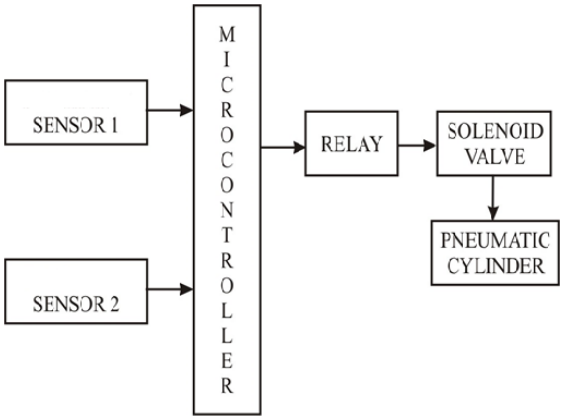
1.2 Problems Due to Current Mannual System

Road accidents at railway gate is a leading cause of death and injury worldwide. Surveys conducted by Indian Railway found that about 17% of total railway accidents in India is crossing accidents of which majority occurs at passive railway crossings. The operation of railway gates at level crossings is not so reliable now a days. Primarily the road users have to wait for a long time before and after the passing of the train. And secondly, the chances of accidents made by the carelessness of the road users or due to the time errors made by the gatekeepers are more. Here comes the importance of automatic railway gate control system.

2. CONCEPT OF PBARGC

Railways being the cheapest mode of transportation are preferred. Accidents occurring at unmanned railway crossings have now become a common news. This is mainly due to the carelessness in manual operations or lack of workers. This paper is a solution for the same. Using simple sensor and pneumatic system automation is introduced to the control of railway gates.

As a train approaches the railway crossing from either side, the sensors placed at a certain distance from the gate detects the approaching train. Let Sensors are fixed at 1km on both sides of the gate. The sensor along the train direction is called as 'foreside sensor' and the other as 'after side sensor'. When foreside receiver is activated the compressed air from the solenoid valve is passed to cylinder in order to actuate the piston and the gate automatically closes because the piston rod is coupled to the one end of the gate and Buzzer immediately sound at the fore side receiver activation and gate will only close after 5 seconds, so giving time to drivers to clear gate area in order to avoid trapping between the gates and stop sound after the train has crossed. Then as the train crosses after side sensors gate gets open again by the same way as it gets closed. This project uses two ultrasonic sensors, solenoid valve, and a pneumatic cylinder. Sensor activation time is adjusted by calculating the time taken for at least one compartment of the standard
minimum size of the Indian railway to cross. That time is considered 5 seconds here. And Sensors are fixed at 1 km on both sides of the gate.



3. BASIC COMPONENTS

The basic component of this system is below.

a) PNEUMATIC CYLINDER
b) ULTRASONIC SENSOR
c) SOLENOID VALVE
d) RELAY
e) MICROCONTROLLER

3.1 Pneumatic Cylinder

Pneumatic cylinders are devices for converting the air pressure into linear mechanical force and motion.

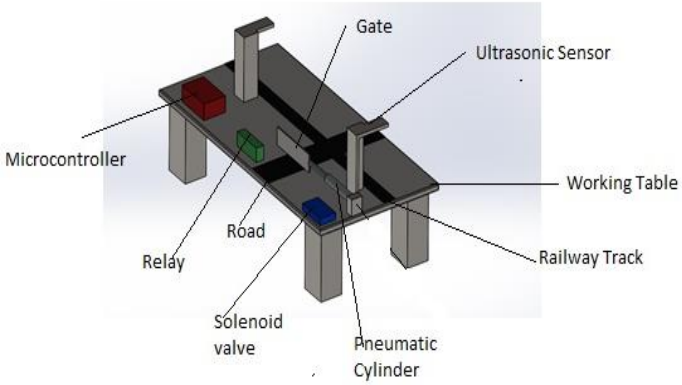
3.2 Ultrasonic sensors

Ultrasound can be used for measuring wind speed and direction (anemometer), tank or channel fluid level, and speed through air or water. Here it is used to detect the train with the help of ultrasonic wave. There are two part of it one is to send the signal and another part receives the ultrasonic waves.

