M.P.C.M

Monitoring & Purifying Carbon Monoxide

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ABSTRACT

Recently, Egypt has experienced various grand challenges like the corruption of the industrial, agricultural bases, the deterioration of the health, and the invasion of pollution. It is arguable that Egypt has witnessed a spread of different kinds of pollution in many industries, which is arisen by contaminating gases such as CO gas. The purpose of our study is to use IoT technology to solve the problem of carbon monoxide gas pollution in the steel factories. The chosen solution involves communication between two systems. The first system monitors and purifies CO gas using a carbon monoxide detector, an alarm, and an air purifier. The second system opens the emergency doors and detects the changes in Methane concentrations. The communication involves sending the second system to the first system that enough time elapsed for workers to come out. Consequently, the first system will stop the alarm. The CO detector will send to the second system that the purification is done, and then the second system will open the doors again. The prototype components constitute of microcontrollers (Arduino), MQ gas sensors, servos, and Antennas. The two design requirements for the prototype are that carbon monoxide gas returns to its normal level, and the door opens once methane exceeds the limit. The test results are successful and met chosen design requirements. The test results proved to us that the system consumes small amounts of energy and has quick response rates to the leakage. Moreover, it's portable and easy to be installed and has applicable, practical utility.

INTRODUCTION

In the last years, Egypt has faced many grand challenges including public health deterioration, the deficiency of the industrial base, the disastrous effects of climate change, and the spread of pollution. The capstone challenge this semester is to utilize modern technologies in communication and IoT to solve one of Egypt's demanding problems. We chose to work on the problem of pollution as it is a matter of a serious concern. For instance, over 43,000 deaths in Egypt are linked to pollution in one year. The major problem to be solved is the pollution from the leakage of carbon monoxide gas in steel industries. This problem induces a lot of respiratory diseases as the risk of developing diseases is 2 persons for every 1000. Many prior solutions were offered to solve this problem. First, a technique to control the vehicle air pollution. This proposed system is designed with a processor that controls the engine of the vehicle when a threshold level of pollution is detected. Although this solution has a point of strength of accuracy, it has the weakness of being expensive. Second, a system that measures CO_2 and dust from surrounding environments and sends data to users using an application called Blynk. This solution is strong for having quick response, but it has the weakness of having restricted results for the determined area. Benefiting from previous solutions and deep research, two design requirements are determined for the prototype which are that carbon monoxide gas returns to its normal level, and the door opens once methane exceeds the limit. The test for the first requirement was by using the carbon monoxide sensor to measure CO level after purification. The second test involved using the gas sensor to sketch various data of the gas concentration and observing the servo response. The chosen solution is to monitor and purify CO gas using the modern technology of IOT and communication. The solution involves usage of microcontrollers (Arduino), gas sensors, and servo. The solution will meet the design requirement through simultaneous communication between two main systems: one for setting alarm for CO pollution, and another for opening emergency doors. Main data are communicated between the systems including gases concentrations and servo responses. The chosen solution was successful because of the usage of precise materials which we will discuss later.

MATERIALS & METHODS

Materials are shown in table (1).

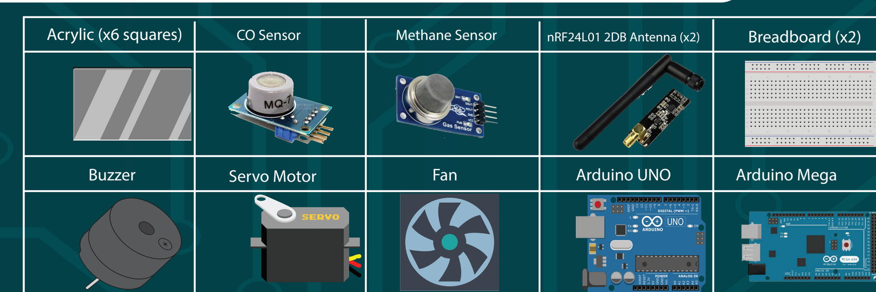


Table (1)

Methods:

First of all, we made a 28 cm3 acrylic (3mm) container to resemble the contamination area.

System 1: 1. Connecting and configurating the MQ-7 carbon monoxide sensor to the Arduino.
2. Connecting the buzzer to the Arduino.
3. Connecting the Arduino to the DC fan.
4. Using an Arduino C IDE to give instructions to our sensors and actuators.

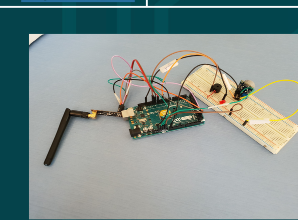


fig (1)

System 2: 1.Connecting and calibrating the MQ-5 gas sensor to the Arduino. 2.Making one opening in the acrylic to resemble emergency door. 3.Fixing a servo on the opening (the door) in the container. 4.Connecting the servos to the Arduino.
5. Using Arduino C IDE to program the gas sensor and the servo.

