Development of IoT based Monitoring of Biogas Plant

[1]Rushikesh Ravindra Pansari, [2]Dr. S.R. Patil, [3]Dr. M.S. Khan

[1]PG Student [Embedded System], [2]HOD, E and TC Engg [Guide], [3]Professor [Co-Guide]
[1, 2, 3]Department of Electronics and Telecommunication Engineering
[1, 2, 3]MIT, Aurangabad Maharashtra, India

Abstract: Development of IoT based Monitoring of Biogas Plant is successive in the project everyone know that management of one biogas plant is done perfectly but when they are several biogas plants then management of these biogas plants are critical. To reduce complexity of manual management of plants IoT platform with cloud server of Raspberry Pi, ThingSpeak or any other can be used where data of the several plants will be collected on a server in the form of temperature, humidity and pressure of the biogas plants. In this system temperature, humidity and pressure sensors are connected from one side to biogas plant to measure respective parameters and sensors are connected to the other side using NodeMCU(ESP8266) where NodeMCU uploads the data of unit(plant) to the cloud server using IoT. This helps to deploy this system in industry where the biogas management of several plants can be done.

Keywords: Biogas, IoT(Internet of Things), Own Cloud, Raspberry Pi, NodeMCU (Node Micro Controller Unit), Sensors and MQTT(Message Queuing Telemetry Transport) Protocols.

I. INTRODUCTION

Biogas is very important renewable source of energy. Use of LPG (Liquid Petroleum Gas), firewood as energy production is harmful for environment in terms of environmental pollution and global warming, it also harmful for living organisms like humans, plant, animals and etc. World needs an eco-friendly fuel for energy production like "Biogas" it can be used as fuel for generation of electricity, for cooking and remaining waste material after gas production can be used as compost and compost is also useful for fertilization.

Nowadays, for a good biogas plant, biogas management is so difficult due to busy schedules of mankind. As world is growing fast, humans are not have time to concentrate on a particular work, they have several works as the world needs multitasking property from the humans. That's why; this type of model introduced a system where management is done through the help of IoT on behalf of readings of temperature, humidity and pressure of the biogas plant and that readings can be taken at anywhere. At in this project MQTT protocol techniques is used,ThingSpeak IoT cloud (server), where ThingSpeak and NodeMCU(ESP8266) with some sensors (temperature, humidity and pressure) are used to share information of biogas plant and many more sensorscan be added as per required.

Due to this experiment, several plants can be managed by using NodeMCUs and one cloud server, where each NodeMCU will connect to each plant and then NodeMCUs publishes temperatures, humidities and pressures of biogas plants on theone cloud server. Others can also use their own cloud server where they can get more privacy and premium less service and that will be created by using Raspberry Pi.

As like of this project there are several biogas plant management systems already been implemented and proposed, between them some researchers used Ardiuno with some sensors[1][2][8][9][10][17], Ardiuno & NodeMCU with some sensors[5], Microcontroller & GSM modules with some sensors[4], PIC microcontroller & GSM with some sensors[6][7], Temperature and pH probes[11], UART STM81151G SX1278 and some network communication units[12], PCU ATmega32 TGS2611SHT11 [13], PLC with some sensors[14][15][16] and herein this project system uses some sensors with NodeMCU that are same as others which they used but the different thing is that no one used cloud server for store information online and it is done on MQTT protocol techniques, these type of system can also help to observe one or more plant / plants on ThingSpeak server which will made the system online and fully IoT based. Others can also use high frequency computer Raspberry Pi for creating their own cloud in against

of ThingSpeak server which also help them to keep more protective data and unlimited free storage as per [22]previous review paper as a proposed model is published.

II. RELATED WORK

Vadiraja Acharya et al. at "IoT (Internet of Things) Based Efficiency Monitoring System For Bio-Gas Plants" Monitor the biogas through GSM module with Ardiuno and sensors for managing pH, temperature and pressure due to the architecture proposed which provide a scalable solution to monitor the usage statistics, and also crucial parameters to maintain the efficiency of the biogas plants.

