Oil Tank Prototype based on Wireless Communication-Controller System using IoT

Ashwaq Q.Hameed[1], Amer S.Elameer[2], Ali Abbas Abbod[3]

[1]University of Technology, Electrical Engineering Department, Iraq
[2]Iraqi Commission for Computers and Informatics (CCI), Institute for Postgraduate Studies, Iraq
[3]Iraqi Commission for Computers and Informatics (CCI), Institute for Postgraduate Studies, Iraq

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***Abstract** - Systems change in response to the requirements of the modern society, where many sensors and control devices of all forms have led to use of wireless control and Internet of thing techniques. These technologies provide advanced functionality for enterprises and oil installations to transmit data wirelessly 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 four sensors, which are level, temperature, fire, temperature and humidity air of sensors.

The connection between the tank station and the control station is wireless connection by XBee s1 pro. 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 proposed system can access its data in two ways, either via graphical user interfaces or via Internet of thing platform. 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.

The technology used in this system has reduced the damage caused by fires and floods largely as it has also reduced major economic losses, environmental pollution and human damage. Finally, most of the problems in oil tanks can be solved by improving some technical elements, such as adding sensors that can detect pollution in real-time products.

Key Words: WSN , IoT , fires, Level .

1.INTRODUCTION

The flooding and fires of the oil tanks result in major economic losses, environmental pollution and possibly human damage. Oil companies lose millions of dollars a year[1]. Because of the large number of tanks in refineries and oil installations, where it has become difficult to control them manually. This huge system will certainly cost millions of dollars while it is not large compared to the economic and human losses caused by fires and flooding of oil reservoirs. So how to make use of benefited from information technology to improve the reality of oil tanks management and protection systems. Through the WSN, preparation can be easily and high flexibility compared to other networks and can be operated without supporting the fixed infrastructure with low energy consumption due to the use of multiple hopping topologies[2, 3]. In addition to the IoT provided the provision of funds through the best use of resources and monitoring losses, which gives systems to correct any errors or losses that may occur in the processes[4, 5]. Through these benefits, can the IoT and WSN can monitor, control and deduce through the sensors in the oil tanks to detect fires or floods in oil tanks in real time. The most important reasons for these problems are the delay in response, which results the flood or the fires, or the omission of workers and other problems. In addition, to the delay in the fight against fire, which is difficult to stop in advanced stages. It is therefore necessary to build a system that gives a precise and rapid signal to the Responsible institutions in a critical situation at any time. With the rapid development of information technology systems has been designed and Development Non-Contact Liquid Monitoring System Based on IoT from (Shreya and Natya ,2017) , where effective management and maintenance of tanks in industries one of the most important parameter is the measurement of liquid levels[6]. In addition, a special system from (Guangdong and et al, 2015) has been set up to measure the level of tanks and avoid flooding, Where a specific algorithm has been proposed to obtain the real height of the liquid level according to the distance measured by the ultrasonic sensors, the data received will be transmitted via the Bluetooth CC2541 and wireless network[7]. In order to avoid fire according to modern technologies, fire detection system has been designed by relying on IoT from (Ashmi and et al, 2018) and the system uses a GSM connection where the user can be notified easily where the study applied to agricultural crops[8].

In this paper, an integrated wireless sensor network and Internet of things are designed to manage the oil tanks until can be 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 I, we introduce the overview of system. Section II, Hardware design description. Section III, System Implementation, and the conclusion.

2. hardware Design

In this, the project is collected of two types of node units: remote tank node, and a main control station node. Tank sensor nodes are implemented with an XBee s1 pro and Arduino connected with four sensors (ultrasound, fire sensor,Dh20,DHT22).in addition ,we have connected each from pump ,LCD 2*16,electric valve and relays. The system is consist of two devices of XBee S1 pro. As for main control station node are implemented with an XBee s1 pro and XBee adapter connected with the personal computer as coordinator in API which is connected to collect data from the tank sensor node. Main control station node are require no other microcontroller besides what is included with XBee s1 pro radios. Figure (1) shows the architectures of the proposed system and Figure 2 represents the internal components of the entire tank management system.