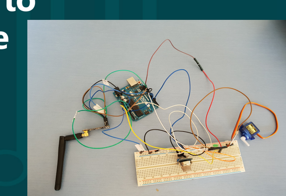


fig (2)

The connection between the two systems:
1. Connecting the nRF24L01 2DB Antennas to the Arduino Mega and Uno.
2. Connecting the two systems then sending and receiving the target data.

Test 1

Steps :
1. We used the MQ-7 sensor to measure carbon monoxide level after the purification was done.
2. We compared the output value with the normal carbon monoxide level (50 ppm).

Test 2

Steps :
We sketched various data from the gas sensor and observed the response angle of the servo.

RESULTS

Test 1

Firstly, we used a small DC fan to suck CO from the air; after that, we got the following data for carbon monoxide concentrations (PP-M) after three trials as shown in table(2):
*the sensor has a sensitivity error of (± 0.1)

Trial	CO concentration (PPM)	Normal level (PPM)
1	53± 0.1	50
2	54± 0.1	50
3	51± 0.1	50

Table (2)

From the results, we observed that the obtained values are not accurate, so we replaced the DC fan with different one and readjusted the MQ-7 sensor. So, we obtained the following results:

Trial	CO concentration (PPM)	Normal level (PPM)
1	50± 0.1	50
2	50± 0.1	50
3	51± 0.1	50

Table (3)

These results are more accurate and compatible with our design requirements as shown in table (3).

Test 2

We sketched various data from the MQ-5 sensor and observed the response of the servo as in table (4).
We obtained a relationship between methane concentrations and angles displaced by the servo, we found these results compatible with our design requirements.
*the sensor sensitivity has an error of (± 0.1).

Trial	CH_4 gas concentration (PPM)	Angle displaced by the servo in (degrees)
1	900± 0.1	0
2	1010± 0.1	90
3	1200± 0.1	90

Table (4)

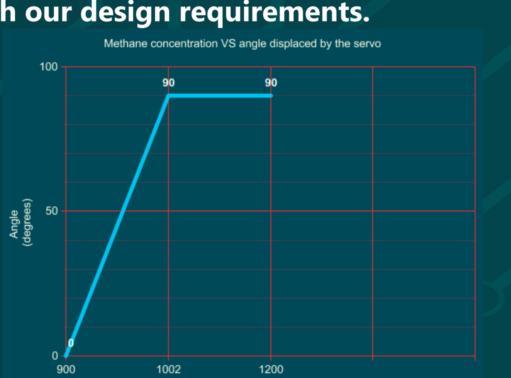


fig (3)

ANALYSIS

Our solution will save millions of lives from Death

The CO leakage from the containers in many factories can cause ultimate deaths. So, our device detects the unfavorable levels of CO in a closed area, especially in the Steel industry. The device will warn the workers of the leakage of the gases and eases their way out of the factory. Moreover, it will clean the leaked gas and inform the employees to come in again.

The first system

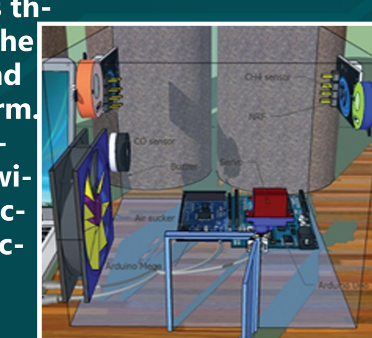
Our solution consists of two systems. The first system is comprised of an air sucker, alarm, and CO sensor. Whenever the percentage of CO exceeds a certain limit (50 ppm), the CO sensor will detect the changes. The CO sensor will, then, send its measurements to the Arduino, to which it's connected. The Arduino will evaluate the readings of Sensor according to a certain limit. If the value of the CO exceeds its limit, the Arduino will switch on the air sucker and the alarm. The air sucker will eliminate the high values of the CO, and the alarm will warn the people of the existence of the toxic gas.

The second system

The second system is composed of a CH4 sensor and a servo. As soon as the CO percentage increases, it will affect the percentage of the CH4 proportionally. The CH4 will detect the rise in the percentage and sends them to its Arduino. The Arduino will, in turn, compare the measurements to a certain limit (1000 ppm). If the level of the CH4 exceeds the limit, the Arduino will instantaneously send instructions to the servo to open the gates for the workers to facilitate their way out.

The communication between the systems

The two systems work independently at the beginning. As th-e people are coming out, the air sucker will be still cleaning the leaked gas. Nevertheless, after a 2-minute dilation, the second system will communicate with the first system to stop the alarm. of the second system will make the servo close the door till t-he air sucker finishes the cleaning efficiently. The air sucker wi-ll take 3 minutes to clean up the whole gas. After that, the sec-ond system will apply the condition it was set to, if the air suc-ker is turned off, open the servos. The doors will open up for the workers to enter the factory.

