International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE)
ISSN: 0976-1353 Volume 30 Issue 3 – April 2023.

DETECTION OF NATURAL GAS LEAKS IN OIL INDUSTRY USING ANN

Dr.S.Prasanna
Department of Computer Science,
Thiagarajar College of Engineering, Madurai,
Tamilnadu

Ramya Bharathi V K
Department of Computer Science,
Thiagarajar College of Engineering, Madurai
Tamilnadu

Abstract:
This article introduces a neural network-based approach for detecting gas leaks in pipelines. The pipeline is divided into multiple segments and modeled based on the inlet/outlet pressure of the gas flow. An Internet of Things (IOT) network is utilized to collect the necessary data. Then, a neural network is used to process the collected data and trained on a set of data to optimize the weights. The leftover data is used to validate the accuracy of the error recognition system based on neural networks. To verify the proposed methodology, practical data from actual pipelines is used.

Keywords:Leakage Detection, Wireless Sensor Network (WSN), Artificial Neural Network (ANN), Gas Pipeline, Internet of Things (IOT)

I. INTRODUCTION

Oil and gas account for 60% of the world's energy, and pipelines have been introduced as a cost-effective method of transportation. Nowadays, pipelines are used to transfer a broad range of products, such as petroleum, crude oil, refined materials, natural gas, condensate, progression gas, fresh and salt water.In total, there are almost two million kilometers of pipelines located in different parts of the globe. Long-distance pipelines are often challenging to build, resulting in restricted physical access.

Pipelines can be installed underwater, underground, in deserts, mountains, and bodies of water, sometimes at depths of a mile or more. Gas pipelines offer a handy mode of transportation, but they also face the possibility of destruction because of inner and exterior pressures, ripples, fatigue splits, tensile capability, and production faults. These dangers can result in leaks and blasts, so it is imperative to observe them on a regular basis.Moreover, effective troubleshooting of these pipelines is essential for ensuring security, protecting the environment, and ensuring the profitability of the project.

II. LITERATURE REVIEW

Prior to the development of a software tool, literature research should be conducted to ascertain the time factors, economics, and strengths of the company. After these elements have been established, a further 10 steps shouldbe followed to identify the most suitable operating systems and languages for the project.In order to ensure successwhendeveloping a system, it is important for programmers to seek assistance from experienced peers, reading materials, and online resources. Prior to beginning the project, they should also conduct research to gain aexclusive conventions of the task at hand. With this support, they will be better equipped to create the proposed system.

Nayagi[1] have created a cost-effective gas leak detector that has been put into practice.Their work takes into account the challenges posed by traditional gas leak detectors and applies the recommended British safety standards. The alarm system is aimed at detecting leaks of LPG gases such as propane and butane, which are often used in residential and commercial buildings. This system has the capability to recognize both the existence and quantity of gas in the atmosphere and trigger relevant audible and visual warnings.In addition, the system is designed to maintain the legal level of butane in the air, which is 600ppm, and control the level of LPG in the bottle as well. An exhaust fan is also included to help manage gas leaks.

In April 2014**,** Meenakshi [2] published their paper "Automatic LPG Detection and Hazard Control". This idea envisioned a system that was able to identify gas leakage and supervise it in real-time with the help of a suction fan which could then be used to regulate it.Additionally, the system was able to monitor the LPG level in the bottle in real-time.

In their research, Pal-Stefan [3] explored a variety of gas leak detection and location techniques. These methods range from non-technical to acoustic, optical, and active approaches. While some of these techniques have been around for a while, others are more recent inventions made possible by advances in sensor making and computational energy. However, every technique has its own advantages and drawbacks. This article also serves as a reminder of the very real danger of gas leaks leading to fatal explosions, and highlights the need for alarm systems and shut-off valves as primary safety measures.

In this research paper, Srinivasan [4] reported on gas leak detection and control. Gas leaks leading to deadly consequences are a major concern in environments where domestic gas is handled and used. This publication proposes an alarm system that alerts subscribers and shuts off gas supply valves for optimal safety.

