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Prototyping of the Pipe Tracking Robot Using Electronic Nose Technology as Gas Leakage Detector

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Abstract:- An industrial gas leak will cause material losses and impede the gas distribution of the company. In addition, it can also threaten human lives if the gas leaked is of toxic and inflammable gasses. Thus, to overcome these issues, the researchers had developed an automatic gas leak detection system through this proto type. In this journal, the researchers described how to make a prototype of a robot for monitoring the gas leak. The designed robot was of Out-Pipe Robot type and a PVC pipe was used as the real replica of the pipe. This study was conducted for three purposes: (1) Determining the design; (2) Describing the making process and (3) Explaining the performance test of the prototype of pipe tracking robot using electric nose technology as the gas leak detector. The working system of this pipe tracking robot is by tracking the pipe using the HC-SR04 ultrasonic sensor. If the MQ6 gas sensor detects the presence of a gas leak, the gas sensor will detect the gas and convert it into voltage. Then, the gas sensors will transmit the input voltage to the Arduino microcontroller, after which the output of the Arduino microcontroller will release the data to the LCD and display it in the form of digital figures in accordance with the level and type of the leaked gas. Besides, the buzzer will start sounding once it detects the presence of the gas. The results of the study were: (1) The device is able to track the pipe which was ± 10 cm in diameter, (2) The device is able to detect gas other than clean air, (3) The flashing LCD screen indicating that it detected the presence of gas, (4) The ideal distance to be maintained between the pipe and the mobile robot was 5 cm. With the ideal distance, the mobile sensors could easily track over a pipe installation without getting distracted by other objects. (5) The time reference used as the detection range was 1 minute. By doing so, the sensor will be more sensitive.

Keywords:- Arduino, Electric Nose Technology, Gas leak detector, Mobile Robot, Pipe Tracking.

I. INTRODUCTION

Pipe as the main medium of gas transportation has various forms of applications such as for gas pipeline of office buildings, sewage pipe, pipeline of chemical factory and so on. Hence, a number of countries have been using the pipeline as the major pathway in the oil and gas delivery installation. The vital role of pipeline installation, nevertheless, demands an undeniably necessary monitoring over the condition of the pipe itself, for a single leakage will cause material losses and impediment of gas distribution of the company. The gas leak can also lead to the disruption of air quality and threaten human lives if the leaked gas is of toxic or inflammable gasses.

In order to overcome these issues, we need a device that can determine the type of the leaked gas and the location of the leakage. There is a wide range of gas leak detection methods that have been developed so far including a wired monitoring system based mobile robot. This method is a detection system using a robot to track the pipe with a wire as the media for sending information about the sensor data from the robot. Thus, the wider the area of pipe to be monitored, the longer the wire required. Therefore, the use of this wired monitoring system is considered inefficient. In addition, the constituent material of the wire itself is also very susceptible to heat, which cause its life to be more limited [1].

Another potential problem is the fact that in order to identify a gas leak in an open air is very difficult since once the gas has leaked out, it will be mixed with outdoor air. Furthermore, if the source of the leak comes from more than a few types of pipes with different gases, this will mean that this matter is of a separate issue [2].

Electronic Nose is an olfactory electronic device that works according to the principle of living things' sense of smell. It is widely used in various fields, including: industrial, food and drug quality testing, medical, environmental monitoring, security, military and so on [3]. One of the implementation of the Electronic Nose is to identify the source of a gas leak.

Pipe tracking is a method which is implemented on mobile sensor, enabling it to identify the areas of the pipe installations which are going to be monitored. By applying this pipe tracking method, then the mobile sensors can perform the monitoring without having to put additional installations or change the existing design

of the piping systems [4] . In order to develop the potency and overcome these problems, the researchers are eager to develop a system that can detect gas leaks in real time. With the use of the MQ6 sensor it is expected that the source of the gas can be accurately detected. This system detector is presented in the form of a mobile robot equipped with the pipe tracking method. Moreover, the sensors which are used for tracking down the pipe are SRF02 ultrasonic sensor, HC-SR04 and also the signal conditioning system of the sensor. Thus, it is expected that the system is able to accurately detect the pipe. Additionally, this tracking pipe robot makes use of arduino uno modules as the main controllers. Hence, this article is conducted for several purposes written below:

1. Determining the design of the prototype of the pipe tracking robot using electronic nose technology as the gas leak detector.
2. Describing the making process of the prototype of pipe tracking robot using electronic nose technology as the gas leak detector.
3. Explaining the testing of the prototype of the pipe tracking robot with using electronic technology as the gas leak detector.

II. RESEARCH METHODS

A. Literature Review

Since the reviewed literatures are from relevant sources, the researchers focused more on books, trusted sites from the Internet, undergraduate thesis / TA, and scientific journals on robotics. The discussion sought included: (1) Sensors and transducers, (2) Microcontroller, (3) Design.

B. Device and System Design.

In this point, the prototype of pipe tracking robot using electric nose technology as the gas leak detector was designed.