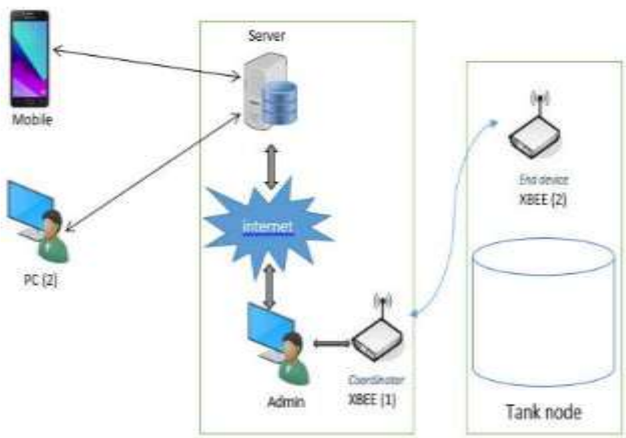

Fig -2: Shows the architectures of the proposed system.

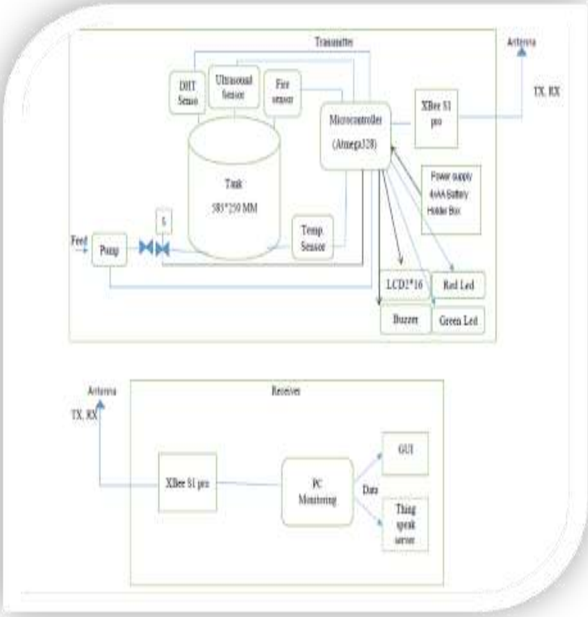

Fig -1: Tank management system

After that, we will show you in detail about Architecture each from remote tank node and a main control station node.

A) Architecture of the remote tank node

In Architecture of the remote tank node in this network are content on: firstly, four sensors are distance sensor (Ultrasound), temperature sensor (DS18B20), DHT22 (air temperature and humidity) sensor, and fire sensor. Second, microcontroller from Arduino type to link all parts this node. Third, XBee s1 pro to send data to coordinator node (main node). Fourthly, two relays to control on pump and electric valve. Two led to know the node state where if the green led is powered mean that the node in normal status but if it the red led is powered mean that found danger status in node. Fifthly, buzzer to alert workers to discovery dangerous status. Lastly, LCD to display the data locally.

B) Architecture of Coordinator node

The central node is the main controller of the system. In This node is responsible about collect data and process it to controlling and monitoring on oil tank. This node consist the following:-firstly, Laptop. Second, XBee S1 pro configure as coordinator. Lastly, XBee adapter interfacing the XBee S1 pro RF modem with the laptop. The XBee S1 pro wireless modem is powered via a USB connection using XBee adapter therefore, no additional power supply is needed.

After connecting all these pieces together for each nodes (remote tank node and a main control station node) which will be the prototype of this system as figure 3.

