THE DEVELOPMENT OF A UV FLAME DETECTOR FOR THE AUTOMATIC FIRE SUPPRESSION SYSTEM FOR ENGINE COMPARTMENT FIRES [1)]

Sung-Mook Lim*, Ki-Chang Jung, Eung-Sik Kim, Hong Kim
Division of Safety Engineering, Hoseo University, Korea

ABSTRACT

In this work, a new type of UV flame detection system was developed. In order to measure the performance of UV flame detector, various kinds of experiments was performed. The results show that the maximum response time of the UV flame detector is 0.2 seconds when the detection distance is one meter. The advantages of this system include wide area, high speed response and high sensitivity. After testing the UV flame detector in engine compartment, it detected fire within 0.09 seconds and extinguished within 5 seconds. Hence, the UV flame detector can be applied in automatic fire suppression system for automobiles.

INTRODUCTION

After 1970's, with the high speed of korea's economic growth, the automobile industry has also shown rapid development. At present time, there are more than one million registered cars in Korea. Due to rapidly increasing number of vehicles, we are facing traffic problems and this is causing more and more automobile accidents and property losses. Because of these kinds of social trends, customers are increasingly looking for safer cars rather than high performance car.

In other countries, fire monitoring and automatic fire suppression system have been studied actively. For example, the U. S. Army had developed and commercialized automatic fire suppression system for armored vehicles.[1],[2]

In Germany, Mercedes Benz also developed automatic fire suppression system for the engine compartment of its passenger cars and putting them on its product line. Lowson Eclipse, the U. K fire suppression company, has developed an automatic fire suppression system for the engine compartment of automobiles using halon alternatives. This system used a dual infrared hydrocarbon flame

1) This thesis is a project report of the development of new generation automotive technology.

detector which can be linked to any type of electrically initiated device.
Therefore, with the increasing number of automobiles and automobile fires, it is clear that there is a pressing need to equip an automatic fire suppression system in the engine compartment of passenger cars to protect lives and property. In this study, a UV flame detector was employed to develop automatic fire suppression system for automobiles.

ULTRAVIOLET FLAME DETECTOR

The automatic fire suppression system consists of UV flame detector, operating device, extinguisher. It can to detect and suppress fires which occurs in engine compartments. In order to extinguish such automobile fires, an automatic fire suppression system should be able to detect the fire rapidly and react instantly. Because of the limited space in engine compartments, automatic fire suppression system should be simple and compact. Since temperature distribution in the engine compartment is so varied, heat detectors or smoke detectors cannot be used. According to the consideration discussed above, a new type of fire suppression system for engine compartments was designed. In this system, a UV flame sensor which has a high sensitivity was adopted to meet the requirement of short response time. The schematic diagram of automatic fire suppression system is shown Figure 1.

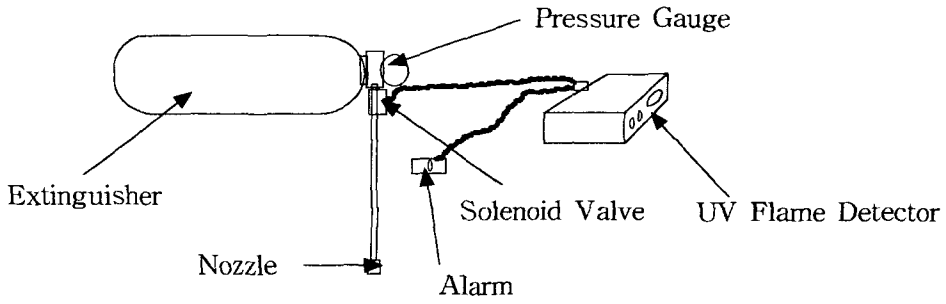

Figure 1. Schematic diagram of automatic fire suppression system

UV Flame detectors operate by sensing the electromagnetic radiation of flames. This type of flame detector is able to detect very weak UV rays even 5m away from match light or lighter. Its working wavelength ranges within 185~280nm.[3] The solar radiation would not cause false alarm in this kind of detector. Therefore, a UV flame detector can be used indoor or outdoor.[4]
UV flame detector is not easily affected by wind, rain, snow, humidity, temperature and pressure and has high sensitivity and high speed.[5]

EXPERIMENTAL METHODS

The UV sensor consists of two electrodes which are maintained at a DC potential 400 volts. They are contained inside a sealed unit which is filled with gas under low pressure.[3] When high energy, short wavelength radiation strikes the cathode, electrons are released which travel rapidly towards the anode, causing the release of more electrons in collisions with the gas molecules in their path. This cause an avalanche discharge which amplifies the current flowing between the electrodes by many orders of magnitude. The rate and amount of electrons released and whether they can cause and avalanche discharge are determined by the radiation intensity and the time of radiation accumulation on the cathode. Therefore, the response time of detector is in inverse proportion to the intensity of flame radiation which the detector receives. The detection effect of flame detector can be evaluated by analyzing the response time of the UV detector.