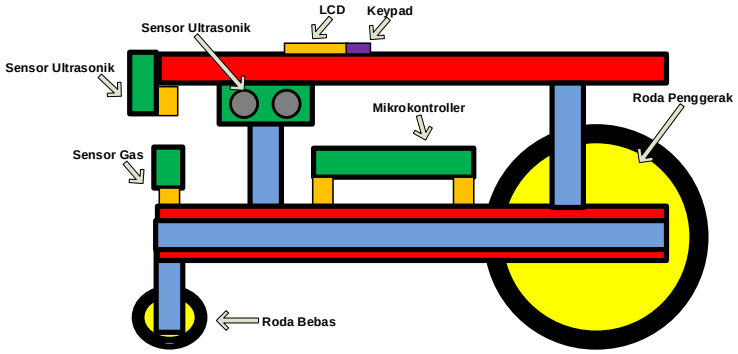

Fig. 1: The side view of Pipe Tracking Robot design (copyright Syifal Fuada, 2013)

C. Working System of the Device

The system of the pipe tracking robot works in a way that the robot tracks the pipe using ultrasonic sensors. If the gas sensor detects a gas leak, the gas sensor will detect the gas and convert it into voltage. Then, the gas sensors will transmit the input voltage to the Arduino microcontroller. Next, the output of the Arduino microcontroller will release the data to the LCD and display it in the form of digital figures in accordance with the type of gas and gas levels. In addition, the buzzer will start sounding when the gas is detected. Users can read the state of the robot in real time through the LCD.

D. Device Assembly

In this section, the prototype of the pipe tracking robot using electric nose technology and all of the system were made as shown previously in figure 1.

E. Performance test

The performance test aims at ensuring that all of the system which have been made are working smoothly.

III. FINDINGS AND DISCUSSIONS

Based on the design, the product resulted from the implementation of the prototype was a robot that is capable of automatically tracking over the pipe and accurately detecting any gas leak. In addition, the data related to the gas leak will be displayed on the LCD screen. Therefore, the users will be able to check whether there is a gas leak through the LCD screen.

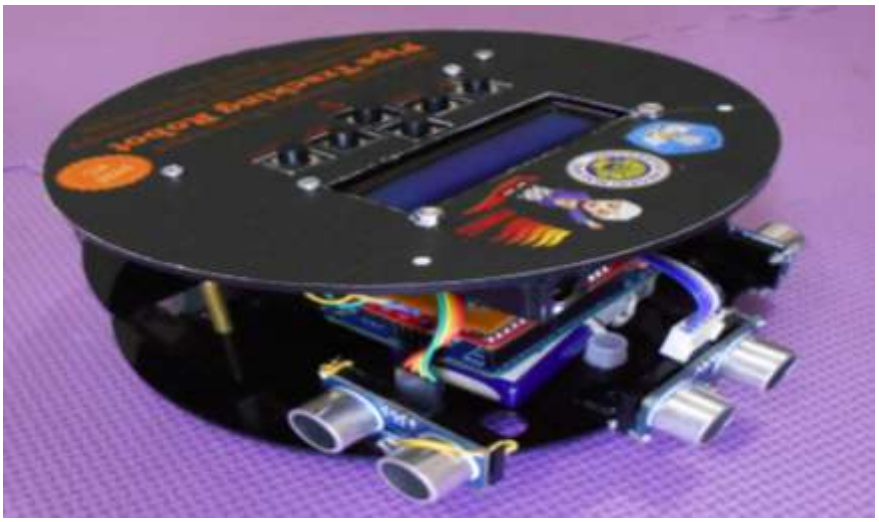

Fig. 2: The prototype of the pipe tracking robot

According to the table of performance test, the system of the robot prototype would be tested in several terms as follow:

1. *HC-SR04 ultrasonic sensor performance test*

This performance test was carried out by testing the sensor of the detector towards the measured distance. The test was started from the range of 1 – 10 inch. The three sensors placed on the front part, the right side, and the left sides of the mobile robot were used as the pipe tracking. Those three sensors then continuously monitored the distance of the pipe.

Table I: The performance test of the analog response to the ultrasonic sensor

No	Distance (Inch)	Time Reflection (mS)
1	1	6,16
2	2	11,70
3	3	18,40
4	4	25,50
5	5	31,20
6	6	35,70
7	7	37,58
8	8	45,30
9	9	52,76
10	10	60,70

Based on table I, it can be concluded that the longer the distance between the robot and the object (in this case is pipe) is, the longer the reflection time will be. Thus, the ideal distance to be maintained based on the design is 5 cm. Within the ideal distance, the mobile sensor will be able to smoothly run the tracking process over a pipe installation without getting distracted by other objects.