3.3 Solenoid Valve

A solenoid valve is an electromechanically operated valve.

The valve is controlled by an electric current through a solenoid.in the case of a two-port valve the flow is switched on or off; in the



case of a three-port valve, the outflow is switched between the two outlet ports.

3.4 Relay

A relay is an electrically operated switch.

Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal

3.5 Microcontroller

A microcontroller is a small computer on a single integrated circuit. In modern terminology, it is a system on a chip or SOC. A microcontroller contains one or more CPUs (processor cores) along with programmable input/output peripherals Program and memory. memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM.

4. CONSTRUCTION OF WORKING MODEL

Two columns are mounted beside the railway track to support the sensor on both sides. These sensors are connected to the microcontroller using connecting wire. A breadboard is kept to connect it with different wire and circuit. A 16*2 size LCD is used for displaying the instruction.

4.1 Circuit connection

Its vss pin is connected to the ground of the breadboard and vdd pin is connected to the 5volt supply. V nod pin which is responsible for the contrast of the circuit is connected to the ground via a resistor. RS pin of the display is connected to the 02 pin of the microcontroller.RW pin is connected to the ground which can be used for reading and write operation. Here it is used for writing purpose only. To enable the latch of the circuit it is connected to 03 number pin. In LCD there are D0 to D7 data pin so up to 8 bit can be written into the LCD display. But only 4 bit is required here so the connection is only from D4 to D7.The anode is connected to 5 V circuit and the cathode is connected to ground. The ultrasonic sensors used here has 4 pins. The vc pin is connected to the breadboard 5 volt. The trigger it is connected with the 8 number pin of the microcontroller. Echo pin of it is connected to the analog 0 and the ground pin is connected to the ground part of the breadboard. Same connection is done with the other ultrasonic sensor. Now one indicator led bulb is kept which is connected with the microcontroller 10 number pin and 5 volts of the breadboard and then connect the relay valve pin to the circuit. Its two pins are connected to the positive and negative part of the adaptor and one which is to be grounded is connected to the ground of the breadboard. Now solenoid valve is connected to the relay circuit and the solenoid valve is finally connected to the two-way double actuated cylinder via a pipe. The piston of the cylinder is hinged with the gate which is given to open and close the system by doing the linear motion the gate is just made up of sheet metal to provide the obstruction to the vehicle. the solenoid valve is connected to the air compressor also via a pipe.

5. EXPERIMENTAL RESULTS

5.1 Calculation of cylinder force, piston velocity, and power

The output force (F) and piston velocity (V) of double acting cylinders are not the same for extension and retraction strokes.

Here Diameter of piston-20 mm

Diameter of rod-7.8 mm

Length of rod-70 mm

Calculating all parameter for volume flow rate of compressed air=17014 mm3/sec

Pressure= 0.5 Mpa

C/S Area of piston=314.159 mm2

C/S area of rod=47.783 mm2

- **Force and Velocity during Extension stroke**

$$v_{ext} = \frac{Q_{in}}{A_p} \text{----------(1)}$$

Gate closing velocity= 17014/314.159

=54.157 mm/sec

$$F_{ext} = p \times A_p \text{----- ----------(2)}$$

0.5x314.159

=157.07 N

- **Force and Velocity during Retraction stroke**

$$v_{ext} = \frac{Q_{in}}{A_p - A_r} \text{----------(3)}$$

Gate opening velocity

=17014/(314.159-47.0783)

=63.703 mm/se

$$F_{ext} = p \times (A_p - A_r) \text{----------(4)}$$

0.5x (314.159-47.0783)

=133.54 N

- **Power developed by a pneumatic cylinder (both in extension and retraction)**

$$Power = Force \times velocity = F \times V$$

----------(5)

