

Development of system to control speed and door unlocking of vehicle in fire hazard

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Abstract - The safety of driver and passenger is very important in a vehicle. more than 2,000 vehicles are damaged by fires every day, On a global scale. Main factor is the lack of fire safety system in automobiles. Due to unexpected fire driver and passenger get panic and they unable to rescue their self. If fire burn electronic and electrical system of door, then driver and passenger unable to unlock the door and driver loose control over the car that causes major injury to driver and passenger. So, we have designed the vehicle control system in case of fire hazard to turn on buzzer, control the speed of vehicle and unlock the doors to escape the driver and passenger. The project aim is to control the vehicle for saving the life or avoid major injury of driver and passenger by using various fire/smoke sensors at high-risk zone and by designing secondary control system for door lock and car speed. Developed system result in safety of driver and passenger.

Key Words: Fire sensor, Smoke sensor, Door lock

1. INTRODUCTION

The rapid growth of electric vehicles (EVs) in recent years has highlighted safety concerns, with EV fires becoming a significant issue. Charging safety is crucial due to potential hazards like overloads and poor heat dissipation. These safety challenges pose obstacles to the widespread adoption of new energy vehicles. Recognizing the importance of standards and testing facilities, the Government of India established the Automotive Industry Standards Committee (AISC) to develop and approve safety standards for vehicles. Additionally, international efforts, such as the FFI-program in Sweden, aim to enhance fire detection systems in heavy vehicles to mitigate fire risks in engine compartments.

1.1 Background

In the past, fire alarms relied on community members to spot fires and alert others using whistles or bells, but as towns grew, this method became impractical. In the 1850s, an improved system with wooden rattles for waking people during fires was introduced in Australia. Moses Farmer and William F. Channing further advanced fire alarm technology by creating telegraphic key fire alarm boxes in 1852, enabling swift transmission of fire locations to central alarm stations for faster fire department response.

1.2 Problem Statement

The safety of vehicle occupants is paramount, as over 2,000 vehicles are damaged by fires globally each day due to the lack of adequate fire safety systems. Fires can lead to panic and immobilize occupants, particularly if electronic systems fail, posing grave risks. Incidents like a bus accident in Nashik and a taxi fire in Ghana underscore the urgency of addressing this issue. Prompt response is crucial, as fire incidents on moving vehicles can escalate rapidly, especially at night or in remote areas. Implementing early fire detection systems alongside fire extinguishers can mitigate risks and aid emergency responders, ensuring timely assistance to passengers and protection of property.

1.3 Objective

The main objective of the project is to develop a fire detection technique in real time.

The main points of the project objectives are given below:

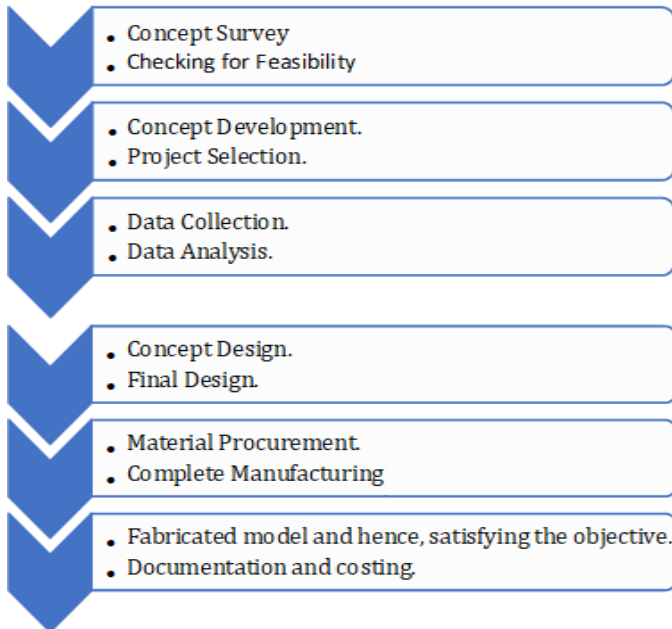
- To reduce the panic attacks of driver and passengers.
- To detect fire while they are still small and have not grown too large.
- To develop a low-cost fire detection system in real time.
- To develop a system that detects fire earlier than conventional fire detectors and more accurate.
- To reduce the panic attacks of driver and passengers.
- To make safer vehicle.
- To unlock doors of vehicle faster in case of fire hazard.
- To reduce speed of vehicle in case of fire hazard.
- To offer security to people inside the vehicle.

