International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 6 [3]Septemebr 2015: 31-38

[ISO9001: 2008 Certified Organization]
www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA **ORIGINAL ARTICLE**

Development of a Smoke Detection and Fire Extinguishing System

Lutfun Nahar Nipa , Md. Rokunuzzaman
Department of Mechanical Engineering
Rajshahi University of Engineering & Technology (RUET) , Bangladesh
E-mail of the corresponding author : nahar_nipa@yahoo.com

ABSTRACT
This paper describes about the development of smoke detection and fire extinguishing system. Automatic fire detection and extinguishing system is important for early detection and promptly extinguishing fire. There are various studies investigating the best sensor combinations and appropriate techniques for early fire detection and automatic extinguishing system. Such capabilities can nicely get a lot more attentions in people and application to help the localization of fire where smoke sensors are used to be the sole source of information input. In this system, the smoke passes through the narrow channel between LED and LDR, then the control unit passes signal to the alarming and extinguishing system. In this case, smoke flame acts as an obstacle between LED and LDR. This system is able to work efficiently and effectively without any consideration of temperature either it is in warm or cold condition. In this paper, the developed system has the ability to detect fire as early as possible and at the same time, automatic fire extinguishing system starts working. The main facility of this work is the automatic disconnection of AC supply line to avoid the spreading of fire due to short circuit. This system also includes the automatic opening of emergency exit so that people can leave the affected area as soon as possible. This system is enough effective to aware people as early as possible about fire
Keywords:Smoke detection; Fire extinguishing system; Smoke sensor.

Received 15/07/2015 **Revised 12/08/2015** **Accepted 13/09/2015**

Citation of this article
Lutfun Nahar N , Md. Rokunuzzaman. Development of a Smoke Detection and Fire Extinguishing System. Int. Arch. App. Sci. Technol; Vol 6 [3] September 2015: 3138. DOI.10.15515/iaast.0976-4828.6.3.3138

INTRODUCTION

Fire hazards occur frequently in Bangladesh. Fire causes huge losses of lives and properties every year. Recently some tremendous firing catastrophes have been occurred in Bangladesh. On 6th January 2005, fire accident caused deaths of 23 people in a building housing factory [1]. On 24th November 2012, fire accident in Tazreen fashion factory also caused the deaths of 117 people along with the loss of almost 170 core taka [2]. These accidents occurred, because existing smoke detection and fire extinguishing system are not efficient for proper localization of smoke sources. When other sensors like electric fire alarming detector, combination of smoke and heat detector fails to reliably detect the odour of smoke and there is no movement of extinguishing system automatically, the developed photoelectric detection and extinguishing system is useful especially in those situations. In comparison the modified photoelectric system does not depend on temperature where the available conventional systems the detection process is fully dependent on temperature. To overcome these problems, automatic or robotic fire detection and extinguishing system should be used which can handle the situation of fire. On the other hand, the respective problems of conventional systems can be diminished by using the proposed system. The system consists of two smoke detective sensors. When smoke is created in any side of the closed room, the respective sensor sense the smoke and showing the ADC value of the smoke in the display. If the ADC value is higher than the programmed value, alarming of buzzer as well as extinguishing of fire (solenoid regulates spraying of water) will commence. During the intermediate time between sensing of smoke and extinguishing of fire, the alternate current (AC) supply line is disconnected with the help of a relay. The available emergency gate is opened according to the sensing performance of the opposite sensor.

