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Human security from death defying gases using an intelligent sensor system

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ABSTRACT

Hazardous gas contamination causes threat to human life. In many developing countries, the sewers are still cleaned by unskilled laborers. Situations may arise where harmful gases may get emitted via sewage and can potentially endanger life. Furthermore, in coal mining, there is a possibility of hitting a source of natural gas which cannot be determined unless or until a sensor is utilized. To prevent such hazardous situations, this new gas detection system detects those types of gases, analyzes them for us and provides essential details about it.

Our system is designed to track the presence of hazardous gases, identify the safety limit and calculate the level in that situation, thereby preventing hazards to human life. It allows detection of carbon monoxide and methane at the given time, along with their accurate concentration values in ppm. The system also provides a threat detection alert so that the persons immediately evacuate that area, thereby preventing any possible dangers. The alert messages are broadcasted using GSM technology and hence, can be used to notify other rescue workers about the potential hazard the worker is facing at the moment.

1. Introduction

The ardent passion towards contributing to the society in order to save human lives was the main reason behind the origin of this project. Various articles which stated the numerous cessations of human lives while attempting to treat underground sewers intrigued our team to develop the model. [1,2] For those who work in atmospheres that could be hazardous to their health, selecting the right gas detector could be the single most important decision they could ever make. Their life could hinge on that decision so it is critical that the user make him aware of the hazards that could be encountered and the proper sensors to protect them. Data gathered in the late seventies and early eighties indicated that 65% of all those who died in confined spaces were unaware that the space they were entering was a potential hazard. Over 50% of confined space deaths occur to the rescuers and over one third of the fatalities occurred after the space was tested and declared safe and the gas detector was removed.

Gas detectors have been around for a long time, starting with that infamous methane sniffing canary, which sadly was a one-shot device, which when subjected to methane, tended to die rather quickly with no audio and visual alarm capabilities other than being slightly cheap and a total lack of motion. Fortunately technology has advanced significantly and we find ourselves at this point in time with some very sophisticated electronic equipment. But even the most sophisticated technology is useless if the sensors used are unable to detect the gases present.

Such references and may more throw light on the fact that the sewer gases contribute a major role in the mortality rate. The overall causal ratio may be small in comparison with others, but is still not a good reason to ignore the situation as life, however small it may be still has to be valued.

Tragedies like this frequently happen when gas monitors either are used improperly or not used at all. Manufacturers tirelessly work to make their instruments easier to use in an effort to eliminate such tragedies. But no matter how user-friendly the instruments become, if employees do not use them properly, injury and death on the job will continue to occur. Deciding to use a gas detector is a smart thing to do. These factors formed the basis behind the origin of the paper.

Sewer gas is a complex mixture of toxic and nontoxic gases produced and collected in sewage systems by the decomposition of organic household or industrial wastes, typical components of sewage. Sewer gases may include hydrogen sulfide, ammonia, methane, carbon monoxide, sulfur dioxide, and nitrogen oxides. Improper disposal of petroleum products such as gasoline and mineral spirits contributes to sewer gas hazards. Sewer gases are of concern due to their odor, health effects, and potential for creating fire or explosions.

In developing countries like India, the sewers are still being cleaned by unskilled laborers. Situations may arise where the hazardous gases emitted by the sewage endanger their lives. Furthermore, a similar situation may arise during the process of coal mining where the miners may get exposed to such harmful gases, a highly concentrated exposure of

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which, may even lead to their death. Thus an efficient method to detect the presence of such harmful gases becomes a necessity.

Our prime objectives are:

- ✓ To track the presence of hazardous gases, the most threatening among them namely carbon monoxide and methane present in trenches
- ✓ To identify the safe limits of these gases and calculate the level in that situation.
- ✓ Concentration of these toxic gases present in the air is identified accurately in ppm (parts per million)
- ✓ To warn the workers about the potential threats that they might face on account of exposure to such gases above a safe limit by sending the effect of the gas at that level through GSM technology.

2. Related work

In 2013, Sunny et al. [3] came up with a new method for classification of gases/odors called average slope multiplication (ASM) using dynamic characteristics of thick film gas sensor array. In 2013, W. Khalaf [4] pointed out in Sensor array system for gases identification and quantification that a practical electronic nose for simultaneously estimating many kinds of odor classes and concentrations. The multi-input/multi-output function is decomposed into multiple many to one task. Dae-Silk Lee et al. [5] designed a sensor array with nine discrete sensors integrated on a substrate to recognize the species and quantify the amount of explosive gases. A review of the pattern analysis of machine olfaction was laid before by Ricardo Gutierrez-Osuna [6] a member of IEEE.