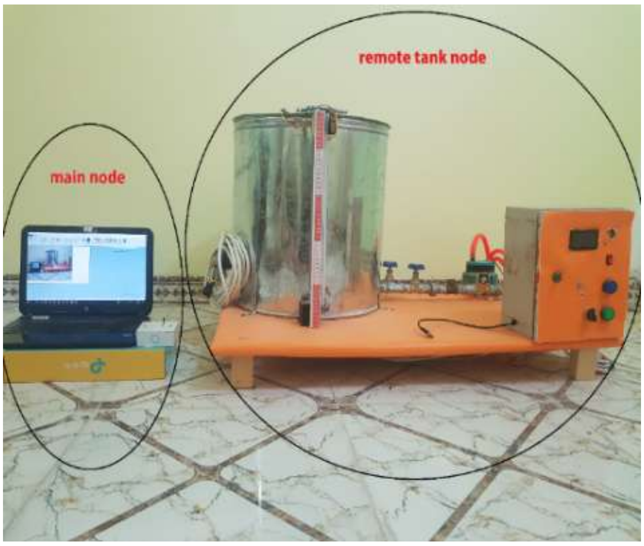

Fig -3:Final Design of the Prototype

Until can to convert traditional things in this system to IOT system based on three steps as the following[9]: .firstly, give a specific and unique address to each of these things called this definition. Second, is to give these things sensors to collect data and variables from the environment in which those things are located called this Sensing. Lastly, give these things the ability to process data and execute certain decisions called this Processing.

3. System Implementation

Now, we will describe the proposed system software which will be divided into four synchronous parts is the first, Arduino programing and configuration XBee for nodes, the second, the data acquisition then display on system interface that build in VB.NET .Third, store the Data that Received in database. Fourth send the data to think speak server.

A)Software Design of Nodes:

In this part of the Software description we perform the programming process depend on Arduino language to Arduino board and XCTU program to configuration XBee, Arduino language has been allocated to develop its own integrated IDE environment, where the environment has been developed based on the Java language in order to be an environment that supports C and C ++ language that called Arduino C. it is special programming environment with boards Arduino , Open-Source, easy to use, includes many effective Libraries may need the developer during his work, In addition, most developers participate in a community Arduino, who periodically added projects and applications, so that they are free of charge and are full to anyone who need to these the programs[10]. Either the program XCTU is free, works on several environments such as Windows, Mac or Linux, offers Configuration for XBee/RF Solutions[11]. In this the project there are two nodes are:

1-Remote tank node that used Arduino Uno to controlling and monitoring the level, temperature of the tank and fire status to tank and this Arduino send the data to control room wirelessly by using XBee S1 pro. This node works according to the flowchart in the figure 4.

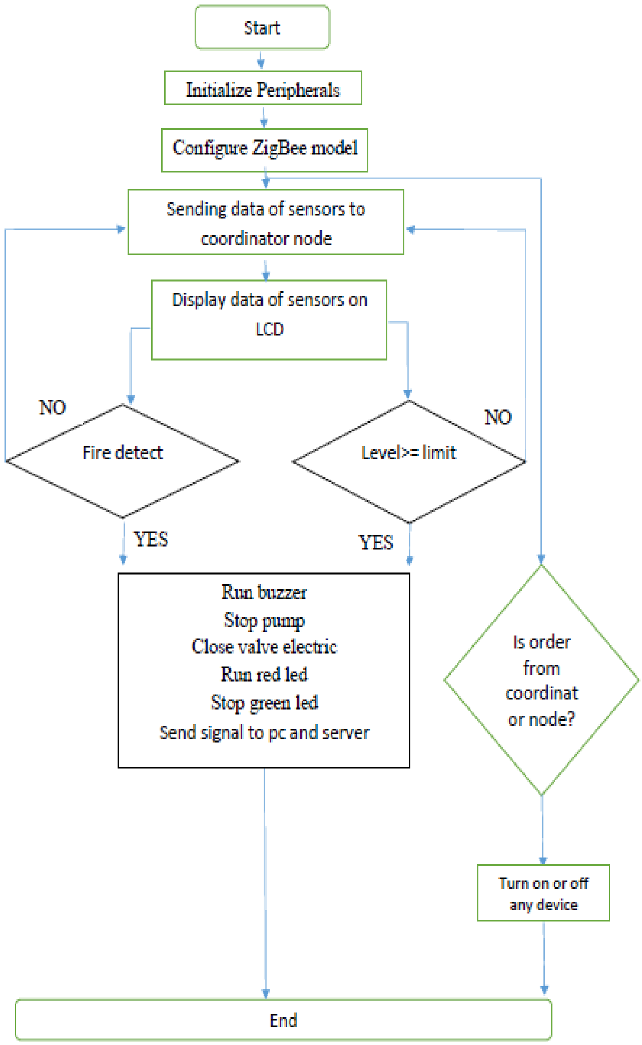

Fig -4: Flowchart of Remote tank node

2-Coordinator or main node that used XBee S1 pro to receive the data from Arduino Uno and sending data to server of think speak. This node works according to the flowchart in the figure 5.