Research in the area of automatic smoke detection is mainly focused on detecting smoke based on the combination of smoke and heat detective sensor. The detector greatly eliminates false alarms caused by

interference from nearby sources which depends on heat and intensity of smoke [3]. The electric fire alarming system, when flame radiation is initially detected, the Alarm Outputs, both relay contact and current loop are instantly activated [4]. Photoelectric smoke detectors use the principle of scattered or reflected light to indicate the presence of visual smoke. They work much like the automatic eyes used to open doors. When there's no smoke, the chamber is dark. If the fire has flames, a good ion chamber will detect it faster than a good photoelectric detector [5]. Fire fighting robots are excellent invention of science of new era. These robotic systems have automatic fire detection mechanism. The robot SCOUT finds fires with 3D thermal imaging. The robot uses a stereo camera and a thermal camera to generate 3D point clouds with thermal overlays, allowing the robot to autonomously generate maps showing hot spots and humans even through smoke [6]. In 2000, the research by Istre and Mallonee in Oklahoma and elsewhwre, suggest that 90% of American homes have smoke detectors in which 25-30% detectors inside resident did not work for various reasons of dead battery, battery taken out or a complete smoke detector malfunction [7]. In case of single point sensor there is a problems of proper localization of smoke. To overcome this localization problem a multi-criteria detector was invented by Boyer in 2010 [8]. Recently a project has been done on the basis of enhanced wireless control system for smoke and fire detection, by Rashedul Qayum, S.M Ehsanul Amin and Md Kamrul Hussain. It works on the principle of photoelectric detectors [9].

METHODOLOGY

System Overview

An overview of the system architecture is shown in figure 1, where all the modules or components interacts each other.

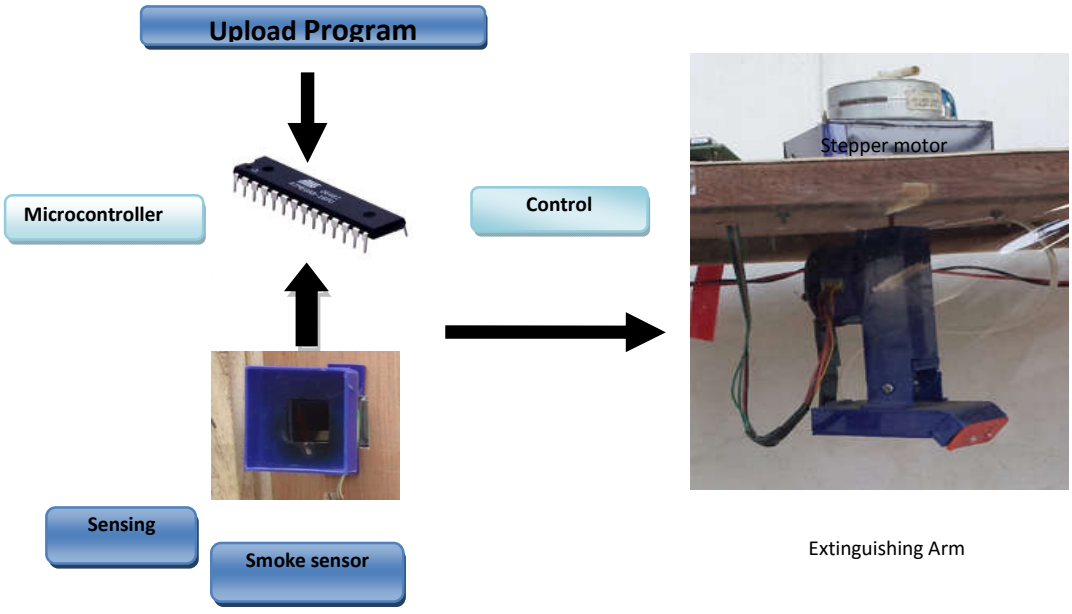


Figure 1: System architecture for smoke detector and fire extinguishing system

The smoke sensor senses created smoke while passing through it and then it gives a signal to the microcontroller. A program is uploaded into the microcontroller which sends a pulse to the stepper motor through which the extinguishing system rotates.