2. LITERATURE REVIEW

Fire detection systems employ various types of detectors, including heat detectors, smoke detectors, flame detectors, and fire-gas detectors, each with distinct working principles. Heat detectors, categorized into fixed temperature and rate-of-rise types, activate upon detecting significant temperature increases, making them reliable and cost-effective. Smoke detectors, utilizing photoelectric or ionization technology, detect smoke particles, with photoelectric detectors being effective for smouldering fires. Ionization detectors, although efficient for sudden flare-ups, pose safety risks due to radioactive elements and are discouraged in some regions. Flame detectors, such as infrared and ultraviolet types, detect

flames based on light wavelengths, with varying response times for different types, and require unobstructed views for optimal performance.

3. METHODOLOGY



4. CONCEPT DESIGN

4.1 Block Diagram

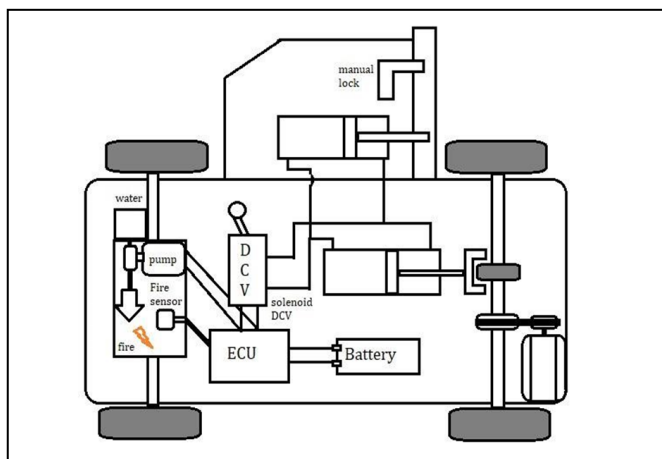


Fig 4.1 Experimental Setup.

5. DETAILED DESIGN

5.1 Design Consideration

5.1.1. Cylinder

If we increase the pressure of air as per formula pressure is directly proportional to the force.

If, P increase then F increases

Design of Pneumatic Cylinder:

Clavarino’s equation for closed end cylinder at both ends. For ductile material to determine the thickness of cylinder.

Let,

Material of the cylinder is Aluminium.

$$t = \gamma i \left[\sqrt{\frac{\sigma t + (1 - 2\mu)p}{\sigma t - (1 - \mu)p}} - 1 \right]$$

Sut = Ultimate tensile strength = 200N/mm² μ = Poisson’s Ratio for the cylinder material = 0.29 (std-) di = Inner diameter of cylinder = 25mm

Consider,

Double acting cylinder Ø25X 100 (Diameter X Stroke) ri = 12.5mm

By assuming pressure in working cylinder is, P = 3bar = 0.3 N/mm²

So according to Clavarino’s equation,

For closed end cylinder at both ends to determine the thickness of cylinder.

Assume, p = 3 bar = 0.3 N/mm²

By considering Factor of safety FOS = 1.5 μ = 0.29 ri = 12.5mm.

$$t = \gamma i \left[\sqrt{\frac{\sigma t + (1 - 2\mu)p}{\sigma t - (1 - \mu)p}} - 1 \right]$$

t = 0.0390mm FOS = 1.5
t = 1.5 x 0.0390 mm = 0.0580 mm.

Available thickness, t = 1mm
Piston diameter(D2) = 25mm
Piston rod diameter(d2) = 10mm.

