

FABRICATION, ANALYSIS AND TESTING OF AUTOMATIC FIREEXTINGUISHER SYSTEM IN ELECTRIC VEHICLES

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Automobile Engineering

By

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**DEPARTMENT OF AUTOMOBILE ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of Shaik Mohammed Sayer (39860020), Sriram.M (39860023) who carried out the project **"FABRICATION, ANALYSIS AND TESTING OF AUTOMATIC FIRE EXTINGUISHER SYSTEM"** under my supervision from November 2022 to April 2023.

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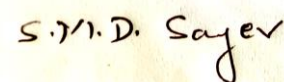
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DECLARATION

We S. Mahammed Sayer (39860020) Sriram.M (39860023) here declare that the Project Report entitled **“FABRICATION, ANALYSIS AND TESTING OF AUTOMATIC FIRE EXTINGUISHER SYSTEM”** done by us under the guidance of **Dr. A. KARTHIKEYAN, ME., Ph.D.**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Automobile Engineering.



DATE: 26.04.23

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SIGNATURE OF THE CANDIDATE

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ABSTRACT

Electric vehicles (EVs) are becoming increasingly popular due to their eco-friendliness and fuel efficiency. However, they pose a potential fire hazard due to their high-voltage battery packs. In this project, we present a prototype of an automatic fire extinguisher system for EVs using an Arduino UNO board, a fire sensor, and a wiper motor. The proposed system consists of a fire sensor that is fixed near the battery pack to detect any signs of fire. The sensor sends a signal to the Arduino UNO board, which in turn triggers the wiper motor. The motor is connected to a gear system that opens the cylinder of the fire extinguisher, releasing the extinguishing agent onto the fire. The prototype was tested in a simulated environment, and the results showed that the system was able to detect the fire and trigger the extinguisher in less than 5 seconds. The system can also be easily installed in any EV, as the sensors can be fixed at desired locations depending on the vehicle's design. The proposed system has several advantages over traditional fire extinguishing systems, such as being fully automated and requiring minimal human intervention. It can also help reduce the risk of fire-related accidents in EVs, ensuring the safety of passengers and the vehicle. In conclusion, the prototype of an automatic fire extinguisher system for EVs presented in this paper has the potential to improve the safety of electric vehicles and can be further improved by integrating additional sensors and safety features.

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CHAPTER 1

INTRODUCTION

With the present world moving towards the generation of electric vehicles we believe that it's mandatory to keep our sight on safety systems. In considering the status of road accidents which is over 1.5 lakh in which around 900 cars according to National Crime Records Bureau (NCRB) fire accidents is one of the major issues and the fire accidents are causing a panic in the public which is resulting in refraining the EVs to roll on roads. So, we believe that until the electric vehicles reach a state where it has an effective cooling system and a good battery management system it's better to have a passive safety system which can tackle the firing problems in electric vehicles.

In this project we have covered causes for fire in battery packs, battery management system, methods to overcome to battery overheating problems and mainly automation of fire extinguishing in electric vehicles.

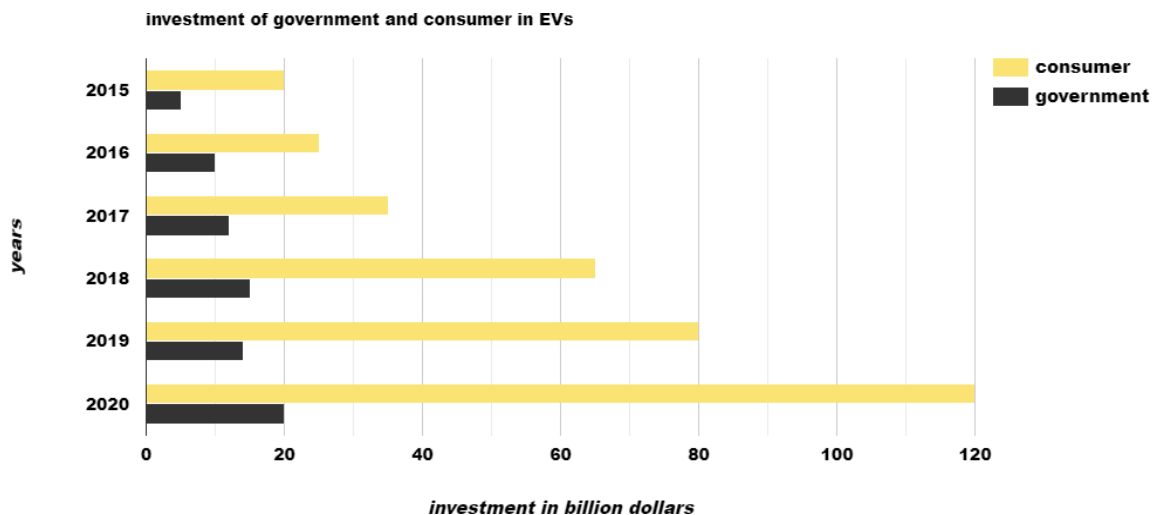


Figure 1. graph of investment of US dollars in electric vehicles from 2015-20

The above graph shows the increase in the investment in EVs. There has been a gradual increase in the investment in electric vehicles since 2015 to 2020. In 2015 the

government spending was around 5 billion dollars whereas it was 20 billion dollars. In 2016 it was increased to 25 billion dollars as the government investment was 10 billion. In 2017 the government investment was almost the same as the previous year up to 12 billion dollars. Whereas the customers invested over 35 billion dollars. In the year of 2018 the customer investment reached over 65 billion dollars but the government stood at 15 billion. In the years of 2019- 2020 the customer investment was 80 and almost 120 billion dollars but the government investment was 14 and 20 billion dollars respectively.