Smoke detection and fire extinguishing system

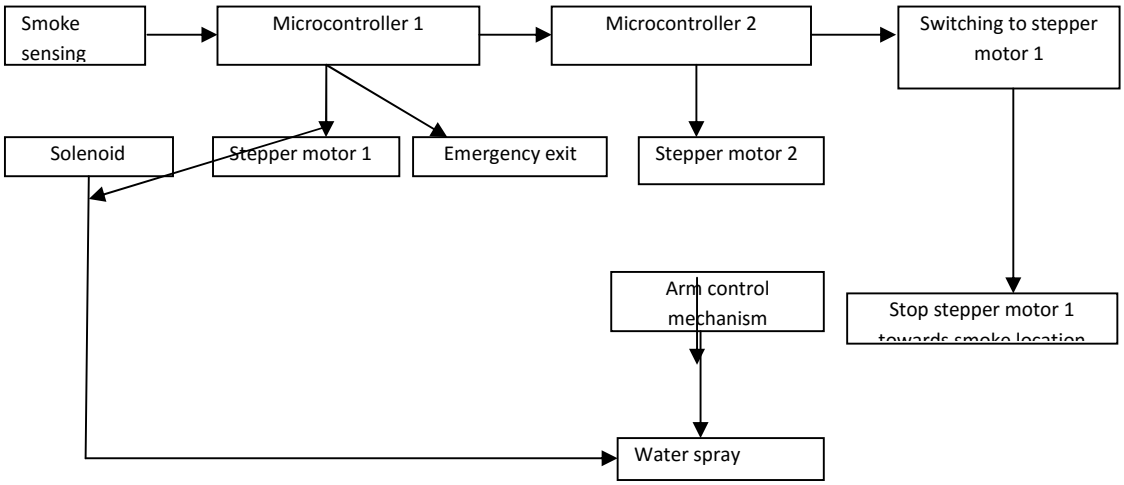
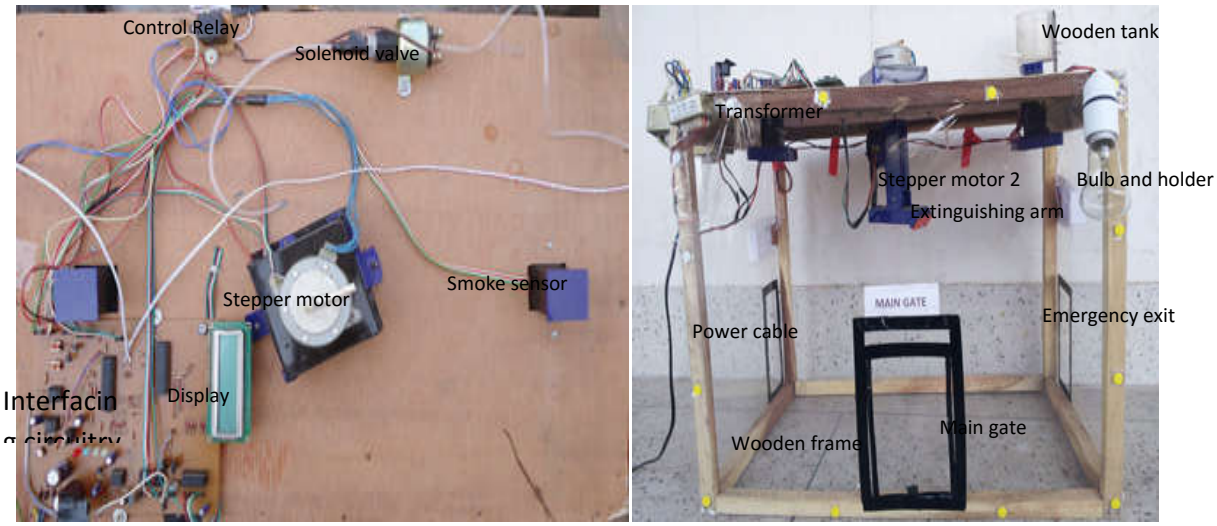


Figure 2: Flow Diagram of System

Figure 2 shows the flow diagram of our system. After sensing smoke it gives a pulse to the microcontroller 1 which helps to switched on the solenoid stepper motor 1 and emergency exit. A signal is given from microcontroller 2 for switching of stepper motor 1. The microcontroller 2 also gives pulse for switching of stepper motor 2. A solenoid valve helps to flow water from water tank to the extinguishing arm for spraying of water to the direction of smoke source.

