Wireless Central Control Gas(LPG) Detection System

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ABSTRACT

A gas detector is a device that detects the presence of gases in an area, often part of a safety system. This type of equipment is used to detect a gas leak or other emission and can interface with a control system, so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals

Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. This type of device is used widely in industry and can be found in locations, such as an oil rigs, to monitor manufacture processes and emerging technologies such as photovoltaic. They may be used in fire fighting

Keywords:-*LPG, Gas Detector, Toxic gases, Oil rigs, Photovoltaic, Photo ionization, Infrared point sensors etc*

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1) INTRODUCTION

“Gas leak Detection & monitoring system” is a project based on a wireless communication to enhance man and machine safety in a petrochemical industry. In today’s world petrochemical industry although being the largest process control industry it is also highly prone to major fire and gas disasters. A petrochemical industry has excessively high amount of crude oil stored within a confined area. Therefore, presence of any external source which can cause heat or fire would lead to a major disaster. Even the gas that are present in petroleum refineries are hazardous.

The Bhopal gas tragedy, which claimed lives of nearly 3,787 people is one of the major accidents due to gas leakage. And another instance, the Vishakhapatnam, HPCL refinery tragedy claimed lives of 30 people. Though a gas and fire detection system were present which is connected to the sensors using large number of wires that run from the control room to various plant areas, during the fire the wire itself got damaged, so the information did not reach the control room.

So, in order to avoid any hazard due fire and gas leakage in a petrochemical industry we have designed an integrated system which is a wireless communication device.

Pipeline systems deteriorate progressively over time. Corrosion accelerates progressively and long-term deterioration increases the probability of failure (fatigue cracking). Limiting regular inspecting activities to the "scrap" part of the pipelines only, results ultimately into a pipeline system with questionable integrity. The confidence level in integrity will drop below acceptance levels. Inspection of presently uninspected sections of the pipeline system becomes a must. This project provides information on the "Gas leak detection".

Pipelines are proven to be the safest way to transport and distribute Gases and Liquids. Regular inspection is required to maintain that reputation. The larger part of the pipelines system is accessible by "In-Line Inspection Tools" but this access is limited to the section in between the launching and receiving traps only. Unfortunately, corrosion does not have this limitation. The industry looks for means of inspecting these in-accessible pressure holding piping systems, preferably, without interrupting the operations. It is a fact that sufficiently reliable and accurate inspection results can only be obtained by direct pipe wall contact/access. If that is not feasible from the outside, we have to go inside. Since modifying pipeline systems for In-Line Inspection is mainly not practical,

2)LITERATURE REVIEW

2.1)A Wireless Home Safety Gas Leakage Detection System- The device is intended for use in household safety where appliances and heaters that use natural gas and liquid petroleum gas (LPG) may be a source of risk. The system also can be used for other applications in the industry or plants that depend on LPG and natural gas in their operations. The system design consists of two main modules: the detection and transmission module, and the receiving module. The detection and transmitting module detect the change of gas concentration using a special sensing circuit built for this purpose. This module checks if a change in concentration of gas(es) has exceeded a certain pre-determined threshold. If the sensor detects a change in gas concentration, it activates and audiovisual alarm and sends a signal to the receiver module. The receiver module acts as a mobile alarm device to allow the mobility within the house premises. The system was tested using LPG and the alarm was activated as a result of change in concentration

2.2)A Lab VIEW Based Remote Monitoring and Controlling of Wireless Sensor Node for LPG Gas Leakage Detection- There is an enormous interest in the development of gas monitoring systems for application in the gas leaks, detection of harmful gases in mines, home safety, exhausts gas monitoring, etc. A key fact in all these is the need of the flexible and practical virtual instrumentation, a way to easily expose the gas sensors to hazardous levels of gas concentrations. The detection of LPG/CNG gases has become a main issue today due to more wellbeing policy wide-reaching. This paper presents a conceptual architecture for a versatile, flexible and cost-effective portable system for monitoring the LPG gas leaks in the presence of air. The software platform in terms of virtual instruments is developed using Lab VIEW programming environment for internet connectivity to cover a large monitoring area. The monitoring of the sensor node is done using G-code created in Lab view. The system provides a very intelligent communication (notifications) and replacement of the wired connection and in turn the gas sensing system. This system can be installed in a place where LPG/CNG gas leak happens instantly. Our system for gas detection plays an imperative role of the prototype model to industry and general public as well.

