Development of Electronic Nose and Program for Monitoring Air Pollutions and Alarm in Industrial Area

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Abstract—**This article presents the development of electronic nose and program for monitoring air pollutions and alarm in industrial area. The design of electronic nose depends on physical connectivity of the sensors, relating to the data management, computing management and information management. Therefore, the sampling, filtering and sensors module, signal transducers and acquisition, data preprocessing, feature extraction and feature classification are applied in the design of an electronic nose. There are 4 sensors are investigated to use as electronic nose in this experiment which consist of TGS2620, TGS2620, TGS2442 and TGS832. These sensors are operated with LabVIEW program. The experiment results show that these sensors can classify and sensitive to the different gas such as Methanol n-Propanol, Hexane and Dichloromethane. The PCA is also used to classify group of gas sensor. The system also performs the warning and alarm system when the gas is leak.**

Index Terms—**Electronic nose, gas sensor, monitoring industrial area.**

I. Introduction

The analysis of air pollution is a commonly required task in our daily life. Since conventional air pollution tools are too expensive and difficult to use, electronic gas sensor systems, called electronic nose (E-nose), have been used in many applications, e.g., in the field of environmental monitoring, industrial monitoring, process and quality control systems [1]. A drawback of the existing electronic nose system is that they ordinarily work offline [2], [3]. The design of electronic nose depends on physical connectivity of the sensors, relating to the data management, computing management, information management, and knowledge discovery management associated with the sensors and the data they generate and how they can be addressed within an open computing environment [4]. Therefore, the sensor data are collected and recorded using an electronic nose system, and then, statistics software is utilized to extract qualitative or quantitative information. Sensors for use in electronic noses need partial selectivity, mimicking the responses of the olfactory receptors in the biological nose. In the design of an electronic nose, sampling, filtering and sensors module, signal transducers and acquisition, data preprocessing, feature extraction and feature classification are applied.

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Electronic nose design is used, which provides rapid responses, ease of operation and sufficient detection limits [5]. Data quality objectives (DQOs) of environment must be considered as part of technology development and a focus should be made on the most urgent problems. It depends on sensors' sensitivity and selectivity [6]. Sensitivity is used to refer either to the lowest level of chemical concentration that can be detected or to the smallest increment of concentration that can be detected in the sensing environment. While selectivity refers to the ratio of the sensor's ability to detect what is of interest over the sensor's ability to detect what is not of interest as interferes.

Many researchers have been proposed interesting works in electronic nose system such as [7] Independent Component Analysis (ICA) algorithm based on intelligent electronic nose in the mixed gas of feature extraction. ICA algorithm is equivalent to the human brain, with analysis, separation of raw data, which aims to separate the constituents of the gas mixture for quick identification. Electronic Nose to rely on independent component analysis as a multi-channel observation signal processing methods, able to break out the method by optimizing the multi-channel signals in a number of separate components, in the electronic nose signal processing, ICA method can effectively remove because the response to superimposed generated error message. In [8] E-nose has been developed to replace human olfactory and it has been proven useful for food freshness identification and environmental classification [9]. E-nose system should be implemented with wireless system so that signal from isolated locations can be expediently combined and processed at a database server. Leilie Pan and Simon X. Yang [10] developed environment monitoring from various workplaces based on 2.4-GHz wireless LAN. The wireless LAN utilized MPR2400 embedded module including a microprocessor, radio and battery. However, embedded module MPR2400 is expensive and requires two AA batteries, which are not necessary. Moreover, the reported electronic nose did not used gas reference for odor measurement, resulting poor odor sensing capablity.

This work focuses to design the electronic nose and program development for the air pollutions monitoring and alarming for industrial factory. There are many types of sensor which had been used in this research such as solvent vapor, air contaminate, CO and Halogen. The next section will explain the design system of the gas sensor system. The Electronic nose is also briefly in Section III. The experiment and results are described in Section IV. Finally, the conclusion is also followed.

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II. Design of the Gas Sensor System

Volatile Organic Compounds (VOC) sensors are recently attracting the interest of industry for the increasing number of applications of electronic noses VOC sensors often employ simple electrical circuits where an integrated heater maintains the sensing element (generally a metal oxide semiconductor layer) within a specific temperature range defined by the manufacturer. The operation of the metal oxide chemical sensors depend on: when oxygen is in the ambient environment reaches a certain level. The amount of oxygen on the sensor surface is constant and it's oxidizing effect results in the removal of electrons from the bulk of the semiconductor. Fig. 1 shows the design of the gas sensor system.