Main Components of the developed System

The main components of the developed system are Control relay, Stepper motor 1, Interfacing circuitry, Solenoid valve, Smoke sensor , Display, Transformer , Stepper motor 2, Wooden frame , Power cable, Water tank , Bulb and holder, Extinguishing arm, Emergency exit with indicator, Main gate.



Top View Front View

Figure 3: Experimental setup for smoke detection and fire extinguishing system

Smoke Sensing System

Figure 4 shows the smoke sensing circuit for two smoke sensors. In this circuit smoke sensors, display, microcontroller (ATmega8) and a timer (LM 358) are used. Here timer (LM 385) is used for receiving an input from the sensor which gives a signal to ATmega8. A display is used to show the ADC value of microcontroller's output.

Figure 4: Smoke sensing system

Controlling System

In the controlling system, there are two microcontrollers are used. Microcontroller 1 controls only the stepper motors and gives a signal to the microcontroller 2 for switching. Moreover two transistors are used to passes a noiseless signal to the stepper motor and two timers are used for controlling the reset switch as well as buzzer respectively.

Fire extinguishing mechanism

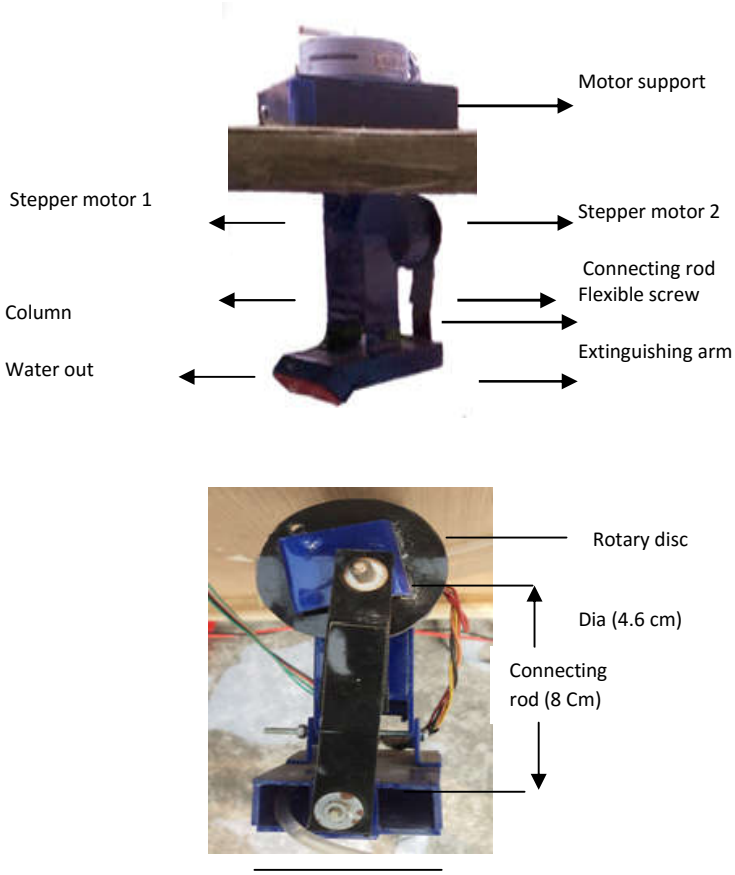


Figure 5: Fire extinguishing mechanism

Figure 5 shows the experimental setup for rotating the extinguishing system towards the latest fire detection point. This setup contains two stepper motor and an extinguishing system through which water

flows out. The stepper motor 1 can rotate 360 degree and thus rotates the whole extinguishing system towards the sensor which detects the latest point of smoke. The stepper motor 2 helps the extinguishing system to move up and down by using cranking mechanism. All the components are supported by wooden and partex board.