Babar Noor et al. create "PROTOTYPE DESIGN OF SMART BIO-GAS PLANT FOR GENERATION OF ELECTRICITY". Ardiuno with sensors for managing pH, temperature, pressure and electricity generation and some mechanical sections also used they conclude that the plant with better monitoring and control process will generate more electricity and in a less time.

Pramod Sahua et al. at "Automation in Biogas Plant for Enhancement of Efficiency and Safety" Author did mixing, digestion, recirculation, scrubbing, finally storage process takes place for make bio gas. For to enhance the gas production material changes of feed passage amalgamated with solar heating was incorporated and to avoid the digester failure, an automated system consisting of gauge, pressure switch, sensor, servo motor and actuator was proposed.

Suruchi Dedgaonkar et al. create "Biogas Monitoring System for Measuring Volume using Microcontroller & GSM" Working done using Arduino with pressure sensor and GSM module. For implement partially the monitoring system for biogas plants for controlling the activities of different contents in biogas plant.

Yatharth Kumar Sharma et al. work on "Enhancement of the Biogas System Application Using Solar Photovoltaic and IoT Based Automation" Working are done with Arduino, ESP8266, and booster pump. IoT based system is implemented to measure the run time of the booster pump and there by measuring the volume of the biogas consumption.

Sunil MP et al. at "Smart Biogas Plant" Biogas plant using PIC microcontroller with GSM & LCD display. These digesters help in two ways: one is to reduce waste and the other is to provide valuable energy.

Liston Matindife et al. at "Fuzzy Logic System for Intermixed Biogas and Photovoltaics Measurement and Control" System work on PIC microcontroller with LDR, LCD, pressure sensor and etc.

1. A new biogas system fault detection and control strategy.
2. A comprehensive photovoltaic system fault detection and control strategy.
3. A biogas and photovoltaic system easily and quickly fixed by persons with no expertise at all in the respective fields.

W. Ait Ahmed et al. at "Biogas Control: Methane Production Monitoring Using Arduino" System work on Arduino with gas sensor. Graphical result of methane author getting in terms of gas detection.

Ilesanmi A. Daniyanet al. show "Development of a smart digester for the production of biogas" Working through Arduino with temperature, pH and pressure sensor. The methane gas was 54% which generated 5.24 kWh of electricity within 84 days.

Dukuzumuremyi D. et al. intended to make "Effectiveness of applying IoT to Improve Biogas digesters in Rwanda" working with Arduino with NodeMCU, temperature and humidity sensor, this system is intended to integrate several numbers of biogas digesters in one platform.

Cindy Priadiet al. created two process for"Biogas Production in the Anaerobic Digestion Of Paper Sludge" working with temperature and pH probes, they checked two process and did comparison on 'paper sludge generated less biogas from primary' and secondary wastewater treatment and on 'more production is found by using cow manure on that paper sludge'.

Many more also as like Mei Xu et al., Helmy Rahadian et al., E. Mudaheranw et al., Kazi Mohammad Arfatul Islam et al., Krzysztof Budnik et al., and Daniyan et al. created some systems some of them tele networking basis, some of PLC basis and some of sensors basis.

As per previous review paper proposed model [23] this project is successively made with so much hard work so much problem rises sensor damage, covid-19 situation programming errors and so much problems but now, it is able to generate perfect output, dissertation report also accepted in MIT college Aurangabad.

III. SYSTEM ARCHITECTURE AND IMPIEMENTATION

A. System Architecture:

Figure 1. Shows the general architecture of the biogas management using IoT framework whose implementation includes following elements:

- Wireless Sensing Nodes – Here the wireless sensing nodes are NodeMCUs and cloud server where NodeMCUs are publish data on one side of cloud and ThingSpeak (cloud) which subscribed data at another side.
- Sensors – Sensors are here temperatures, humidities and pressures.
- Cloud based server- This is an application platform for IoT that receives, stores, displays and analysis the data provided by the various wireless sensing nodes in real time. It also notifies to the authorized person to take suitable action.
- Monitor –Monitor/ Screen are used to watch or display the readings of temperature, pressure and humidity of the biogas plant.

