Using Internet of Things Techniques to Measure Parameters of Oil Tanks

Ali A.Abbod[1*], Nour Basim Zwyer[2]

[1]SRC\ Thiqar Refinery

[2]Ministry of Education

[*]Corresponding Author E-mail: AliAbbasAbbod17@gmail.com, Nourbasim90@gmail.com

Abstract

Systems change currently response to the requirements of modern society where the emergence of a lot of sensors and controllers in all forms it led to the use of IoT that make things connect with Internet These technologies provide advanced functionality for enterprises and oil installations to transmit data in real time to avoid flood and fire situations in oil Tanks.

The system consists of two stations: the tank station and the control station for monitoring and controlling the level and temperature of the products and the detection of fire. Where, the tank station is equipped with three sensors, which are level, temperature, fire sensors.

The connection between the tank station and the control station is wireless connection by XBee. The control station is to display data to the user via graphical user interface that were programmed by Visual Basic.net and stored in a local database designed by SQL Server simultaneously sending data to the Think Speak so that authorized persons can access the data remotely.

The system tested for several months proved during this period that it has the ability to address some problems such as floods and fires where it gives alerts before the problem occurs.

Keywords: Wireless Sensor Network; internet of things; Oil Tanks; monitoring; fire sensor.

استخدام تقنيات إنترنت الأشياء لقياس متغيرات خزانات النفط

الخلاصة

تتغير الأنظمة الحديثة استجابة لمتطلبات المجتمع الحديث حيث أدى ظهور الكثير من أجهزة الاستشعار ووحدات التحكم بجميع أشكالها إلى استخدام إنترنت الأشياء التي تجعل الأشياء تتصل مع الإنترنت. هذه التقنيات توفر وظائف متقدمة للمؤسسات والمنشآت النفطية لنقل البيانات في الوقت الحقيقي لتجنب حالات الفيضانات والحرائق في خزانات النفط.

و النظام يتكون من محطتين: محطة الخزان ومحطة التحكم لرصد ومراقبة مستوى ودرجة حرارة المنتجات واكتشاف الحريق، حيث تم تجهيز محطة الصهريج بثلاثة مجسات، وهي مستشعرات درجة الحرارة ومستوى الحريق. والاتصال بين محطة الخزان ومحطة التحكم هو اتصال لاسلكي بواسطة XBee. تهدف محطة التحكم إلى عرض البيانات على المستخدم عبر واجهة المستخدم الرسومية التي تم برمجتها بواسطة Visual Basic.net وتخزينها في قاعدة بيانات محلية صممت بواسطة SQL Server وفي نفس الوقت ترسل البيانات إلى منصة Think Speak حتى تمكن الأشخاص المخولون من الوصول إلى البيانات عن بُعد.

أثبت النظام الذي تم اختباره لعدة أشهر خلال هذه الفترة أنه قادر على معالجة بعض المشكلات، مثل الفيضانات والحرائق، حيث يعطي تنبيهات قبل حدوث المشكلة.

الكلمات الرئيسية: شبكة الاستشعار اللاسلكية؛ انترنت الأشياء؛ خزانات النفط؛ استشعار الحريق.

1. Introduction

Most Oil facilities in Iraq such as Industrial refineries, Closed Refineries, Petrochemical plants, Terminals, Pipelines Companies, where most of these petroleum products go into the tanks and because of the importance of these products necessitated us to study the problems that occur while storing these products within the tank. And, the Tanks are synthetic containers that that may contain water, oil, Oil products, compressed gases (gas tank) or mediums used for the short- or long-term storage of heat or cold. Where Oil Tanks need into controllers for most operations, for example, need to measure level, temperature, Fire status pressure, density, etc. And Because of the large number of tanks in refineries and oil installations, where it has become difficult to control them manually. Therefore, it can be used oil tank management systems based on Wireless Sensor Network and IoT technologies to avoid the flooding and fire problems, which provides is composed of a large number of micro-sensor nodes, which have small volume and low cost[1]. Where, WSN architectures and communication protocols increasing the lifetime of the network [2]. An Internet of things (IOT) provides access to device and data from remote locations where, it can connect different people or objects in accordance with the specific protocol, communicate with each other at any time and any place, identify any information with the dynamic information of intelligent products and provide a quick and efficient information sharing network platform [3].