AC Supply Disconnecting System

After sensing smoke the smoke sensor gives signal to the microcontroller. Then the microcontroller passes a signal to the relay, which acts as a magnetic switch for automatic disconnection of the AC supply line. This disconnection of AC supply helps to avoid the spreading of fire due to short circuit.

Emergency Exit Opening System

When smoke is sensed by the smoke sensor then it gives a pulse to the microcontroller unit to open the emergency exit. In this system, a signal to the green LED light indicates the opening of emergency exit. In order to open the emergency exit a stepper motor and a rack-pinion must be needed.

Algorithm and Control Circuit of smoke detection & fire extinguishing system

Algorithm of smoke detection and fire extinguishing system

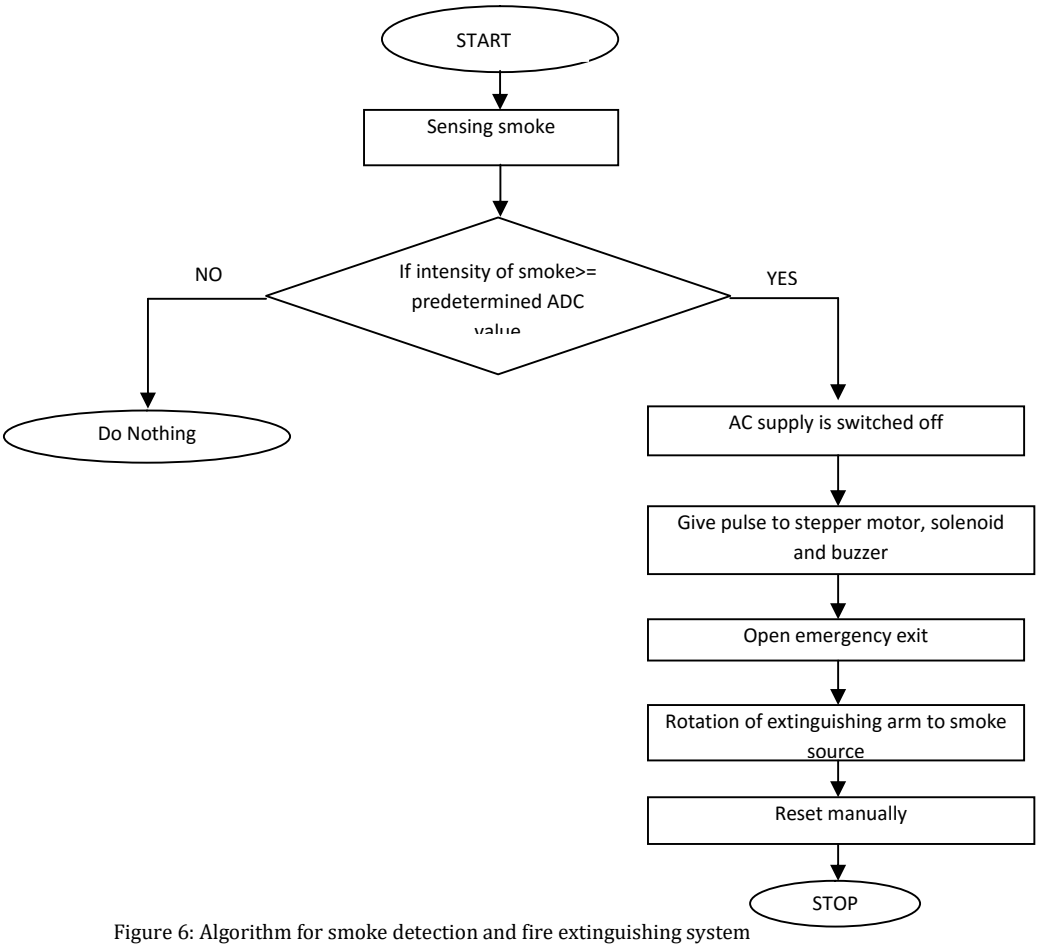


Figure 6: Algorithm for smoke detection and fire extinguishing system

Figure 6 shows the Algorithm for smoke detection and fire extinguishing system.

