

Integration of Smart Sensors and Actuators for a Fully Automated 360° Fire Suppression System

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Abstract

In today's modern era fire safety continues to be a major concern. Therefore, creating a dependable fire safety system is essential. This abstract represents an innovative solution: a 360-degree rotating fire protection system. This system is designed to revolutionise fire suppression by offering comprehensive coverage of enclosed spaces and it also reduces the damage done to surroundings during fire suppression as well as reduces the risk of human life. This system is equipped with a nozzle that rotates via motors and sensors are provided for fire detection. The nozzle is connected through a pump and all of these are associated with a fire alarm panel where all these are automatically controlled. 360-degree rotating fire protection system is an advancement in fire suppression systems and represents improvements in fire safety technology.

Keywords: Design, motors, pumps, smart sensors, actuators

INTRODUCTION

In the case of a fire, fire safety systems are essential preventative measures designed to provide building occupants with prompt notification and guidance on how to safely evacuate the facility. Smoke detectors and pre-installed sprinkler systems are the most immediate fire prevention tools available today [1]. But these types of Systems' efficacy is low because they lack the fire's precise target and selective targeting. Fabricated Model of 360° Rotating Fire Protection System is shown in Figure 1.

OBJECTIVE

The main objective of this project is to reduce the risk of life caused by the fire, prevent the occurrence of fire and explosion, and damage to cargo and warehouses. Its objective is to provide comprehensive coverage and efficient detection, suppression and mitigation of fire from all directions within a designated area or space.

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PROBLEM STATEMENT

Ensuring the security of homes, laboratories, offices, factories, and buildings is crucial for protecting human lives. We have developed an advanced security system that includes a remotely controlled 360-degree fire protection mechanism, incorporating sensors and a motorized pump with movable wheels. Unlike traditional fire protection systems, which often rely on manual lifting mechanisms, our design allows for mobility with wheels attached to the unit. The system can be activated and controlled remotely to extinguish

fires. Fire outbreaks are known to result in severe loss of life, property, and pose significant risks to both victims and rescuers. Given the high temperatures and the presence of dangerous materials, fire-fighting robots prove especially valuable in combating fires in areas where human intervention is not feasible. These robots help minimize injuries by performing fire suppression tasks in dangerous environments. Traditional sprinklers often release small amounts of water that may not be sufficient to fully extinguish a fire. Additionally, they tend to spray indiscriminately across a floor or building, potentially damaging valuable equipment, furniture, and documents.

ADVANTAGES OF THE SYSTEM

If we talk about the traditional fire fighting systems they are very costlier, not all are able to afford them, We have built a system which is moderate and affordable to all. This model has many advantages such as:

1. No harm is done to the remaining area because the water sprayed is only to where the fire has been located [2].
2. This system is easy to understand and anyone can understand, tend to operate it [3].
3. This system is automated so it reduces the loss of human life.
4. Nozzle used is adjustable to ensure water is sprayed to its wanted distance [4, 2].

Research Gap

Addressing the research gaps can help advance the understanding and implementation of the 360-degree rotating fire protection system, ultimately enhancing fire safety measures and reducing risks of fire-related incidents in various settings. Researching the optimal design configuration and placement of the system within industries and warehouses to maximise coverage and effectiveness in detecting and suppressing fires.

Exploring the challenges and opportunities of integrating 360-degree rotating fire protection systems existing traditional fire protection systems, alarms, emergency response and overall safety measures. Accessing the environmental impact of 360-degree fire protection systems, including their energy consumption, use of resources, and potential emissions and exploring it improves every aspect through technology.



Figure 1. Fabricated Model of 360-Degree rotating fire protection system.

EXPERIMENTAL RESEARCH

The nozzle, pump, motors and fire alarm panel. All are fixed on the metal plate stand (90*43). A metal pipe is mounted on the metal screw, at the top of the pipe a dc motor of 24 volts is fixed at the centre. On the shaft of that motor, a circular aluminium disk is placed which helps in the rotation of the nozzle. Below the nozzle on the disk, another DC-gear motor of 12 volts is placed which provides up-down motion for the nozzle.

The nozzle's length is nearly about 3m which end is fixed with a water pump which is 1 hp. A wooden plank is used where flame sensors, hooters and fire alarm panels are fixed. This plank is joint on a metal frame, with ends attached to a metal plate stand. Whenever there is a fire, UV flame sensors will detect it and send a message to the panel ultimately the pump, hooter and motors will start working towards extinguishing flames. The fire will automatically go out once it has been put out.

List of Materials: List of Materials is shown in Table 1.