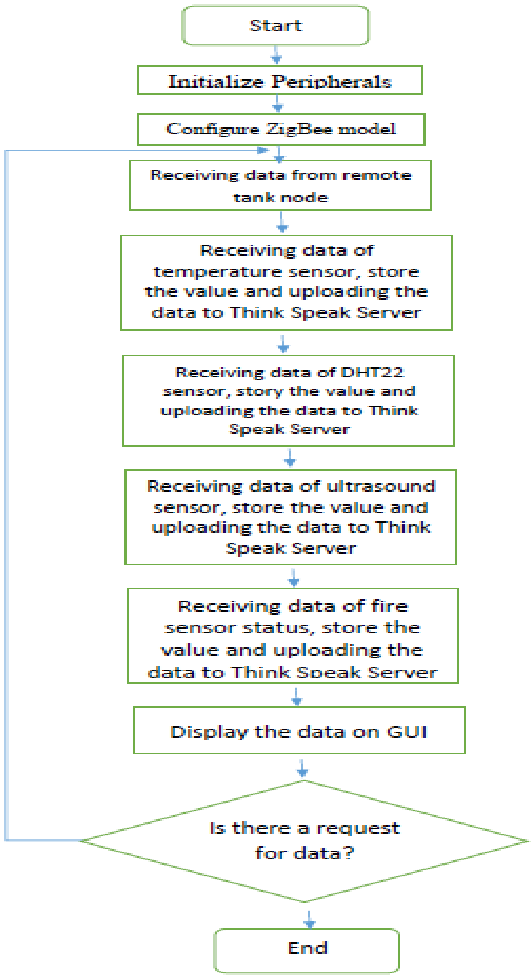

Fig -5: Flowchart of Coordinator node

These nodes have been programmed by the program Arduino Version 1.8.6 and XCTU Version 6.3.13.

B) Graphical User Interface (GUI):

The graphical user interface of the system was designed using Visual basic.NET, which displays the data we obtained from the remote tank node. After obtaining the data, the system can be programmed according to the flowchart of the system as figure 5, which shows the mechanism of displaying and storing data in the local system but the storing the data will be dealt with in section C in detail and also displaying and storing it in Internet of things servers (thing speak) which will be dealt with in section D in detail. GUI was developed carefully to serve the purpose of this project. Where the design of the GUI was is quite simple and convenient that even a beginner could effectively operate the system in a matter of hours. The GUI consists of six windows are :(Main window, Monitoring and control window, Database window, setting window, about program and Call us).

Beginning by the user window, in this window the user must be enter the username and password to authorize him. After that the user can be enter to the system and move to the control system window which will contain all sub windows of the system , if the user select the first button "Monitoring and Controlling of Tank" he will be able to see the data of the tank. Where if the color of the box change to the red color that mean the tank cross the allowable level and warning the user by alarm will be work to avoid flood or fires of tank as in Figure 6.

Fig -6: Monitoring when reaching the limit is not allowed

C)Database Programming:

The project database has been programmed by (SQL server) a release Microsoft SQL Server 2014 Express Advanced, where the database in this project was very simple It is consist of a set of the following columns, which represent (ID, Tank Level, Tank Quantity, Tank Temperature, Fires Status and Date) which can print the reports at any time.

D)Internet of things (IOT)

In this part of the Software description through which remote data can be accessed at any time by the concerned authorities only where Think speak platform has been used. It 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. After registering in this platform and configuring the channel through which data can be received, the platform becomes ready for In order to access the platform and view data remotely where, we follow the following three steps.

Step 1: open the thing speak site in link the following https://thingspeak.com.

Step 2: click on the private view.

Step 3: send data after receive from PC to my channel in think speak across Visual Basic.net where there are chart to display data as the figure 7. In addition, the process of updating the values occurs once every 15 seconds.