Table 1. Specification of UV flame detector

Sensor Type	UV tron[R] R2868
Operating Range of Sensitivity	185~260nm
Operating Voltage	DC 12 volts
Operating Temperature	-20 ~ +60℃
Applied Voltage	DC 400 volts
Average Current	1mA
Peak Current	30mA

The response time of UV flame detector was measured using a variety distances and angles from the anode and cathode to flame UV radiation. Pool fires with the diameter of 10cm, including gasoline and LPG flame, were used as the flame source. The schematic diagram of the test section is shown in Figure 2.

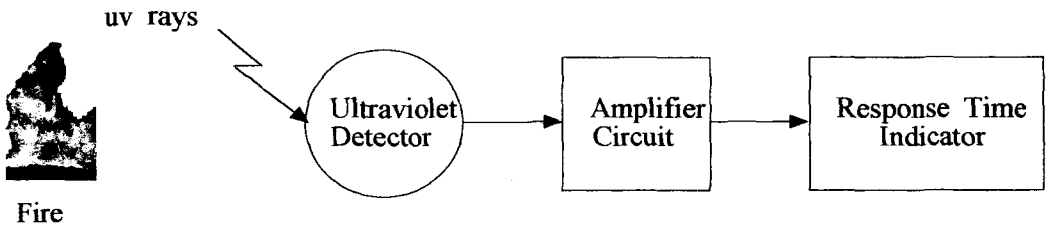

Figure 2. Schematic diagram of the test section.

In order to verify the performance of the UV flame detector, a fire extinguishing ability tester containing 2000cc engine compartment and response time indicator were produced by Hoseo University. This device can measure minimum time interval of 1/100 seconds. A fan and heater were installed to simulate engine room temperature and influence of wind while driving. After installing the UV flame detecter in fire extinguishing ability tester, fire was placed at five different points to measure response time and performance. The schematic diagram of fire extinguishing ability tester and fire point is shown in Figure 3.

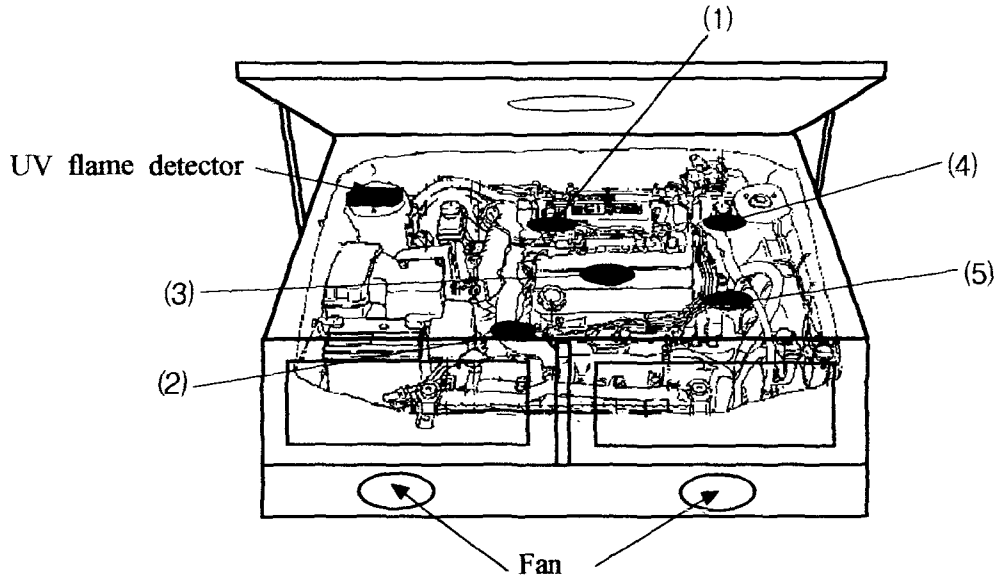

Figure 3. Schematic diagram of fire extinguishing ability tester and 5 different fire point.