In this paper, an integrated wireless sensor network and Internet of things are designed to manage the oil tanks until can monitor the state of the products inside the tank from level and temperature in addition to detect the fires of products in real time dynamically. The aim of this paper is to reduce the damage caused by fires and floods in oil reservoirs due to the delays, omissions and errors.

This paper is organized as follows. In Section 1, we introduce the overview of the system. Section 2, Hardware design description. Section 3, System Implementation, and the conclusion.

2. Related Works:

A large number of researchers have worked on the systems of the control of the reservoirs in general using various techniques, including Internet of things technologies, where they presented different results and based on the type and number of sensors used in these systems. A brief review on some of these researches is introduced in following:

Authors in [4] have submitted a study on the use of liquid-level measurements in reservoirs, based on internet of things technologies, using Wi-Fi, but researchers have not provided a detailed study about WSN, which provides solutions to energy problems. Well the lack of sensors that support the measurements and that make the system more reliable in real time. In addition to not using methods to view and store data locally, this poses a significant risk to data in several cases.

The architecture and initial testing results of a low power wireless system for tank level monitoring using ultrasonic sensors. Also have been useful and effective tools to collect information from bulk storage tanks and to monitor the same. The researchers were very interested in the use of techniques and the age and reduce the use of energy, but did not support those measurements with other sensors increase the reliability of measurements in real time as well as the researchers did not use IOT technologies that provide remote access. In addition to storing and analyzing data and taking decisions at a high level at the concerned authorities. [2]

Authors in [5] have Discussion and Design of Dynamic Liquid Level Intelligent monitoring system and were able use a dedicated algorithm to calculate the true level of the liquid by using HSS-04 and using the DS 1820 to compensate the temperature and transmitted data via a wireless network via Bluetooth. However, they have away far about the IOT technologies for access to the data remotely.

It has been designed fire detection system based on Internet of things, where the system uses a GSM connection where the user can be notified easily to avoid fire in feild, the study applied to agricultural crops. [6]

The designe fire monitoring system based on Internet of things and wireless sensor network where it discussed about the requirements of user, wireless sensor network hardware and software for monitoring fire.in addition, it discusses function IOT and WSN in a detailed way. It also discusses application features of IoT technology and Wireless Sensor Network technology for according to fire monitoring system requirements. [7]

3. Hardware Design

This part involves the hardware part of the project, which display a description of the proposed system components. It involves the reasons to select a specific type of sensor technology over other technology and describe the electronic model that selected in the propose system.

A. Block Diagram

After that, we will show you in detail the Block Diagram of the transmitter node circuit as in the Figure (1) and its receiver node circuit as in Figure (2).

