CARBON MONOXIDE POLLUTION DETECTION AND MEASUREMENT USING KNOWLEDGE-BASED AND PROBABILITY APPROACHES

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ABSTRACT

This paper presents the implementation of knowledge-based instrument to detect and measure pollution in a certain area. The instrument in discussion is the MQ-7 carbon monoxide sensor. Wastes from heavy traffic and industry production processes create bad pollution, which deteriorates people's health as well as the environment. The knowledge-based approach is one of the methodologies to model human reasoning and thinking to solve problems. The mechanism to detect the pollution is integrated in a board.

***Keywords**: Knowledge, Pollution, Instrumentation.*

1. INTRODUCTION

Pollution is a problem of today everywhere and anywhere. As the guidance of measurement technical and report on the information of air pollution standard index have been shown that the problem of pollution is an important case that must be overcome immediately. Not just as pollution problems in a province, but also pollution problems in all of the world (Kutatók & Szimpóziuma, 2006). The impact of heavy traffic and huge industrial productions is affecting the supplies of energy because the waste energy is on the freezing state, like fuel combustion by machines, air conditioning (AC), etc. The road capacities are also not equal to the operated transportation numbers. The real impact due to the problem of heavy traffic is the reducing health of the people and environments that caused by the waste of fuel combustion containing carbon dioxide (CO_2) as the human toxic (Oprea, 2003).

Ozon (O_3) is also secondary pollutant formed by the reaction of the other primer pollution like volatile organic compound (VOC) and nitrogen oxide (NOx) that can be found at the heat and sun light. VOC is emmited from the vehicles, chemical plant, factories, and industries. Meanwhile, NOx is emmited from the vehicles, power plant, and other combustioning sources. The impacts of the emmition are infection of respiratory tract, ashtma, reducing lungs function, cough, etc. The unit of measurement of pollution is in part per billion (ppb). Prevention that can be done to reduce pollution is limitation the usage of vehicles at day light and using fuels with good condition of machine to get perfect combustion of fuel because the caharacteristics of carbon monoxide (CO) are unseen, unsmelled, and toxic gas formed when the carbon in fuel not good combutioned. At the town, about 95% of carbon monoxide is produced from automobile disposal and the rest percentage is produced by industrial processes, transportation fuels disposal, and burning nature resources (Oprea, 2003). A huge concentration of carbon monoxide is happening at the rainy season or cold season. The other impact of health is capable to reducing oxigen (O_2) that is delivered to organs and problem of cardiovascular. The unit of measurement of carbon monoxide is part per million (ppm). Particulate matter (PM) is a solid and fined liquid that is freely in the air. A lot of natural resources can be provided from particulate matter directly or from reaction of others pollutant that make compound in the atmosphere. A fined particle can reduce human health, e.g. infection and respiratory problems. So, to detect the concentration of the pollutant can be done by sensor. A lot of gases sensor that have been made, but for such a pollutant concentration for today can be predicted using one sensor. A good sensor must have a good sensitivity to detect such matter.

This paper describes the performance of MQ-7, the carbon monoxide detector, which detect the existence and predict the concentration of carbon monoxide using knowledge-based method. Some internal and external factors can affect the performance of the sensor when detecting particles of carbon monoxide. So the performance of this sensor has an uncertainty result, although from datasheet can be known for some conditions.

2. THEORETICAL BACKGROUND

2.1. Knowledge-Based

Knowledge-based is a technique to support human decision-making, learning, and action. Human is always using a decision between sure and unsure on something. An example of this reason can be seen on how people choose a coin that tossed up to get number or picture on a coin. The emerging of number or picture can't be determined how many will show the number or picture in ten times of tossing up. Human can determine one condition that is it will show the number or picture on that coin. The probability of throwing up coin ten times thus showing times of number or picture on coin make a prediction of uncertainty. The causal-network formulation of probabilities can be used to represent confidence measures as an integral part of a knowledge system that is requiring specialized denotation or probability (Ay&Polani, 2006). Probability of a destination condition on each of the possible outcomes of these effecting events shown in equation 1 (Pearl, 1988).