Let,

A= Force area of cross-section of piston.

$$A = \pi / 4 * (D2)^2 \quad A = \pi / 4 * (25)^2$$

$$A = 490.87 \text{ mm}^2$$

APR= Force area of cross-section of piston on rod side.

$$APR = \pi / 4 * (D2 - d2)^2 \text{ mm}^2$$

$$APR = \pi / 4 * (25 - 10)^2 \text{ mm}^2$$

$$APR = 412.33 \text{ mm}^2$$

Piston force acting during forward stroke.

$$\begin{aligned} F_a &= P \cdot A \\ &= P \cdot \pi / 4 (D_2)^2 \\ &= 0.3 \times 490.87 \\ F_a &= 147.261 \text{ N.} \end{aligned}$$

Piston force acting during return stroke.

$$\begin{aligned} F_r &= P \cdot \pi / 4 (D_2 - d_2)^2 \text{ mm}^2 \\ &= 0.3 \times 412.33 \\ F_r &= 123.7 \text{ N} \end{aligned}$$

5.2 PIC Microcontroller

The PIC microcontroller is a low cost 'computers on a chip' manufactured by Microchip. They allow electronic designers and hobbyists impart intelligence and logic to a single chip for special purpose applications and products. The PIC microcontroller programming is done using the popular software 'Micro C'. This powerful yet easy to program into a 40-pin package is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. (Shoewu, 2015)

5.2.1 Why PIC is used

- High speed
- High performance RISC (Reduced Instruction Set Computer) CPU
- Instruction Set simplicity
- Integration of operation features
- Programmable timer options
- Interrupt control
- EPROM/OTP/ROM options
- Inbuilt modules
- Low power consumption
- Wide operation voltage range: 2.5 to 6 volt
- Programmable code protection mode
- Power saving sleep mode

5.2.2 PIC Components

1. Power supply
2. PIC16F877A microcontroller
3. Resistors ¼ watt (1kΩ x 2)
4. Capacitors (22pF x 2)
5. Electrolytic capacitor (1μF)
6. Push button switch (for resetting the PIC)

7. Crystal (4MHz)

8. LED

5.2.3 Basic connection of PIC Microcontroller

To start a microcontroller project you need to configure the PIC as follows (Basic requirements)

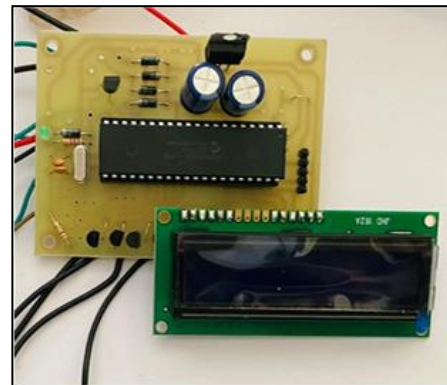


Fig. 5.1 PIC microcontroller

5.2.4 Core Architecture of PIC 16F877A

PIC controller architecture is simple. single cycle execution (4 clock cycles), The RAM location of PIC controller function as registers. The data space mapped CPU, port, and peripheral registers in PIC 16F877A microcontroller and the program counter is mapped. (Limited, n.d.)

5.2.5 Performance of PIC 16F877A

The clock speed is 20MHz. The TACQ or acquisition time is 19.2 μs. The architectural decisions are directed at the maximization of top-end speed, or more precisely of speed to cost ratio. PIC architecture was among the first scalar CPU designs, and is still among the simplest and cheapest. The Harvard architecture in which instructions and data come conveniently from separate sources simplifies timing and microcircuit design greatly. (Limited, n.d.)

5.3. Disc Brake:

Brakes are very crucial for stopping a vehicle. Without brakes, it is impossible to drive a car or any vehicle. Brakes are of different types and according to the requirement, the types of brakes are chosen for the application. So we choose disc brake according to torque and speed.

1. Brake pad: It makes contact with the rotor disc and due to the friction between the brake pad and rotor disc the vehicle speed reduces and it stops.
2. Caliper bracket: support to assembly
3. Caliper frame: support to pads

4. Piston: It applies the brake force on the brake pads when brake lever is pressed.
5. Slider pin: It is the sliding pin which slides in the hole when brake is applied.
6. Dust boots: It prevents the entry of dust into the caliper pin or slider pin hole.

