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Design and Realization of Digital Console for Monitoring Temperature and Humidity in a Biodigester

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ABSTRACT : *The enzymatic activity of anaerobic digestion bacteria is closely dependent on temperature. Thisresearch work focuses on the design and construction of an experimental digital console that can be integratedinto a biodigester for temperature and humidity monitoring. A first report first presents the technologies suitablefor this application. Then, the choice is made on the design and modeling of a digital console through anArduino board, a DHT11 sensor and a 2x16 LCD display. A biodigester (25 liters plastic container) andaccessories were used. The experimental device produced (digital console) made it possible to monitor theevolution of temperature and humidity in the biodigester loaded with cow dung, for a retention period of 30days. The evolution of the digestion temperature has shown that the measurement results of the digital consoleand the probe thermometer are almost the same, with a correlation coefficient equal to 99%. During thisdigestion period, the temperature varied from 25°C to 41°C (mesophilic mode) and the humidity levels variedfrom 70% to 95%. The results obtained show the reliability of the console achieved. An improvement isnecessary in order to monitor with more precision in real time the other parameters (pH, C/N ratio, productionkinetics, etc.) of optimal production of biogas on site.*

Keywords – *Realization, Digital Console, Monitoring, Temperature, Humidity, Biodigester*

I. INTRODUCTION

Nowadays, our society gets involved and questions the environmental impacts of energy consumption and the questions of what becomes of the waste that we generate. She also wonders about an energy future to adopt. We can thus see in several countries a gradual exit from the era of fossil fuels, to reorganize around energy from local and renewable sources [1].Anaerobic digestion is a biological process, which takes place naturally, in marshes and the intestines of animals and insects. It is a transformation, which takes place in the absence of oxygen and converts organic matter into methane and carbon dioxide, through a microbial consortium [2]. The first research leading to the identification of methane was associated with Volta in 1776. He identified methane as a gas with high combustible potential and therefore recoverable in the form of energy [4]

In Guinea, it was in 1977 that the first experiments were carried out with three 0.2 m3 steel digesters in Kindia and Macenta. Between 1981 and 1982, seven additional 10 m3 Chinese-type (fixed dome) digesters were installed. Subsequently, from 1983 to 1999, 80 additional fixed dome digesters with a volume ranging from 6 m3 to 23 m3 were installed. These biodigesters gradually died out due to lack of monitoring, so much so that today, in the whole country there is hardly any functional biodigester [5].

The proper functioning of a biodigester depends on the operating parameters (temperature, humidity, pH, C/N ratio, etc.). There are three temperature zones for anaerobic digestion, namely: from 4 to 25°C psychrophilic digestion, characterized by very slow reactions; from 32 to 42°C mesophilic digestion the most used temperature range because the production of biogas is quite rapid and the medium is stable; from 50 to 57 ° C thermophilic digestion, in this temperature range the production of biogas is rapid but the medium is very sensitive to temperature variations and to the quality of the incoming feed [6] , [7].

Humidity expresses the presence of water vapor in a mixture of air or in ambient air. In general, a measure of humidity refers to the level of humidity expressed as a percentage which is relative humidity.

Humidity is a function of temperature and pressure, which makes its determination complex. The humidity of the fermentation medium must be greater than 50% and is more often greater than 75% [8].

In 2016, the Guinean Government with the support of the GEF and the UNDP was able to obtain funding for the implementation of a project entitled: "Creation of a market for the development and use of biogas resources in Guinea. »With the construction of around 2000 biodigesters throughout the country [5].

Nowadays, there are several dysfunctional biodigesters due to lack of monitoring and which tend to gradually die out. To overcome this problem, we must have an automated monitoring device to facilitate monitoring for the operator and also to know the parameters of the biodigester in real time. Monitoring each parameter is essential for the proper functioning of the biodigester. The objective of this research is to design an electronic device (digital console) for the automatic monitoring of temperature and humidity for better monitoring of digesters locally.

In many areas (industry, scientific research, services, leisure, agriculture, health ...), we need to control many physical parameters (temperature, force, position, flow, speed, brightness, ...) [7].

A sensor is a device for collecting information which develops from a physical quantity, another physical quantity of a different nature (very often electrical). This quantity representative of the quantity sampled can be used for measurement or control purposes.The performance of a measurement system depends above all on the sensor which is part of the measurement chain. The links between a sensor and the quantity it measures are defined by its characteristics of use. The sensors are generally classified according to: the measurand (temperature, pressure sensor, etc.); their role in an industrial process (control of finished products, safety, etc.); the signal they provide (analog sensor, logic sensor, digital sensors); their principle of translation of the measurand (resistive sensor, Hall effect, etc.) and their operating principle (active, thermoelectric, piezoelectric, electromagnetic, photoelectric, Hall, etc.) [9].