$$\varsigma(\vartheta) = \rho \tag{1}$$

If the statement $\zeta(\vartheta)=\rho$ is one state of certainty regarding the truth of ϑ, then there is only one such state at any time. It means if there are two sensors of carbon monoxide, one is used to measure the certainty value and the other one is used to measure its reliability. The idea of $\zeta(\vartheta)=\rho$ is a random variable whenever the assesment of $\zeta(\vartheta)$ depends substantially on the occurence or nonoccurence. The case for set of the events could be denoted by ϑ_i, which means i is for enumeration from 0 to n represented as ϑ_1, ϑ_2, ϑ_3, until ϑ_n. If the object event is believed having contingencies of ϑ, then that is known as ρ_i. The denotation of ρ_i for i has same meaning as enumeration that represents as ρ_1, ρ_2, ρ_3, until ρ_n. The probabilities of occurences believed on such case have prediction of each occurence as $\zeta(\vartheta)$ which are $\zeta(\vartheta_1) = \rho_1$, $\zeta(\vartheta_2) = \rho_2$, and $\zeta(\vartheta_3) = \rho_3$, until $\zeta(\vartheta_n) = \rho_n$.

The confidence interval could be measured by the standard deviation formula shown in equation 2 (Pearl, 1988).

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(\rho_i - \rho'\right)^2}{n-1}} \tag{2}$$

The standard deviation is used to know dispersion of data. The denotation of standard deviation in equation 2 written as σ and denotation of sample number written as n. The denotation for mean of data written as ρ'. The mean data could be written as equation 3 (Pearl, 1988).

$$\rho' = \frac{\sum_{i=1}^{n}\rho_i}{n} \tag{3}$$

A small standard deviation shows that set of the data is very close to the mean, while a high standard deviation shows that set of the data has a large range of values.

3. RESEARCH METHOD

In this paper uses MQ-7 gas sensor for sensing carbon monoxide (CO) to get the concentration of pollutant. This sensor used to capture data of carbon monoxide to be managable by Propeller microcontroller and displayed the data value of carbon monoxide on monitor. The sensor composed by micro AL_2O_3 ceramic tube, tin dioxide (SnO_2), plastic and stainless steel net. The sensor has uncertainty condition to get its working area. The factor that impact of this sensor depends on parameters of heating temperature, resistance load (R_L), heating time (T_H), oxygen concentration (O_2), and relative humidity (RH). From the datasheet showed that this sensor has high sensitivity to carbon monoxide, stable, and long life. The standard work condition has been written on (Hanwei Electronics, -) due to some factors shown in table 1.

Table 1. MQ-7 Standard Work Condition (a)

Parameter Names	**Technical Conditions**
Circuit voltage (Vc)	5V ± 0.1 Volts
High Heating Voltage(V_H)	5V ± 0.1 Volts
Low Heating Voltage (V_L)	1.4V ± 0.1 Volts
Load Resistance (R_L)	Adjustable
Heating Resistance (R_H)	33 ± 5% Ohms
High Heating Time (T_H)	60 ± 1 seconds
Low Heating Time (T_L)	90 ± 1 seconds
Heating Consumption	About 350 mW

Sensitivity adjustment for carbon monoxide sensor has some steps to get its good performance. Resistance value of MQ-7 for such gases concentration has different setting. So, this sensor need for calibration in the usage to capturing data of concentration of carbon monoxide in the air. From the datasheet, recommended to calibrate the sensor for 200 ppm of carbon monoxide in air and use value of load resistance (R_L) about 10 KΩ. During accurately measuring, the proper alarm point for carbon monoxide sensor shall be determined after considering the temperature and humidity effects. The programming steps for sensitivity adjusting of carbon monoxide concentration are when the power has turned on, keep sensor during preheating by electricity over 48 hours. Thus, set the load resistance (R_L) until get a signal value that is formed from capturing carbon monoxide concentration for 90 seconds. The last step, set the load resistance (R_L) until get a signal value that is formed from capturing carbon monoxide concentration for 60 seconds (Hanwei Electronics, -).

The standard work condition of carbon monoxide sensor showed in the table 1 has some external factors i.e. using temperature, storage temperature, relative humidity, and oxygen concentration. The external factors that affect work condition of carbon monoxide sensor for measurement shown on table 2.

Table 2. Environment Condition of Measuring CO Using MQ-7 (Hanwei Electronics, -)

Parameter Names	**Technical Conditions**
Using and Storage Temperature	-20^{o}C – 50^{o}C
Relative Humidity (RH)	Less than 95% of relative humidity
Oxygen (O_2)	2% - 21%

From the datasheet of (Hanwei Electronics,-) also shows the sensitivity characteristic correlating with MQ-7 performance is affected by temperature and humidity, thus making a different values on the resistance of the sensor. R_0 is a sensor resistance at 100 ppm carbon monoxide (CO) in the clean air at 33% relative humidity (RH) and at the place where has a temperature of 20^{o}C. In another resistance R_s is a sensor resistance at 100 ppm carbon monoxide using a different temperatures and humidities. The correlation between temperature and the sensor resistance values shown in figure 1.