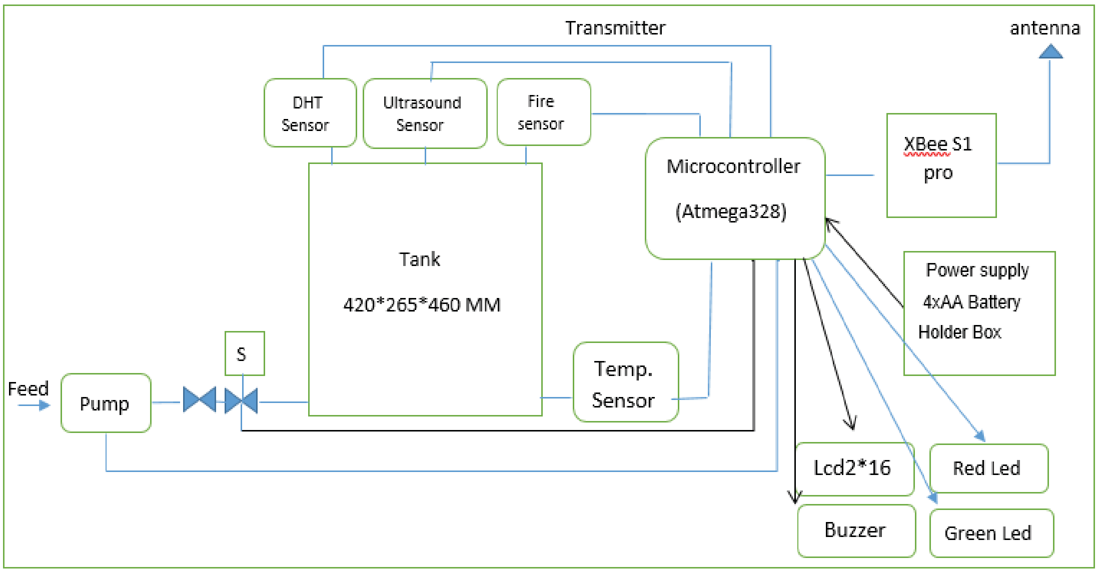

Fig. (1) Block diagram of Transmitter node

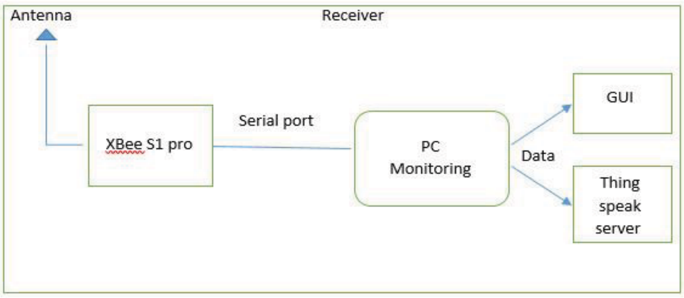

Fig. (2) Block diagram of Receiver node

B. System Architecture:

The project is composed tank of iron with Cylindrical shape (Length=42cm, Radius=23 cm) with a capacity of 74,785.61cm 3 storage. Then we installed manual valve, electric valve and pump for pumping product to the tank, where that the pump designed to be transported the manually and automatically in addition we installed all sensors on the tank. Then connected the electric wires to the panel.

In this project, we used an Arduino board to monitor tank levels, temperature and fire status, then display on the LCD then send to control room by wireless communication using ZigBee. While the second ZigBee was to receive data, from the Arduino board and control on the system. The proposed architecture of this system is as in Figure (3).

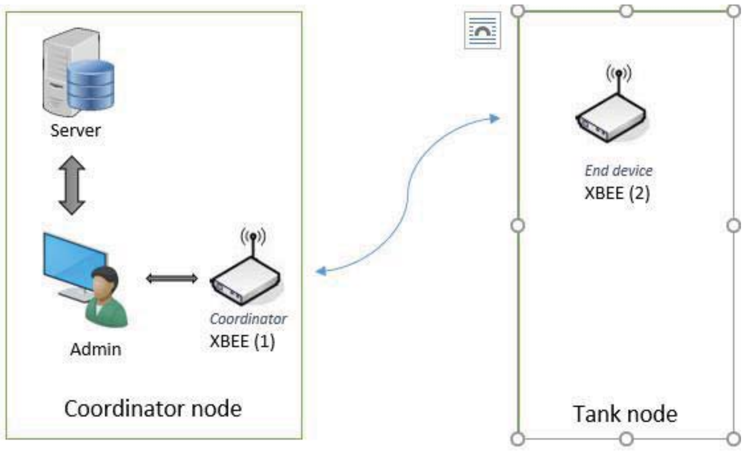

Fig. (3) The architectures of the proposed system.

4. System Implementation

Desccription the proposed system software includes Arduino programing, data acquisition, system interface that builds in VB.NET, Data's story in the database (SQL server) and IOT Interface.

A. Arduino & Database Programming:

Programmed by the program (Arduino Version: 1.8.6 and XCTU Version: 6.3.13) and database has been programmed by (SQL server) a release Microsoft SQL Server 2014 Express Advanced.

B. Interfaces Design:

All the graphical user interface of the system designed using Visual basic.NET; it was developed to serve this project. In addition, the design of the GUI is quite simple and convenient that even a beginner could effectively operate the system. Figure (4) shows the flowchart how the system works beginning from receive the data from the remote node to the last step when the user turns off the system. The GUI consists of three windows: (1) Main window (2) Monitoring and control window (3) Database window. Beginning of the user window, in this window the user must enter the username and password to authorize him.

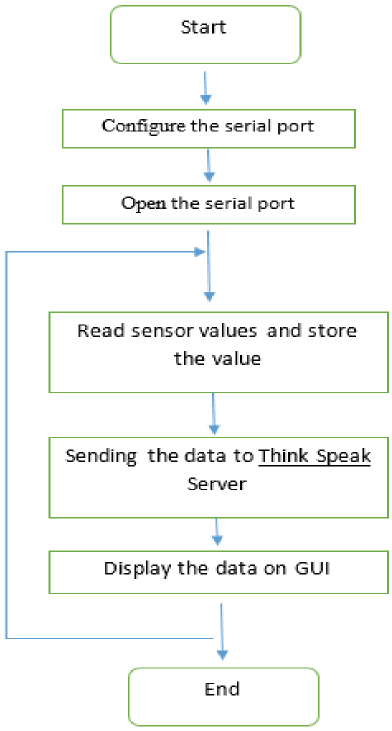

Fig. (4) Flowchart of the system work

When user wants to see the data of the tank must choose the first button (Monitoring and Controlling of Tank) show as a Figure (5).

