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Ammonia Gas Leakage Monitoring System using MQ-137 Sensors, IoT and Framing suitable Reflexive Actions

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Abstract: Over the past decade, several major industrial accidents have led the chemical industries and national regulatory bodies to reinforce the safety and regulatory measures. Chemical leaks, such as ammonia, can be the origin of toxic releases. This can lead to severe consequences on the installations as well as the environment and nearby inhabitants. In this paper, we propose one such ammonia gas leakage monitoring system using Internet of Things (IoT), which is an advanced and efficient solution for connecting the things to the internet and to connect the entire world of things in a network. The values of ammonia gas, during leakage are measured using MQ137 sensors and are sent to the cloud wirelessly using a Wi-Fi module. The data is retrieved from the cloud automatically by the receiver and required action is taken (like sprinkling water, sounding loud alarms, issuing warning to the respective institutes for safety, etc.). In this paper, we also present to you the reflexes that have to be carried out after such accidental leakage of ammonia gas.

Keywords: Chemical leaks, gas leakage, Internet of Things (IoT), MQ 137 sensors, Wi-Fi module.

I. INTRODUCTION

Ammonia or azane is a compound of nitrogen and hydrogen with the molecular formula NH_3. [1] The simplest pnictogen hydride is a colourless gas with a characteristic pungent smell. [2] Ammonia is used as a refrigerant and has a low boiling point. Ammonia refrigeration systems cost 10-20% less to install than systems using CFC, HCFC, etc. Thermodynamically, ammonia is 3-10% more efficient than other refrigerants and uses less electricity. [3] The cost of ammonia itself is significantly lesser than other refrigerants and less ammonia is also required to perform the job. Ammonia is corrosive and exposure to it will result in chemical-type burn. It is highly hygroscopic; and readily transforms the moist areas of the body such as eyes, nose, throat and moist skin areas. Inhaling ammonia causes irritation in the upper respiratory system.

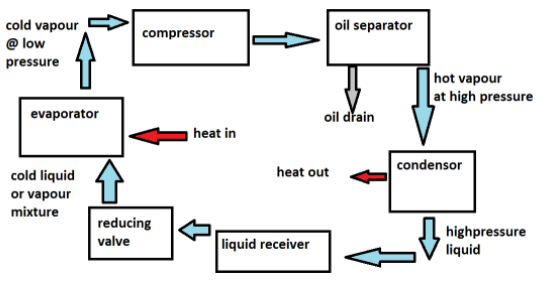

Figure 1 Ammonia refrigeration system

[4] Exposure to 50 ppm or more results in immediate irritation to the nose and throat. Exposure to 500 ppm of ammonia leads to immediate dangers to life and health and 30 minutes of exposure to 500 ppm of ammonia leads to hyperpnoea. Table 1 shows physiological response to ammonia.

Table 1 Physiological Response to Ammonia

Response	Concentration (ppm)
Immediate danger to life and health	500
Minimal Irritation	5
Moderate Irritation	9 - 50
Definite Irritation	125 - 137
Cyclic hyperpnoea	500 (for 30 minutes)
Immediate Irritation	700
Dyspnoea, conclusive coughing, chest pain, pulmonary edema, may be fatal	1500 – 10000

II. FEW INCIDENTS OF AMMONIA LEAKAGE

The paper describes three incidents that occurred in and around Kolkata, India in a cold storage and ice factory. Before that, we present a simple diagram of ammonia

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refrigeration system. Figure 1 shows the flow diagram of Ammonia refrigeration system.