RESULT AND DISCUSSION

Because the flame source is gasoline fire, the response time of UV flame detector with different distance and angle are respectively shown in figure 4 and figure 5. In a horizontal position, the response time of UV flame detector increased with the growing detecting distance. When the detecting direction was set in anode side of UV detector and the detection distance was within 5m, the response time increased rapidly. Moreover, the response time on the anode side was much faster than on the cathode side. In this situation, the slowest response time is 0.2 seconds when the detection distance is one meter, and 9.98 seconds when the distance is 5m. In a vertical position, as the detection angle ranged from -90 degrees to 90 degrees, and detecting distance increased, the response time of UV flame detector slowed. In this situation, UV flame detector has the shortest response time while the detection angle ranging between -30 and -60 degrees.

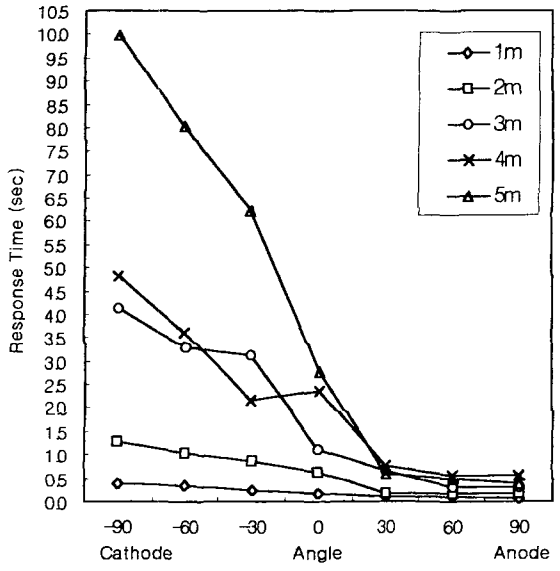

Figure 4. Response time of UV flame detector as a variation of detection distance and angle by using gasoline flame (Horizontal)

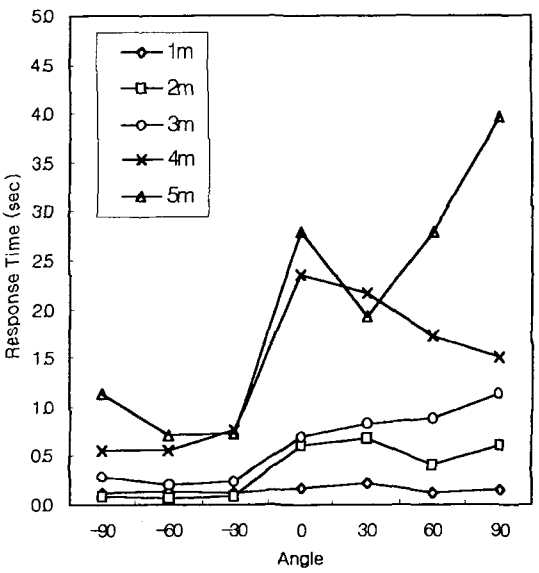

Figure 5. Response time of UV flame detector as a variation of detection distance and angle by using gasoline flame (Vertical)

In figure 6 and figure 7 LPG was used as the fuel instead of gasoline. In a horizontal position, the response time of the UV flame detector increased with the lengthening of detecting distance. When the detecting distance was set on the anode side of UV detector and detection distance was within 5m, the response time increased rapidly. Similarly, the response time on the anode side was shorter than on the cathode side. In this situation, the slowest response time to sense fire within one meters is 0.23 seconds while the slowest detection time is 3.97 seconds when the distance is 5m. In a vertical position, as the direction angle ranged from -90 degrees to 90 degrees and detecting distance increased, the response time of UV flame detector increased. In this situation, the UV flame detector has the shortest response time when the detection angle ranges between -30 and -60 degrees. These result show that as the UV flame detector has similar detecting characteristic whether the flame source is LPG or gasoline. As the detecting distance increased, we found that LPG flames responded faster than gasoline flame. This is caused by the fact that much more smoke is produced during the combustion of gasoline than LPG. The smoke affected the performance of the sensor by absorbing or scattering UV radiation. the results of these experiments showed that the UV flame detector has high sensitivity, high speed and wide detecting range no matter what horizontal or vertical position.