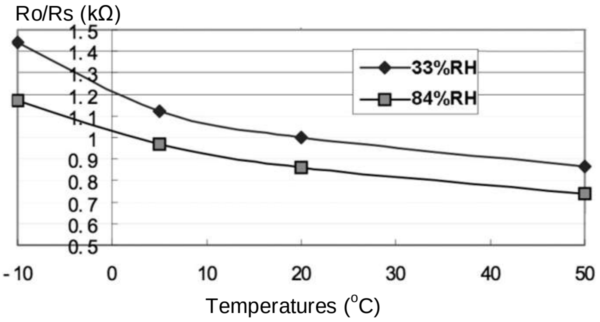

Figure 1. Temperatures vs R_o/R_s

Figure 1 shows the first line symboled by diamonds that have relative humidity rate of 33% and the second line symboled by squares that have relative humidity rate of 84%. The first and the second lines have different values of sensor resistances of MQ-

7. When the relative humidity value is lower, the sensor resistance is higher at the same temperature. The line gradient is more stable at range of temperatures between 20°C to 50°C for the relative humidity rates.

4. RESULT AND DISCUSSION

The data shown on the datasheet of MQ-7 can be used to determine the effect of evidence on confidence the work condition of MQ-7 as Carbon Monoxide sensor. Point values that interfere the performance of carbon monoxide sensor are the concentration of oxygen (O_2), heating temperature, power consumption, and surface resistance. The allowed concentration of oxygen for suited measurement of carbon monoxide is about 2% up to 21%, because more than 21% of oxygen can affect sensitivity characteristic of sensor. So Meanwhile the surface resistance for sensitivity is about 2Ω up to 20KΩ per 100 ppm of carbon monoxide.

In this paper the using temperatur has temperatur value range of -20°C up to 50°C, so if measuring done in the environment using temperatur of 20°C, then probability of temperatur is 0.8. In the table 3 shows the probability of events and probability of results that determined by such a range. Denotation of external factors that affect on the impact of MQ-7 resistance sensor generating for ppm concentration in the clean air i.e. oxygen (O_2), relative humidity (RH), and environment temperature (T_s). The events probability of oxygen, relative humidity, temperature represented by ρ(e) and the probability of result from the events represented by ρ(p|e).

Table 3. Probability of events and results

O_2	RH	T_s	ρ(e)			ρ(p|e)
$\neg O_2$	¬RH	$\neg T_s$	0.6	0.3	0.2	0.6
$\neg O_2$	¬RH	T_s	0.6	0.3	0.8	0.7
$\neg O_2$	RH	$\neg T_s$	0.6	0.7	0.2	0.4
$\neg O_2$	RH	T_s	0.6	0.7	0.8	0.7
O_2	¬RH	$\neg T_s$	0.4	0.3	0.2	0.4
O_2	¬RH	T_s	0.4	0.3	0.8	0.6
O_2	RH	$\neg T_s$	0.4	0.7	0.2	0.4
O_2	RH	T_s	0.4	0.7	0.8	0.5

The affected elements to yield range of accepted condition for the performance of MQ-7 sensor in the table 3 shows that the outcomes have some probabilities resumed as the mean of distribution denoted by ρ(p) and written by equation 4.

$$\rho(p) = \sum \rho(p \mid e).\rho(e) \qquad (4)$$

In the equation 4 can be defined more flexibel for knowing a details of its meaning. So, in this paper is written ρ(p) as ρ(ppm) for the probability value of MQ-7 sensor. The events are symboled by e containing of oxygen (O_2), relative humidity (RH), and environment temperature (T_s). This definition is shown in the equation 5.

$$\rho(ppm) = \sum \rho(ppm \mid O_2, RH, T_s).\rho(O_2, RH, T_s) \qquad (5)$$

The set assesment for the probability values that have been defined can be found for determining range values of events and result. This value is needed in such a way to get set variables of probability. The set variables gotten from by multiplication of element values of oxygen, relative humidity, and temperature. The resume of correlation between event variables and range value of results can be written as table 4, which is the multiplication of probability of each element value denoted by $\rho(e_{O2}.e_{RH}.e_{Ts})$.