Electric vehicles (EVs) are becoming increasingly popular due to their environmental benefits, including reduced greenhouse gas emissions and improved air quality [1]. However, concerns over their safety have also emerged, particularly with respect to the risk of fire. EV fires can be caused by a range of factors, including battery overheating, electrical faults, thermal runaway, and collisions [2]. These fires can pose a serious threat to passengers and the environment as they emit poisonous gases like hydrogen fluoride into the atmosphere [3] and can be difficult to control and extinguish due to the unique characteristics of EV batteries. Current passive safety measures in EVs are not always sufficient to prevent or mitigate fires, highlighting the need for new and innovative approaches to improve EV safety. One promising solution is the development of automatic fire extinguisher systems that can detect and extinguish fires quickly and effectively. However, the design and implementation of such systems is complex, requiring careful consideration of factors such as system weight, power consumption, and compatibility with existing EV systems.

With this project, we present a new approach to improving the passive safety of EVs by developing and testing a prototype of an automatic fire extinguisher system. Our study builds on previous research in automatic fire extinguisher systems in the area of EV safety [4] and introduces a novel solution to address the problem of EV fires. Specifically, our objectives are to design and develop a prototype of the automatic fire extinguisher system, evaluate its effectiveness in reducing the risk of EV fires, and assess its potential for implementation in commercial EVs.

To achieve these objectives, we conducted a series of experiments and simulations to evaluate the system's ability to detect and extinguish fires electric vehicles and compared its performance to existing passive safety measures which include multi secure fault detection [5].

of EV fires and provide insights into the design and implementation of automatic fire extinguisher systems for EVs. Overall, our study represents a significant contribution to the field of EV safety and highlights the potential for automatic fire extinguisher systems to improve the passive safety of EVs. By providing a detailed analysis of the system's design and performance, we aim to inform future research and development in this area and contribute to the ongoing efforts to improve the safety and sustainability of EVs.

Date	Place	Vehicle model	Incident	Comments
Jan	Chongqing China	Tesla, BEV	Fire in parked vehicle	Sudden ignition
March 18	Bangkok Thailand	Porsche Panamera PHEV	Fire while incharge	Absence of inbuilt safety system
March 25	Catalonia Spain	BMW i3 REx, PHEV	Fire while parking	Sudden ignition
march 23	California USA	Tesla model X, BEV	Accident	Fire extinguisher but happened again
May8	Florida, USA	Tesla model S, BEV	Accident	Fire exhausted but ignited while loading ontow truck
May 15	Ticino, Switzerland	Tesla, BEV	Accident	Bursted into flames after hitting a barrier
May 21	Hubei China	Zhong Tai, BEV	Fired while driving	Self-ignited

Dec 12	Gelderland Netherlands	Jaguar I-pace, BEV	Fire while parking	Front part was burned
Dec 18	California, USA	Tesla model S	Fire while parking	Fire reignited twice

Table 1.1 List of EVs firing up in the year of 2018 in different places.

CHAPTER-2

LITERATURE SURVEY

M. J. A. Khan, M. Imam, R. J. Uddin, and M. Sarkar, "Automated firefighting system with smoke and temperature detection," in 2012 7th International Conference on Electrical & Computer Engineering (ICECE), 2012, pp. 232-235.

Here they have created an automated firefighting mechanism with locally available components in the market. The system can react in the presence of smoke or high temperatures. If any or both of them crosses a certain limit and is sensed, the alarm turns on warning and the valve of a water spraying nozzle opens up to extinguish the fire. The presence of smoke and temperature is sensed by the change of resistance of a LDR or a NTC accordingly. A latch circuit is incorporated to make the alarm goes on continuously. The system is effective and as well as affordable

T. Chen, H. Yuan, G. Su, and W. Fan, "An automatic fire searching and suppression system for large spaces," Fire safety journal, vol. 39, pp. 297-307, 2004.

A novel approach of near-field computer vision (NFCV) used to be developed to display the jet trajectory in the course of the jetting process, which was once used to exactly predict the falling factor function of the jet trajectory. By ability of a high-resolution webcam, the NFCV sensor gadget gathered near-field photos of the jet trajectory.

F. Yuan, "An integrated fire detection and suppression system based on widely available video surveillance," Machine Vision and Applications, vol. 21, pp. 941-948, 2010.

A built-in gadget based totally on video surveillance is introduced for computerized fire detection and suppression. The gadget is composed of two modules, which includes flame detection and fire suppression. The furnace detection module makes full use of typical CCD cameras for furnace recognition. Some spatio-temporal features, such as

color and motion, are extracted to become aware of flame in actual time via making use of sequential photo processing techniques. Once a furnace is detected, the device will manipulate the fire suppression module to extinguish the fireplace automatically. It in general consists of manage device, cellular device, and water gun. Experiments carried out in a giant area corridor exhibit that the built-in device can observe a fireplace about a few seconds after ignition and mechanically suppress the fireplace quickly.