In 2014, Sunny et al. [7] proposed a new feature technique called average slope multiplication to quantify individual gases/odors using dynamic responses of sensor array. Ozmen and Tekce [8] presented a system which is made of an array of eight phthalocyanine-coated QCM sensors and an ANN to find the corresponding composition of a gas mixture. In 2011, Ravi Kumar et al. [9] laid before a new soft computational approach using multi scale principle component analysis/ (MSPCA) for discrimination of gases. The network was found to identify the gases with a high success rate. Ali Gulbag and FevzullahTemurtas [10] put forward an adaptive neuro-fuzzy inference system (ANFIS) for quantitative identification of individual gas concentrations in their gas mixtures. S. Capone et al. [11] proposed an array of highly sensitive and mechanically stable gas sensors based on different sol–gel fabricated Pd-doped SnO2 nanocrystalline thick films which were used to detect concentrations of the range 0–100 ppm CO and 0–4000 ppm CH4 at 50% relative humidity. Li Jing et al. [12] applied the principle of electronic nose system in artificial olfactory system which combines gas sensor array and artificial neural network recognition.

3. Proposed method

A gas detecting system is developed to protect the life of trench workers from toxic gases. The basic idea of this system is to calculate a safe limit point 'x', when the system detects a value 'y' (near to and less than 'x') and then alert the environment. If the value exceeds 'x', then system should provide a higher level threat detection alert so that the persons immediately evacuate that area, thereby preventing any possible dangers. The alert messages are broadcasted using GSM technology.

The system is designed in such a way to detect the presence of carbon monoxide and flammable gases. The most commonly found flammable gas in trenches is methane. The system uses two sensors namely MQ-2 and MQ-7 for the detection of these gases in air. An Arduino board containing an Atmega 328 microcontroller is used for processing. Arduino senses the environment by receiving inputs from the two sensors, and affects its surroundings by controlling the actuators. The actuators used are an alarm and a LED light. The actuators are configured in such a way they light up or give out a warning noise only if the gases present in air exceed the threshold value. The whole system is developed using the Arduino programming language in the Arduino development environment. A GSM shield is used to alert the user about the presence of toxic gases using text messages. It can also be used to alert co-workers or rescue workers to help the users in case of an emergency. Given below is the basic system's architecture Fig. 3.1

The components present in the gas detecting system are:

- Power Device and Sensor System
- Arduino Component
- Voltage Divider Circuit
- Calibration
- LCD Arduino Circuit
- GSM System

3.1. Power device and sensor system

The power device is designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. This unit in the gas detecting system is used to convert the 230 V Alternating current from the mains and provide the electrical components with the required regulated 5 V direct Current. The sensors, Arduino board and the LCD display need a regulated power supply but the GSM modem contains an inbuilt voltage regulator and hence does not need the power device.

The transformer of 230v/15-0-15v is used to perform the step down operation where a 230 V AC appears as 15 V AC across the secondary winding. The rectifier is used to convert the Alternating Current (AC) to Direct Current (DC) with the use of four diodes. This process is known as rectification. The filtering circuit is used to smoothen out the circuits so that it doesn't damage even the most sensitive of the circuits. Capacitor is introduced into the circuit to accomplish the filtering process. The voltage regulator is used to maintain a constant voltage level which is being supplied to devices.

A sensor is a transducer whose purpose is to detect some characteristic of its environment. It detects any change in events or change in quantity and provides an output as an electrical signal. The two metal oxide semiconductors used are MQ-7 for the detection of carbon monoxide and MQ-2 for the detection of flammable gases. The sensors can work with very less amount of power supply and hence it makes them portable. The sensors contain 6 pins, 4 of them are used to fetch signals and the other two are used for providing heating current. Optimal heating current is needed for the working of the sensor. The sensors are connected to a power supply of 5 V which provides the required circuit voltage for the proper functioning of the sensors. The sensor unit detects the change in environment and reports it to the Arduino in the form of electrical signals.

The preferred wiring for the sensor is to connect both 'A' pins together and both 'B' pins together. It is safer and it is assumed that is has more reliable output results. In the picture, the heater is for +5 V and is connected to both 'A' pins. This is only possible if the heater needs a fixed +5 V voltage. The variable resistor in the picture is the load-resistor and it can be used to determine a good value. A fixed resistor for the load-resistor is used in most cases.

3.2. Arduino-sensor circuit

Arduino is used for the processing of the electrical signals received from the two sensors. The connections between the Arduino and the sensor board are shown in the figure below. The black wire indicates the ground connection and the red wire indicates 5 V circuit voltage. The analog output from the sensor is connected to the analog input