Development of a Test Board for Measuring and Analyzing Characteristics of 5 Gas Sensors

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***Abstract*— In this study, a test board was developed to test the gas concentration and initial response time. This test board can test five gas sensors simultaneously. First, we selected five commercially available methane gas sensors with excellent performance. We also used software and hardware to check and collect measurement data of sensors in real time. The data values can be stored in the text file of the sensor number in real time until the end of the measurement at the set time interval. On the front panel of the software, we can see that the voltage values measured by each sensor are plotted in real time. Using this test board, we will consider how to improve the measurement accuracy of the gas sensor to be applied to future gas detectors.**

Keywords—combustible; gas leak detector; IR; circuit;

I. INTRODUCTION

The use of gas (LPG, LNG, etc.) in various gas facilities has increased together as the gas industry has increased [1]. Preventing accidents of leaks and explosions in this industrial environment is essential for safety [2]. For example, On October 17, 2015, an accident on LPG gas leakage and explosion happened at Korea. The accident involved three people and about 1400 dollars in property damage [3]. Prevention and safety management of gas accidents is a prerequisite for industries using toxic or combustible gases [4]. To protect various risks and accidents, Korea Gas Safety Corporation, Korea Gas Safety Corporation conducts initial inspections of gas facilities and regular inspections of joints, valves and pipelines. In safety management and inspection processes, gas leakeage instruments must have fast initial response time, high accuracy and robust durability [5].

II. MAIN

A. Selection of Gas Sensor

Sensors that detect combustible gases include semiconductor gas sensors and catalytic combustion method gas sensors. In Korea, the use of catalytic combustion method-type gas sensors is high. Because it is easy to manufacture, has a fast response time, and can be made smaller and lighter. However, there is a disadvantage in that the selectivity of the detection gas is lacking and the life of the sensor is short. Compared to catalytic combustion method gas sensors, optical gas sensors have the advantage of long life, high accuracy and low power consumption. The infrared gas sensor has excellent selectivity and sensitivity by using the voltage fluctuation of the output terminal by absorbing the infrared wavelength depending on the type and concentration of the gas to be measured. Despite the fact that the sensor has such excellent characteristics, there is still a lot of room for improvement such as measurement accuracy and detection speed.

Therefore, five kinds of infrared gas sensors with excellent performance, which are currently available in Korea and overseas, and applied them to this test board. An important condition for the sensor selection is explosion proof certification, and sensor with an accuracy error rate of less than 3% and a lifetime of more than 5 years, so that they can be applied to future portable combustible gas detectors. The specifications of the selected sensors are shown in Fig. 1.

Specifications						
		D社 MSH-P	D社 MSH-DS/HC/CO2	N社 INP20-CH45	K社 KGS801	E社 CH4-D3-3V
						
Voltage		3.0 - 5.0 DCV		3.0 - 5.5 DCV	3.0 DCV	3.2 - 3.6 DCV
Response time T_{90}		Less than 30 seconds			Less than 10 seconds	100 seconds
MTBF		More than 5 years			-	-
Explosion proof	ATEX	II 2G Ex d IIC Gb				-
	IECEx	Ex d I and/or Ex d IIC			Ex d IIC T6 Gb	-
Hydrocarbon compound						
		Dynament	Dynament	N.E.T.	KNC	ELT sensor
Range	CH_4	0-5%, 0-100%vol				
	HC	0-100%LEL.				
Accuracy		10% (reading)		± 1%FS(≤ 25%) ± 2%FS(≤ 50%) ± 5%FS(> 50%)	± 3% FS	± 3% FS
Response time (T_{90})		Less than 30 seconds			Less than 10 seconds	100 seconds

Fig. 1. Specification of five gas sensors sold in Korea and overseas

B. Configuration of the Test Board

Fig. 2 shows the structure of a test board with five gas sensors. The structure consisted of gas sensors, a suction pump, a power supply, switches, and a data communication unit. A suction pump with a motor serves to inject the gas sample to be measured into the sensors and to discharge the gas through the

outlet for continuous measurement. The power is supplied via a DC 12V 5A adapter.

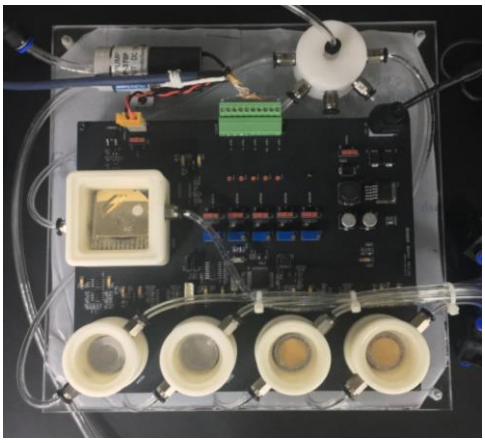

Fig. 2. Structure of manufactured test board

Fig. 3 and 4 show the block diagram and front panel of the LabView software. The voltage values measured by the sensors are designed to be displayed on the front panel graph in real time. Also, the voltage values measured by each sensor are stored in the same folder as output(0).txt ~ output(4).txt files. On the front panel, six graphs can be viewed, the output of each of the five sensors can be seen in each graph, and one graph can compare the all outputs of five sensors.