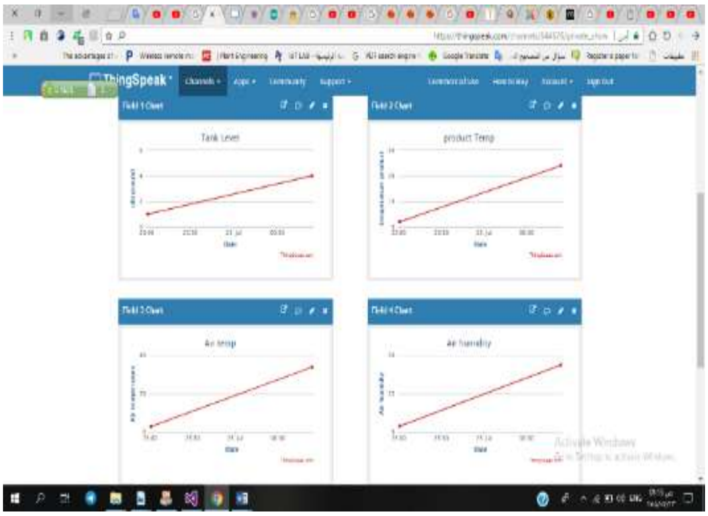

Fig -7:Data display on thingspeak platform

4. Results and Discussion

The objective of this chapter is to evaluate the efficiency of sensors and wireless device that have a direct impact on solving the problems of accuracy of measurement, flood and fires in oil tanks. Where practical experiments were divided into four sections: first, Study the effect of noise on wireless devices. Second, the use of practical experiments of ultrasonic wave sensor to treat level measurement accuracy problems and reduce flood exposure.

Evaluation of noise in wireless signal

In order to evaluate the radio signal, we must test and measure the range of the radio range specified by the spectrum, which the analysis reports the noise level of each channel indicating its best, worst and average measure. This can be done through an existing tool in a XCTU program called spectrum analysis. We will depend on adding some noise to evaluate the state of each channel through the distance and the walls of the rooms where the rooms were connected vertically. After that, we conducted a test cases on effect of wall on channels as in Figures 8, 9, 10.

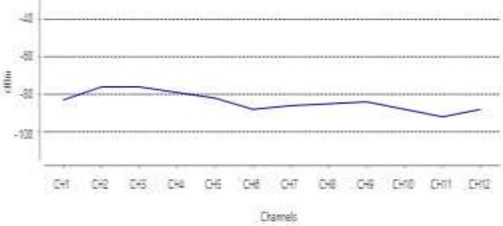

Fig -8: Noise level of each channel at room

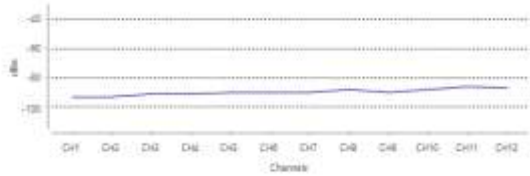

Fig -9: Noise level of each channel at second room

Fig -10: Noise level of each channel at third room

It was found in the three tests that the effect of the walls on the signal makes the noise high in some channel where the best rated for the first test is the first and second channel at the value of (-76.0 dBm) for each channel as figure 8 . The best assessment for the second test in the second room, at 8 meter, the best channels were the eleventh and twelfth at a value (-86.0 dBm) and (-86.0 dBm) as figure 9. The third test at the third room, 20 meters away, the best channels were the fourth and fifth at the value (-83.0 dBm) and (-84.0 dBm) as figure 10. Through this, we conclude that the best solution is to use the antenna to get rid of the effect of the walls

Practical experiments of ultrasonic sensor

Before using the practical experiments of the ultrasound sensor, it is necessary to know that the most important factor affecting the measurement by ultrasound sensor is temperature and humidity in the air in general. We measure the result of the measurement in two ways based on the temperature and humidity in the case of normal, which we make it constant and the other case is measure the temperature and humidity of the air by a DHT22 sensor.