In2016, Falohun [5] proposed the use of integrated circuits and an MQ-9 for dangerous gas detection. This was accomplished through embedded designs which incorporated input/output devices such as sensors, radio frequency devices, LCD displays, LEDs, relays solenoids, and switches for measuring, humidity, temperature and light intensity. These systems that are built into a device lack the traditional input/output components found in a personal computer, meaning that no interaction with a human is necessary. When deciding what sort of fire alarm system to put in a home, it is important to evaluate the homeowner's needs in terms of security, the worth of the house, and the insurance policy requirements.

III. METHODOLOGY

Leak detection methods can be broadly divided into two categories based on their technical properties: hardware-based methods and software-based methods (Scott and Barrufet, 2003). These are sometimes referred to as external or internal grounded leak detection systems (Geiger et al., 2003). There is a third class covering alleged biological approaches, although not often presented as a differenttype in the recent literature (Zhang, 1997). We call these approachesuntechnical. Figure 1 shows these main kinds and the varied methodologies allied with each. This category is alike to that presented in the previous paragraph, but indirect or inferable methods overlay with software-based approaches, and direct methods entail hardware-based and non-technical approaches. Note that both are included. Leak detection methods that do not use any equipment, but instead rely on the senses of humans or animals (i.e., hearing, smell, sight) are known as non-technical detection techniques.

Hardware-based techniques for gas leak detection include acoustic, optical, wire sensors, ground monitoring, ultrasonic flowmeters, and vapor sampling. These methods rely on the use of specialized sensor devices to accurately detect gas leaks. The type of sensor or device used will determine the effectiveness and accuracy of these techniques. Software techniques depend on a software application to stay vigilant of the condition of flow, temperature, pressureor any other pipeline characteristics.Through the implementation of algorithms, these methods canfind leaks by analyzing changes in the variables. Software methods can applyvariousways to leak detection: real-time transient modelingans Mass-volume balance are two key concepts for understanding acoustic or digital signal processing or statistical, pressure point analysis, and negative pressure waves. By using these techniques, researchers can gain valuable insight into the underlying physics of these phenomena.

The ensuing few parts describe all of these methods, using the taxonomy in Figure 1 as a template for arranging this research. The working principles of the individual methods and their application strengths and weaknesses are presented. 3. Non-Technicalapproaches as mentioned earlier, these approaches include patrolling pipelines seeming for visual effects of gas leaks, sniffing for substance that may be released by leaks, You hear certain sounds that mayleak out. Tamed dogs are sometimes accustomed because they are acute to some gas odors.

The use of dogs to detect leaks has certain limitations. Continuous searches tend to be inefficient, lasting no more than 30-120 minutes. Furthermore, accuracy can be compromised by the handler's analysis of the dog's response, as well as fatigue. Despite this, dogs are still used for leak detection in countries such as the United States, where this on-site investigation is mandated by law for hazardous material pipeline operators (USDT, 2007). While the level of susceptibility can range from 10 parts per billion (ppb) to 1 part per 500 trillion (ppt), these results are only observed under laboratory conditions (Johnston, 1999).

Soap bubble screening (Liu et al., 2008), an inexpensive method for finding small leaks, also falls into this approach. This includes sprinkling a soapy solution onto different elements of the pipeline or suspect appearencesof the pipe. Screening with soap is typically employed to check for gas leaks in valves and plumbing connections.

The procedure is quick and inexpensive, making it useful as part of a routine inspection procedure. The benefit of using this method is that no special equipment is needed, and you can locate the leak instantly upon detection. However, it also has some disadvantages. For example, detection times are dependent on the prevalency of these tests and are actualltylowered (for example, US regulations state that these tests must be performed at least once every three weeks). Finding leaks is highly dependent on the expertise and diligence of the manpower deployed. Further drawback is that this technique can only be used to pipelines attainable to personnel, not concealed pipes. Hardware-Based Methods encompass acoustic methods, where leaking gas generates an acoustic signal as it passes through a ruptured pipe. Acoustic detection is used to detect gas flow and identify potential gas leaks.This signal can therefore be applied to adjudge that a blunder has occurred. Acoustic sensors should be used to record noise in pipelines. They could be merged into wearable sensing devices applied bypersonnel patrolling pipelines, or into smart pigs driven to inspect pipelines (Furness and van Reet, 2009).