A Review of Battery Fires in Electric Vehicles January 2020 Fire Technology DOI:10.1007/s10694-019-00944-3 Projects: Battery fires Fire Safety of Lithium-Ion Batteries in Road Vehicles.

In this paper they have talked about battery fires methods to suppress the fire. They have also given the data of burned passenger cars in the year of 2018. It includes about the toxic gases of EV while burning and the growing demand for electric vehicles.

In terms of control systems, the existing automatic fire extinguisher system uses an Arduino MEGA as the microcontroller to monitor for signs of a fire and trigger the release of the extinguishing agent. Which was done by Manas Kulkarni, et al. (April 2020). While effective, this system could potentially be improved through the use of more sophisticated sensors and algorithms that can more accurately detect and respond to fires. There is a need for further research and development of automatic fire extinguisher systems that are more effective and suitable for use in confined spaces such as electric vehicles. This could include the development of new fire suppression agents, as well as more sophisticated control systems that can better detect and respond to fires. Because the extinguisher that had been used is an ABC powder which will cause visibility problems when in use.

Smoke and fire sensors are critical components of any automatic fire extinguisher system. These sensors are designed to detect the presence of smoke or fire and send signals to the microcontroller. Dr. (Mrs.) Saylee Gharge, et al. (July 2014), developed a system to detect fire and smoke which are being captured by a camera. There are several types of sensors used in fire detection systems, including optical, ionization, and heat detectors. Each type of sensor has its own strengths and limitations, and the choice of sensor will depend on the specific application and the level of sensitivity required.

Arduino UNO is a popular micro-controller board that can be used for IoT projects

which has come into the Indian market in the recent years it has numerous applications especially in development of VLSI test bench especially of sensors which was tested by Leo Louis. (July 2018). In the context of an automatic fire extinguisher system for electric vehicles, the Arduino can be connected to smoke and fire sensors to detect the presence of a fire.

Carbon dioxide (CO₂) fire extinguisher is being used in this experiment which is commonly used in indoor environments as they are effective in extinguishing fires without leaving residue or causing visibility issues. The 2-4 kg gas inside CO₂ extinguishers is stored in a high-pressure container and released as a cold gas that displaces oxygen, thereby suppressing electrical fires explained by Anirudha Kulkarni. (September 2020). Several studies have explored the efficacy and safety of CO₂ fire extinguishers, including their impact on human health and the environment.

CHAPTER-3

AIM AND OBJECTIVE

SCOPE OF PRESENT INVESTIGATION

Passive safety systems play a critical role in electric vehicles' safety, especially in the event of an accident. To establish a reliable passive safety system, electric vehicles must incorporate various technologies that can help minimize the damage in case of an unfortunate situation. One such technology is the incorporation of an automatic fire suppression system. These systems can detect and extinguish fires quickly, minimizing the risk of severe damage to the vehicle and passengers. By integrating such systems, electric vehicles can help reduce the risk of fire catching up problems.

To ensure passenger safety in electric vehicles, the design must prioritize the use of fire-resistant materials in critical components such as the battery pack and wiring harnesses. Additionally, implementing strict quality control measures can help detect any faulty components or manufacturing defects that can lead to potential fires. By prioritizing passenger safety, electric vehicles can instill consumer confidence and reduce the likelihood of accidents or damage to the vehicle.

Finally, to maximize vehicle safety, electric vehicle manufacturers must continuously innovate and improve their passive safety systems. They must also prioritize the use of environmentally friendly fire suppression agents that minimize harm to the environment and ensure the vehicle's longevity. By doing so, electric vehicles can offer consumers the benefits of both environmental friendliness and reliable passive safety systems. In conclusion, a reliable passive safety system must incorporate fire suppression systems, fire-resistant materials, strict quality control measures, and eco-friendly fire suppression agents to ensure both passenger and vehicle safety.

CHAPTER-4

MATERIALS AND METHODS

4.1 EXPERIMENTAL PROCEDURE

The creation of an automatic cap opening and closing mechanism for a CO2 fire extinguisher cylinder involved several steps that were critical to the success of the project.

4.1.1 WELDING

Welding, which is also known as electric arc welding, is a process that uses an electric current to create an arc between the welding electrode and the metal being welded. The heat generated by the arc melts the metal and creates a weld. In welding, aluminum is commonly used as a welding material due to its lightweight and high strength-to-weight ratio. This process is ideal for joining aluminum alloys that are used in the aerospace industry, as well as in the construction of boats and automobiles.

On the other hand, gas welding is a process that uses a flame to heat the metal being welded. In this process, a mixture of gases such as oxygen and acetylene, propane or natural gas is used to create a high-temperature flame. Gas welding is versatile and can be used to weld a wide range of materials, including steel, aluminum, copper, and brass. One of the most common gas welding methods is oxy-fuel welding, which uses a combination of oxygen and a fuel gas such as acetylene to produce the flame. This process is often used in industries such as metalworking, automotive repair, and manufacturing.