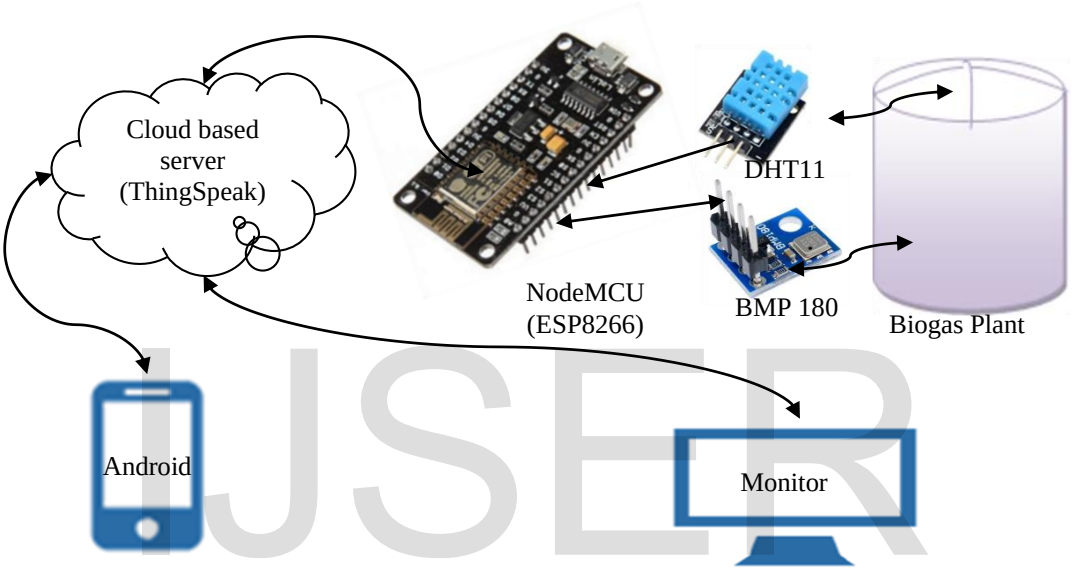

Figure 1. System Architecture of Biogas Management Using IoT

B. Block Diagram :

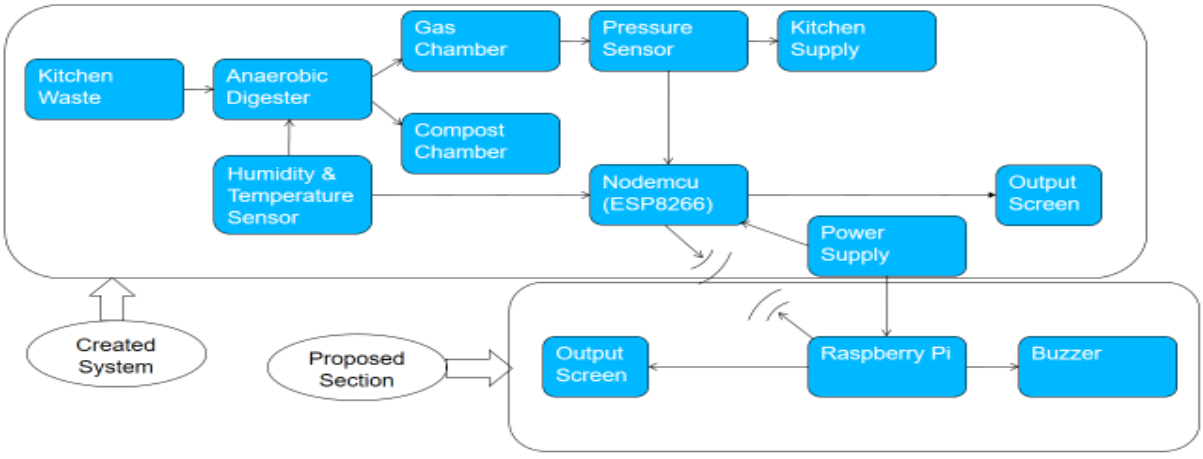

Figure 2. Block diagram of Biogas Management Using IoT

The block diagram of the IoT based biogas management system is shown in Figure 2. It basically consists kitchen waste where from waste is putted into anaerobic digester where humidity and temperature are read by humidity and temperature sensor by using NodeMCU, anaerobic digester have two sections which are compost chamber and gas chamber where compost chamber collect compost and gas chamber is used for store the gas where at gas chamber's pipe: pressure sensor is connected for measure the pressure of gas when the gas is release from gas chamber to kitchen supply.