During extension- 54.15x157.07

=8.505 watt

During retraction-63.703x133.54

=8.506 watt

5.2 Calculation of time taken by sensor to detect the train

distance between toy train and sensor(S)-5cm

Speed of ultrasonic wave in air(V)- 343 m/sec

Time to detect the toy train by the sensor T=2S/V

=2x5/(100x343)

T= 0.291 micro sec

5.3 Calculation of distance of the sensor from the gate:

Average speed of train=70 km/hr
Time of closing the gate before train reaches=3 min
Distance between train sensor and gate
= velocity x time = 70x3/60

S= 3.5 km

The small-scale model for the automatic railway gate opening system was produced by us using an ATmega328 microcontroller, SPDT 10A Relay, Aeroflex V4-08 solenoid valve, HC-SR04 ultrasonic sensor and Aeroflex 120M50 pneumatic cylinder. The base frame is of mild steel. The modeling was done in solid works. The Mild steel, fabrication equipment, compressor facilities and work space was provided by V-Metal Pvt. Ltd Bangalore. The working of the sensors in conjunction with the microcontroller and pneumatic actuator was tested two times.

Here a test specimen (a cardboard box) was moved 50 mm below the sensors in the horizontal direction. We have found out that sensors sensed the object in 0.29 microseconds, assuming the sound wave travel in the air at 343m/s and the gate closed. We have deducted that if the gates have to be locked at least 3 minutes before the arrival of the train, the sensors have to be located on at least 3.5 Km away from the gate on each side, assuming that the average speed of train passing through the gate is 70 Km/hr. The test was conducted two times and the system worked consistently both the times.

5.4 MERITS AND DE-MERITS

MERITS:

- An Automatic Railway Gate Control is implemented with very simple hardware and easy control.
- Human intervention at level crossings can be removed with the help of this project and many railway level crossing accidents can be prevented.
- No manpower is required.
- It will give better output as compared to another type of systems.
- This system has higher efficiency as compared to others.
- There are very rare chances of an accident.

DE-MERITS:

- The system can be implemented more efficiently by incorporating more efficient sensor network.
- A combination manual wireless control and sensors based control can be used for the better operation.
- Regular maintenance is required for efficient working of the system.
- Since the system uses compressed air so while compressing air it creates noise.

6. FUTURE SCOPE OF PROJECT

i. This project is developed in order to help the INDIAN RAILWAYS in making its present working system a better one, by eliminating some of the loopholes existing in it.
ii. Based on the responses and reports obtained as a result of the significant development in the working system of INDIAN RAILWAYS, this project can be further extended to meet the demands according to the situation.
iii. This can be further implemented to have a control room to regulate the working of the system. Thus becomes the user friendliness.
iv. This circuit can be expanded and used in a station with any number of platforms as per the usage.
v. Additional modules can be added without affecting the remaining modules. This allows the flexibility and easy maintenance of the developed system.

CONCLUSION

The automatic railway gate control system is centered on the idea of reducing human involvement for closing and opening the railway gate which allows and prevents cars and humans from crossing railway tracks. The railway gate is a cause of many deaths and accidents. Hence, automating the gate can bring about a ring of surety to controlling the gates. A human may make errors or mistakes so automating this process will reduce the chances of gate failures. Automation of the closing and opening of the railway gate using the switch circuit reduces the accidents to a greater extent. The obstacle detection system implemented reduces the accidents which are usually caused when the railway line passes through the forest. Most of the times greater loss have been caused when animals cross the tracks. The limitation of this project is the use of ultrasonic sensors. Hence, any obstacle in the way of the sensor will be detected. Another important limitation is that this project does indeed close and open the gate but it cannot control the crossing of cars and vehicles. It only controls the gate. To combat this problem pressure sensor can be used as an extension to the present work. Here in this project, ultrasonic sensors are used but it is better to use load sensors or vibration sensors. By considering the economical feasibility in this project vibration sensors has not been used. As a future scope of work, our system can be implemented in real time by fixing the current limitations using new technologies.

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