Fig :4.1 gas welding of ring gear

Two gears have been customized, one for the cap and one for the motor. A ring gear with a diameter of 40 mm has been selected for the welding process because removing the cap is essential during the refilling process. So, the experiment was carried out while satisfying necessary conditions like refilling. To create the gear setup, welding equipment was used to attach another gear with a diameter 56 of onto a bolt with clearance, which would be connected to the motor's shaft caliper because in that way if the motor is busted then a new motor can be replaced. During the welding process of motor gear, thin aluminum rods have been used. Copper rods were used for the gas welding process of cylinder gear, as they provided a high level of durability and strength. Gas welding was done using both oxygen and carbon dioxide gases, which were chosen for their ability to weld various types.



Fig: 4.2 welded gear for wiper motor

of metals. Two metal washers, one is aluminum and another one is made of iron with diameters 20 and 40mm respectively have been sandwiched between copper valve and the gear of cylinder for gas welding during the customization of the cap.



Fig 4.3: Gear assembly of wiper motor and CO2 fire extinguisher

4.1.2 GRINDING

Grinding is a post-welding process that involves the use of an abrasive wheel or disc to remove excess material and smooth out the surface of the welded joint. After welding, the surface of the metal may be uneven, rough, or have excess spatter, which can compromise the integrity of the weld. Grinding helps to restore the surface to a smooth and even finish, ensuring that the joint is strong and secure. The abrasive wheel or disc spins at high speeds, and the friction generated between the abrasive material and the metal surface causes the excess material to be removed. Grinding can be done by hand, using a handheld grinder, or with the use of a grinding machine. Depending on the size of the welded joint and the amount of material that needs to be removed, grinding can be a time-consuming process. In addition to creating a smooth and even surface, grinding also helps to prepare the welded joint for additional treatments, such as painting or coating. An angle grinder machine was used to smooth out any rough edges or imperfections on the welded surfaces .



Fig: 4.4 grinding process of the welded part



Fig 4.5: side and top view of grinded ring gear

4.1.3 SOLDERING

Soldering is a process of joining two or more metal pieces together using a filler metal called solder. The process involves heating the metal pieces to be joined and then applying the solder, which melts and flows into the joint, creating a strong and permanent bond. Soldering is commonly used in electronic and electrical applications, as well as in plumbing and jewelry making. Soldering is done to create a strong and permanent joint between metal pieces, without the need for welding or other more complicated methods of joining. It is also a useful technique for joining metals with dissimilar melting points, as the solder has a lower melting point than the metal being joined. Additionally, soldering is a relatively quick and inexpensive process, making it a popular choice for a wide range of applications.

After the gear setup was completed, the hardware connections were made using

soldering process for a strong metal bond between joints. This ensured a secure connection between the various components, including the fire sensors, dc-dc step down voltage regulator, a two- dimensional relay and a bread board for all the connections that were connected to Arduino UNO in fig 4.6.

4.2 MATERIALS

4.2.1 ARDUINO UNO

Arduino UNO is an open-source microcontroller board based on the ATmega328P chip. It is used by makers, hobbyists, and professionals alike for a wide range of projects, from simple LED blinkers to complex robotics and automation systems. One advantage of using Arduino UNO is its ease of use, as it comes with a user-friendly IDE and a vast library of pre-written codes and tutorials, making it ideal for beginners. Another advantage is its versatility, as it can be easily extended with various shields and modules, allowing users to customize and scale their projects to fit their needs.

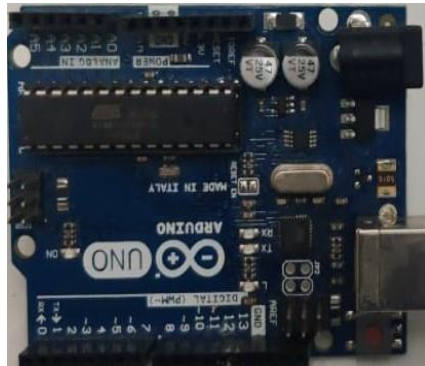


Fig 4.6: Arduino UNO

4.2.2 BATTERY

A 15-volt lithium-ion battery has been used. It is a rechargeable battery that uses lithium ions as its primary source of energy. These batteries are commonly used in laptops, power tools, and electric vehicles due to their high energy density and long-life span. One advantage of a 15-volt lithium-ion battery is its ability to store a large amount of energy in a compact size, making it ideal for portable devices. Additionally, these batteries have a low self-discharge rate, meaning they can hold their charge for longer periods compared to other types of rechargeable batteries.



Fig 4.7: Li-Ion battery

4.2.3 DC-DC CONVERTER

A DC-DC converter is an electronic circuit that converts a DC voltage level to another DC voltage level. It is used in a circuit to regulate or step up/down the input voltage to match the requirements of a load or other circuit components. DC-DC converters are widely used in electronic devices such as mobile phones, laptops, and power supplies to efficiently manage power consumption and reduce energy waste. They offer advantages such as higher efficiency, smaller size, and reduced heat generation compared to traditional linear regulators. DC-DC converters come in various types such as buck, boost, and buck-boost, each designed for specific voltage level conversion needs.