2.3)Design and implement of a flammable gas detection system based on Wireless Sensor Network

It introduces a flammable gas detection system based on wireless sensor network which adopts chip design of JN5139 and ZigBee. In this system, gas monitoring nodes can self-organize into wireless sensor network, monitor the gas leak status timely and upload to the monitoring center. Flammable gas concentration of each node can be displayed in real time. Once gas concentration is higher than threshold value, the audible and visual alarm will be started. And the information will be shown on upper computer, in order to inform the staff to handle it. The experimental results show that the system has quick, reliable and accurate functions.

2.4)A Survey on Automatic Detection of LPG Gas- In the modern world, human (woman/man) adopted the system of cooking food and their daily needs from wooden fire to a LPG (Liquid Petroleum Gas) supply system. During the usage of the system, number of instances that will happen around us where there is a result of losing a life or the destruction of the mankind. A kind of self-killing scenario of human being because of their negligence or busy schedule. To prevent this to happen knowingly or unknowingly, this paper gives the details of existing methods to prevent the reason for causing damage due to leakage of LPG cylinders in closed areas like kitchen. Along with this we list the drawback of existing methods and propose a method that may resolve the identified drawbacks.

3)GAS SENSOR

3.1)mq-6 gas sensor- A **gas sensor** is a device which detects the presence or concentration of gases in the atmosphere. Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor, which can be measured as output voltage. Based on this voltage value the type and concentration of the gas can be estimated.

Fig1-MQ-6 Gas Sensor

The type of gas the sensor could detect depends on the **sensing material** present inside the sensor. Normally these sensors are available as modules with comparators as shown above. These comparators can be set for a particular threshold value of gas concentration. When the concentration of the gas exceeds this threshold, the digital pin goes high. The analog pin can be used to measure the concentration of the gas

3.2)GAS SENSOR CONSTRUCTION- All Gas sensors will consist of a sensing element which comprises of the following parts.

1. Gas sensing layer
2. Heater Coil
3. Electrode line
4. Tubular ceramic
5. Electrode

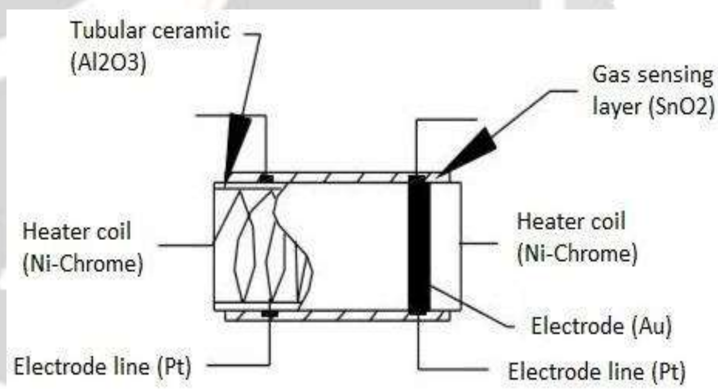

Fig2-image illustrates the parts present in a metal oxide gas sensor

3.2.1)Gas sensing layer: It is the main component in the sensor which can be used to sense the variation in the concentration of the gases and generate the change in electrical resistance. The gas sensing layer is basically a chemiresistor which changes its resistance value based on the concentration of particular gas in the environment. Here the sensing element is made up of a Tin Dioxide (SnO_2) which is, in general, has excess electrons (donor element). So whenever toxic gases are being detected the resistance of the element changes and the current flown through it varies which represents the change in concentration of the gases.