The results is recorded and compared with the Manual measure to calculate MAE and draw graph by Microsoft Excel so that we can assess the best way to use the ultrasound sensor. Where, the mean absolute error (MAE) can be calculated according to the following equation[12]:

$$MAE = (\sum|A-B|) / N \quad \ldots (1)$$

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

To calculate the level product by the ultrasound sensor that measure the distance then subtracted from the empty tank height as the following equation of measurement [13].

S = V * T ... (2)

Where S: Distance
V: speed of sound
T: time

Either the manually measure is placing measure ruler on the front side of the tank to compare the level with it. Therefore, we will conduct some practical experiments to find the best solutions to measure the level of products in the oil tanks. Where Kerosene have 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).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 reading taken is 10 because of the maximum height of tank used is 48.50 cm.

1- Manual Measurement against ultrasonic Sensor Measurement in constant temperature and humidity of air

In these methods we will used speed of sound in air =331.3m/s At 0 C temperature and 0% humidity in the equation of measurement (2) to get the results.

1-Normal method

The result conducted on Experiment is as shown as in figure 11, which shows us the result of the real measurement by the ruler compared to the measurement using the sensor.

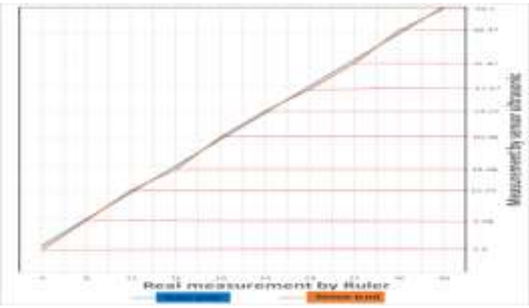

Fig -11: Graph Analysis on Normal method

After we get the results, we enter these values into Microsoft Excel to get the graph as figure 11, 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 same value in figure 11 to obtain MAD= (|4.00-3.40|+|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|+|36.00-36.47|+|40.00-39.70|)/10= ±0.406.

2-Duration Median method

By using function another go, make the sensor reading smoothing by take the average five readings (iterating). The result conducted on Experiment is as shown as in figure 12, which shows us the result of the real measurement by the ruler compared to the measurement using the sensor.

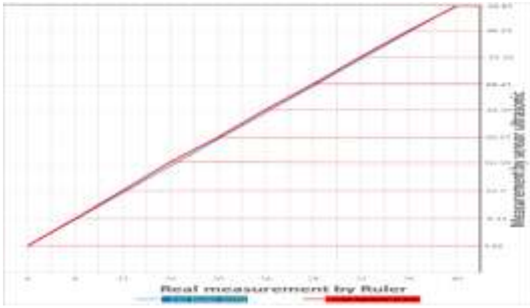

Fig -12: Graph Analysis on duration median

After we get the results, we enter these values into Microsoft Excel to get the graph as figure 12 which, we observe a mismatch normal method between the actual measurements with the measurement by the sensor but better than normal method. In addition, The Mean Absolute Deviation is calculated between measurement of sensor and ruler on same value in figure 12, to obtain MAD=± 0.26.

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

In these methods we will used speed of sound in air depend on calculate the temperature and humidity values from DHT22 sensor by using the equation [14]:

V=331.4+ (0.606*T) + (0.0124*H) ………… (3)

Where V: speed of sound
T: Air temperature
H: Air humidity

Then enter speed of sound into the equation of measurement (2) to get on the results.

1-Method of add ultrasonic Sensor with DHT22

The ultrasound waves are transmitted at different speeds at different temperatures and humidity in the air. We will calculate the speed of sound from the equation 3 based on the DHT22 sensor and enter these values into the equation 2.The result conducted on Experiment is as shown as in figure 13.