Fig 4.8: dc-dc converter

4.2.4 2-CHANNEL RELAY

A 2-channel relay is a device that is commonly used in electronic and electrical circuits to switch high voltage or high current loads on and off. It consists of two independent relays, each with a normally open and normally closed contact. The relay is used to isolate a low voltage control signal from a high voltage power supply, providing safety to the user and the electronic device. It allows control of a high-powered circuit with a low-powered circuit. A 2-channel relay is often used to control the power supply to devices such as motors, lights, and appliances, enabling them to be turned on and off remotely, or automatically as per the circuit's requirements. In addition to controlling power supply, the relay is also used as a safety mechanism. If a short-circuit occurs in the circuit, the relay will cut off the power supply, acting as a fuse and preventing damage to the devices and the circuit. The 2-channel relay is available in different types, including electromechanical and solid-state relays. The electromechanical relay uses a mechanical switch, while the solid-state relay uses electronic switching elements, such as transistors or thyristors. The choice of relay depends on the application, load, and the required switching speed. Overall, the 2-channel relay is a versatile device that provides a safe and efficient means of controlling high-powered circuits and protecting against faults such as short-circuits.

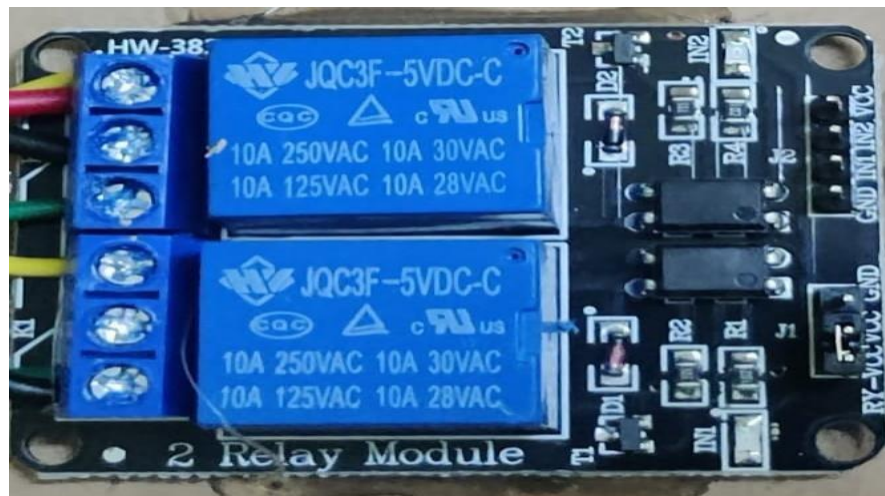


Fig 4.9: 2 channel relay module.

4.2.5 WIPER MOTOR

A wiper motor is an electric motor that powers the windshield wipers on automobiles. It is typically mounted on the vehicle's firewall or on the wiper assembly. The motor is designed to provide a good amount of torque to operate the wipers efficiently, even under heavy loads such as when wiping snow or debris from the windshield. The wiper motor is usually controlled by a switch on the dashboard, which sends a signal to the motor to turn on and off at the desired speed. Most modern wiper motors are made using permanent magnet technology, which allows for a smaller size, lighter weight, and higher efficiency. In addition to windshield wipers, wiper motors can also be used in other applications, such as in the marine industry for controlling boat windshield wipers. The wiper motor is an essential component in ensuring driver visibility during inclement weather conditions, making it a crucial safety feature in automobiles. Regular maintenance of the wiper motor, such as checking the wiper blades and ensuring proper lubrication, is important to ensure optimal performance and longevity of the motor. In some cases, wiper motor failure can be caused by a blown fuse or a faulty switch, and these issues should be addressed before replacing the motor itself. Overall, the wiper motor is a vital component in maintaining safe driving conditions and providing clear visibility for the driver.