Placing acoustic sensors along the pipeline and at a certain distance from each other (Brodetsky and Savic, 1993) allows for nonstop observing. The space between the two acoustic sensors might be adjusted depending on their sensitivity and the available funds. Too much separation increases the risk of false alarms, whereas too little proximity increases system costs. Many types of sensors has been used to find gas leak noises, including accelerometers, acoustic sensors, microphones, and dynamic pressure transducers (Loth et al., 2003). All these sensors are thoroughly explained in the source.

Since the 1930s, the development of acoustic leak detection methods has been extensively studied and discussed. In 1989, Rocha utilized pressure sensors to monitor sound pressure waves generated by leaks (Rocha, 1989). Furthermore, Brodetsky and Savic (2003) presented a compendious review on the subject, providing an in-depth overview of the progress of the field,on the other hand, used a K-nearest neighbor classifier to develop a system requiring a permanent monitoring unit along the pipeline to distinguish background and detect leaks. Noise (Brodetsky and Savic, 1993).

He utilizes two acoustic signals to evaluate every section of a pipe. By analyzing these measurements, Kim and Lee (2009) suggest that leaks can be pinpointed via the time-frequency method and Loth et al. (2003) propose the lower frequency impulse technique as viable options. A more contemporary experimental study immersed on using time-frequency analysis to distinguish between the signal from the leak and the background noise, and adjusted the leak locality formula for greater accuracy (Meng et al. 2011). The benefits of utilizing this approach involve the ability to continuously operate in a seamless manner and the ability to automate the system.

Acoustic sensors could be employed to detect the presence of a leak in a pipeline and ascertain its magnitude. This approach can be employed in both new and existing conduits. By using a continuous monitoring mode, the system can quickly respond to incidents. Unfortunately, ambient noise such as the sound of vehicles passing by, valves, or pumps can obscure the real gas leak noise.The economic downside is the high expense of inducting the large number of sensors necessitate for long pipelines. 4.2. Optical Methods, Two main categories of optical leak detection are active and passive (Reichardt et al., 2002). Active methods involve using a radiation source to detect leaks, while passive methods rely on existing background radiation or gas-emitted radiation. Optical leak detection has a range of benefits, such as being portable, enabling remote detection, and helping to pinpoint the exact location of a leak.

A general approach is to inspect natural gas pipeline networks utilizing the
Airborne Optical Leak Detector (ITT Corporation, 2009). The outcome map provides an outline of the whole network and shows the location of extant leaks rapidly than a handheld ground patrol can find them.
The only exception for portability is fiber optic sensingactive technique. The immersion or dispersion of radiation radiated by natural gas molecules can be monitored to identify potential leaks. To identify natural gas spills, several approaches have been created, including backscatter imaging,millimeter wave radar systems, diode laser absorption, LIDAR (Light Detection and Ranging) systems, broadband absorption, and fiber optics. Specifically, LIDAR systems (as documented by Minato et al., 1999 and Ikuta et al., 1999) deploy a pulse laser to light up the surroundings and a specific detector to assess the quantity of energy absorbed by the laser beam's trajectory.
This is a perceptivemethod that can be applied for remote monitoring. Nevertheless, pulsed lasers have the drawback of being expensive. Diode laser immersion (Iseki et al., 2000) is technically analogous to his LIDAR system, but with one major dissimilarity. Rather than using a luxurious pulsed laser, a diode laser can be applied to deliver illumination. This technique is suitable for both handheld detectors at short distances and high-altitude air detection.