II. MATERIALS AND METHODS

II.1. Materials

The material used in this work consists of: design tools, electronic components and simulation software (plastic container, air chamber, flexible tube and valve, Arduino board, temperature sensor, humidity sensor, display LCD, LED, computer, USB cable, microcontroller).

II.2. Method

The methodology adopted in this work consists of the design, production and testing of the temperature and humidity monitoring device in anaerobic digestion. This device consists of two parts: the biodigester with accessories and the digital console [10].

II.2.1. Biodigester

The biodigester consists of a plastic container, an air chamber, a flexible tube and a valve. The 25 liter can (digester) was loaded with 10 kg of fresh cow dung, diluted with 10 liters of tap water, a ratio (1: 1). The air chamber (gasometer) with a valve is linked to the digester by flexible tube of 8mm internal diameter [11].

II.2.2. Digital console

The digital console consists of an Arduino board, microcontroller, temperature and humidity sensors, LCD display, LEDs, computer and USB cable. The Arduino UNO module is a microcontroller board based on the ATMEGA328. It is made up of two parts (hardware and software). The console has 14 digital input and output pins of which 6 can be used as outputs (PWM); 6 analog inputs are used as digital input/output pins [9].

The microcontroller receives the program, stores it and executes it. From the program, it flashes the LEDs, displays the characters on a screen, sends data to a computer, starts or stops the engine [12]. The HE connectors are the support of the microcontroller. They allow all the pins of the ATmega328 circuit to be connected to connectors soldered on the edges of the board. They are divided into three main groups: digital pins, analog input pins, and power pins.

Digital pins D0 to D13 send and receive digital signals, analog pins receive analog values, analog outputs are simulated by digital pins and power pins (Vin and GND). The Vin pin (input voltage), is the current source equivalent to that used by the power connector (12V). The GND pins (Ground or Earth) are used to close the circuit. The USB connector allows you to connect a cable for data transfers, but also for its own power supply. The Power Jack is the external power port to meet power needs beyond the possibilities of the USB port. There are four LEDs L, RX, TX and ON. The reset button is used to reset or stop the Arduino board [13].

The fuse (circuit breaker) serves as a circuit safety device against possible electrical overloads. Two 220V/110V step-down type transformers and 220 / 12V or 220/24 mid-point transformers were used. Electrical resistors are dipoles that oppose the flow of electric current. The capacitors make it possible to store electrical charges on the reinforcements, they are reservoirs of electrical tension. We used a dry capacitor for voltage filtering and an electrolytic capacitor for voltage smoothing.The diodes made it possible, on the one hand, to transform alternating current and voltage into direct current and voltage, and on the other hand, to protect certain components. The relay made it possible to separate the power part and the control part.

Lingt Emitting Diodes (LED) emit light when an electric current passes through them. LED D1 is connected to the main circuit, LED D2 is connected to the pin of the Arduino, and LED D3 is connected to the pin of the Arduino. The 16x2 Liquid Crystal Display (LCD) was used to display the level and temperature of the liquid collected in the jar. This 16x2 display is made up of 16 pins which are: VSS (ground pin), VDD (positive power supply pin), VEE (display contrast adjustment pin), RS (register select pin) , RW (read or write pin), E (enable input pin), D0 to D7 (bidirectional data bus pins), A (backlight anode pin) and K (backlight cathode).7812 voltage regulator was used for protection, its characteristics are: output voltage 12V, maximum output current 1.5A, maximum input voltage 3.5V, number of pins 3, minimum operating temperature 0oC, number output 1, and quiescent current 8mA. It is made up of three pins (the 1st In or Input pin for the power supply, the 2nd pin linked to ground and the 3rd Out or Output pin is Arduino board power pin) [14]. The DHT11 sensor provides digital information proportional to the temperature and humidity measured.It consists of an NTC-based temperature sensor and a resistive humidity sensor, a microcontroller takes care of making the measurements, converting them and transmitting them [15].The device produced is illustrated by Figures 1 and 2.

Photo 1: Device photo

Photo 2: Parameter display

II.2.3. Block diagrams, electrical and the operating algorithm

The block diagrams, electrical and the operating algorithm of the digital console are shown in Figures 1, 2 and 3.