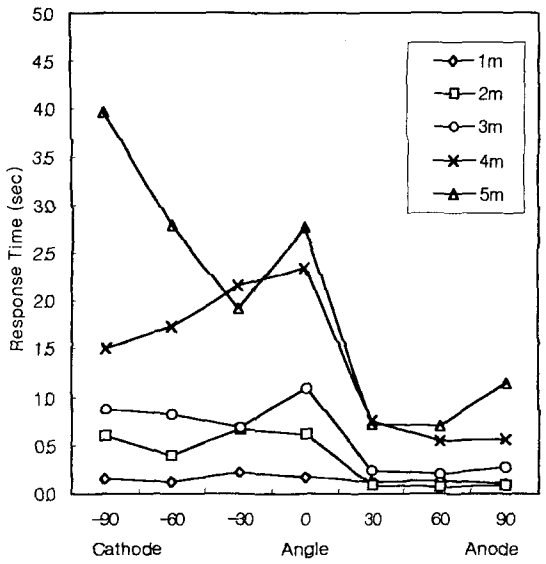

Figure 6. Response time of UV flame detector as a variation of detection distance and angle by using LPG flame (Horizontal)

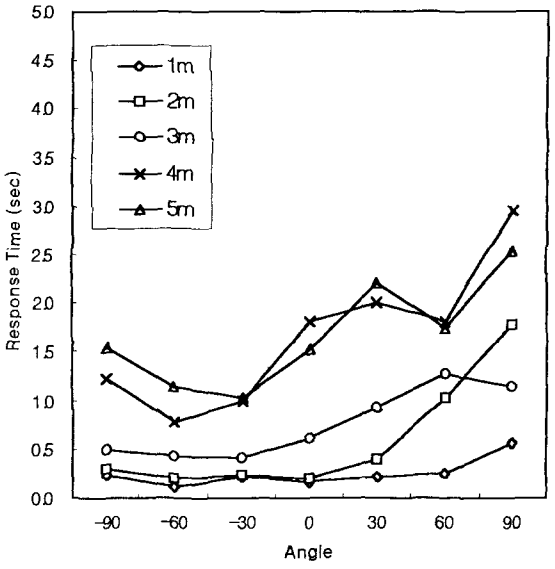

Figure 7. Response time of UV flame detector as a variation of detection distance and angle by using LPG flame (Vertical)

Figure 8 and figure 9 shows response time of the UV flame detector as a temperature profile. In figure 8, with the variation of temperature from 20℃ to 70℃ and 5 different fire points, the UV flame detector was able to detect fire and operate as an automatic fire suppression system with minimum response time of 0.03 seconds and slowest response time of 0.05 seconds when fan was not operating. In figure 9, the UV flame detector had slowest response time of 0.09 seconds when fan was operated at 3000 rpm. The result showed that variation of wind and temperature do not have a strong influence on the performance of the UV flame detector.

Table 2 shows the different extinguishing time of automatic fire suppression system at different positions in the automobile engine compartment. In this system, FM-200 gas filled AFFF agents were adopted as extinguishing agent[6] and the nozzle was set at 5cm height above the engine surface. Fires were extinguished within 5 seconds and they originated at 5 different points in the engine compartment. Further, wind and temperature do not particularly affect the performance of this system. As a result, automatic fire suppression systems can successfully extinguish engine compartment fires.

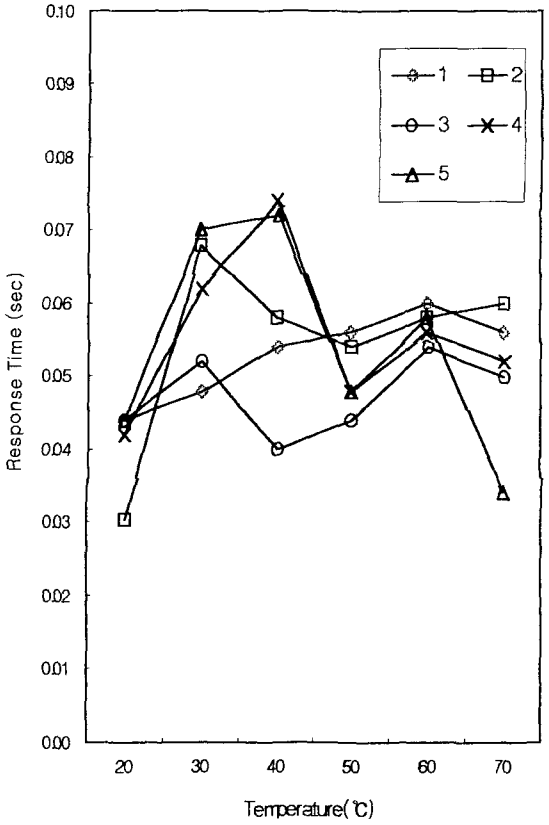

Figure 8. Response time of UV flame detector as a variation of temperature by using fire extinguishing ability tester when fan was not operated.

