A Study on the Fire Gas Detection Algorithm

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목 차

1. Introduction

In Korea, the damage caused by fire is enormous. In 2017, 44,178 fires resulted in 2,197 casualties and $ 560 million in property damage. The damage caused by the fire is unlikely to improve unless there is a big change in the idea.

In Korea, where the installation of a fire detector has been mandatory since February 2017, most recent large-scale fires are close to man-made accidents caused by a building owner or tenant suspending operation of fire detectors and crushers.

Existing fire detectors are mainly based on the results of heat and gas detection, and are used as a basis to reduce the damage of people and property by executing the notification and alarm in the shortest time. The basic principles and underlying technology of such fire detectors have not been introduced to breakthrough innovations and have been maintained for more than a generation.

The industry and life around each field are actively utilizing the element technology of the fourth industrial revolution such as big data, IoT, cloud, artificial intelligence, and block chain, but the discussion about application of fire detection field is extremely weak.

Over the past several years, the development of ICT / IOT has entered the consumer selection market through the development of services that utilize artificial intelligence and other technologies through the period of connection. In the case of the fire sector, if it is reviewed from the point of view of the cause analysis of the fire, it will find a breakthrough fire suppression method.

This paper focuses on the ignition of the fire spread, as compared to the existing fire detection focused on the fire occurrence and the suppression aimed at shortening the time of flight on the fire scene and the equipment and training of the large fire suppression In order to secure the highest level of fire detection in the shortest time from the ignition of the fire time, the accuracy of the ignition judgment, the determination of the ignition position and the material, the fire using the collected data such as the ignition gas identification information and the collected ignition gas distribution Gas algorithms.

2. Golden Time in Fire

Fire causes chemical and physical changes in the material. Therefore, identifying the precursors of fire within the golden time of a broken fire is crucial to reduce fire damage.

In this paper, I define five golden time factors for the first time in fire detection field.

2.1 Gas Diffusion Theory

According to Graham's law[1], the diffusion rate of two gases is inversely proportional to the molar mass root. That is, the following relation is established between the diffusion rates Rate 1 and Rate 2 of the gas 1, which is the molar equivalent M 1, and the gas 2, which is M 2, respectively.

$$\frac{\mathrm{Rate}_1}{\mathrm{Rate}_2} = \sqrt{\frac{M_2}{M_1}}$$

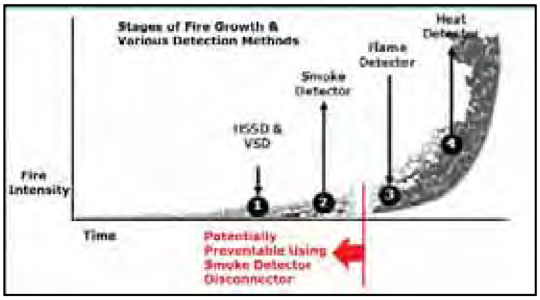
Therefore, the diffusion rate of H_2 (2) is 4 times faster than that of O_2 (32). The numbers in the bracket are the molar mass of gases.

2.2 Fire Gas Diffusion

Fires generate gas, flame, heat and so on, among which the gas diffuses the fastest. Therefore, if it is aimed at securing fire golden time, it is desirable to target gas detection rather than heat and flame.

Typical gases resulting from combustion are generally known as eight types of gases[2,5,6].

When Graham's gas diffusion theory is applied, the ignition gas diffusion rate is inversely proportional to the root of the generated gas molar mass, so hydrogen cyanide (27), carbon monoxide (28), formaldehyde (30), hydrogen chloride (36), carbon dioxide (44), nitrogen dioxide (46), and acrolein (56).



(Figure 1) Physical and Chemical Changes of Fire[3]

2.3 Fast Catch-on-Fire Detection

Rapid detection of gas generated by ignition is a key to preventing the escalation of fire-related disasters. The regulation range of the conventional fire detectors, such as the Fire Service Act, can be assumed to be approximately 50 square meters[4].