A drawback of these systems is that they can generate false alarmsThe mmWave radar system Gopalsami [16] is predicated on the radar signature of the regionover the gas pipeline.The buoyancy of methane gas makes it lighter than air, which consequently results in reduced radar detection of possible leaks. Although this method is efficient, it is also luxurious. Backscatter imaging is an even more extravagant process that utilizes a carbon dioxide laser to illuminate the surroundings. The resulting laser light is scattered off the natural gas, which is then recorded by an infrared camera. It is through the patterns identified by the camera that the presence of a gas leak can be identified.A broadband absorption system (Spaeth and O'Brien, 2003) uses an inexpensive lamp as the light source. The monitoring process involves utilizing multiple wavelengths of light., reducing the chance of false alarms. Although this method can deliver remote detection,Optical fibers are often used to detect various physical and chemical properties (Tapanes, 2001).

Temperature transaformation effected by gas leaking out of the pipe line are signaled through the sensor's fiber optic able.Thesensor's fiber optic cable should be placed close to the pipe.Optical fibers can be used to detect gas leaks due to their sensitivity to hydrocarbons. By measuring the changes in transmission properties with lasers and optical detectors, these leaks can be accurately identified.

Fiber optic detection is an effective way of both pinpointing the source of a leak and assessing the concentration of the leaked gas. Its principal benefit is that it is unaffected by electromagnetic obstacle.Somedisadvantages ofapplying thismethod havealsobeenreported.Forexample,the over expense and sturdy overtime of man-made fiber coatings. Additionally, using this technique toexistingpipingsystemscan be complicated.This is because the buried pipe may need to be excavated inorderto position the fiber optic cable adjacent to the pipe line.It is important to note that passive surveillance need not require a radioactive source, setting it apart from active surveillance.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

It takes roughly 200 seconds before natural gas, in the form of a falling gas pipe, is discovered.After a span of 1096 seconds of gas escaping, the volatility of the gas reaches its minimum explosive level, and around 2300 seconds, the natural gas quantity fragment stabilises at 7.1%. whether the switch does not fully shut, it will take 550 seconds for natural gas to be detectable after it is activated. The volume percentage stabilises at roughly 9000 seconds and reaches 5.8% at the earliest time, which is 4670 seconds. Natural gas was initially noticed as a corrosion crack leakage at around 400 seconds; it first approached the explosive limit on the ceiling over the gas stove at around 3018 seconds; and it stabilised at around 6000 seconds, achieving 6%. A small pinhole leak of natural gas can be detected in less than 450 seconds and the concentration of it will reach the lower explosive limit after about 5,131 seconds. 8,300 seconds later, the volume of gas will reach a plateau of 5.7%. It should be noted that this type of natural methane gas leak has the greatest rate of release, the speediest increase of the gas fraction, the highest value, and the most severe consequences.

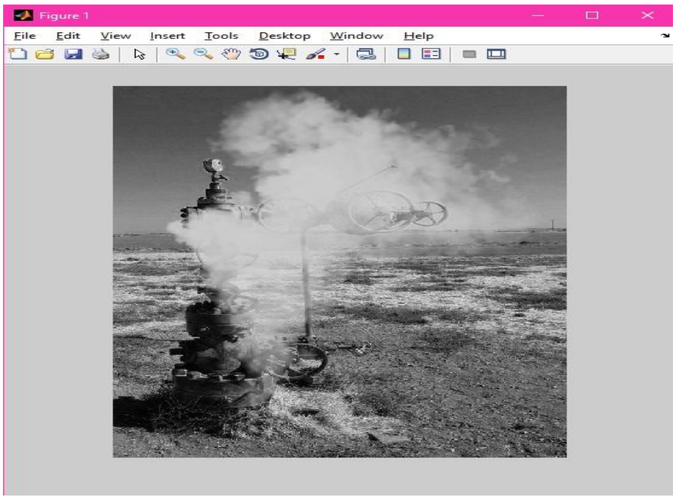

Figure 1: Output1

By examining the laws of natural gas leakage and diffuseness, it was observed that when a gas hose is not tight, the rate at which the gas accumulates to a dangerous level is the highest, while a hard object puncturing a natural gas line and producing a small leak requires the longest time for the gas to reach a flammable level. During the early stages, the volume fraction of the gas escaping the leak increases rapidly, but eventually stabilizes due to the gap between the door and the window, resultingin a slower increase.