Circuit diagram for a smoke detection and fire extinguishing system

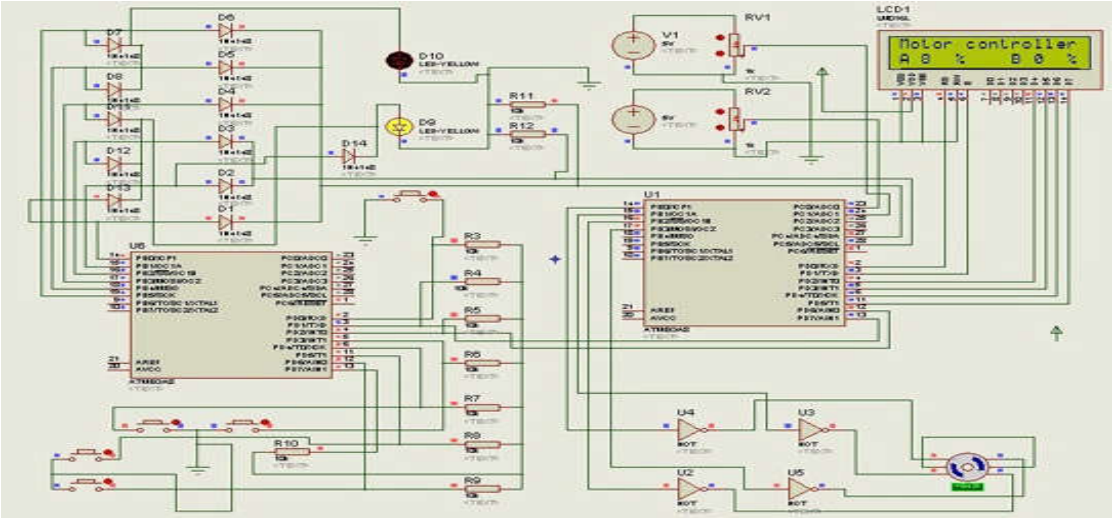


Figure 7: Circuit diagram for smoke detection and fire extinguishing system

Figure 7 shows the complete circuit diagram of smoke detection and fire extinguishing system. When smoke acts as an obstacle between LED and LDR in the smoke sensor, then it passes a signal to the microcontroller 1. So that microcontroller 1 gives a pulse to the stepper motor, display and microcontroller 2. Therefore, microcontroller 2 gives a signal to LED which is attached with the rotary disc inside the support box of stepper motor 1. There are two LDR inside the support box, which are preciously fastened with fixed disc. When the rotary disc moves with stepper motor 1, then the LED also moved. If the LED can passes a signal to the LDR (both are in support box), then the microcontroller 2 gives a signal to microcontroller 1 for switching. This switching helps to stop the stepper motor in the position, where the LED can pass signal to LDR.

RESULTS AND DISCUSSION

Experimental data

Sensing voltage when no smoke = 5.50 V.
Sensing voltage when smoke = 2.20 V.
Travelling time for stepper motor between sensors = 13.20 sec.