3.2.2)Heater coil: The purpose of the heater coil is to burn-in the sensing element so that the sensitivity and efficiency of the sensing element increases. It is made of Nickel-Chromium which has a high melting point so that it can stay heated up without getting melted.

3.2.3) Electrode line: As the sensing element produces a very small current when the gas is detected it is more important to maintain the efficiency of carrying those small currents. So Platinum wires come into play where it helps in moving the electrons efficiently.

3.2.4) Electrode: It is a junction where the output of the sensing layer is connected to the Electrode line. So that the output current can flow to the required terminal. An electrode here is made of Gold (Au –Aurum) which is a very good conductor.

3.2.5)Tubular ceramic: In between the Heater coil and Gas sensing layer, the tubular ceramic exists which is made of Aluminum oxide ($Al_2\ O_3$). As it has high melting point, it helps in maintaining the burn-in (preheating) of the sensing layer which gives the high sensitivity for the sensing layer to get efficient output current.

3.2.6) Mesh over the sensing element: In order to protect the sensing elements and the setup, a metal mesh is used over it, which is also used to avoid/hold the dust particles entering into the mesh and prevent damaging the gas sensing layer from corrosive particles.

4) GAS SENSOR WORKING

The ability of a Gas sensor to detect gases depends on the **chemiresister** to conduct current. The most commonly used chemiresistor is Tin Dioxide (SnO_2) which is an n- type semiconductor that has free electrons (also called as donor). Normally the atmosphere will contain more oxygen than combustible gases. The oxygen particles attract the free electrons present in SnO_2 which pushes them to the surface of the SnO_2. As there are **no free electrons** available output current will be zero. The below fig shown the oxygen molecules (blue color) attracting the free electrons (black color) inside the SnO_2 and preventing it from having free electrons to conduct current.

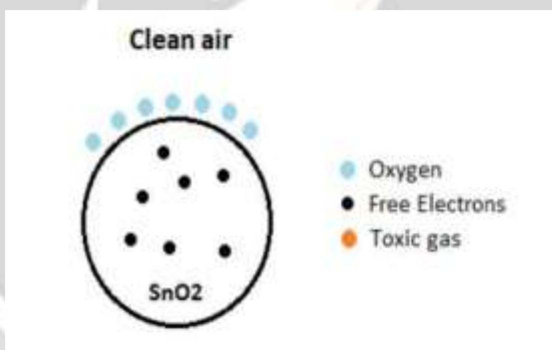

Fig3-ILLUSTRATION OF SENSOR WORKING

When the sensor is placed in the toxic or combustible gases environment, this reducing gas (orange color) reacts with the adsorbed oxygen particles and breaks the chemical bond between oxygen and free electrons thus **releasing the free electrons**. As the free electrons are back to its initial position, they can now conduct current, this conduction will be proportional the amount of free electrons available in SnO_2, if the gas is highly toxic more free electrons will be available.

5)TYPES OF GAS DETECTOR

Gas detectors can be classified according to the operation mechanism (semiconductors, oxidation, catalytic, photo ionization, infrared, etc.). Gas detectors come packaged into two main form factors: portable devices and fixed gas detectors.

Fixed type gas detectors may be used for detection of one or more gas types. Fixed type detectors are generally mounted near the process area of a plant or control room, or an area to be protected, such as a residential bedroom. Generally, industrial sensors are installed on fixed type mild steel structures and a cable connects the detectors to a SCADA system for continuous monitoring. A tripping interlock can be activated for an emergency situation**.**

5.1) Electrochemical-

This gas detectors work by allowing gases to diffuse through a porous membrane to an electrode where it is either chemically oxidized or reduced. The amount of current produced is determined by how much of the gas is oxidized at the electrode indicating the concentration of the gas. Manufactures can customize electrochemical gas detectors by changing the porous barrier to allow for the detection of a certain gas concentration range. Also, since the diffusion barrier is a physical/mechanical barrier, the detector tended to be more stable and reliable over the sensor's duration and thus required less maintenance than other early detector technologies.