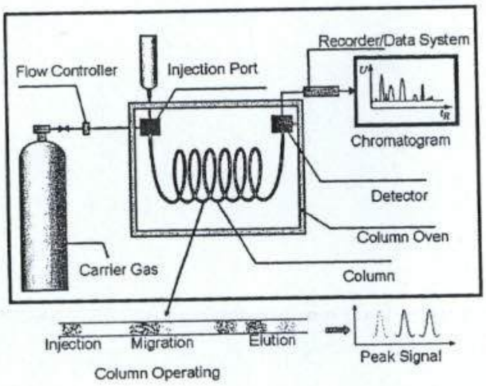
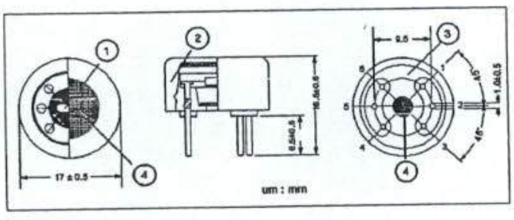


Fig. 1. Gas sensor system (gas chromatography)

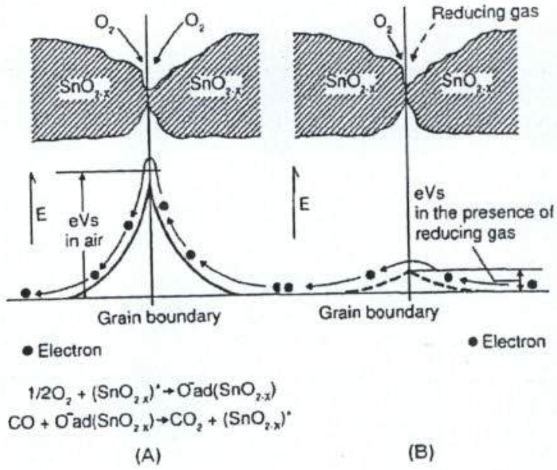
III. Electronic Nose

Gas sensor, which is used in this experiment, shows the structure in Fig. 2. This gas detection is produced from metal oxide such as SnO_2. When this oxide gets the high temperature, oxygen molecule will stick at surface oxide metal as negative change. This courses the electrical potential at the surface with the positive change of outer surface. It shows in Fig.3 (a). The oxygen molecule creates the electrical potential between oxide metal which will block the electron flow. This increases the sensor resistance. When the example of gas flows in the gas system, it will reduce the oxygen or deoxidizing from the oxide metal as shown in Fig. 3 (b).



(1) Sensing Element:
SnO2 is sintered to form a thick film on the surface of an alumina ceramic tube which contains an internal heater.
(2) Cap:
Nylon 66
(3) Sensor Base:
Nylon 66
(4) Flame Arrestor:
100 mesh SUS 316 double gauze

Fig. 2. Gas sensor



$1/2O_2 + (SnO_{2-x})^* \rightarrow O^-ad(SnO_{2-x})$

$CO + O^-ad(SnO_{2-x}) \rightarrow CO_2 + (SnO_{2-x})^*$

Fig. 3. (a) Model of potential electric surface metal oxide
(b) Model of potential electric surface metal oxide during gas measurement

TABLE I: Percentage of Quantity of Gas in Normal Environment

Gas	% of quantity	Gas	% of quantity	Gas	% of quantity
N_2	78.09	CH_4	0.00015	O_3	0.000002
O_2	20.94	Kr	0.0001	NH_3	0.000002
Ar	0.93	H_2	0.00005	NO_2	0.00001
CO_2	0.032	N_2O	0.000025	SO_2	0.00000002
Ne	0.0018	CO	0.00001		
He	0.00052	Xe	0.000008		

IV. Experiment and Results

The electronic nose system is shown in Fig. 3. It consists of 4 sensors. There are solvent vapor (TGS2620), air contaminate (TGS2602), CO (TGS2442) and Halogen (TGS832). Those sensors are selected in order to relate to the volatile organic compounds of industrial.