DESCRIPTION OF MATERIALS

Water Pump

Because of its special qualities and benefits, water pumps (Figure 2). are widely used in industries. In our model, we have used a 1HP Lubi centrifugal pump as per our requirement [5]. Water is pumped with this single-phase pump. The speed at which this product operates is 2880 rpm. It has a cast iron body and can draw water up to 20 feet. It runs on a single-phase power source. This type of pumps are typically used in domestic and industrial places.

Uv Flame Detector

We have used a ultraviolet flame detector to detect flame accurately. It has a range of 15-18m to detect flames. Its operating voltage is 24V. UV flame detector is shown in Figure 3 [6].

Fire Alarm Panel

An essential part of a fire alarm system is a fire alarm panel, sometimes referred to as a fire alarm control panel (FACP) or just an alarm panel [7]. It is a central hub that receives information from various fire detection devices such as UV flame detectors, smoke detectors and manual call points. Our Whole system is operated through this panel. Fire alarm panel is shown in Figure 4.

Table 1. List of Materials.

Sr. No.	Description	Quantity
1	UV conventional flame sensors	1
2	Fire Alarm panel	1
3	Manual Call point	1
4	Hooter	1
5	Relay	1
6	Ac Converter	1
7	Dc Converter	1
8	Dc Speed Converter	2
9	3 Way Switch	2
10	Wooden Plank	1
11	Bearings	2
12	Water Sprayer Nozzle	1
13	1 hp Water pump	1
14	Foot valve	1
15	wheels	4



Figure 2. Water pump.



Figure 3. UV flame detector.



Figure 4. Fire alarm panel.

Fire Hooter

Whenever the flame detector detects a fire, the fire hooter will make a sound that will alert the people surrounding it that a fire has taken place [8]. This plays a crucial role in emergency situations or whenever there is a fire accident. Fire hooter is shown in Figure 5.

Manual Call Point (MCP)

Also known as manual pull station. It's a device to manually activate a fire alarm system in case when sensors or detectors don't work. This is used only when the model does detect fire automatically. We have manually push the button to operate the system (Figure 6).



Figure 5. Fire hooter.



Figure 6. Manual Call Point.



Figure 7. Bearing.



Figure 8. Base frame.

Bearing

A bearing as shown in Figure 7 is a mechanical component that restricts relative movement to a specific type of motion while minimizing friction between moving parts. Depending on its design, a bearing may allow unrestricted linear motion of a part or enable smooth rotation around a stationary axis. Alternatively, it may restrict certain movements by managing the forces acting on the moving components. In most cases, bearings help achieve the intended motion by reducing friction. Here we have used bearing for the motion of nozzle's upward and downward movement [9].

Base Frame

Our Whole project including the fire alarm panel, metal pipe, pump, detector and the rotating disk is fitted on the base frame, we have given wheels to it so that it can be easily moved. It is made of metal plates and angles with wheels fitted at the end. Base frame is shown in Figure 8.

3-Way Switch

This switch is used to control the direction of the nozzle, we have used two switches, one to control the up-down direction of the nozzle and the second to control the right-left direction of the nozzle to provide 360 coverage as shown in Figure 9 [10].

DC Motors

We have used 2 DC motors as shown in Figure 10. To provide movement in horizontal and vertical directions. One motor is 12v and another motor is 24v. We have used a Worm geared motor

and another motor with planetary gear. We have used 2 DC speed controllers to control its speed according to its application.

DC Speed Controller

DC speed controllers as shown in Figure 11. are used to control the speed of the two motors we have used because to provide exactly the speed required for the motor to rotate horizontally and vertically. These controllers have an operating voltage of 24V.

Relay Driver

A relay is an electromagnetic switch that electrically isolates two circuits while connecting them magnetically. We have used it amplify the voltage of one of the motors as it was of 12V. Relay Driver is shown in Figure 12.