The pressure sensor also connected with NodeMCU. NodeMCU (ESP8266) need power supply of 3.3V minimum to operate, NodeMCU helps to connect humidity and temperature sensor and also pressure sensor to theIoT cloud and at other side of IoT cloud the system uses ThingSpeak server. ThingSpeak gets subscribed data on monitor through the using MQTT protocol techniques from IoT cloud, Also project unit can include buzzer and Raspberry Pi for making more perfect to the model where Raspberry Pi can do the work as a cloud server as well as show the readings on his monitor and also used as storage and buzzer it can be used as to generate alert if temperature, humidity and pressure sensors increases or decreases readings of plant.

C. Hardware and Software Description:

Hardware Description: The proposed hardware details of the project are two types:

i) At in mechanical terminology (non-technical): Digesters, gas chambers and compost collectors.

- Anaerobic Digesters: Anaerobic digesters will be needed for breaking kitchen waste in slurry form.
- Gas Chambers: Gas chamber will needed for collection of gas.
- Compost Collector/Chambers: It will need for collect the compost, where from compost will usable for fertilization.

ii) At in electronics terminology (Technical): Temperature and humidity sensors (DHT11), pressure sensors (BMP180), NodeMCU (ESP8266), Modem or hotspot of mobile. But proposed section need Raspberry Pi 3 model B+, SD card 16-32 GB, for own cloud router, and external hard drive in TB if storage need more above 16-32 GB.

- Temperature and Humidity Sensors (DHT11): This sensors is required for collecting temperatures and humidities information of the digesters which helps to manage digesters where temperature and humidity should be according to bacteria need.

  Specifications:
  Supply Voltage: +5 V
  Temperature range:0-50 °C error of ± 2 °C
  Humidity:20-90% RH ± 5% RH error

- Pressure Sensor (BMP180): Pressure sensor used for measuring the gas pressure in mb.
  Specifications
  Supply Voltage: +1.8 to 3.6 (VDD) and 1.62v to 3.6(VDDIO)
  Pressure range 300 to 1100hpa
  Interface: Digital

- NodeMCU (ESP8266): Here NodeMCU is used to connect the temperature, humidity and pressure sensors where this NodeMCU publishes data on server as per schedule of time require.

- Raspberry Pi: In the project as a proposal Raspberry Pi will connected to NodeMCU through IoT cloud where Raspberry Pi publishes subscribed data on monitor by using own cloud and that can be accessible from smart phones also. Raspberry Pi consist SD card for running the OS and Also Raspberry Pi will be used as to create self-cloud.

Software Description:

Arduino Software with NodeMCU board is required for programming NodeMCU. NodeMCU can run program of temperature, pressure and humidity sensors for acquisition of data of the biogas plant and this data is

stored on ThingSpeak server or cloud, for storage model need to create an account on ThingSpeak and behalf of API Key of ThingSpeak server can store the information of sensors. In addition, others can able to create their own cloud if they need privacy and premium less service then user can use Raspberry Pi where by doing Raspberry Pi programming with according to link of Raspberry Pi cloud setup (http://www.chris-cunningham.co.uk/uni/2019/cloud-server-raspberry-pi-3). The software details and cloud setup will be as:

- Downloading and installing NOOBS and Raspbian – the easiest part.
- Installing a LAMP server (LAMP – Our Linux OS will be Raspbian, Apache as the Web server, MySQL as the database management system and PHP as the scripting language) – this takes a while and is the start of a pile of terminal commands!
- Getting Ready to Install OwnCloud Installing OwnCloud 10.
- Mounting an external HDD for additional capacity.
- Enabling SSL for external access.

D. System Process:

The flow chart shows the process of biogas plants where biogas management using IoT can be done easily. In the process of flow chart: the first input system is biogas plant, then temperature, pressure and humidity sensors processes sensors data on NodeMCU controller after that NodeMCU processes that readings on the cloud server using IoT platform here system usesThingSpeak server for that then server processes that analytic information on monitor and as well as on cloud storage. By checking the temperature, humidity and pressure in terms of variable ‘x’, and considering A and B will be constants of predefined limits of the readings of sensors there A is the lower limit and B is the higher, if the limit is crossed then operator have to full fill the requirements of the biogas plant, If limit not crossed by variable ‘x’, then system continues its work, minutes wise sensors reading will collecting on the cloud server others can use RaspberryPi’s cloud storage also for more safety.