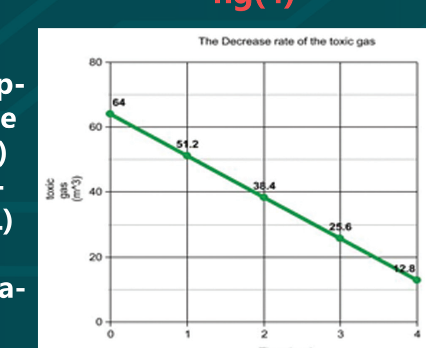


fig(4)

Interfering with scientific laws

How did we calculate the rate of purification?

Related time rates are an application of implicit differentiation we used to calculate the rate of purification of toxic (CO) and (CH4) gases. We took the derivative for the volume of the chamber which is V=L3, where (L) is the side length of cube (dV/dt=3L2× [dL/dt]). (dV/dt) is the rate of leakage of the toxic gasses by air purifier (required), and (dL/dt) is the rate of shortage of side of the toxic gases volume. During the purification, the volume will decrease and the length will decrease consequently at a rate of (dV/dt). Also, the side (L) decreases by rate of (dL/dt). We studied this concept in MA.3.01.



fig(5)

How did we write the code for the Arduino?

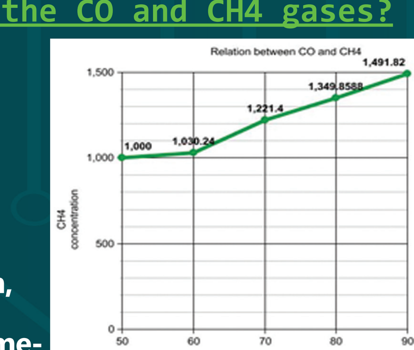
From various programming languages in different in computer fields, we relied on the Arduino c language. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards can read inputs - light on a sensor - activating a motor, turning on an LED, publishing something online. One can tell his board what to do by sending a set of instructions to the microcontroller on the board. To do so, one should use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. We learned this concept in CS.3

How did we calculate the weight that the servo can rotate?

Torque is the forces which cause an object to rotate about a certain axis. According to the law of toque, torque = moment of inertia X angular acceleration. Moment of inertia is defined as the body's tendency to resist angular acceleration. The door's moment of inertia around the fringes is $(1/3)MR^2$. (R) is the distance from the axis of rotation to the hinge, and (M) is the mass of the door. So, torque = $(1/3)MR^2$ * angular acceleration. So, the mass that the servo can afford is 3torque/(R^2 * angular acceleration).

How did we determine the relation between the CO and CH4 gases?

Carbon monoxide presence affects concentrations of other greenhouse gases including methane, tropospheric ozone and carbon dioxide. Carbon monoxide readily reacts with the hydroxyl radical (OH) forming a much stronger, greenhouse gas - carbon dioxide. This, in turn, increases concentrations of methane, another strong greenhouse gas, because the most common way methane is removed from the atmosphere is when it reacts with OH. So, the formation of carbon dioxide leaves fewer OH for methane to react with, thus increasing methane's concentration.
The results show that our solution meets the design requirements efficiently. Our solution is applicable and practical. The results matched with the expected ones; Thus, our solution solved the grand challenge we've chosen, that is,pollution.



fig(6)

CONCLUSION

The problem of pollution is invading our country that might cause serious problems, which we will solve using IoT technology in the steel industry as the carbon monoxide could leak from its containers. The solution's first system will monitor the levels of CO and purify it. The second system will open the emergency doors for the workers and detects the levels of the CH4. The communication between the systems will facilitate the people's way. The design requirements are that CO gas reaches back its normal level, and the door opens once CH4 exceeds 1000 ppm. The device has achieved the desired design requirements with an error in a range of (± 0.1) in the CO, CH4 measurements. The device has from 1 to 2 seconds time range to react to the leaked gas, yet the communication between the two systems occurs is negligible. Hence, the test results were promising and as expected and met chosen design requirements, and proved that it consumes small amounts of energy, 61.407 W; Our device is portable and easy to be installed.

RECOMMENDATION

For further modifications:
1. Replacing the methane sensor by a people amass sensor that measures the random motion of the workers for further accuracy.
2. We recommend the user company to develop our device by exploiting it to measure more leakages other than the CO leakage.
3. In case of a device failure, the workers will use a mobile application to indicate whether they feel any symptoms. The application will decide on if the symptoms indicate a certain leakage, and the device will then check for that.
4. Merging each system with its components together for the simplicity in the usage.

For the real usage:
1. Replacing the servos by an impeded rotating system into the gates of the factory.
2. Utilizing our device in various industries and in restricted areas like stores and moles.
3. Developing a mobile application for the workers to be informed when the air purifier finishes cleaning.
4. Replacing the air sucker (fan) by an air purifier for more efficiency.
5. Installing many sensors in various places to measure the leakages simultaneously.
6. Replacing the buzzer with an alarm to make all the workers hear the warning.

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