However, the sensors are subject to corrosive elements or chemical contamination and may last only 1–2 years before a replacement is required. Electrochemical gas detectors are used in a wide variety of environments such as refineries, gas turbines, chemical plants, underground gas storage facilities, and more.

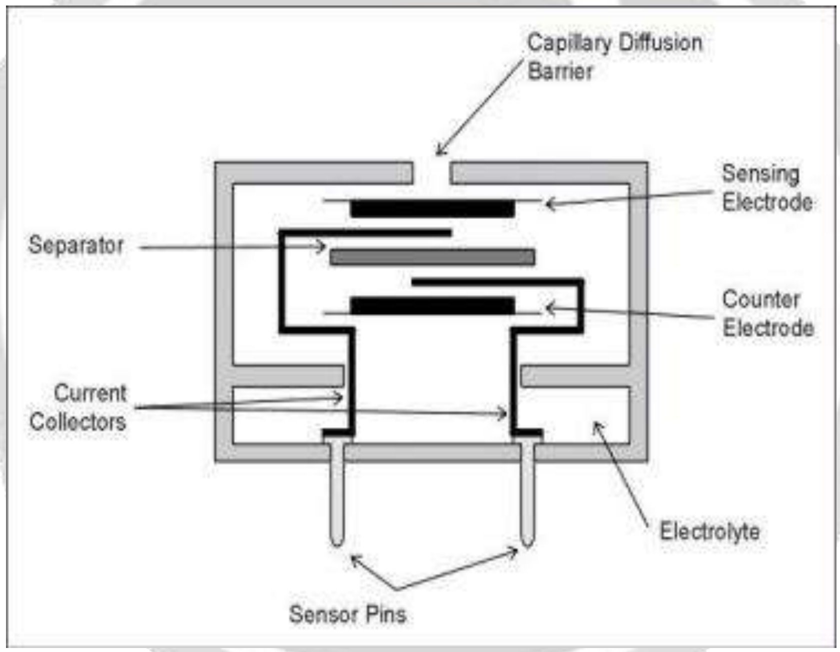

Fig4-Electrochemical Gas Sensor

5.2)Catalytic bead (palliators)-

Catalytic bead sensors are commonly used to measure combustible gases that present an explosion hazard when concentrations are between the lower explosion limit (LEL) and upper explosion limit (UEL). Active and reference beads containing platinum wire coils are situated on opposite arms of a Wheatstone bridge circuit and electrically heated, up to a few hundred ^{0}C. The active bead contains a catalyst that allows combustible compounds to oxidize, thereby heating the bead even further and changing its electrical resistance. The resulting voltage difference between the active and passive beads is proportional to the concentration of all combustible gases and vapors present. The sampled gas enters the sensor through a sintered metal frit, which provides a barrier to prevent an explosion when the instrument is carried into an atmosphere containing combustible gases. Pellistors measure essentially all combustible gases, but they are more sensitive to smaller molecules that diffuse through the sinter more quickly.

The measureable concentration ranges are typically from a few hundred ppm to a few volume percent. Such sensors are inexpensive and robust, but require a minimum of a few percent oxygen in the atmosphere to be tested and they can be poisoned or inhibited by compounds such as silicones, mineral acids, chlorinated organic compounds, and sulfur compounds.