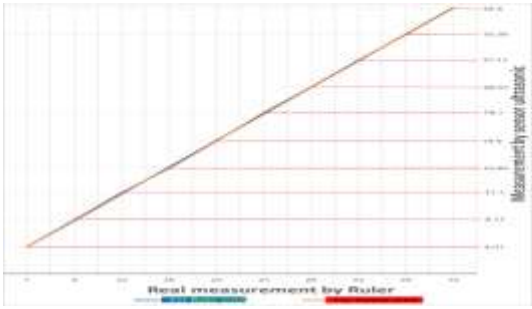

Fig -13:Graph Analysis on method add DHT22 sensor for measurement

After we get the results, we enter these values into Microsoft Excel to get the graph as figure 13, which, we observe a nearly complete match between the actual measurements with the measurement by the sensor that is better than normal method and Duration Median method. In addition, The Mean Absolute Deviation is calculated between measurement of sensor and ruler on same value in figure 13 to obtain MAD=± 0. 112.Through figures (11, 12, and 13) with MAD results for each method, we note that the best method is use Method of add ultrasonic Sensor with DHT22 calculate to correct and calibrate the measurement.

5. CONCLUSIONS

The oil tanks have many problems, including fires and floods, which cause great economic losses, environmental pollution and possibly human damage. Where it is difficult to control manually because of the large number of tanks in refineries and oil installations. This huge system will cost millions of dollars, while not large compared to the economic and human losses caused by fires and flooding of oil tanks.

An oil tanks system based on the WSN and the IoT was designed in this research for monitoring, controlling level and temperature of the product and detect fires status in the tanks in real time.

The terminals, especially mobile ones, should be used to receive, identify, and deal with warning messages online whether flooding; fires, and Critical level or critical Heat in oil tank. The integration of management methods and advanced information technology is preferred to an IoT system for anti the flooding, the fires and product pollution in tanks over the coming decades. Based on present project, the following conclusions can be made:

1. The Internet of things and wireless sensor network can monitor and control by the oil tanks in real time from anywhere.
2. The design of this monitoring and controlling system to know level and temperature of the product and detect fires status in the tanks in real time.
3. The proposed system is useful because its simplified operational requirements, user-friendly interface (easy to use, easy to learn), and hence low maintenance cost.
4. This system is capable to save data in a local database. It also can search in the database with specific information and get report to this information.
5. The system can provide early warning in case of danger; this informs the user in advance time in order to take the proper action.
6. The best solution to avoid noise is use the antenna to get rid of the effect of the walls.

References

[1] [1] J. I. Chang and C.-C. Lin, "A study of storage tank accidents," Journal of loss prevention in the process industries, vol. 19, pp. 51-59, 2006.

[2] [2] A. K. Talele, S. G. Patil, and N. B. Chopade, "A survey on data routing and aggregation techniques for wireless sensor networks," in Pervasive Computing (ICPC), 2015 International Conference on, 2015, pp. 1-5.

[3] [3] M. Chen and S. Gonzalez, "Applications and design issues for mobile agents in wireless sensor networks," IEEE Wireless Communications, vol. 14, 2007.

[4] [4] M. Singh, A. Kumar, N. Kaur, and S. Chuchra, "Proposing a New Method for Automatic Environmental Temperature Detection (AETD) by using IOT," International Journal of Computer Applications, vol. 121, 2015.

[5] [5] C.-W. Tsai, C.-F. Lai, and A. V. Vasilakos, "Future Internet of Things: open issues and challenges," Wireless Networks, vol. 20, pp. 2201-2217, 2014.

[6] [6] 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 2017.

[7] [7] 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.

[8] [8] 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.

[9] [9] D. Singh, G. Tripathi, and A. J. Jara, "A survey of Internet-of-Things: Future vision, architecture, challenges and services," in Internet of things (WF-IoT), 2014 IEEE world forum on, 2014, pp. 287-292.

[10] [10] T. Pan and Y. Zhu, Designing Embedded Systems with Arduino: Springer, 2018.

[11] [11] D. International. (2018). XCTU Configuration and Test Utility Software. Available: https://www.digi.com/resources/documentation/digidocs/PDFs/90001458-13.pdf

[12] [12] 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, pp. 1474-1485, 2017.

[13] [13] K. Mohanaprakash, S. Brindha, S. Gowri, and K. Lathamaheswari, "IMPLEMENTATION OF VECHILE SPEED LIMITING AND POTHOLE IDENTIFICATION USING ULTRASONIC SENSOR," 2016.

[14] [14] M. Kara-Mohamed, "Design and control of compact legged-wheeled robot" Spicar," 2017.