5.3.1 Working



Fig. 5.2 Disc Brake

The working of a disc brake is based on Pascal law:

1. The high pressure fluid from the master cylinder forces the piston outward when the brake pedal is depressed.
2. The piston pushes the brake pad against the rotating disc.
3. The calliper travels inward and drags the outward brake pad towards the rotating disc until it reaches the disc as the fluid pressure exerts more force as the inner brake pad makes contact with the rotor.
4. Now both the brake pads are pushes the rotating disc, a large amount of friction is generated in between the pads and rotating disc and slows down the vehicle and finally let it stop.
5. When the brake pad is released, the piston moves inward, the brake pad moves away from the rotating disc. And the vehicle again starts to move.

5.4 Flame Sensor

A flame sensor is a type of sensor that responds most strongly to ambient light. This sensor module is utilised in flame alarms as a result. When the light source's wavelength is between 760 and 1100 nano meters, this sensor can detect flames. High temperatures have the potential to easily harm this sensor. So, a specific distance from the flame can be chosen for this sensor's placement. The flame may be detected from a distance of 100 cm, and the detection angle is 600.

5.4.1 Working Principle

This sensor/detector can be built with an electronic circuit using a receiver like electromagnetic radiation. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice.

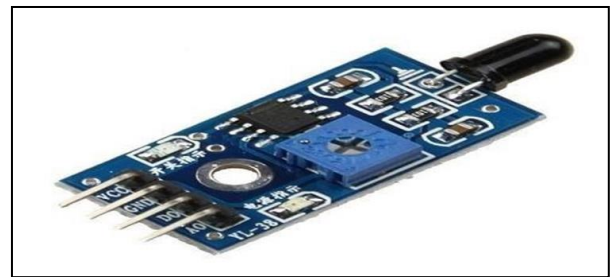


Fig 5.3 Flame Sensor [4]

5.4.2 Flame Sensor Module

The pin configuration of this sensor is shown below. It includes four pins which include the following. When this module works with a microcontroller unit then the pins are

Pin1 (VCC pin): Voltage supply rages from 3.3V to 5.3V

Pin2 (GND): This is a ground pin

Pin3 (AOUT): This is an analog output pin (MCU.IO)

Pin4 (DOUT): This is a digital output pin (MCU.IO)

5.4.3 Features & Specifications

The features of this sensor include the following.

- Photosensitivity is high
- Response time is fast
- Simple to use
- Sensitivity is adjustable
- Detection angle is 600,
- It is responsive to the flame range.
- Accuracy can be adjustable
- Operating voltage of this sensor is 3.3V to 5V
- Analog voltage o/ps and digital switch o/ps
- The PCB size is 3cm X 1.6cm
- Power indicator & digital switch o/p indicator

If the flame intensity is lighter within 0.8m then the flame test can be activated, if the flame intensity is high, then the detection of distance will be improved.

5.5 Relay

We know that most of the high end industrial application devices have relays for their effective working. Relays are simple switches which are operated both electrically and

mechanically. Relays consist of an electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its working. But they differ according to their applications. Most of the devices have the application of relays.

5.5.1 Why is a relay used:

The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The application of relays started during the invention of telephones. They played an important role in switching calls in telephone exchanges. They were also used in long distance telegraphy. They were used to switch the signal coming from one source to another destination. After the invention of computers they were also used to perform Boolean and other logical operations. The high end applications of relays require high power to be driven by electric motors and so on. Such relays are called contactors.

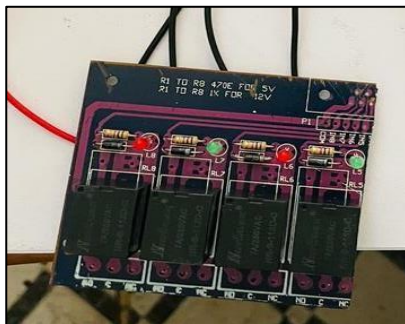


Fig 5.4 Relay

The diagram shows an inner section diagram of a relay. An iron core is surrounded by a control coil. As shown, the power source is given to the electromagnet through a control switch and through contacts to the load. When current starts flowing through the control coil, the electromagnet starts energizing and thus intensifies the magnetic field. Thus the upper contact arm starts to be attracted to the lower fixed arm and thus closes the contacts causing a short circuit for the power to the load. On the other hand, if the relay was already deenergized when the contacts were closed, then the contact move oppositely and make an open circuit.