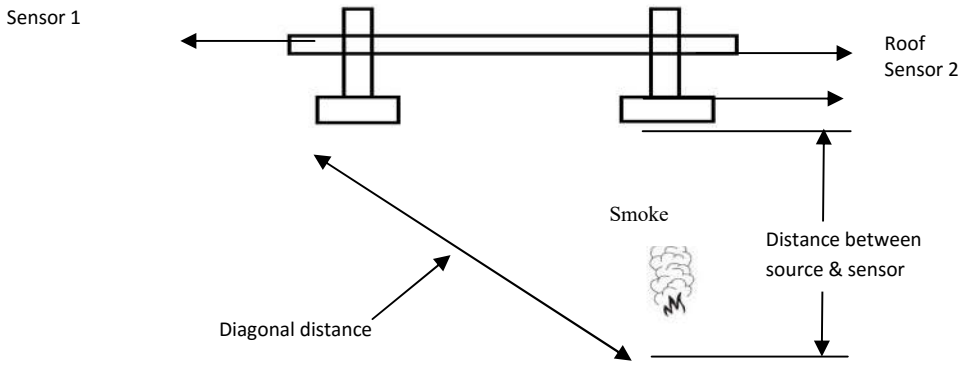


Figure 8: Performance parameters

Figures 9, 10, 11, 12 show the performances and characteristic curves of sensors 1 and 2, respectively with respect to various experimental distances when smoke source far from sensors at various height. The performances are computed on the basis of smoke sensors responds. When the smoke source is on the floor in the middle of the room then the smoke sensing time of any sensor is about 7.25 seconds which seems quite satisfactory for desired purpose. From figure 4.4, it can be said that the total time range from the initiation of smoke sensing to the completion of extinguishing is about 18-25 seconds. On the other hand, figure 4.5 shows the extinguishing time versus horizontal distance between smoke source and sensor. This curve also shows the time range, which is needed for the extinguishing arm to reach at a fixed point where fire should be extinguished.