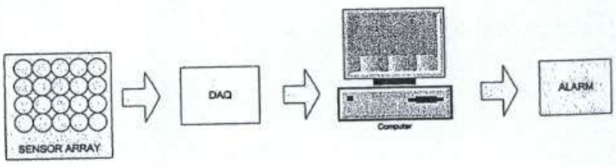


Fig. 4. Electronic nose system of this experiment

In Fig.4 when the gas is flowed in the system, all sensors will response to each compound of gas. The sensitivity of sensor will effect to different compound, this make the different of resistance and flow current. Those resistance and current is converted to digital data and pass through the data acquisition.

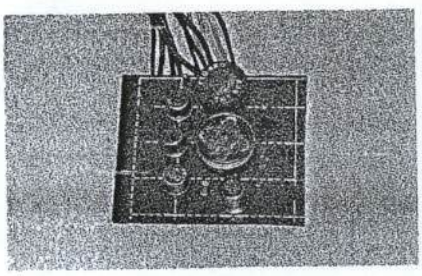


Fig. 5. Sensor array

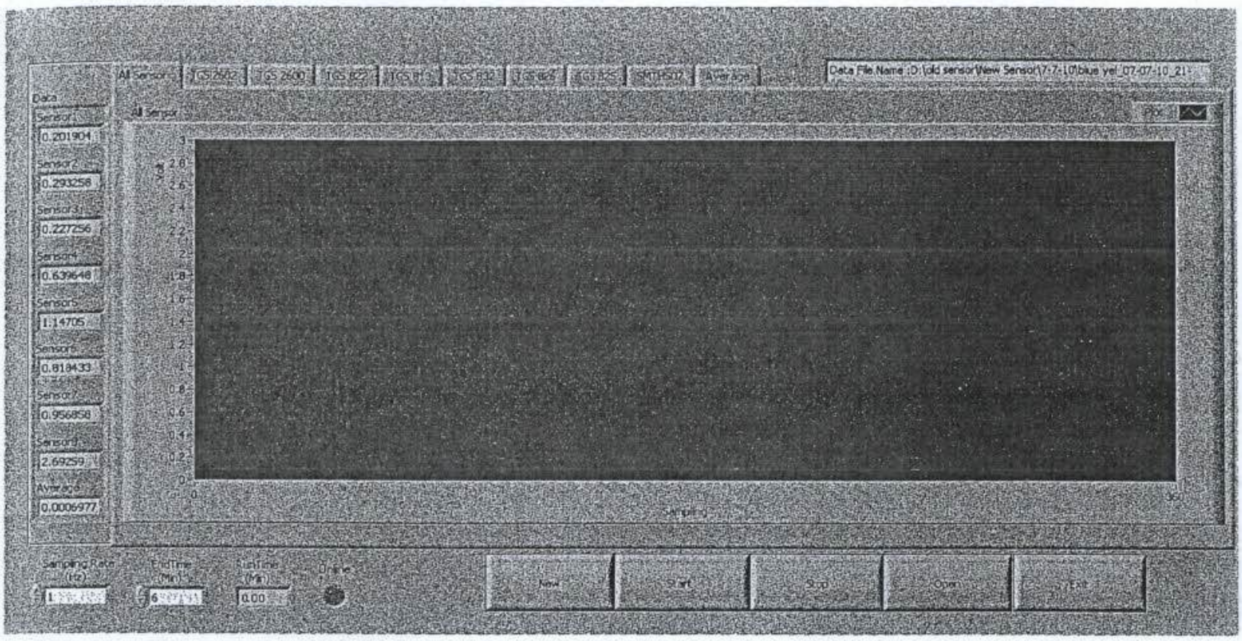


Fig. 6. Data acquisition program when it starts.