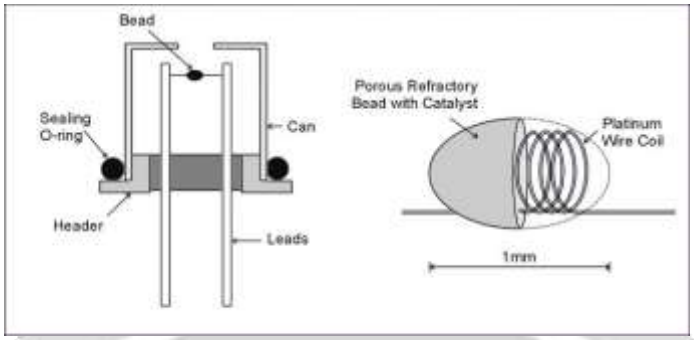

Fig5- Palliators

5.3)Photoionization-

(PIDs) use a high-photon-energy UV lamp to ionize chemicals in the sampled gas. If the compound has an ionization energy below that of the lamp photons, an electron will be ejected, and the resulting current is proportional to the concentration of the compound. Common lamp photon energies include 10.0 eV, 10.6 eV and 11.7 eV; the standard 10.6 eV lamp lasts for years, while the 11.7 eV lamp typically last only a few months and is used only when no other option is available. A broad range of compounds can be detected at levels ranging from a few ppb to several thousand ppm. Detectable compound classes in order of decreasing sensitivity include: aromatics and alkyl iodides; olefins, sulfur compounds, amines, ketones, ethers, alkyl bromides and silicate esters; organic esters, alcohols, aldehydes and alkanes; H_2S, NH_3, PH_3 and organic acids. There is no response to standard components of air or to mineral acids. Major advantages of PIDs are their excellent sensitivity and simplicity of use; the main limitation is that measurements are not compound-specific. Recently PIDs with pre-filter tubes have been introduced that enhance the specificity for such compounds as benzene or butadiene. Fixed, hand-held and miniature clothing-clipped PIDs are widely used for industrial hygiene, hazmat, and environmental monitoring.

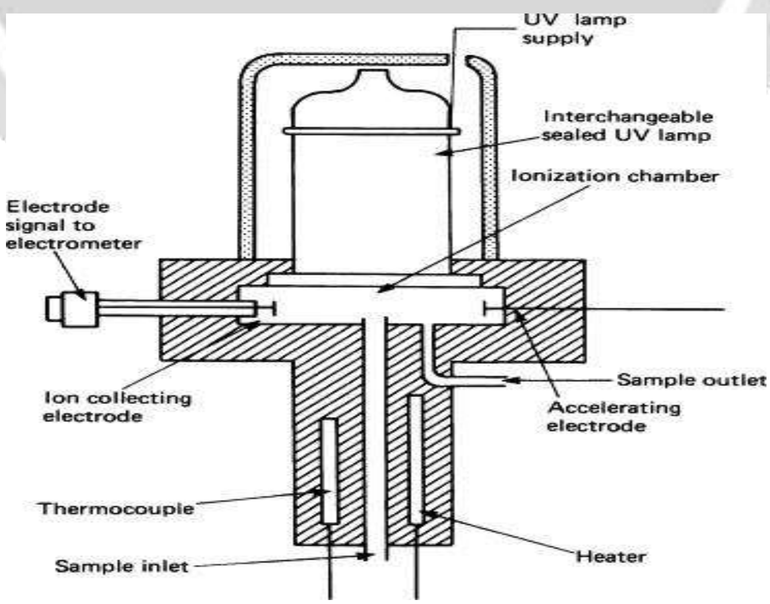

Fig6-Photoionization

5.4)Infrared point-

This sensors use radiation passing through a known volume of gas; energy from the sensor beam is absorbed at certain wavelengths, depending on the properties of the specific gas. For example, carbon monoxide absorbs wavelengths of about 4.2-4.5 μm. The energy in this wavelength is compared to a wavelength outside of the absorption range; the difference in energy between these two wavelengths is proportional to the concentration of gas present

This type of sensor is advantageous because it does not have to be placed into the gas to detect it and can be used for remote sensing. Infrared point sensors can be used to detect hydrocarbons and other infrared active gases such as water vapor and carbon dioxide. IR sensors are commonly found in waste-water treatment facilities, refineries, gas turbines, chemical plants, and other facilities where flammable gases are present and the possibility of an explosion exists. The remote sensing capability allows large volumes of space to be monitored.