Performances

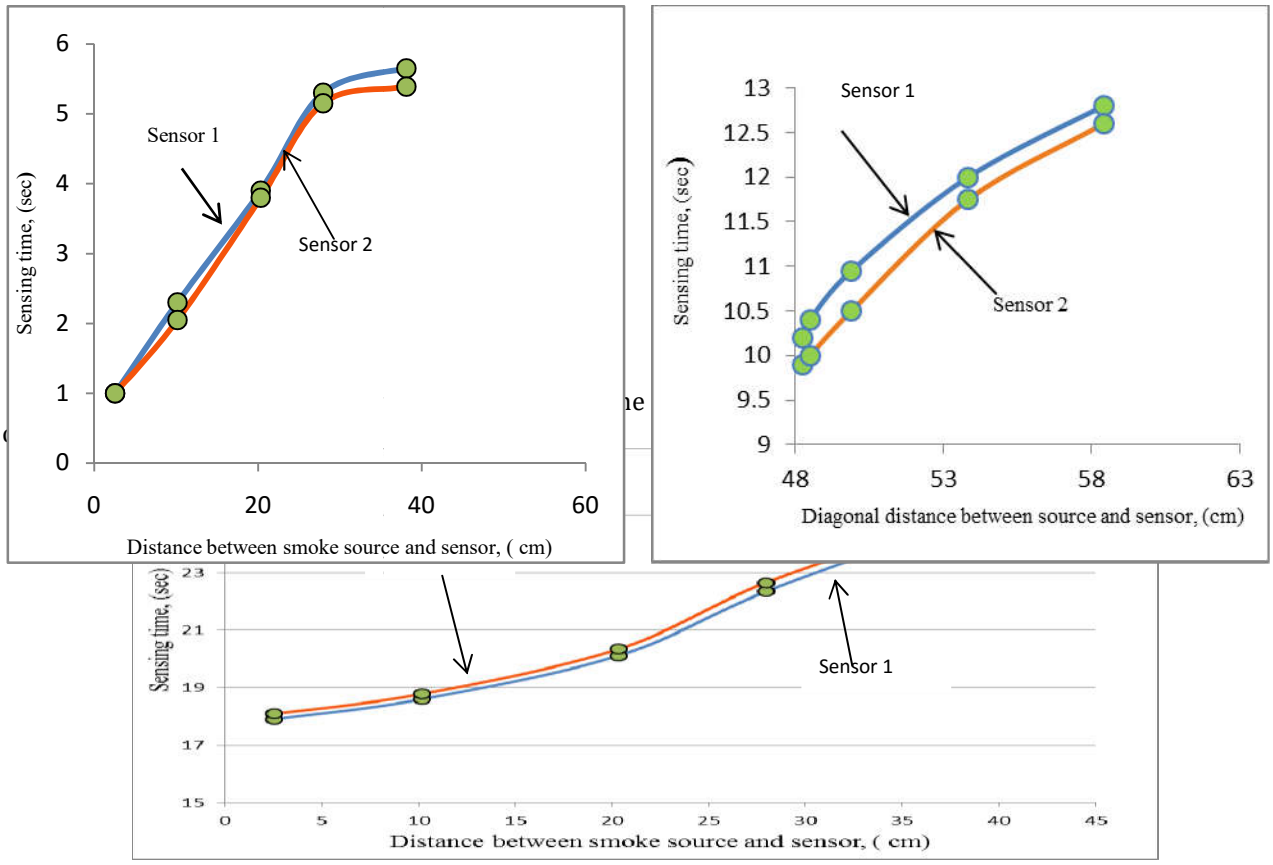


Figure 11: Sensing time versus Distance between smoke source and sensor (after the initiation of fire)

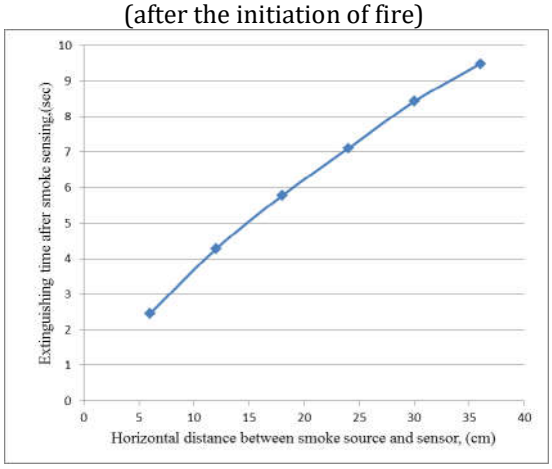


Figure 12: Extinguishing time versus horizontal distance

During the measurement of performance of this the time range for the disconnection of AC supply line is about 0.0001sec.

CONCLUSIONS

The sensing time for each sensor is difficult to keep same because it is not possible to create correct amount of smoke every time. The accuracy smoke detection is satisfactory. In this case, when the experimental distance between source and sensors is small (2.54 cm), the accuracy of the sensors becomes high. The multidirectional rotating mechanism of the extinguishing system on this experimental setup is satisfactory after smoke is detected. The spraying of water to extinguish fire is more sensitive

because a solenoid valve circulates water. This experimental setup also has an automatic disconnection mechanism of AC supply to avoid the spreading of fire due to short circuit.

REFERENCES

1. Article FIRE retrieved from the website http://www.ddm.gov.bd/fire.php
2. http://thediplomat.com/2013/12/more-than-a-year-later-bangladesh-factory-owners-charged-in-deadly-fire/
3. J.T Quigley, international current-affairs magazine for the Asia-Pacific region, December 25, 2013
4. ASHRAE Research Project, "The application of duct Smoke detectors in heating, ventilation and air conditioning ducts", 2002, RP1079.
5. He GuiXiong , Pan Deng , Jiang Li Min,Meng Jun Xia1 , Chen Xiao Shuang, "Design of and Electrical Fire Monitoring andWarning System Based on Transducers", in *International Journal of Automation and Power Engineering (IJAPE)* volume 2 Issue 4, May 2013.
6. Paul R. Steinmeyer, "Ion Chamber", *RSO Magazine* ,volume 8, Number 5.
7. Debbie Sniderman, "The MVF-5 autonomous firefighting robotic vehicle", in ASME.org on September, 2011.
8. Istre and Mallonee, "Research on various reasons for the failure of smoke detectors", in *Proceeding NEPA*, in 2000.
9. Rashedul Qayum, S.M Ehsanul Amin and Md Kamrul Hussian, " Wireless control system for smoke and fire detection". In *Proceedings International Journal of Scientific & Engineering Research*, volume 3, Issue 10, October, 2012 (ISSN 2229-5518).