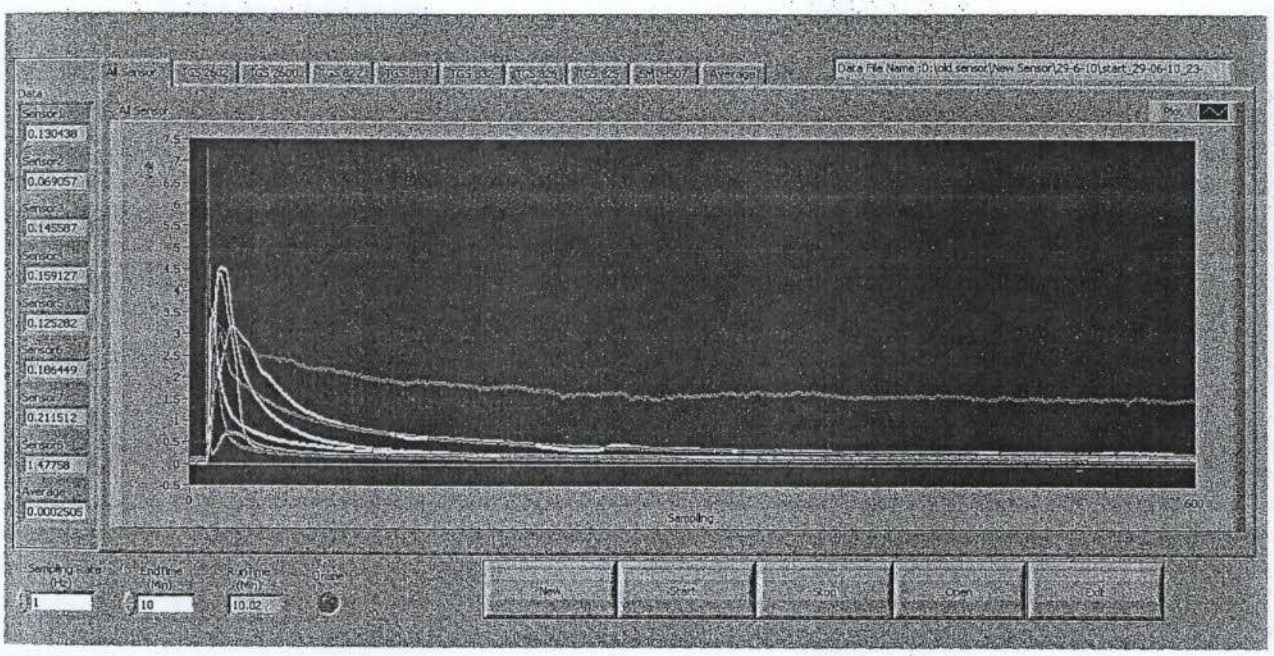


Fig. 7. Data acquisition program when electronic nose operates.

TABLE II: THE VOLTAGE OUTPUT EACH SENSOR IN THE TERM OF DIFFERENT COMPOUND QUANTITY

Sensor	mV	$1mg/m^3$ (mV)	$10mg/m^3$ (mV)	$0.1g/m^3$ (mV)	$1g/m^3$ (mV)
2620	303	385	732	1651	3509
2602	104	166	278	666	1646
2442	604	901	1297	2235	3499
832	119	150	211	415	2069

TABLE III: THE SYSTEM OPERATION

Compounds	Warning Time (sec)	Alarm Time (sec)	Warning Sensor	Alarm Sensor
Methanol	230	332	2620	2620
n-Propanol	168	228	2620	2620
Hexane	117	155	2602	2602
Dichloromethane	125	582	2602	2602

V. CONCLUSION

This article presents the electronic nose and program development for air pollutions monitoring and alarming for industrial area. There are 4 sensors are used as electronic nose which consist of TGS2620, TGS2620, TGS2442 and TGS832. The experiment results can be notice that those sensors can classify and sensitive to the different gas as shown in Fig. 7 and Fig. 8. In Fig. 8, the PCA is also used to classify group of sensor results.

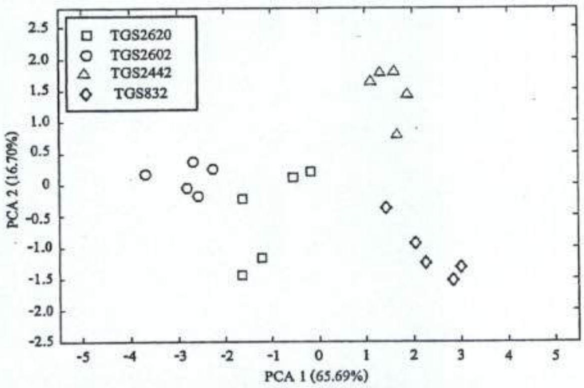


Fig. 8. The PCA is also used to classify group of sensor results

Moreover, this system can completely identify the methanol, n-propanol, hexane and dichloromethane as shown in Table II and III. The warring and alarm time are also provided. The maximum is 230 sec for warning of methanol and 582 sec for alarm of dichloromethane.

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