Engine emissions are another area where IR sensors are being researched. The sensor would detect high levels of carbon monoxide or other abnormal gases in vehicle exhaust and even be integrated with vehicle electronic systems to notify drivers.

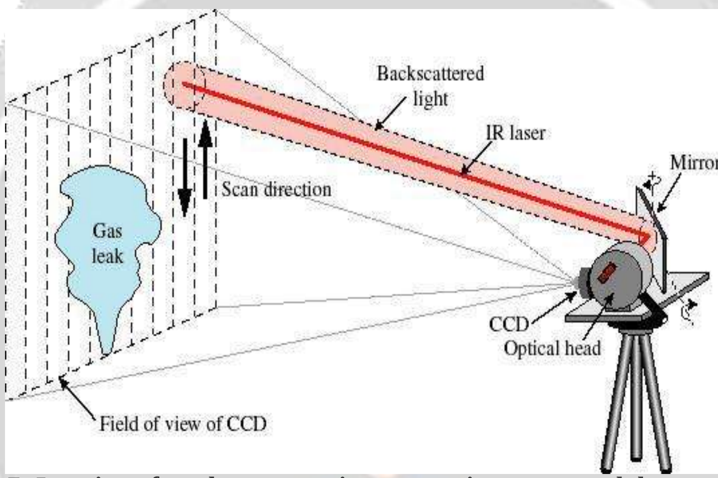

Fig7- Imaging of methane gas using a scanning, open-path laser system

5.5)Infrared imaging-

This sensors include active and passive systems. For active sensing, IR imaging sensors typically scan a laser across the field of view of a scene and look for backscattered light at the absorption line wavelength of a specific target gas. Passive IR imaging sensors measure spectral changes at each pixel in an image and look for specific spectral signatures that indicate the presence of target gases. The types of compounds that can be imaged are the same as those that can be detected with infrared point detectors, but the images may be helpful in identifying the source of a gas.

5.6) Semiconductor-

It detect gases by a chemical reaction that takes place when the gas comes in direct contact with the sensor. Tin dioxide is the most common material used in semiconductor sensors, and the electrical resistance in the sensor is decreased when it comes in contact with the monitored gas. The resistance of the tin dioxide is typically around 50 kΩ in air but can drop to around 3.5 kΩ in the presence of 1% methane. This change in resistance is used to calculate the gas concentration. Semiconductor sensors are commonly used to detect hydrogen, oxygen, alcohol vapor, and harmful gases such as carbon monoxide. One of the most common uses for semiconductor sensors is in carbon monoxide sensors. They are also used in breathalyzers. Because the sensor must come in contact with the gas to detect it, semiconductor sensors work over a smaller distance than infrared point or ultrasonic detectors.