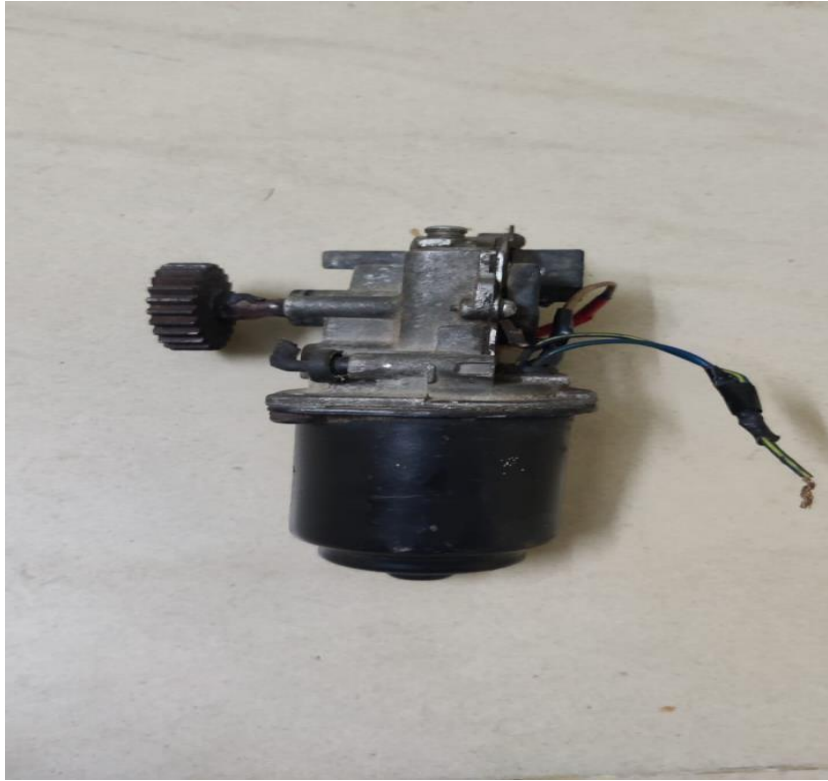


Fig: 4.10 wiper motor with welded gear

4.2.6 PIPE

A threaded water pipe is a versatile component that can be used in various applications, including filling water containers or as a hose pipe for a fire extinguisher cylinder. In a fire extinguisher system, the threaded water pipe is used to transport water from the source to the cylinder, which is then dispersed through the nozzle holes in case of a fire. The nozzle holes are drilled into the pipe at desired locations, allowing for targeted water dispersal and maximum effectiveness in extinguishing the fire. Threaded water pipes are often made from high-quality materials, such as PVC or stainless steel, to ensure durability and a long lifespan. Their threaded ends make them easy to connect to other components in the system, such as valves or other pipes. In our project, we used a 1200mm long threaded water pipe as a hose pipe for the fire extinguisher cylinder, taking advantage of its long life and resistance to corrosion. Proper maintenance of the threaded water pipe is important to ensure optimal performance and prevent any leaks or damage that could

compromise the effectiveness of the fire extinguisher system. Overall, threaded water pipes are an essential component in fire safety systems and provide a reliable and long-lasting solution for transporting water and extinguishing fires.



Fig 4.11: threaded pipe

4.1.7 FIRE SENSOR

A fire sensor is a device designed to detect the presence of fire or smoke in a building or other enclosed space. It is typically connected to a fire alarm system, which will sound an alarm and alert occupants to the potential danger. The fire sensor works by detecting the particles or gases produced by a fire or smoke, using various methods such as ionization, photoelectric, or heat detection. One important component in a fire sensor is the potentiometer, which is used to adjust the sensitivity of the sensor. The potentiometer is essentially a variable resistor that can be adjusted to change the voltage or current flow in the sensor circuit. By adjusting the potentiometer, the sensitivity of the sensor can be changed to suit the specific environment in which it is being used. For example, in a kitchen or other area with a high likelihood of false alarms, the potentiometer can be adjusted to make the sensor less sensitive to minor smoke or heat fluctuations. In contrast, in an area with a high risk of fire, such as a chemical storage facility, the potentiometer can be adjusted to increase the sensitivity of the sensor, ensuring that any signs of a fire are detected quickly. Overall, the potentiometer is an essential component in the fire sensor, allowing for fine-tuning of the sensitivity to ensure optimal performance and minimize the risk of false alarms or undetected fires.

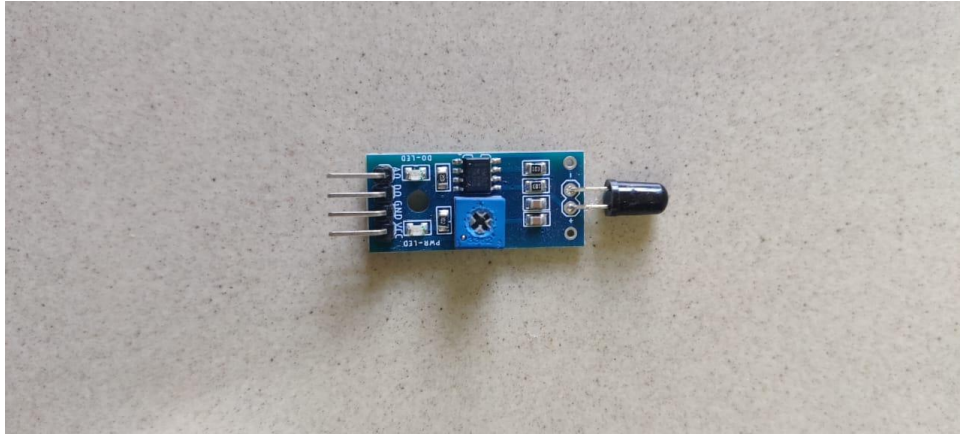


Fig 4.12: fire sensor

4.2.8 U-BOLTS

U-bolts are a type of fastener that are shaped like the letter U and are commonly used to secure pipes, tubes, and cylinders to a surface. They are known for their rigidity and strength, which makes them an ideal choice for applications where the load is heavy and needs to be securely fastened. In the case of CO₂ fire extinguishers, U-bolts are used to attach the cylinder to a wooden board or other surface for stability and ease of access. These bolts typically have a diameter of 3mm, which makes them suitable for a range of applications, including those involving smaller or medium-sized loads. The use of washers in conjunction with U-bolts can help to improve their performance and ensure a better, tighter fit. The washers also help to distribute the load more evenly across the surface being secured, which can help to reduce the risk of damage or failure. When installing U-bolts, it is important to ensure that they are tightened to the recommended torque specification to avoid overloading or damaging the bolt or the surface to which it is attached. U-bolts can be made from a range of materials, including stainless steel, galvanized steel, and zinc-plated steel, depending on the application and environment. They are commonly used in the construction, marine, and automotive industries, among others. U-bolts are a versatile and reliable fastener for this project