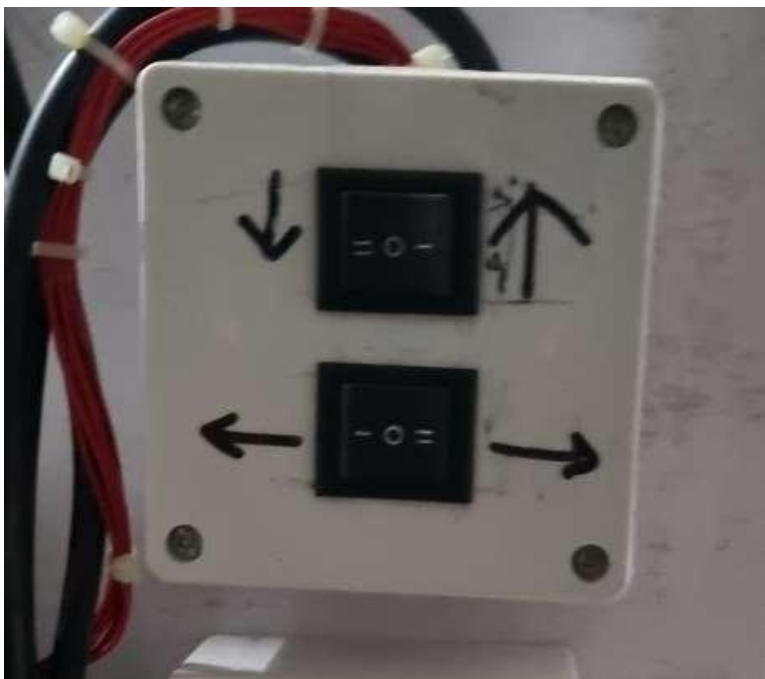


Figure 9. 3-Way switch.



Figure 10. DC motor.

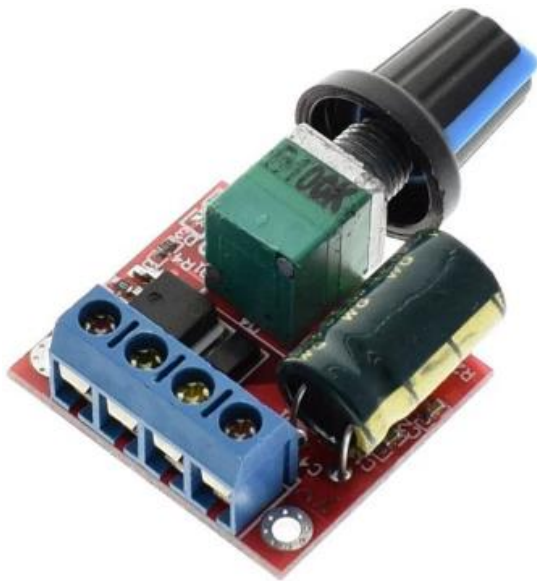


Figure 11. DC speed controller.



Figure 12. Relay driver.

Table 2. Comparison table based on different features.

Particulars	Traditional Fire Protection Systems	360-Degree Protection System
Coverage Area	Limited coverage area, usually focused on specific zones or area	Comprehensive Coverage across the entire space due to multi-directional sensors and devices
Detection Method	Smoke Detector, heat detectors or manual detection	Multi Sensors, Uv flame sensors which help in accurate flame detection.
Response Time	Response time can vary depending on the location of detectors and system design.	Response time is very quick compared to traditional systems
Suppression Method	Primarily uses fire extinguishers, sprinklers and blanket	Offers a combination of suppression methods with water-based and foam-based solutions.
Integration with other systems	May lack integration with other building systems, requiring separate monitoring and control.	Often integrated with building management systems (BMS) for centralized monitoring and control.
Maintenance requirements	Requires regular maintenance and testing of individual components.	Maintenance is streamlined with self-diagnostic capabilities and automated testing features.

RESULTS

The 360-degree fire protection system successfully detected and extinguished flames. UV Flame Sensors accurately detected flame and triggered the pump and motor to start. The System also includes a hooter to alert nearby individuals close to the fire.

Testing the systems under different conditions showed that they could detect fire at a distance of approximately 10m and could extinguish the fire. 360-degree fire protection was possible thanks to the system's ability to cover all directions. In comparison to our conventional firefighting systems, it has also shown itself to be more economical. The system's capacity to offer security and safety within the structure was a major benefit, guaranteeing people's protection from flames.

All things considered, the "360 Degree Fire Protection System" turned out to be a dependable and effective fire safety solution. Proving effective outcomes in identifying and putting out flames.

Comparison of Traditional Fire Protection System 360 Degree Rotating Fire Protection system: Comparison is shown in Table 2.

CONCLUSION

Comparing this prototype with existing technology we have implemented sensor and automation technology. Nowadays fire fighting is done manually but we tend to implement automation and wireless technology in the future. In conclusion, there are numerous ways to extinguish flames, but it is safer to employ this concept to minimize human involvement, which lowers the possibility of bodily harm and life-threatening situations.

Future Scope

For now, we are operating DC motors manually. Further, we can use them fully automatically by using Arduino UNO, which will rotate the nozzle according to the direction of the fire. Also, we can use Firefighting foam instead of water according to its application use. Further, we can use a camera for its live monitoring as it will be fully automated. The system can be adjusted to meet various needs depending on its intended use and the surroundings.

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