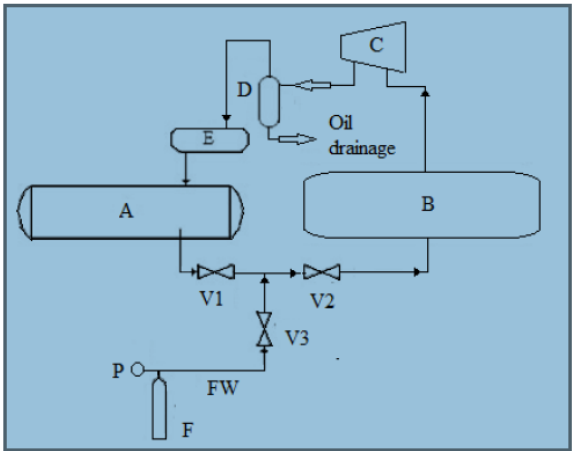

Figure 2 Detailed connection of cylinder to main line

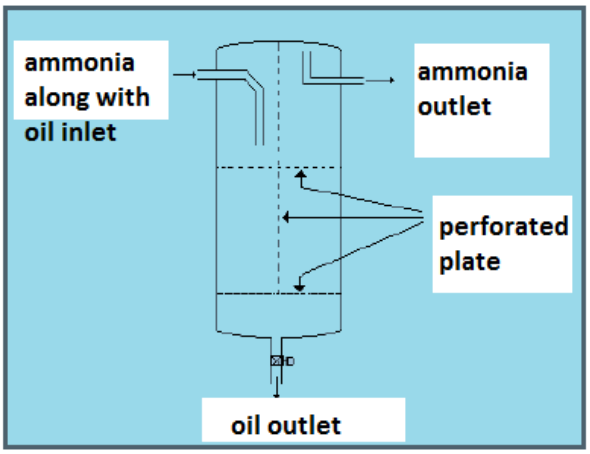

Figure 3 Schematic diagram of oil drum

A. Incident 1- Rupture of Manifold during Transfer of Ammonia from Cylinder to Receiver

The charging of ammonia from the ammonia cylinder of 65 kg capacity into the liquid line connected to the suction side of the ammonia compressor. The connection was made by a flexible rubber hose (maximum pressure withstand 12 kg/cm2) coupled by fixing nozzle. Figure 2 illustrates the detailed connection of the cylinder to the main line. The charging line was provided with a ¼ inch globe valve, V3, and a short piece of iron pipe. The ½ inch angle valve, V1, of the storage tank and V2, reducing valve connected into the system as shown in figure 2. In the transfer process, the operator opened valve V1 not the valve V2. So the line was directly connected with the storage tank with a pressure 15-18 kg/cm2. As soon as the operator opened the V3 valve he observed that ammonia was coming out profusely from the junction point of the short iron pipe and the rubber hose where a crack of 2 inch length was developed. Two fire brigade engines arrived in the spot and sprayed large amount of water to dissolved ammonia. The operator used the self-containing breathing apparatus from the fire brigade and closed the valve V1 and V3. The leakage of ammonia lasted about 30 min. Nine people from adjacent areas were affected and all of them were sent to local hospital for first aid treatment.

B. Incident 2- Oil Separator Drain Line Thread Failure

In a refrigeration unit drain line of the oil separator detached from the oil separator (2 ft in diameter and 6 ft in height) body all on a sudden causing massive leakage of ammonia inside and outside the factory. Figure 3 shows the schematic diagram of the oil drum. Two workers with self containing breathing apparatus entered into the accident spot and isolate the oil tank. The plant management started thewater sprinkler arrangement in the plant to control the situation. Entire plant was shut down after about 10 minutes of the incident occurs. The situation was controlled partially with the help of water sprinkler arrangement. Thirty workers were affected and all were transferred to local hospital for treatment and released after first-aid.

C. Incident-3 Leakage of Ammonia from Cold Storage [5]

At least 70 people fell ill in Dum Dum's Nagerbazar area, West Bengal, India on 23rd Jan. 2011 Sunday evening after inhaling poisonous ammonia gas which leaked out of a cold storage in the neighbourhood. There was widespread panic, leading to the deployment of BSF's disaster-response team. The entire area was cordoned off and traffic diverted for several hours. Around 3,000 people were evacuated before the leak could be plugged. Six fire tenders were sent to the spot. But when the fire fighters and the police were unable to locate the source of the leak, a BSF disaster-response team was called in. Equipped with gas masks, the team entered the cold storage premises around 9.30 pm and spotted broken valves and within an hour the valves and the cracked cylinder were repaired.

III.IOT

The Internet of Things (IoT) is the internetworking of physical devices, buildings and other items- embedded with electronics, software, sensors, actuators and networking connectivity. In this paper, we make use of IoT for environmental monitoring and building automation or plant automation. Environmental monitoring describes the processes and activities that need to take place to characterise and monitor the quality of the environment (indoor or outdoor). Building automation is the automatic centralised control of a building's heating, ventilation and air conditioning. All modern building automation systems have alarm capabilities. It does little good to detect a potentially hazardous situation like a gas leak. A threshold for the leakage of a gas is fixed and appropriate auto-reflexes are designed or programmed.