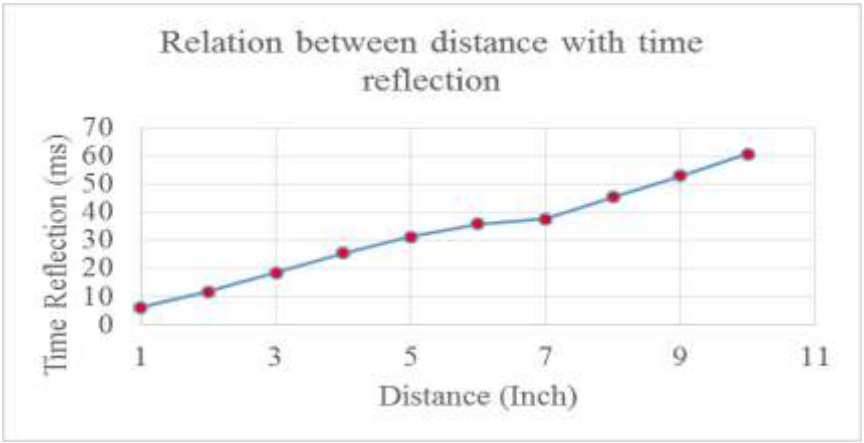

Fig. 3: The analog response to the ultrasonic sensor in the form of a graph

2. MQ6 gas sensor performance test

The sensor performance test aims at examining the sensor performance and identifying whether the sensor runs well by testing the output voltage value. The voltage value would be used to convert the time into voltage. Furthermore, the gas sensor would transmit the input voltage to the arduino microcontroller. After that, the output of arduino microcontroller released the data to the LCD and displayed it on the screen in the form of digital figures in accordance with the level and type of the gas.

Table II: The result of gas sensor performance test

No.	Time (Minute)	Output Voltage (Volt)
1	1	0,90
2	2	0,85
3	3	0,60
4	4	0,53
5	5	0,46
6	6	0,42
7	8	0,40
8	10	0,37
9	12	0,35
10	18	0,31
11	20	0,32
12	30	0,31

As shown in the table II, it can be concluded that the longer it takes for the sensor to detect the gas, and then the data will be saturated and tends to decline. Therefore, the researchers used the reference time of 1 minute as the detection range. By doing so, the sensor would be more sensitive in a way that if the sensor detected the presence of gas, then the arduino microcontroller would identify the output voltage.

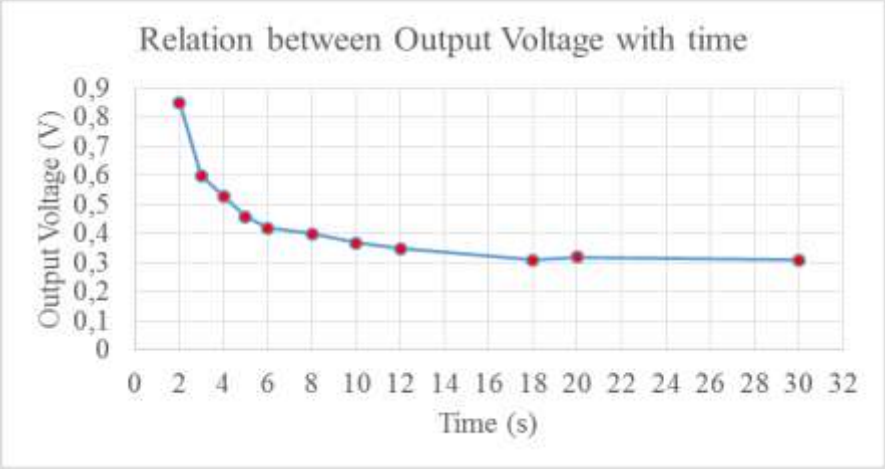

Fig. 4: The response of gas sensor in the form of graph

IV. CONCLUSIONS

The researchers have designed a prototype of pipe tracking robot using electronic nose technology as the gas leak detector. The design comprises of (1) the mechanical design; (2) the systemic design and (3) the working principle. In addition, the researchers have made the prototype of pipe tracking robot using electric nose technology as the gas leak detector: (1) it is able to track over pipes with ±10 cm diameter, (2) it is able to detect the presence of any gas other than clean air, (3) its LCD screen will flash if it detects a gas leak. Moreover, the researchers have tested the system of the prototype of pipe tracking robot using electric nose technology as the gas leak detector. The ideal distance to be maintained based on the analysis is 5 cm. The ideal distance will enable the mobile sensor to smoothly run the tracking process over a pipe installation without getting distracted by any other objects. In addition, the time reference used as detection range is 1 minute, enabling the sensor to be more sensitive, which means that if it detects a presence of gas, then the arduino microcontroller will identify the output voltage.

V. SUGGESTIONS

It is suggested that the robot still needs further development in term of the gas leak data transfer into a wireless transfer system so that the users can monitor remotely. Besides, the researchers also note that the tracking data should be transferred through radio wave. Unlike the satellite communication, which is expensive, the communication via radio wave is considered advantageous since the costs of the tools are relatively affordable and it can reach a considerable distance. In addition, the development of robot in term of the algorithm is still needed in order for the resulted data to be more accurate. In this case, the MQ6 sensors are installed in an array using neural network algorithm so that any type of gas will be detected based on the type of the gas. Last but not least, it is expected that this device is can spearhead the development of a more complex system applied in petroleum industry.

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