Fig. 3. Front panel

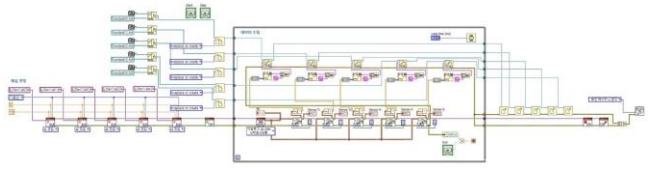

Fig. 4. Block diagram

C. *Operation of the Test Board*

In this experiment, 5 kinds of infrared gas sensors were mounted on the test board of the manufactured gas sensor, and 7 types of methane standard gas (0.5%Vol, 1.25%Vol, 2%Vol, 2.75%Vol, 3.5%Vol, 4.25%Vol, and 5%Vol) were exposed to the sensor. The output voltage was measured in real-time by connecting the test board and computer to the NI USB-6002 instrument. The environmental temperature at the time of the experiment was 22.5℃ and the humidity was 62%. The standard gas used in the experiment has uncertainty, but we assume that there is no uncertainty in this experiment.

Table 1 shows the average output voltage obtained by repeating the measurement of the output voltage 10 times while injecting 7 kinds of methane standard gas into the test board for 5 minutes. As shown as Fig. 5, the sensors A, B, and C will be able to detect more detailed methane gas concentrations because the variation in average output voltage from 0 to 5%Vol. Volts varies from 2.1V to as much as 3.3V. In addition, there will be less errors in external environmental factors.

Methane gas concentration (%Vol)	Sensor A (MSH-P)	Sensor B (MSH-DS)	Sensor C (INP20-CH45)	Sensor D (KGS801)	Sensor E (CH4-D3-3V)
0	-3.20907	-2.61057	-1.42705	-0.04535	3.654428
0.5	-3.01806	-2.29819	-1.25218	0.014466	3.654176
1.25	-2.6852	-1.79308	-0.9716	0.015547	3.653974
2	-2.36575	-1.34393	-0.70201	0.021064	3.653886
2.75	-2.03678	-0.90681	-0.3924	0.023756	3.654093
3.5	-1.6994	-0.47162	-0.1401	0.047375	3.654231
4.25	-1.35908	0.092354	0.222665	0.072236	3.653686
5	-0.92861	0.680029	0.638348	0.079316	3.653038

Table 1. The average value of the output voltage per concentration of each sensor

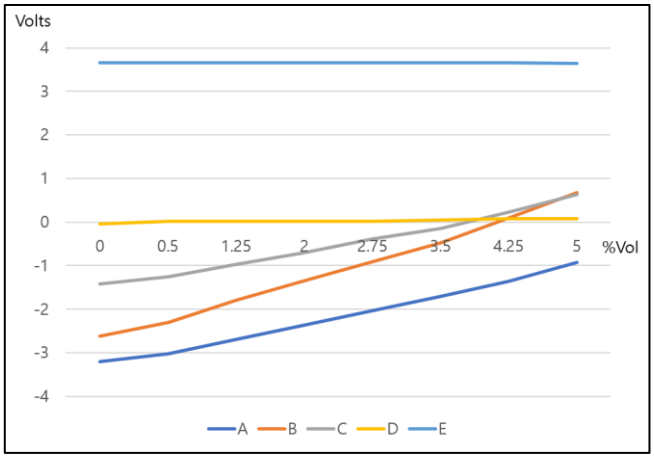

Fig. 5. Schematic representation of sensor output voltage values

III. CONCLUSION

Numerous gas accidents are occurring in industries using various gases. It is important to effectively prevent and manage those gas risks. In order to ensure gas safety, excellent gas leak detectors are installed in industrial fields, and safety managers must inspect and manage gas facilities using gas leak detectors. So, we are developing a gas detector with good performance to prevent any small accidents.

In this study, we developed a test board which can measure the performance of the gas sensors of the gas leak detector and even study the improvement of measurement accuracy. This board measures the detecting accuracy and initial response time of the gas

sensors. And this test board can test the characteristics of five types of gas sensors in real time in conjunction with computer software. Test results can be checked in real time and saved as a text file after the test. In the near future, this test board will be utilized in research such as the development of algorithms to improve the measurement accuracy of the sensor.

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