5.5.2 Relay Selection

You must note some factors while selecting a particular relay. They are

- Protection – Different protections like contact protection and coil protection must be noted. Contact protection helps in reducing arcing in

circuits using inductors. Coil protection helps in reducing surge voltage produced during switching.

- Look for a standard relay with all regulatory approvals.
- Switching time – Ask for high speed switching relays if you want one.
- Ratings – There are current as well as voltage ratings. The current ratings vary from a few amperes to about 3000 amperes. In case of voltage ratings, they vary from 300 Volt AC to 600 Volt AC. There are also high voltage relays of about 15,000 Volts.
- Type of contact used – Whether it is a NC or NO or closed contact.
- Select Make before Break or Break before Make contacts wisely.
- Isolation between coil circuit and contacts.

5.5.3 Specification of relay

- RELAY, 5A, SPDT, 12V
- Product Range: OMRON - G5SB Series
- Coil Voltage: 12VDC
- Contact Current: 5A
- Contact Configuration: SPDT
- Coil Resistance: 360ohm
- Coil Current: 33.3mA
- Coil Type: DC
- Coil Voltage VDC Nom: 12V
- Contact Current Max: 5A
- Contact Voltage AC Nom: 250V
- Contact Voltage DC Nom: 30V
- External Depth: 20.3mm
- External Height: 15.8mm
- External Width: 10.3mm
- Relay Type: Power relay.

5.6 5/2 Solenoid Valve

5/2-way pneumatic valve has five connection ports and two states. It has one pressure port (P,1), two ports (A,2) and (B,4) that connect to the device that needs to be controlled, and two exhaust ports (EA,3) and (EB,5). The two states of the valve are:

- Pressure port (P,1) connects to port (A,2), while port (B,4) vents through exhaust port (EB,5)
- Pressure port (P,1) connects to port (B,4), while port (A,2) vents through port (EA,3). (TAMESON, 2022)



Fig 5.5 5/2 solenoid valve



Fig 6.1 Frame

Frame material: Mild steel

Frame dimension: 30*24 inch

Height of frame: 6 inch

5.4 Design system modelling

Software used: Creo Parametric Student Version 3.0

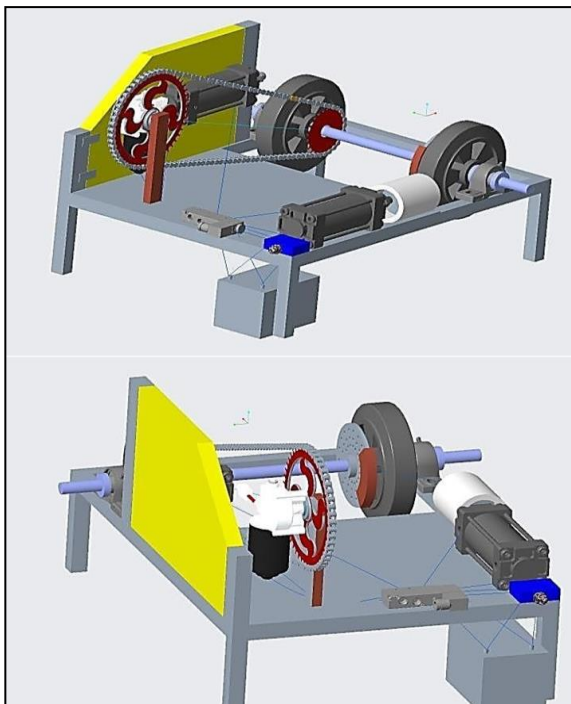


Fig: 5.6 Prototype Model

6. PROJECT IMPLEMENTATION

6.1 Fabrication

6.1.1 Mounting Frame :

Weight = 5 kg

Part Size = (550X750) mm

Part Material = MS Square Bar

Part Quantity = 1

Table 6.1: Frame Operation

Sr.No.	Operation	Machine	Tool	Time
1	Cutting the material	Power Hacksaw	Hacksaw Blade	30 min.
2	Welding	Welding	Arc Welding	20 min.