Fig 4.13: U-bolts

4.3 CONTROL ALGORITHM

A code of 58 lines using embedded C has been integrated into the Arduino UNO. An inbuilt library called 'serial' has been used to enable communication between Arduino UNO and the computer using a USB cable. Several functions have been used to build the code like 'setup()' it initializes the serial communication, sets the input/output pins, and sets the initial state of the relays, 'loop()' it checks the sensor data and triggers the wiper motor and relays based on the sensor readings, 'sensor data()' this function reads the data from the fire sensor and updates the fire-value variable based on the sensor readings. 'Fmotor()' and 'Rmotor()' functions are used to run the wiper motor in forward and backward directions and 'allmotorclose()' is used to stop the wiper motor rotation after the demonstration is done. While in real live scenarios the motor doesn't have to rotate in reverse direction until the fire is totally extinguished, this can be achieved with some changes to the code which is embedded in the microcontroller. These sensors would trigger the automatic mechanism to activate the wiper motor which cranks the cylinder's gear allowing the cylinder to open in the event of a fire with a torque of 5Nm.

4.3.1 INTEGRATED CODE OF ARDUINO UNO

```
#define FIRESENSOR 3

bool flag1 = false;
const int period1 = 1100;
volatile unsigned long time_now1 = 0; const int period2 = 1000;
volatile unsigned long time_now2 = 0; const long event_1_sensorA = 50; //in ms volatile
unsigned long previousTime_1 = 0; volatile int firevalue=1;

void setup() { Serial.begin(9600);
  pinMode(FIRESENSOR,INPUT);

  pinMode(FORWARDRELAY, OUTPUT); pinMode(REVERSERELAY, OUTPUT);
  digitalWrite(FORWARDRELAY, HIGH); digitalWrite(REVERSERELAY, HIGH);
}
void loop() {

  Sensor_data();

  if ((firevalue==0) && (flag1==false)) {

    Fmotor(); delay(1000); allmotorclose(); flag1=true;
  }
  if ((firevalue==1) && (flag1==true)) Rmotor();
  delay(1000); allmotorclose(); flag1=false;

}
}

void Sensor_data(){

  /* Updates frequently */
  volatile unsigned long currentTime = millis()
```

```

/* This is my event_1 */
if (currentTime - previousTime_1 >= event_1_sensorA) {
  //Serial.print("SENSOR A:");
  firevalue = digitalRead(FIRESENSOR); Serial.println( firevalue);
  /* Update the timing for the next event*/ previousTime_1 = currentTime;
}
}

void Fmotor() {

  time_now1 = millis();
  // Serial.print("on"); digitalWrite(FORWARDRELAY, LOW); while (millis() < time_now1
  + period1) {
  }
  digitalWrite(FORWARDRELAY, HIGH);
}

void Rmotor() {
  time_now2 =
  millis();
  // Serial.print("on"); digitalWrite(REVERSERELAY, LOW); while (millis() < time_now2 +
  period2) {
  }
  digitalWrite(REVERSERELAY, HIGH);
}

void allmotorclose(){ digitalWrite(FORWARDRELAY,
HIGH);digitalWrite(REVERSERELAY, HIGH);
}

```

4.4 WORKING

Whenever there is a fire accident the fire sensors which are previously installed sense it and send signals to the controller, which in this case is an Arduino UNO. All the sensors and Arduino UNO receive an external voltage supply of 12 V after regulating to required voltage using a buck converter. It allows DC current to reach wiper motor which then cranks cylinder's gear through a 2 channel 5V relay so that the relay can act as both a switch and a fuse to save Arduino UNO from getting damage if there is an abnormal power supply. The current supply is achieved with the help of a 15V battery. which finally allows the gas to flow into the hose pipe resulting in the stopping of further fire spread in battery compartment or any other desired locations. In summary, the creation of an automatic opening and closing mechanism for a CO2 fire extinguisher involved a careful design process of welding and soldering techniques to create the gear setup and hardware connections. With the automatic mechanism, the fire extinguisher can be activated quickly and efficiently, providing greater protection against potential damage or injury.



Fig :4.14 final customized cap mechanism of CO2 fire extinguisher



Fig: 4.15 top view of bare CO2 fire extinguisher



Fig 4.16 front view of the prototype



Fig 4.17: side view of the prototype

CHAPTER-5

RESULTS AND DISCUSSIONS

In **fig 5.1**, the circuits connections between Arduino UNO, dc-dc converter, a wiper motor, fire sensor, battery and a 2-channel relay. The NO and NC pins of the relay are connected together with battery positive and negative terminals respectively. The common (CO) pins are connected with wiper motor's positive and negative terminals. The voltage is regulated as it flows through buck converter. The VCC pins of relay and sensor are connected. The inputs of the relay are connected to 5 and 6 volts of digital analog of Arduino UNO. The analog input's ground and 5 V pins of Arduino UNO are connected to the fire sensor.