I understand that, at steady state, the gas quantity fragment at every measurement point will exceed the leastferocious limit (5%) if the origin of the leak is in the cooking cupboard. If the leak origin is inside, the quantity fragment of anotherweighing points besides cooking cupboards will exceed the least fierce ends as well. The justification why the natural gas quantity fragment is lower in the cooking cabinets is due to the length of the leak root. Particularly, If the leak source is a small hole, it is located higher than the surface of the natural gas closet, so it is not detected in the natural gas cabinet. Generally, the natural gas quantity fragment distribution law exhibitsthat enhanced the measurement point, the high quantity fragment, and the nigher the measurement point at the similar peak to the leak origin, the higher the quantity fragment, which agrees to Cheng's inference. Examining the progressionordinance of natural gas attentiondispensation at various leak points can assist in determining leaks and accidents.At a natural gas absorption of 9.5%, the energy released by the ignition head is relatively low, estimated at around 10J. This causes the gas to undergo three stands of unhurried combustion, deflagration, and unhurried combustion within a span of 6 seconds after ignition. When set alight, a large ball of flame materializes around the point of ignition. The falling ignition head will create a fire source in many areas every 0.2 seconds, which in turn produces a light blue circular blaze. This blaze unleashes a great deal of energy, which causes the inner pressure of the surrounding unblazedregion to rise and a pressure gradient to form. This leads to a pre-shock wave that widens the gateinterval, allowing the blaze to escape outward. Shock waves and flame surfaces from multiple light blue ball flames overlap, causing turbulence in the unburned area and increasing the speed of the chemical reactionofcombustion.

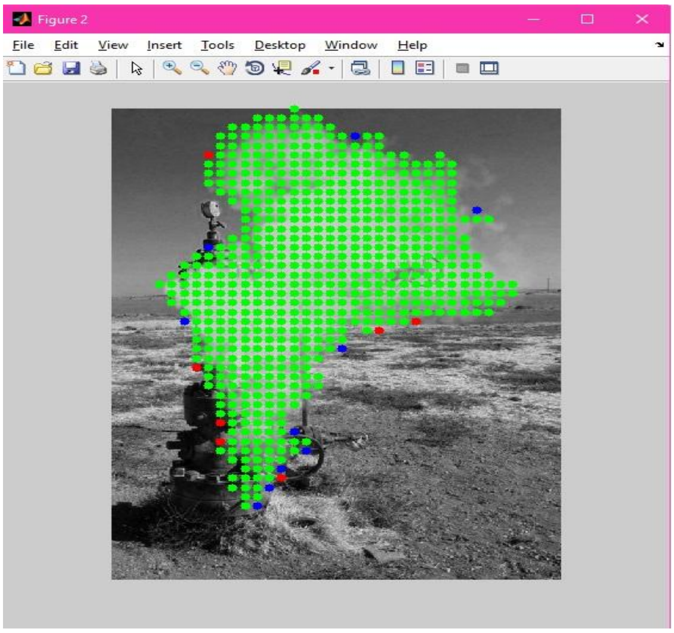

Figure 2: Output2

The chemical reaction rate is increased, which not only creates shock swellsthough releases more energy, resulting in a 0.8 second blaze that is emitted through the interspace. This causes the gas cloud to be agitated, leading to even more chemical combustion. The blaze progresses from a leisure burn to deflagration, changing out of light blue to light white. Atmostblaze injection spacing is 2.5m, and after 2.8 seconds of ignition, the blaze will no longer be injected out of interspace to the gate frame. The flame injection period is ~2.4 seconds and after the fuel runs out, the combustion condition turns into a leisure burn, gradually extinguishing until it is completely gone after 8 seconds.