6.2. Fabricated Model

Weight = 20 kg

Part Size = (550X750) mm

Part Material = MS Square Bar

Part Quantity = 1 assembled model

Frame material: Mild steel

Frame dimension: 30*24 inch



Fig no. 6.2 Fabricated model

Table 6.2: Operations

SrNo.	Operation	Machine	Tool	Time
1	Cutting the material	Power Hacksaw	Hacksaw Blade	30 min.
2	Welding	Welding	Arc Welding	20 min.
3	Fastening	-	Spanner	180 min
4	Drilling	Drill m/c	Drill bit's	120 min
5	Circuit building	Solder gun	Lead wire	180 min
6	Wiring	-	Splitter, Plier	120 min
7	Assembly	Welding, Fastening	-	240 min

1. Fire sensor: To detect the fire
2. Electronic control unit: Microchip (PIC16F877A)
Take signal from fire sensor and transfers to solenoid valve and pump
3. Solenoid DCV: Control direction of air to actuate pneumatic cylinder.
4. Double acting cylinder: Lash unlash and actuate brake lever.
5. Disc brake: To control speed of vehicle.
6. Battery: 12V battery for power supply
7. Water tank: To store water
8. Pump: Pumps the water
9. Chain drive: Transfer power motor to wheel
10. Chain sprocket: Carry the chain
11. Door lash: Operate by pneumatic cylinder.
12. Car door: As shone in fig.
13. Pipes: Passes the air to actuator.

Operation

- Cutting the material
- Welding
- Fastening
- Drilling
- Circuit building
- Wiring
- Assembly

Machine

- Power Hacksaw
- Welding
- Drill m/c
- Solder gun
- Welding, Fastening

Tool

- Hacksaw Blade
- Arc Welding
- Spanner
- Drill bit's
- Lead wire
- Splitter, Plier

Technology

- FEA software.
- Caliper
- Creo Parametric
- Ansys

7. COST ESTIMATION (IN RUPEE)

Sr no	Name of part	Material cost(raw)	Material cost(bought)	Machine &assy. cost	total
1	Foundation frame	87/kg	1580	1500	3080
2	Disc Brake	685	-	685	685
3	Electronic unit		-	-	1920
4	Air tube	210	-	-	210
5	Wheel	175 X 2	-	-	350
6	Solenoid valve	1200	0	-	1200
7	Bearing	290	-	-	580
8	motor	200	0	-	200
9	Nut bolt	-	-	-	120
10	Screw nut adjustment	780	-	-	780
11	Pneumatic cylinder	3200	0	-	3200
12	Flow control valve	-	-	0	240
13	Fire sensor	0	200	25	225
14	miscellaneous	0	10	0	500
15	Chain Drive	0	0	700	700
16	Battery	0	0	650	650
				TOTAL	14640

8. CONCLUSION

The importance of prioritizing the safety of vehicle occupants has led to the virtual design of a vehicle control system capable of responding to fire hazards. This system includes features such as activating a buzzer, controlling vehicle speed, and unlocking doors to facilitate the rescue of drivers and passengers. Through extensive research, the project team has gained a comprehensive understanding of the challenges and requirements involved. Utilizing a 3D model, various parameters have been calculated to inform the manufacturing process effectively. Additionally, analysis conducted using Creo analysis software has enabled the determination of permissible loads on the model's frame,

ensuring robustness and effectiveness in real-world scenarios.

9. FUTURE SCOPE

- Electric vehicles present a significant area for future scope in enhancing safety systems due to their heightened risk of fire hazards.
- There is a growing interest in vehicle safety design, indicating potential advancements and innovations in this field.
- The adaptable nature of the system allows for modifications based on vehicle type and passenger safety requirements, emphasizing its importance.
- Future developments may involve the application of hybrid technology and solar-powered rechargeable batteries to enhance system capabilities.
- Expansion beyond vehicles to include residential and workplace settings prone to fire risks presents an opportunity for broader implementation.
- Consideration of scenarios where the vehicle battery is implicated in the fire highlights the need for separate power sources to ensure functionality of safety mechanisms.

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BIOGRAPHY



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