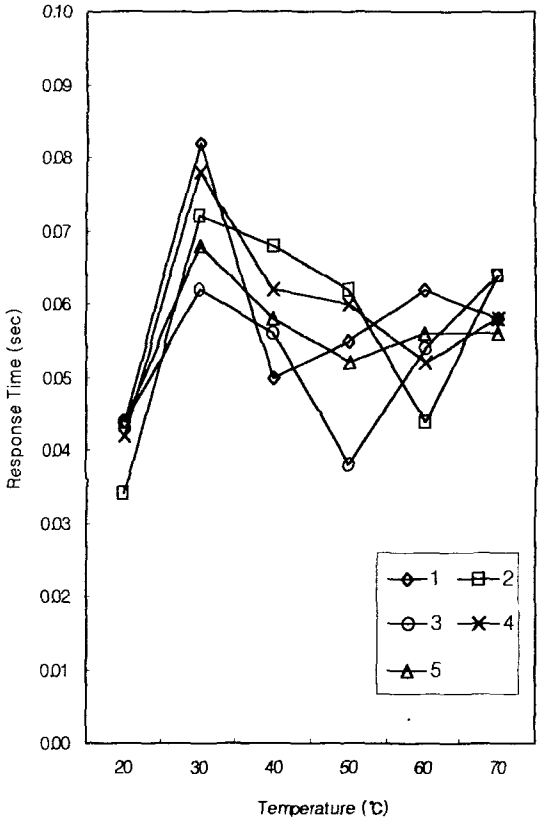

Figure 9. Response time of UV flame detector as a variation of temperature by using fire extinguishing ability tester when fan was operated in 3000 rpm.

Table 2. Extinguishing time of automatic fire suppression system for automobiles by using UV flame detector and FM-200 gas filled AFFF agents in the fire extinguishing ability tester.

Fire Point	Extinguishing Time Fan : 0 rpm	Extinguishing Time Fan : 3000 rpm
1	3.72 sec	4.15 sec
2	4.37 sec	4.87 sec
3	1.62 sec	1.79 sec
4	2.47 sec	3.07 sec
5	1.18 sec	2.55 sec

CONCLUSION

UV flame detecter developed in this study was able to sense gasoline fire with slowest response time of 0.2 seconds and 9.98 seconds when the detecting distance is 1m and 5m respectively. In LPG fire, it was able to sense fire with slowest response time of 0.15 seconds and 3.97 seconds when the detecting distance is 1m and 5m. In a horizontal position, response time on the anode side is shorter than on the cathode side. In a vertical position, the UV flame detector has the shortest response time when the detection angle ranged from -30 to -60 degrees.

This detector is able to detect fire with a slowest response time of 0.09 seconds and operate the automatic fire suppression system within 5 seconds. Our experiments also demonstrated that variation of wind and temperature do not particularly affect the performance of the UV flame detector.

In conclusion, this detector has advantages of high sensitivity, high speed and wide detecting range. It has successfully protected engine compartment from fires. Therefore, this detection system can by used in an automatic fire suppression system for automobiles.

REFERENCE

[1] Finnerty, A.E., and Polyanski, S., Using Powder Packs for Passive Fire Protection of Military Vehicles, Journal of Fire Sciences, Vol. 11, No. 3, May/June, 1993, pp. 242-254.

[2] Vector, Y., Replacing Halon Systems in Tanks, Fire International, No. 147, Summer, 1995, pp. 23-24.

[3] J. F. Middleton, Developments in flame detectors, Fire Safety j., No. 3, pp. 175-182, 1983,

[4] Dinko Tuhtar, Fire and Explosion Protection a Systems Approach, 1989, Ellis Horwood Limited, pp. 84-99

[5] Beyler, C. L. A Design Method for Flaming Fire Detection, Fire Technology, Vol. 20, No. 4, pp. 5-6, 1984

[6] Ki-Chang Jung, The development of the FM-200 gas filled AFFF fire extinguisher for automatic fire suppression system in the engine compartment of automobiles, Hoseo University, 1996