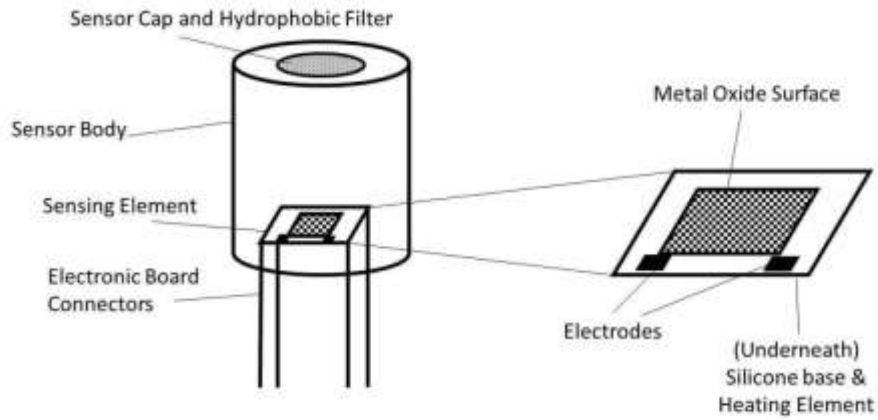

Fig8- Semiconductor-Gas Sensor Working

5.7)Ultrasonic-

This detectors are not gas detectors per second. They detect the acoustic emission created when a pressured gas expands in a low-pressure area through a small orifice (the leak). They use acoustic sensors to detect changes in the background noise of its environment. Since most high-pressure gas leaks generate sound in the ultrasonic range of 25 kHz to 10 MHz, the sensors are able to easily distinguish these frequencies from background acoustic noise which occurs in the audible range of 20 Hz to 20 kHz. The ultrasonic gas leak detector then produces an alarm when there is an ultrasonic deviation from the normal condition of background noise. Ultrasonic gas leak detectors cannot measure gas concentration, but the device is able to determine the leak rate of an escaping gas because the ultrasonic sound level depends on the gas pressure and size of the leak.

Ultrasonic gas detectors are mainly used for remote sensing in outdoor environments where weather conditions can easily dissipate escaping gas before allowing it to reach leak detectors that require contact with the gas to detect it and sound an alarm. These detectors are commonly found on offshore and onshore oil/gas platforms, gas compressor and metering stations, gas turbine power plants, and other facilities that house a lot of outdoor pipeline.

Fig9-Ultrasonic Gas Detection

5.8)Holographic-

This sensors use light reflection to detect changes in a polymer film matrix containing a hologram. Since holograms reflect light at certain wavelengths, a change in their composition can generate a colorful reflection indicating the presence of a gas molecule However, holographic sensors require illumination sources such as white light or lasers, and an observer or CCD detector.

5.8.1) Hydrocarbons and VOCs-

Detection of hydrocarbons can be based on the mixing properties of gaseous hydrocarbons – or other volatile organic compounds (VOCs) – and the sensing material incorporated in the sensor. The selectivity and sensitivity depend on the molecular structure of the VOC and the concentration; however, it is difficult to design a selective sensor for a single VOC. Many VOC sensors detect using a fuel-cell method.

VOCs in the environment or certain atmospheres can be detected based on different principles and interactions between the organic compounds and the sensor components. There are electronic devices that can detect ppm concentrations despite not being particularly selective. Others can predict with reasonable accuracy the molecular structure of the volatile organic compounds in the environment or enclosed atmospheres and could be used as accurate monitors of the chemical fingerprint and further as health monitoring devices.

Solid-phase micro extraction (SPME) techniques are used to collect VOCs at low concentrations for analysis.

Direct injection mass spectrometry techniques are frequently utilized for the rapid detection and accurate quantification of VOCs. PTR-MS is among the methods that have been used most extensively for the on-line analysis of biogenic and anthropogenic VOCs. Recent PTR-MS instruments based on time-of-flight mass spectrometry have been reported to reach detection limits of 20 pptv after 100 ms and 750 ppqv after 1 min measurement (signal integration) time. The mass resolution of these devices is between 7000 and 10,500 m/Δm, thus it is possible to separate most common isobaric VOCs and quantify them independently

6) CONCUSION AND FUTURE SCOPE

"Gas monitoring system" is developed to enhance man and machine safety in a petroleum refinery, Pipeline gassing cities, hotels, flats, Malls etc..... The main objective of the project was early detection of gas leakage around the Detection area. With the detection of a gas leak the sensor present in the onsite area as well as with the plant area workers alerts the control room personnel. Therefore, with this system even the human density in the area was determined. We have also analyzed various wireless technologies and various hardware and software approaches that can be implemented. After implementing this system, it was found out to be more efficient than the previously existing system. And with the introduction of this system the whole project cost was also reduced and human safety level was also increased.

FUTURE SCOPE

In addition to the developed system, the system can be enhanced by adding a control element which controls the gas leakage if it exceeds the specified upper explosive level for the various gases in the plant area. This can be achieved by any gas leakage indication in any part of the plant alerts the control room and then the control valve is shut off. Therefore, preventing any hazard arising due to gas leakage.

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