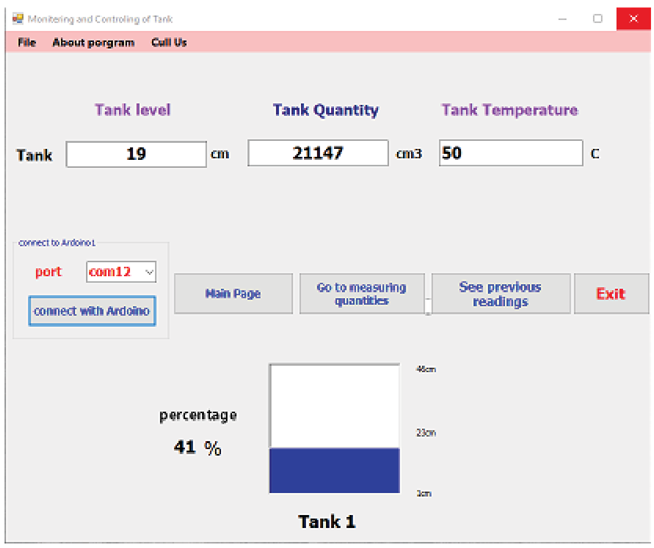

Fig. (5) Monitoring and Controlling of Tank window

When monitoring the levels of tanks if the blue color of the box to change the red color that mean the tank cross the allowable level and warning alarm will be working to avoid tank flood as in Figure (6).

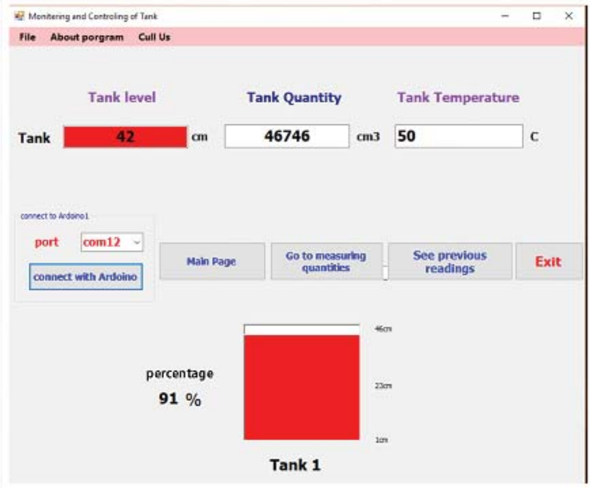

Fig. (6) Monitoring when reaching the limit is not allowed

When user wants to see the data of the tank from the database must choose the first button (Stored Data) in the main window.

C. Internet of things (IOT)

Think speak is an open source platform for the Internet of things useful to store and analyze data using HTTP over the Internet. In addition, can be linked the status of updates with some social networking applications. In order to access the platform and view data remotely, we follow the following steps

Step 1: open the thing speak site.

Step 2: click on the private view as the Figure (7).

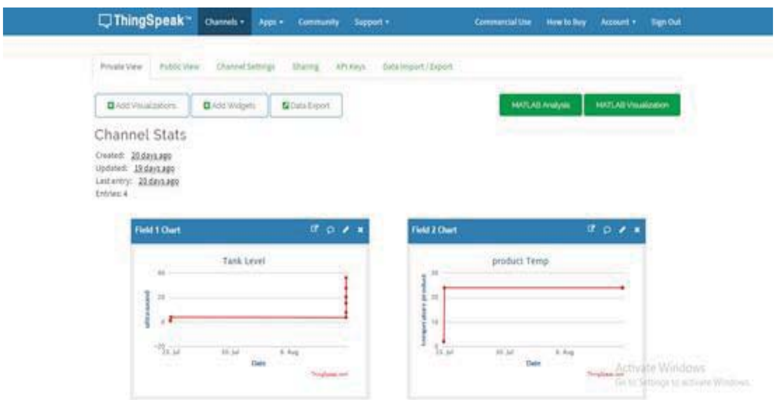

Fig. (7) My channel in private view

Step 3: send data after receiving from Arduino to my channel in think, speak across Visual Basic.net where there are five charts to display data as the Figure 8.Updating of the values happens once in every 15 seconds.