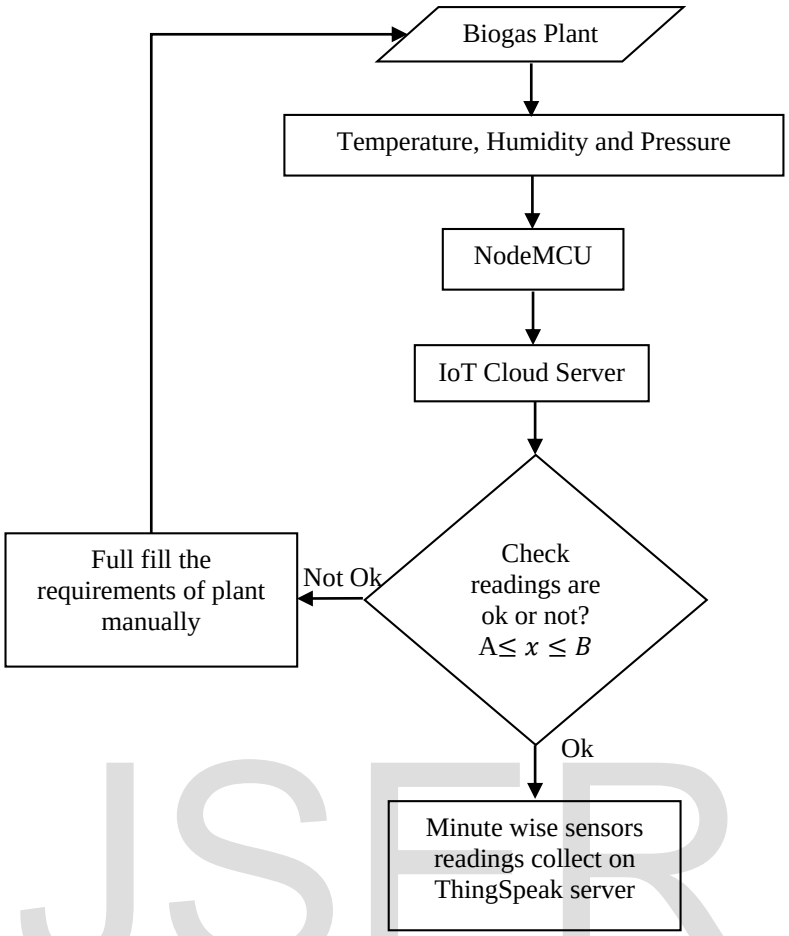

Figure 3. Flow Chart

IV. RESULTS AND DISCUSSION

In previous paper the complete model as a proposed model but now in this paper model ready and ready to generate output, biogas from kitchen waste is made under the temperature range of 26^0C to 36^0C, Humidity which is calculated from digester is 80% to 100% and absolute pressure which is 955.3. This kind of readings got from biogas plant. It produces biogas for 10:00 Minute from 2 KG Jar (Gas Chamber). For monitoring these parameters this type of automatic monitoring system is essential which uses latest technology for managing the biogas plant. IoT technology is used in plant which helps to show the readings of temperature, pressure and humidity of the plant and it also be done from online monitoring by using ThingSpeak server. This online monitoring helps to provide more production of biogas and also let the people do alternative work. Raspberry Pi is used for creation of our own cloud, where data storing limit will be more as per requirements and that will more protectable and premium less.

V. CONCLUSION

In this paper efficient Biogas management using IoT is presented through by development of such monitoring system, this is novel system as compared to traditional which monitors parameters of Biogas plant viz temperature, pressure and humidity using sensors and IoT. Several plants also can be managed using NodeMCUs and one ThingSpeak server where user can able to create more channels for manage several plants from one area. User can also use one Raspberry Pi where Raspberry Pi helps to create self-cloud server and from using Raspberry Pi data stored online and there is no need to subscribe other cloud servers which are based on premium. Due to use of self-cloud server, this system is more protective in terms of data security.