IV.METHODOLOGY AND SYSTEM DESIGN

Figure 4 shows the block diagram of the ammonia gas detection system using MQ 137 sensor [6], Wi-Fi module and IOT. 'n' number of sensors are connected in 'n' areas,

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where n=1,2,3,....n. MQ137 sensors are used to sense any leakage of ammonia in a particular area of the building or plant and the readings are fed to the microcontroller for processing. The data is then wirelessly transmitted to the local server or cloud using a Wi-Fi module. The cloud or server holds the past and present data of the air quality in the plant, and the system will be alerted if there is any variation in the same.

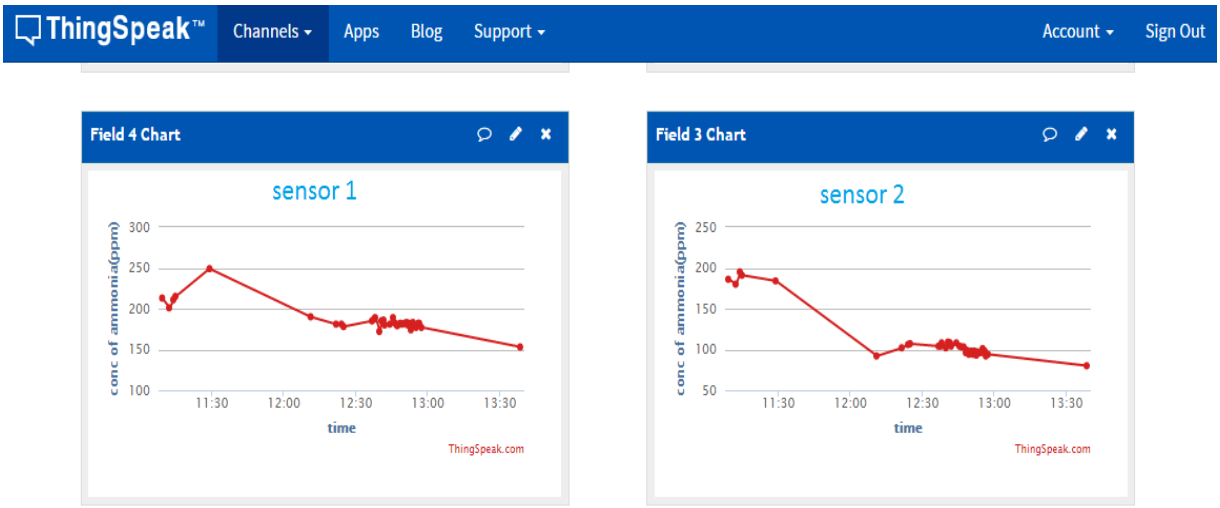


Figure 5 Graph of Concentration of Ammonia (in ppm) vs. Time and the readings are continuously displayed and recorded (thingspeak.com) in the cloud

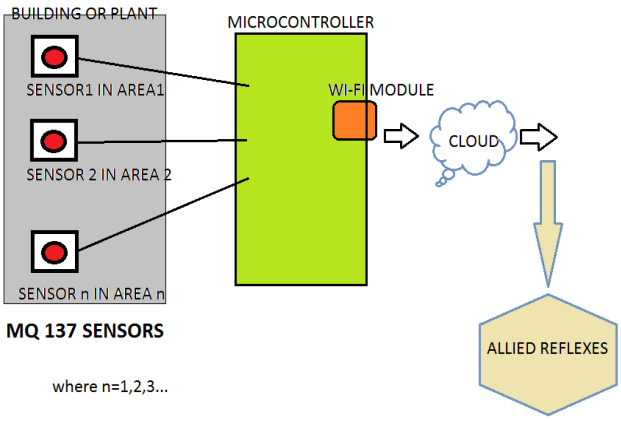
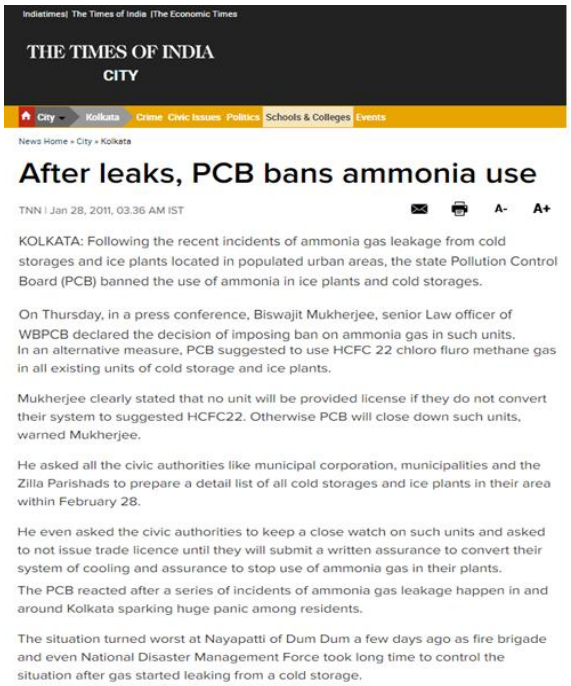