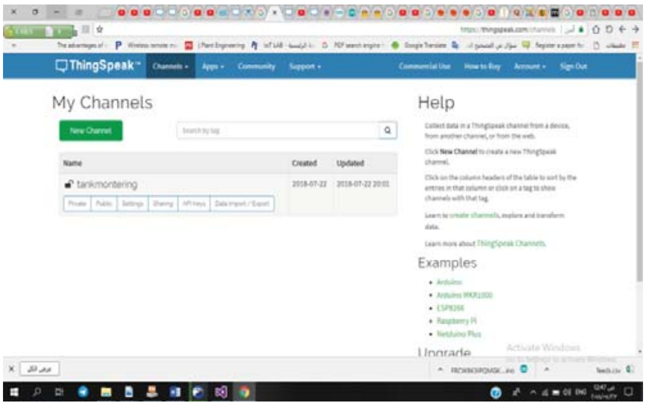

Fig. (8) Data display on thingspeak platform

5. Results and Discussion

Several experiments were carried out to test the reliability and feasibility of the system design. All Experiments were carried out at the in my house. Kerosene has been used in the experiment to know the measurement accuracy. The tank that used in these experiments has the following dimensions: (Height = 58.50 cm & Radius=25 cm)

Now, we measure the result of the measurement in two ways based on the temperature (normal temperature, temperature and humidity) where the sensor measures the distance and subtracts with the empty tank displacement to get the level. Either the manually measure is by placing measured ruler on the front side of the tank. The result is recorded and compared with the ruler measure to calculate the mean absolute error (MAE) and graph analysis by Microsoft Excel. All results will be discussed later based on the results of the mean absolute error (MAE) and the analysis of the graph. The mean absolute error (MAE) can be calculated according to the equation following [8].

$$MAE= (\sum|A-B|) / n \qquad \text{.............} (1)$$

Where; A: first variable B: second variable N: is the number of values

The height of the tank was divided into ten readings where first reading is 4 cm followed by next reading of 8cm, 12cm, 16cm, 20cm, 24cm, 28cm, 32cm, 36cm, and 40cm. The number of readings taken is ten because of the maximum height of the tank used is 48.50 cm and the critical level of tank 40.00cm.

A) Ruler Measurement against ultrasonic Sensor Measurement in natural temperature

Now we will measure the measurement result in two ways based on Normal temperature

1) Normal method

We enter these values into Microsoft Excel to get the graph as Figure (9), which we observe a mismatch between the actual measurements with the measurement by the sensor. In addition, The Mean Absolute Deviation is calculated between measurement of sensor and ruler on the same value in Table (2) in order to compare these methods later as follows:

MAD= (|4.00-3.60| +|8.00-7.78| +|12.00-12.34|+|16.00-15.48|+|20.00-20.38|+|24.00-24.27|+|28.00-27.57|+|32.00-31.67|+|36.00-36.17|+|40.00-39.70|)/10= ±0.336