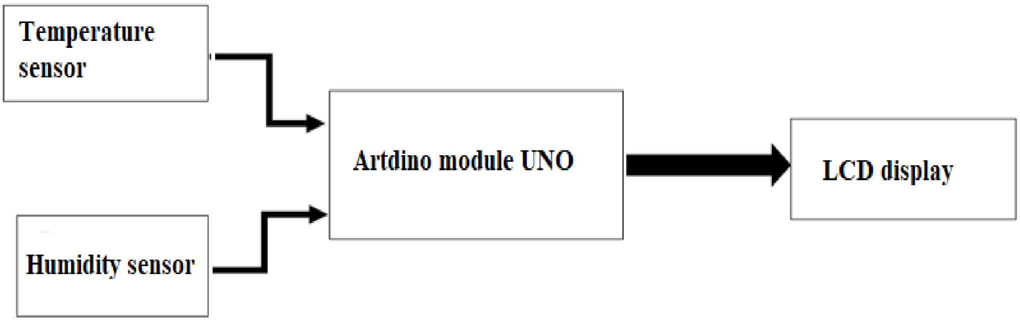

Figure 1: Block diagram of the digital operator

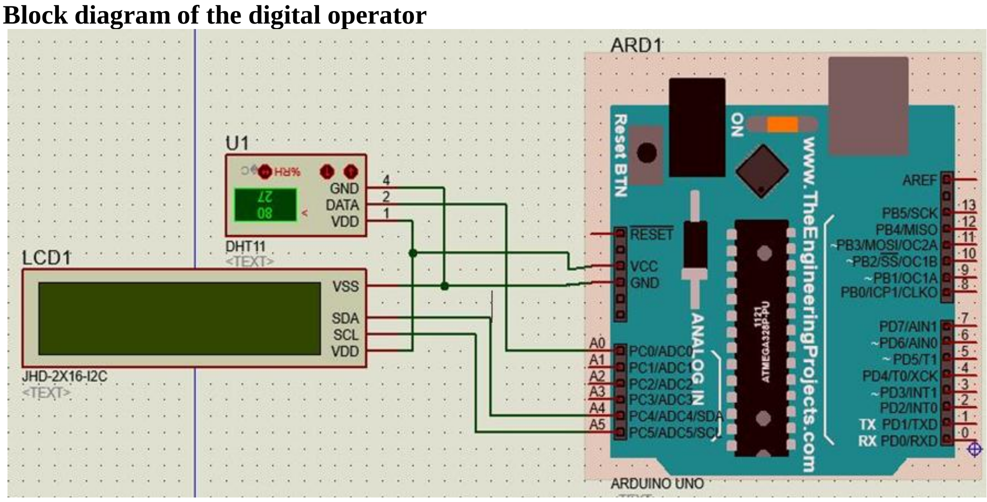

Figure 2: Electrical diagram of the console

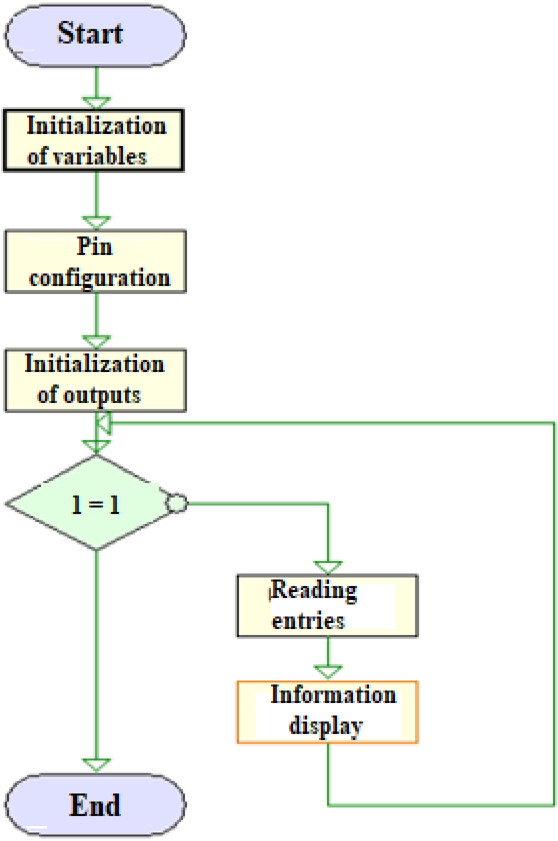

Figure 3: Console operating algorithm

III. RESULTS AND DISCUSSION

III.1. Results

The results obtained relate to monitoring the evolution of humidity in the digester, the temperature of the ambient environment and that provided by the console and the probe in the digester. These results are illustrated by the curves in Figure 4 for better interpretation and discussion.