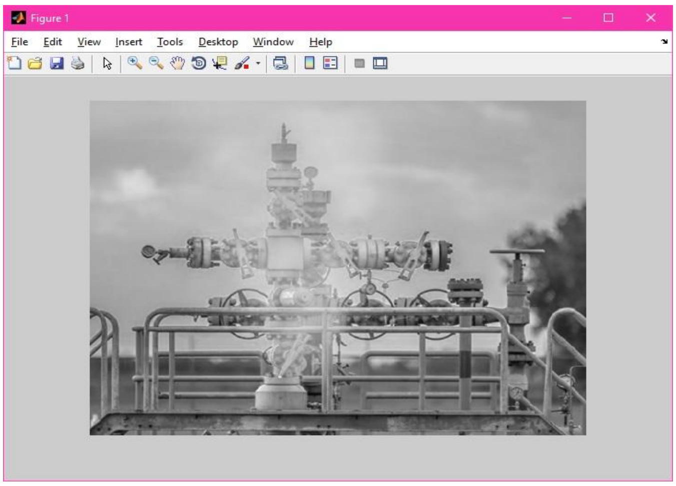

Figure 3: Output3

Temperature sensors were placed in the middle of the room along with 1 m from the floor along the window wall. This allowed for the monitoring of temperature changes at two measurement points. After ignition, an open flame was produced in the room. The temperature in the middle of the space, being nearest to the ignition origin, peaked at 0.0812 seconds and reached a maximum temperature of 1440 °C. Analyzation of the temperature-time bend and blaze propagation progression assisted in these results.

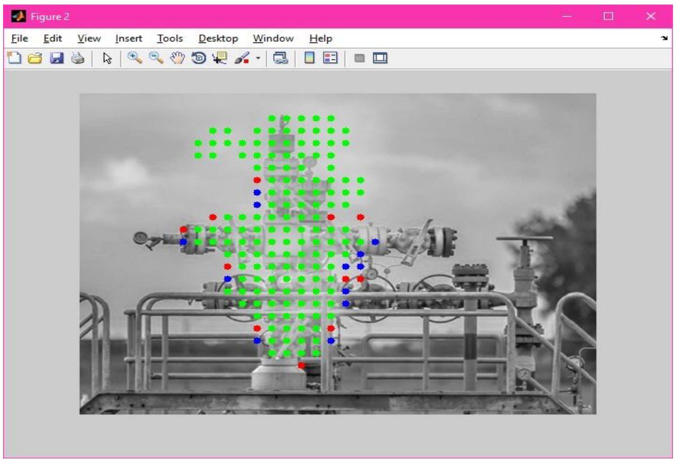

Figure 4: Output4

Cen et al, simulated an internal temperature of a natural gas explosion to be around 1900°C,the temperature readings taken during the experiment are inferior to the values calculated. However, the actual temperature peak at the wall measurement point was only 1386°C, which was reached 0.5778 seconds after its peak time of 0.4966 seconds at the central internal measurement point. This difference of 54°C is possibly due to the reality that the gas cannot respond completely, as the detonation progression is very compact and it is hard to attain real-time measurements. Experiments have provided temperature data that is enough to demonstrate that explosions can lead to secondary fires. Results have shown that a temperature of 700 °C is adequate to inflameextrememalleable objects, with the center of the room reaching a high of 4.58 seconds and the measured point on the wall staying at 2.75 seconds. Examining the temperature bends of both ends, it is clear that the temperature at the wall measurement point attains a peak before steadily declining, whereas the intermediate position in the room experiences recurrent spikes above 1000 °C. The repeated passage of clouds of unburned gas and hot products of combustion through the blazeexterior and the superimposition of higher-temperature products are what causes this phenomenon. This results in the inner core being able to preserves a higher temperature to a prolonged period.