When this is applied, the time to reach the fire gas detector from the ignition position can be calculated as follows.

According to the Korean Fire Statistics[7], the arrival of the fire scene within 5 minutes after the fire occurred in 2017 is only 40% (17,854/44,178), and 60% is included in the time when the fire spreads in full swing.

2.4 Accuracy of Catch-on-Fire Detection

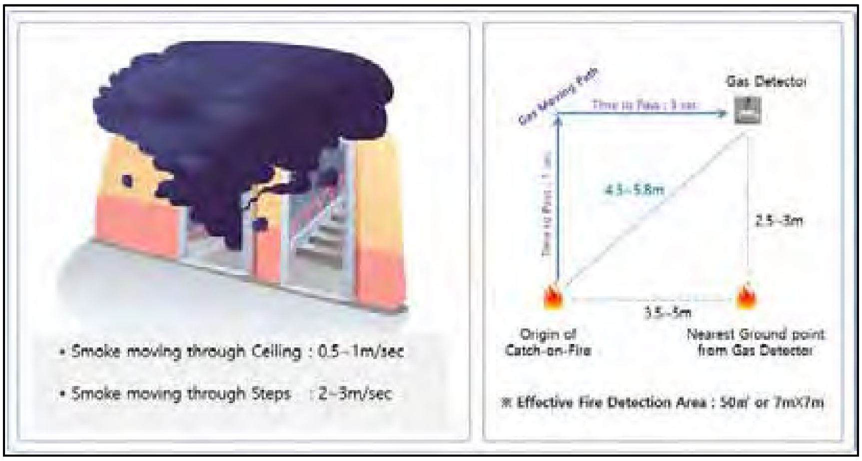
In Korea, fire detectors are installed in most buildings, but fire alarms (alarm malfunctions) account for 25% (11310/44178) of all fires in 2017[7].

Therefore, it is impossible to expect complete fire notification with existing technology, so a new fire detection technology is required.

2.5 Precision of Catch-on-Fire Location

Accuracy of location of ignition gas can be improved if existing information is also combined with fire detector. However, if the fire detector is designed to be included in the network, it can be more accurate than existing fire detectors with new functions and can eliminate the error of location verification considering interdependency between network elements.

In early 2014, the NEST fire detector, which was acquired by Google, was able to construct an efficient mesh network even though the fire detection performance was the same as that of the existing sensor[8].



(Figure 2) Gas Moving Speed (Left : [6])

2.6 Classifying Catch-on-Fire Materials

Water from fire hydrants or fire trucks is mainly used for fire suppression. However, sometimes a foam fire extinguisher, a sodium bicarbonate powder fire extinguisher, a Halon fire extinguisher, a carbon dioxide fire extinguisher and the like are used.

The distribution of the generated gas from the complexing material and the total amount of the sensor receiving gas are set through the generation of the preliminary data or given through the network through the post-installation operating process.

In this paper, the necessity of correlation between the information of complex material based on network information and the optimal fire suppression system will be raised.

2.7 Excluding Confused Catch-on-Fire Gas

It is necessary to verify and accumulate data for establishing the validity period of each specific substance or complex substance due to ignition[9].

The unit time can be set by analyzing the preliminary data using the captured gas or the big data obtained in the operation process, and thus, the estimated total amount can be determined according to the type of gas collected in the unit time and the receiving sensitivity of each gas.

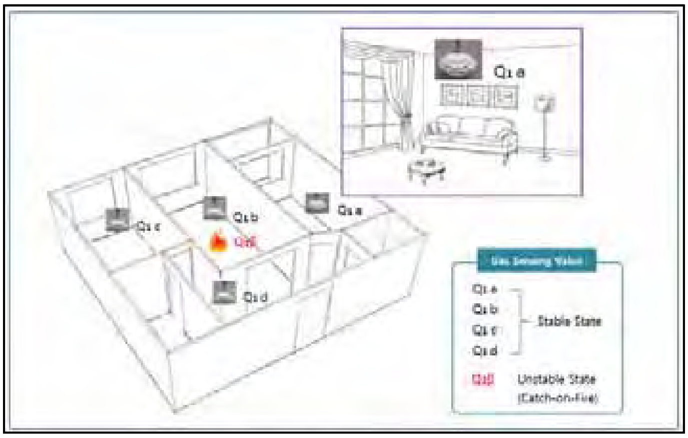
3. Fire Gas Detection Algorithm

3.1 Structure of Fire Detection Network

Fire alarms (fire detection errors) of fire detectors using the highest level of existing technology are very high.