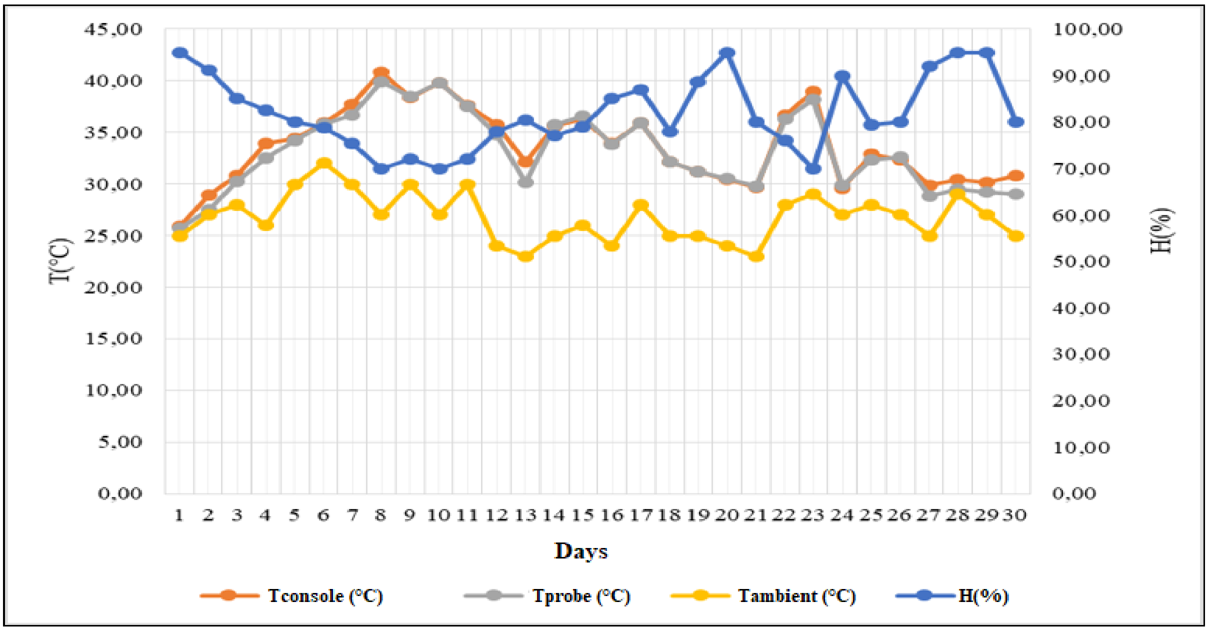

Figure 4: Evolution of humidity, temperature of the ambient environment and that provided by the console and the probe in the digester

III.2. Discussion

The enzymatic activity of anaerobic digestion bacteria closely depends on the temperature change. During the 30 days of digestion, the curves in figure 6 show that:

The temperatures provided by the probe thermometer vary from 25.70°C to 39.90°C, with an average digestion temperature of 33.15°C. Those provided by the console sensor ranged from 25.90°C to 40.80°C, with an average of 33.62°C. The temperature measurements taken place the functioning of the biodigester in the mesophilic phase (25 - 50°C) [5]. The ambient temperature varied from 23°C to 32°C, with an average of 26.80°C; which shows a favorable environment for the proper functioning of the biodigester. The humidity levels recorded by the DHT11 sensor ranged from 70% to 95%, with an average of 81.92%. This humidity range remains favorable for anaerobic digestion microorganisms [7].

The analysis of the results obtained shows that the temperatures obtained from the console sensor reproduce almost the same values as the probe thermometer with a correlation coefficient 0.99 or 99%. The two temperature curves are relatively confused. This shows a good reliability of the experimental device produced.

IV. CONCLUSION

This research work was carried out in the Applied Energy Education and Research Laboratory of Gamal Abdel de Nasser University in Conakry, in partnership with the Higher Institute of Technology of Mamou in the Republic of Guinea. It focused on the creation of a digital console under Proteus ISIS and ARES to monitor the evolution of temperature and humidity in an experimental biodigester during 30 days of anaerobic digestion. The digital console consisting of an Arduino UNO board, a DHT11 sensor and an LCD display has been designed. The biodigester consists of a 25 liter plastic container, a flexible tube, the air chamber and a valve. Fresh cow dung was used as a substrate. The program written in Arduino language governs the operation of the console.