Table 4. Correlation of events variables in range value of results

ρ(e)			$\rho(e_{O2}.e_{RH}.e_{Ts})$	ρ(p|e)
O_2	RH	T_s		
0.6	0.3	0.2	0.04	0.6
0.6	0.3	0.8	0.14	0.7
0.6	0.7	0.2	0.08	0.4
0.6	0.7	0.8	0.34	0.7
0.4	0.3	0.2	0.02	0.4
0.4	0.3	0.8	0.09	0.6
0.4	0.7	0.2	0.06	0.4
0.4	0.7	0.8	0.22	0.5

From the table 4, the value of each multiplicated variable in the same range can be grouped in one part and summing each multiplicated variable, so in this case, the range of ρ(p|e) has values between 0.4 until 0.7 and each range of member yielded by equation of $\Sigma\rho(e_{O2}.e_{RH}.e_{Ts})$. From this definition each range of ρ(p|e) has values as follow :

0.4 ⇔ 0.08+0.02+0.06 = 0.16
0.5 ⇔ 0.22

0.6 ⇔ 0.04+0.09 = 0.13
0.7 ⇔ 0.14+0.34 = 0.48

Range of ρ(p|e) = 0.4 has value of 0.16, range of ρ(p|e) = 0.5 has value of 0.22, range of ρ(p|e) = 0.6 has value of 0.13, and range of ρ(p|e) = 0.7 has value of 0.48. The graphic of correlation between ρ(p|e) and Σρ(e_{O2}.e_{RH}.e_{Ts}) shown in figure 2.

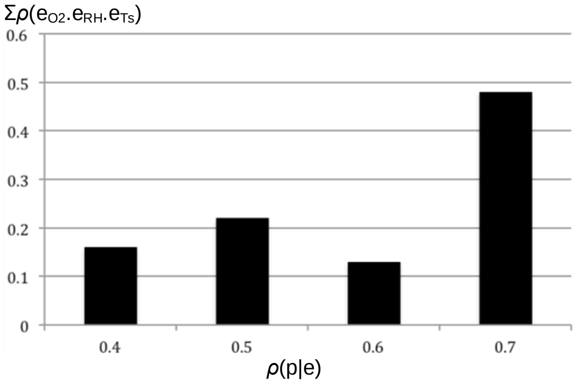

Figure 2. ρ(p|e) vs Σρ(e_{O2}.e_{RH}.e_{Ts})

Figure 2 shows that the condition that most affect on the performance of MQ-7 sensor at point ρ(p|e) = 0.7 considering to the concentration of oxygen and the temperature. The probability of the performance of MQ-7 sensor is given by the distribution mean on the data. The equation of mean for this case shown in equation 5 can be found as table 5.

Table 5. Founding mean value

ρ(e_{O2}.e_{RH}.e_{Ts})	**ρ(p|e)**	**ρ(e_{O2}.e_{RH}.e_{Ts}). ρ(p|e)**
0.04	0.6	0.02
0.14	0.7	0.10
0.08	0.4	0.03
0.34	0.7	0.24
0.02	0.4	0.01
0.09	0.6	0.05
0.06	0.4	0.02
0.22	0.5	0.11
ρ'		0.59

Table 5 shows that the mean of data for probability of ρ(e_{O2}.e_{RH}.e_{Ts}). ρ(p|e) is 0.59. From this result can be predicted dispersion of such data to get closer variable of probability using standard deviation as written on the equation 2. So the equation of standard deviation for this case can be written as equation 6.

$$s = \left[\sum \left[\rho\left(ppm \mid O_2, RH, T_s\right) - \rho'\right]^2 . \rho\left(O_2, RH, T_s\right)\right]^{\frac{1}{2}} \tag{6}$$

from the equation 6, the variable values can be entered to the equation as shown in equation 7.

$$s = \left[\left(0.4 - 0.59\right)^2 .0.16 + \left(0.5 - 0.59\right)^2 .0.22 + \left(0.6 - 0.59\right)^2 .0.13 + \left(0.7 - 0.59\right)^2 .0.48\right]^{\frac{1}{2}} \tag{7}$$

The result value of standard deviation for this case is 0.116.

5. CONCLUSION

This paper shows that the performance of MQ-7 sensor can be predicted by manipulating the external factors. Due to the dispersion of data in preparing this paper, they are tested using the standard deviation to obtain the mean of the data.

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