REFERENCES

[1] Vadiraja Acharya et al., Paper Name: "IoT (Internet of Things) Based Efficiency Monitoring System For Bio-Gas Plants" and Publisher: IEEE's (CSITSS) 30 Aug 2018.

[2] Babar Noor et al., Paper Name: "PROTOTYPE DESIGN OF SMART BIO-GAS PLANT FOR GENERATION OF ELECTRICITY" and Publisher: IJSER in Volume 9 issue 12 cited on 12 Dec 2018.

[3] Pramod Sahu et al., Paper Name: "Automation in Biogas Plant for Enhancement of Efficiency and Safety" and Publisher: ScienceDirect in Volume 4 issue 4 part D cited on 22 July 2017.

[4] Suruchi Dedgaonkar et al., Paper Name: "Biogas Monitoring System for Measuring Volume using Microcontroller & GSM" and Publisher: IJCET in Volume 6 no. 5 cited on 02 Sept. 2016.

[5] Yatharth Kumar Sharma et al., Paper Name: "Enhancement of the Biogas System Application Using Solar Photovoltaic and IoT Based Automation" and Publisher: ICICICT on 7 July2017.

[6] Sunil M P et al., Paper Name: "Smart Biogas Plant" and Publisher: SemanticScholar in 2013.

[7] Liston Matindife et al., Paper Name: "Fuzzy Logic System for Intermixed Biogas and Photovoltaics Measurement and Control" and Publisher: Hindawi in Volume 2018.

[8] W. Ait Ahmed et al., Paper Name: "Biogas Control: Methane Production Monitoring Using Arduino" and Publisher: WASET in Volume 11 no. 2 on 2017.

[9] Ilesanmi Afolabi Daniyan et al., Paper Name: "Development of a smart digester for the production of biogas" and Publisher: ResearchGate in June 2018.

[10] Dukuzumuremyi Dieudonne and Hisato Shima, Paper Name: "Effectiveness of applying IoT to improve biogas digesters in Rwanda" and Publisher: IEEE's ICASI in 25 June 2018.

[11] Cindy Priadi et al., Paper Name: "Biogas Production in the Anaerobic Digestion of Paper Sludge" and Publisher: ScienceDirect in Volume 9 2014.

[12] Mei Xu and Chunmei Wang, Paper Name: "Research and Application of the Intelligent Biogas Monitoring System Based on LoRa Technology" and Publisher: IEEE's AIAM in 9 Jan 2020.

[13] Helmy Rahadian et al., Paper Name: "TGS2611 performance as biogas monitoring instrument in digester model application" and Publisher: IEEE's ISITIA in 2015.

[14] E. Mudaheranwa et al., Paper Name: "Development of PLC based monitoring and control of pressure in Biogas Power Plant Digester" and Publisher: IEEE's icABCD in 2019.

[15] Kazi Mohammad Arfatul Islam et al., Paper Name: "Design and performance analysis of a hybrid Solar PV and biogas power plant using PLC" and Publisher: IEEE's ICGET in 2015.

[16] Krzysztof Budnik et al., Paper Name: "Control and Supervision System for Micro Biogas Plant" and Publisher: IEEE's CPEE in 2018.

[17] Daniyan et al., Paper Name: "Development and Optimization of a Smart System for Biogas Production Using Animal Waste" and Publisher: IJAER in Volume 13 no. 23 year of 2018

[18] A Short History of Anaerobic Digestion (https://extension.psu.edu/a-short-history-of-anaerobic-digestion)

[19] IoT - Using Cloud IoT Core to connect a microcontroller (ESP32) to the Google Cloud Platform (http://nilhcem.com/iot/cloud-iot-core-with-the-esp32-and-arduino).

[20] Study Material link (www.irena.org/publications.)

[21] Report by 'usa sustainable conservation' for pressure of biogas.

[22] For study: VJER-Vishwakarma Journal of Engineering Research www.vjer.in

[23] Dr. S.R. Patil et al., Paper Name: “Biogas Management using IoT” and Publisher: IJRASET in Volume 8 Issue VIII Aug 2020.