Figure 4 Ammonia gas detection system

In case of ammonia leakage in the plant, MQ137 sensors detect the same and following allied reflexes are framed:

- Sounding a loud alarm.
- Opening emergency exits.
- Activation of Water Sprinklers (as ammonia gas is soluble in water) to nullify the leakage.
- An alert signal passed to the nearest hospital, fire station, police station and other authorities.
- Alert the inhabitants in the vicinity of the plant.

The leakage data is recorded for study of the situation and to develop innovative methods to take preventive measures. This is the major advantage of using cloud computing and IoT.


THE TIMES OF INDIA
CITY

After leaks, PCB bans ammonia use

TNN | Jan 28, 2011, 03.36 AM IST

KOLKATA: Following the recent incidents of ammonia gas leakage from cold storages and ice plants located in populated urban areas, the state Pollution Control Board (PCB) banned the use of ammonia in ice plants and cold storages.

On Thursday, in a press conference, Biswajit Mukherjee, senior Law officer of WBPCB declared the decision of imposing ban on ammonia gas in such units. In an alternative measure, PCB suggested to use HCFC 22 chloro fluro methane gas in all existing units of cold storage and ice plants.

Mukherjee clearly stated that no unit will be provided license if they do not convert their system to suggested HCFC22. Otherwise PCB will close down such units, warned Mukherjee.

He asked all the civic authorities like municipal corporation, municipalities and the Zilla Parishads to prepare a detail list of all cold storages and ice plants in their area within February 28.

He even asked the civic authorities to keep a close watch on such units and asked to not issue trade licence until they will submit a written assurance to convert their system of cooling and assurance to stop use of ammonia gas in their plants.

The PCB reacted after a series of incidents of ammonia gas leakage happen in and around Kolkata sparking huge panic among residents.

The situation turned worst at Nayapatti of Dum Dum a few days ago as fire brigade and even National Disaster Management Force took long time to control the situation after gas started leaking from a cold storage.

Figure 6 Newspaper article which indicated how serious a problem gas leakage is, published in the Times of India Newspaper, January 28th, 2011

V. FINDINGS AND RESULT

- An experiment was conducted using three MQ137 sensors placed in three different areas in a closed chamber at Konigtronics. Ammonia gas was deliberately leaked. MQ137 sensors were controlled

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using Arduino Uno. [7] The data was wirelessly transferred to the server using a Wi-Fi module. Figure 5 shows the graph of concentration of ammonia (in ppm) vs. time and the readings are continuously displayed and recorded (thingspeak.com) in the cloud.

- A provision was made to sprinkle water as soon as the ammonia gas levels in the closed chamber exceeded the threshold value, to nullify the gas; as ammonia is soluble in water.
- Along with this a loud alarm was sounded and an alert message was sent to Konigtronics branch office which is approximately 2 miles from the Konigtronics Headquarters.

Figure 6 shows the newspaper article published in The Times of India, January 28th, 2011, 03:36 AM IST. [5] This newspaper article indicates how serious a problem this is. Hence proper monitoring and safety measures have to be followed in industries or buildings deployed with ammonia based refrigerating or cooling system.

VI. CONCLUSION

Ammonia gas leakage is more dangerous than we had ever imagined, causing many fatalities like any other poisonous gas; in industries or laboratories. In this paper we have proposed and developed a system for monitoring ammonia gas levels during its leakage using MQ 137 sensors, cloud computing and IoT. Also, proper reflexive actions to be carried out immediately during such incident are described in this paper.

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BIOGRAPHIES

Vishesh S who hails from Bangalore (Karnataka) has completed B.E in Telecommunication Engineering from VTU, Belgaum, Karnataka in 2015. His research interest includes embedded systems, wireless communication and medical electronics. He is also the founder and director of the firm Konigtronics (Pvt. Ltd.)

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