3.2 Catch-on-Fire Material Detection Algorithm

The type and amount of gas generated by the



(Figure 3) Network based Fire Detector

complex is variable. 2.7 Exclusion of ignition mixture gas The amount of gas captured in the unit time and the estimated total amount of gas received per gas are constant, but the total amount of received gas sensor increases (Q1a, Q1b, Q1c, Q1d) Fluctuates when it occurs.

Section 2.6, the complexing material is detected according to the prior information on the complexing substance mentioned in the complexing substance category or the distribution of the gas given through the network.

If ΔQ is a significant change in the gas distribution, the complex is identified as follows.

$$\Delta Q \geq |Q_2\alpha, Q_2\beta, Q_2\gamma, Q_2\delta|(\tau) - |Q_1 a, Q_1 b, Q_1 c, Q_1 d|(\tau-1)$$

Here, Q_2 α, Q_2 β, Q_2 ɣ, Q_2 δ are the gas distributions of the unstable states, and Q_1 a, Q_1 b, Q_1 c, and Q_1 d are the steady-state gas distributions.

3.3 Alignment Location Detection Algorithm

Section 2.5 Ignition gas position accuracy is closely related to the section 3.2 Ignition material detection algorithm for section 2.6 ignition material classification.

In the case of network support such as network fire gas detector, ignition position detection determines the position of the change value of the gas distribution and the time variation value of the gas distribution at the time of occurrence of the unstable state gas distribution of the stable state gas distribution to the ignition position as follows.

$$\Delta Q \geq |Q_1 a, Q_1 b, Q_1 c, Q_1 d|(\tau) - |Q_1 a, Q_1 b, Q_1 c, Q_1 d|(\tau-1)$$

and

$$\Delta Q \geq |Q_1 a, Q_2\beta, Q_1 c, Q_1 d|(\tau) - |Q_1 a, Q_1 b, Q_1 c, Q_1 d|(\tau-1)$$

4. Fire Detecion Algorithm in Service

4.1 Simulation

The complex material and ignition position detection algorithms proceed with a periodic simulation in preparation for the rapid on-the-fly operation of the gas distribution for each complexing material and the network fire gas detector. The simulation period determines the optimum value of variability depending on the installation environment of the fire gas detector, the battery performance, the amount of non-fire detection gas, and so on.

4.2 Error Correction in Operation

Three error correction methods can be applied to the detection algorithm of the complex material and the ignition position detection algorithm.

When the reference data for the location where the ignition gas detector is installed is secured, the fire gas detector detects the ignition position and the ignition position through comparison between the trap gas data and the reference data. The detection performance of the fire gas detector in which the ignition gas detection occurs is lost. This is mainly due to malfunction caused by detector ignition.

If ignition gas reference data is not obtained, the fire gas detector will store any data on the network during the initial installation. The ignition gas detection value obtained in the simulated sensor installation environment is updated with the reference data of the fire gas detector.

The ignition gas reference data periodically re-establishes the confidence range for the existing data according to the self-calibrating function of the fire gas detector. Edge computing and loop or fog computing can be applied to the existing data calculation.

5. Conclusion

In this paper, we propose a detection algorithm and ignition position algorithm to identify the five elements of fire golden time assuming the trap gas distribution and gas amount of fire gas detector.

The reference data, which is the basis for ensuring the performance of the ignition material and the ignition position algorithm, is changed according to the installation environment, but it should be designed to maintain the optimum state when applied to the network fire gas detector.

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