The monitoring of the digestion temperature showed that the results obtained by the console and the probe thermometer are almost identical with a correlation coefficient 0.99 or 99%. The range of digestion is the mesophilic phase. Humidity levels seen by the digital console ranged from 70% to 95%. The results of this study are basic elements for real-time monitoring of other parameters of biogas production on site.

REFERENCES

[1]. I. BARRY, A. SAKOUVOGUI, M. KEITA, R. DONG, S. B. DIALLO, 2021. « Evaluation of the Potential of Biogas and Methane a Party of the Cow Dung ». International Journal of Academic Multidisciplinary Research, Vol. 5, Issue 1, 151 - 154.

[2]. E. Auma Omondi, P. Gikuma-Njuru, and P. Kuria Ndiba, 2019. Anaerobic Co-Digestion of Water Hyacinth (E. crassipes) With Ruminal Slaughterhouse Waste for Biogas Production, Int. Journal of Renewable Energy Development 8 (3) 253-259.

[3]. K. Ignatowicz, J. Piekarski and P. Kogut, 2021. Influence of Selected Substrate Dosage on the Process of Biogas Installation Start-Up in Real Conditions, Rvew MDPI Energies, 14, 5948.

[4]. J. R. BAUTISTA ANGELI, 2019. Etude de faisabilité de la micro-méthanisation par codigestion à l'échelle des quartiers, Thèse de doctorat Bretagne Pays de la Loire, 203p.

[5]. A. SAKOUVOGUI, M. F. BARRY, Y. M. BALDE, C. KANTE, M. KEITA, 2018. Sizing, Construction and Experimentation of a Chinese Type Digester in Mamou Prefecture (Republic of Guinea). International Journal of Engineering Science and Computing, Volume 8 Issue, No.9, 18926 – 18933.

[6]. A. Nsair, S. Onen Cinar, A. Alassali, H. Abu Qdais and K. Kuchta, 2020. Operational Parameters of Biogas Plants: A Review and Evaluation Study, Rvew MDPI Energies, 13, 3761, pp. 1 - 27.

[7]. F. OULARE, F. CISSE, A. SAKOUVOGUI, Z. ZOUMANIGUI, M. KEITA, 2020. Realization and Experimentation of a Digester from a Fut at Julius Nyerere University af Kankan, Guinea. International Journal of Academic and Applied Research, Vol. 4, Issue 12, 1 - 6.

[8]. OJO, OM BABATOLA JO, 2020. Association between Biogas Quality and Digester Temperature for Selected Animal Dung-Aided Water Hyacinth Digestion Mixes, J. Appl. Sci. Environ. Manage, Vol. 24 (6) 955-959.

[9]. P. L. Morpoo Rebeca, T. I. Barry, A. Sakouvogui, C. Kanté, M. S. Camara, D. Mamy, 2021. Design and Realization of a Surgical Aspirator, International Research Journal of Innovations in Engineering and Technology, Volume 5, Issue 4, pp 120-125.

[10]. M. Yantidewi, N. A. Lestari, and U. A. Deta, 2018. Conducting A Real-Time Instrument System for Observing Biogas Digesterrs Temperature and Humidity, Mathematics, Informatics, Science, and Education International Conference (MISEIC 2018), Advances in Intelligent Systems Research (AISR), volume 157, pp 239 - 242.

[11]. Y. M. Baldé, C. Kanté, S. Diop, S. Tebbani, 2019. An expérimental study for the characterization of biogas production from cow dung and droppings, Ecological Engineering and Environment Protection,

No 1, p. 54-61.
[12]. W. Lim, H.K. Torres, C.M. Oppus, 2014. An agricultural telemetry system implemented using an Arduino Android interface. Proceedings of the International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), 1-6.
[13]. S. D Panjaitan, N. Fratama, A. Hartoyo, R. Kurnianto, 2016. Telemonitoring Temperature and Humidity at Bio-energy Process using Smart Phones, Telkomnika, Vol.14, No.2, pp. 762-771.
[14]. I. A. Abdulrazzak, H. Bierk, L. A. Aday, 2018. Humidity and temperature monitoring, International Journal of Engineering & Technology, 7 (4) 5174-5177.
[15]. S. Sukamta, S. Sunardiyo and F. Ambarwati, 2018. Prototype of Temperature, Humidity and Soil PH Measurement as a Analysis Tool Soil Resistance in Grounding System, The 7th Engineering International Conference (EIC), Engineering International Conference on Education, Concept and Application on Green Technology, EIC, 5p.