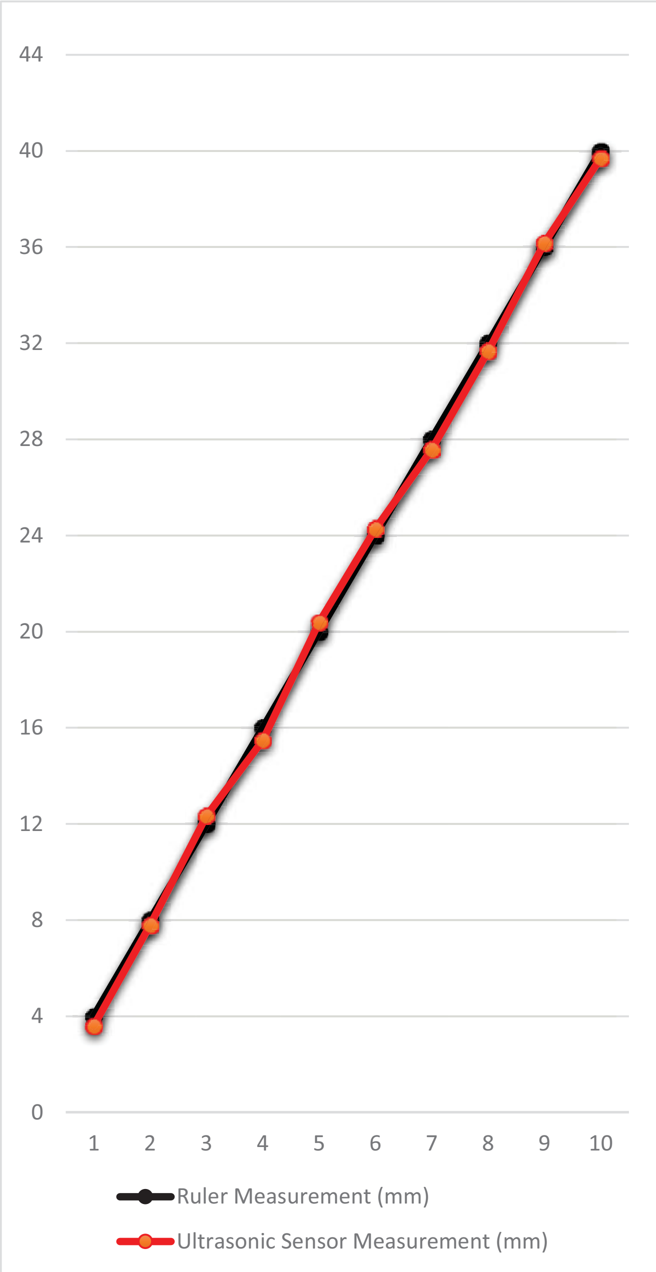

Fig. (9) Graph Analysis on Normal method

2) Duration Median method

By using function another goes make the sensor reading smoothing by taking the average between five readings (iterating), where, these values was added into Microsoft Excel to get the graph as Figure (10) to observe a mismatch between the actual measurements with the measurement. In addition, the Mean Absolute Deviation is calculated between measurement of sensor and ruler on the same value in Table (2) in order to compare these methods later as follows: MAD=± 0.26.

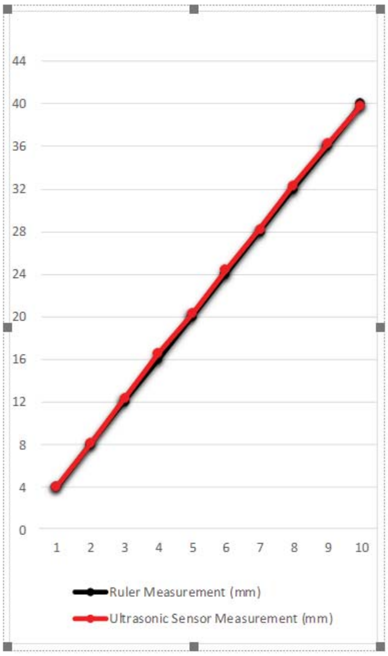

Fig. (10) Graph Analysis on duration median

B) Ruler Measurement against ultrasonic Sensor Measurement in different temperature and humidity

Now we will measure the measurement result in two ways based on different temperature and humidity

1) Speed of sound calculates method

Now, as you can see our readings are close, but there are not completely accurate and there are a couple of reasons for that some of them of course, being the way that I am just holding my board, but there is another source of inaccuracy in our circuit and it has nothing to do with the HC SR-04 it actually has to do with the speed of sound. There are wrong the speed of sound well the thing is sound travels at different speeds in different medians it also travels at different speeds at different temperature. Because sound travels depend on the humidity and temperature According to the equation following [9]:

$$SP=331.4+ (0.606*T) + (0.0124*H) \quad (2)$$

Where; SP: speed of sound T: temperature H: humidity

Note: speed of sound to air =331.3m/s At 0 C temperature and 0% humidity. The result conducted an Experiment is as shown as in Table (4).

Figure (11) shows the complete match between the actual measurements with the measurement by the sensor. In addition, the Mean Absolute Deviation is calculated between measurement of sensor and ruler on the same value in Table (4) in order to compare these methods later as follows: MAD=± 0.112.