V. CONCLUSION

There are numerous ways to detect gas leaks using Artificial Neural Networks (ANN). This technique can be used to monitor flow and pressure signals, alert personnel to occurrences, andfigure out how large the leak is and where it is located.To ensure safest operation and prevent the risks of gas leaks, a nonlinear pipe model is needed to process the data and simulating the flow of the leaking gas in natural gas allocation networks, industrial, commercial, and residential pipelines. Numerical solutions can be validated with experimental setups on the pipeline. For large pipe transmission infrastructures, regional control and recording is not feasible. Therefore, wireless sensor networks and Industrial IOTs are the smartest and most effective method for aggregating and transfering data to regulate units for the last decision. Utilizing Advanced Process Control (APC)and cloud-based control loops surveillance systems allows domain experts to monitor controls across the organization.

REFERENCES

[1] R.T.Naayagi, A.Mahalingam, N.E.Mastorakis,"Designand Implementation of an Economic Gas LeakageDetector" 6thInternational Conference, 2012.

[2] P. Meenakshi Vidya, S. Abinaya, G. Geetha Rajeshwari, and N. Guna, "Automatic LPG Detection and Hazard Control" 5th National Conference, 2014.

[3] Pal-Stefan Murvaya and IoanSileaa, "A survey on gas leak detection and localization techniques" Survey paper, 2008.

[4] Srinivasan A, Leela N, Jeyabharathi V, Kirthika R and Rajasree D, "Gas Leakage Detection and Control," International Journal of Advance Engineering and Research Development, vol. 2, no. 3, pp. 464-467, 2015.

[5] Falohun A.S., Oke A.O., and Abolaji B.M, "Dangerous Gas Detection using an Integrated Circuit and MQ-9" International Journal of Computer Applications, volume 135, 2016.

[6] R. B. Santos, E. O. de Sousa, F. V. da Silva, S. L. da Cruz and A. M. F. Fileti, " Detection and online prediction of leak magnitude in a gas pipeline using an acoustic method and neural network data processing" Vol. 31, No. 01,Brazilian Journal of Chemical Engineering, 2014.

[7] Andr´e L. Maitelli and Andres O. Salazar , "Real Time Leak Detection System Applied to Oil Pipelines Using Sonic Technology and Neural Networks" , DOI: 10.1109/IECON.2009.5415324 · IEEE 2009.

[8] P. Rajeev, J. Kodikara, W. K. Chiu and T. Kuen, "Distributed Optical Sensors And Their Applications In Pipeline Monitoring," Key Engineering Materials Vol. 558 , pp 424-434, 2013.

[9] MortezaMohammadzaheri, "Fault Detection of Gas Pipelines Using Mechanical Waves and Intelligent Techniques "Conference Paper 2015.

[10] Soham Adhya, Dipak Saha, Abhijit Das, Joydip Jana, HiranmaySaha," An IoT Based Smart Solar Photovoltaic Remote Monitoring and Control unit" 2nd International Conference on (CIEC), 2016.

[11] Feng Zhang, Min Liu, Zhuo Zhou, and Weiming Shen, "An IoT Based Online Monitoring System for Continuous Steel Casting" DOI 10.1109/JIOT.2016.2600630, IEEE Internet of Things Journal, 2016.

[12] L. Kong, M. Xia, X. Y. Liu, G. Chen, Y. Gu, M. Y. Wu, and X. Liu, "Data loss and reconstruction in wireless sensor networks," Proceedings-IEEE INFOCOM vol. 25, no. 11, pp. 2818-2828, 2014.

[13] M.S. Pan, P. L. Liu, and Y.P. Lin, "Event data collection in ZigBee treebased wireless sensor networks," Computer Networks, vol. 73, 2014

[14] H. Lu, J. Li, and M. Guizani, "Secure and efficient data transmission for cluster-based wireless sensor networks," IEEE Trans. Parallel and Distributed Systems, vol. 25, no. 3, pp. 750-761, 2014.

[15] Ignacio Barrada Luis E. Garza, Ruben Morales-Menendez and Adriana Vargas-Mart´ınez "Leaks Detection in a Pipeline Using Artificial Neural Networks" LNCS 5856, pp. 637–644, Springer- 2009.

[16] Gopalsami and Raptis, "Millimeter-wave radar sensing of airborne chemicals" Journal Volume: 49, 2001.