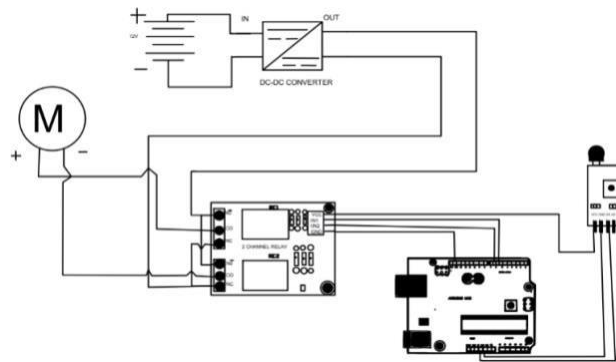


Fig 5.1Circuit diagram

The cylinder with a height of 580mm and with a diameter 108mm is installed because it's smaller compared to the other ones in the market. A hosepipe of diameter of 20 mm and of length 1200mm with nozzles was then installed to release the CO₂ gas at desired locations. To hold the fire extinguisher cylinder in place, a wooden board of 600x320x10mm which contains 2KG gas was used, along with two U bolts of 3mm diameter bolted to the wooden board to secure the cylinder from moving around while operating. Regular testing and maintenance of the fire extinguisher is important to ensure that it remains in good working condition. This includes checking the mechanism, hose pipe, nozzles, and sensors periodically to ensure that they are functioning properly. A rubber hose pipe has been used for the circulation of gas throughout the battery pack. The effectiveness of this experiment depends on the sensing ability of the sensors used. In this experiment fire sensors have been used to detect the fire which usually emits

infrared rays. Those rays can be detected with the help of an infrared light on the fire sensor.

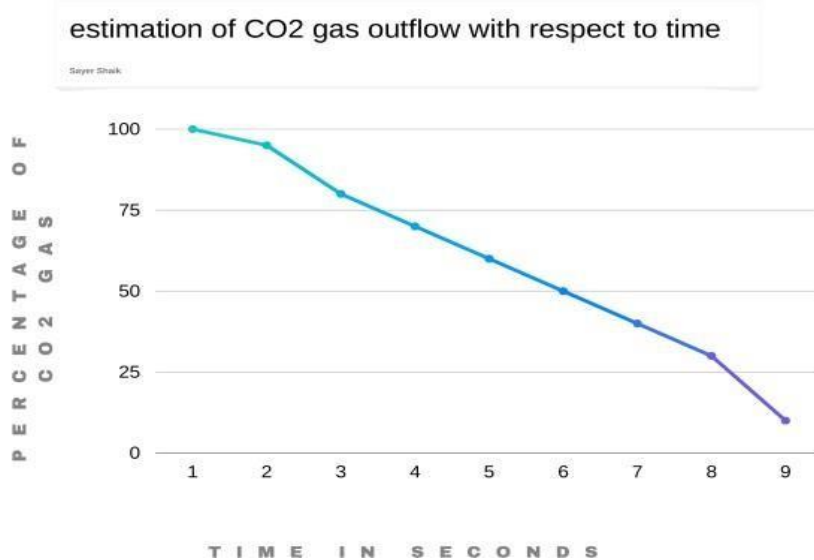
The sensitivity of the sensor can be adjusted by loosening or tightening a screw of the potentiometer of the fire sensor. Table.2 shows the sensor status at different temperatures.

level	Temperature in degrees	Sensor Status
Low (room temperature)	Below 30	Inactive
medium	30-40	Inactive
high	40-50	Inactive
Firing	Over 50	Active

Table.5.1: status of sensor at different temperatures

A ring gear with 21-teeth and with diameter 40 mm has been used for the cap of cylinder and a 24-teeth gear with a diameter 56 has been used for the wiper motor. The gear ratio of the two gears used in this experiment is 1.14 rpm.

It took 9 seconds to empty the fire extinguisher. Graph 2. is showing estimation of the rate of gas outflow with respect to time.



Graph 5.2: Estimation of CO2 gas outflow with respect to time

CHAPTER-6

CONCLUSION

In conclusion, the automatic fire extinguisher system for electric vehicles presented in this journal paper represents a significant step forward in ensuring the safety of passengers and drivers in the event of a fire. By integrating the code into the Arduino UNO, we have developed a system that can be easily integrated into the vehicle's ECU, providing an added layer of protection against fire hazards. The use of fire and smoke sensors, along with the gear setup for opening and closing the fire extinguisher cap, has enabled us to create a robust and effective fire extinguishing system that can detect fires quickly and extinguish them before they can spread, potentially saving lives and preventing significant property damage. Moreover, this prototype can be installed in a variety of electric vehicles, such as cars, buses, and vans, providing a much-needed safety measure for these increasingly popular modes of transportation. With the rise of electric vehicles, it is essential that we take steps to ensure their safety, and this automatic fire extinguisher system is an important step in that direction. In addition, this system can be further improved by incorporating machine learning algorithms, which can analyze the data from the sensors and provide more accurate and timely responses to potential fire hazards. This is particularly relevant given the increasing complexity of electric vehicle systems and the potential for multiple failure points. Overall, we believe that this automatic fire extinguisher system for electric vehicles represents a significant advancement in vehicle safety, and we hope that it will be widely adopted in the industry to ensure the safety of passengers and drivers alike.

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