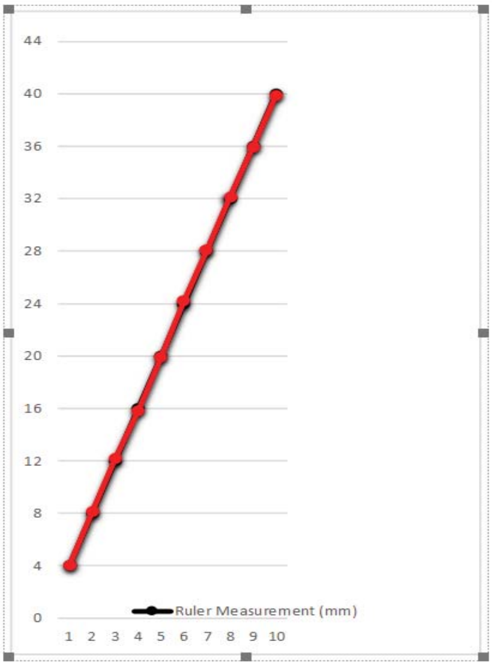

Fig. (11) Graph Analysis on speed of sound method

2) Product temperature method

Here will choose the water to apply because the oil and its derivatives can cause the fire in the experiment and away from the danger was using water to see whether the product heat effect or not. We will take the temperature at 20,30, 40, 50, 60, 70 and 80 ° C at any product level Here we will take a constant level of 40 cm for all previous temperatures.

Through Figures (9, 10, and 11) with MAD results for each method, we note that the best method is the use of Speed of sound calculate to correct and calibrate the measurement.

6. Conclusion

The flooding and the fires in oil tanks often happened with the omission of workers In addition, to the delay in the fight against fire, which is difficult to stop in advanced stages. The huge major economic losses, environmental pollution and possible human damage. In addition, Oil companies lose millions of dollars a year were incurred once the flooding and the fires cannot be found and stopped timely.

An intelligent oil tanks management system based on the WSN and the It was designed in this paper to monitor, control level and temperature of the product and detect fire status in the tanks in real time under different scenarios.

The smart terminals, especially mobile ones, should be used wisely to receive, identify, and deal with warning messages online, whether flooding; fires, and Critical level or critical Heat in oil tank. Whereas, the implementation of intelligent oil tank management system is facing numerous difficulties amid security and privacy, non-unified professional standards, and wireless sensors used in large scale. The integration of management methods and advanced information technology is preferred to intelligent IoT system for anti the flooding, the fires and product pollution in tanks over the coming decades. For the future work, we suggest adding the following things:

- Add other sensors to detect the state of contamination that gets in the tanks early.
- Update the project by adding other sensors like density and water content in order to be increased system capabilities.
- It's possible to add new interfaces for the project in order to improve system performance and scalability.
- Supports Visual Studio language of many of the functions that increase the security support for the project and deal with multi- (Serial) to be very high accuracy.

.

References

1. N.-C. Wang, Y.-L. Chen and H.-L. Chen, "An Efficient Grid-Based Pairwise Key Predistribution Scheme for Wireless Sensor Networks," Wireless personal communications, vol. 78, 2014.
2. S. Viswanath, M. Belcastro, J. Barton, B. O'Flynn, N. Holmes, and P. Dixon, "LOW-POWER WIRELESS LIQUID MONITORING SYSTEM USING ULTRASONIC SENSORS," International Journal on Smart Sensing & Intelligent Systems, vol. 8, 2015.
3. J. Choi, Y. Shin, and S. Cho, "Study on information security sharing system among the industrial IoT service and product provider," in Information Networking (ICOIN), 2018 International Conference on, 2018.
4. N. S. Shreya.U.Shetty, "Design and Development of Non Contact Liquid Monitoring System Based on IOT," International Journal of Innovative Research in Science, Engineering and Technology, vol. Vol. 6, July 2017.
5. Z. L. a. G. Z. Guangdong Qiu, "Discussion and Design of Dynamic Liquid Level Intelligent monitoring system," International Journal of Smart Home, vol. 9, 2015.
6. s. E. Ashmi V K, Anisha V,Sree Sankar.J,D.Ramalingam, "Fire detection and Irrigation automation based on IOT," international journal of electronics ,electrical and computational system, vol. 7, 2018.
7. S. Vijayalakshmi and S. Muruganand, "Internet of Things technology for fire monitoring system," Int. Res. J. Eng. Technol, vol. 4, 2017.
8. C. Coskun, U. Toygar, O. Sarpdag, and Z. Oktay, "Sensitivity analysis of implicit correlations for photovoltaic module temperature: A Review," Journal of Cleaner Production, vol. 164, 2017.
9. M. Kara-Mohamed, "Design and control of compact legged-wheeled robot" Spicar," 2017.