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Eğitim Amaçlı Basit Bir Biyogaz Dedektörü Tasarımı

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Anahtar Kelimeler
Biyogaz,
Metan,
Dedektör,

Özet: Biyogaz metan, karbondioksit, hidrojen sülfit gibi renksiz - kokusuz, yanıcı olan ve organik maddelerin bileşimine bağlı olarak, organik bazlı atıkların anaerobik anaerobik ortamda fermantasyonundan kaynaklanan gazlardan oluşur. Biyogaz teknolojisi ile organik kökenli atıklardan hem enerji elde etmek hem de toprağa atığı geri vermek mümkündür. Aynı zamanda çevre dostu bir enerji ve gübre kaynağıdır. Ev tipi biyogaz tesisleri, kullanım yerlerine yakın yerlerde kullanılmaktadır. Ev tipi biyogaz tesisleri dışındaki çoğu tesiste, optimum biyogaz üretimi için fermentörün gerekli olduğu ortamın ısıtılması gerekmektedir. Biyogaz üretimi herkesin kendi başına yapabileceği bir şey değildir. Bu üretim için eğitilmiş ve donanımlı insanlar tarafından desteklenmesi gerekmektedir. Türkiye'de az sayıda insan bu konuda yeterli bilgiye sahiptir. Bu çalışmada, pratik eğitim için elde taşınabilen biyogaz dedektörü geliştirilmiştir. Dedektör hem gerçek zamanlı hem de uzun süreli kayıtlarda metan ve karbon monoksit ölçümleri gerçekleştirebilmektedir. Teknik personel eğitiminde bu tür pratik eğitimlerin önemli olduğu bir gerçektir.

Design of a Simple Biogas Detector for Educational Purposes

Keywords
Biogas,
Methane,
Detector

Abstract: Biogas consists of gases such as methane, carbon dioxide, hydrogen sulfide, which are colorless - odorless, flammable and depending on the composition of organic substances, resulting from the fermentation of organic based wastes in anaerobic anaerobic environment. With biogas technology, it is possible to obtain both energy from wastes of organic origin and to bring waste to soil. It is also an environmentally friendly energy and fertilizer source. Home-type biogas plants are used close to the places of use. In most other facilities other than home- type biogas plants, heating of the environment in which fermentor is required for optimum biogas production. Biogas production is not something that everyone can do on their own. It needs to be supported by people who are trained and equipped for this production. In Turkey, the small number of people have enough information about it. In this study, hand-held biogas detector has been developed for practical training. The detector performs methane and carbon monoxide measurements in both real-time and long-term recording. It is a fact that such practical trainings are important in the training of technical personnel.

1. Introduction

Biogas is a gas mixture that is produced by decomposition of animal and vegetable wastes in the anaerobic environment. Its composition contains 60-70% methane (CH_4), 30-40% carbon dioxide (CO_2), 0-2% hydrogen sulfide (H_2S) and very little nitrogen (N_2) and hydrogen (H_2). Biogas is also known by names such as swamp gas or fertilizer gas. Biogas, which can be liquefied at very low temperatures (-164 ^{0}C), smells like a rotten egg due to the sulfur compounds it contains - but it loses its smell when it burns [1-3].

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Animal wastes (fertilizers of animals such as cattle, horses, sheep, chickens, slaughterhouse wastes), herbal wastes (untreated parts of plants such as finely chopped stalks, straw, corn scraps, sugar beet leaves, plant product wastes) can be used in biogas production. Biogas production of animal and herbal wastes can be used alone or mixed with certain principles [4, 5].

The biogas obtained by anaerobic fermentation of organic materials is a flammable gas similar to natural gas due to its properties. It can be used easily by making small modifications in all devices working with natural gas or LPG. The attractiveness of biogas systems is to use organic wastes that cause environmental and health problems as input and turn these wastes to value. Animal wastes, which are quite abundant especially in rural areas, are the most important inputs for biogas systems [6, 7].

Anaerobic fermentation consists of three stages in the most basic sense. These are respectively hydrolysis, acid production and gas formation.

In the hydrolysis stage; because of the extracellular enzymes of microorganisms, complex organic molecules like protein, carbohydrate, fat are transformed into smaller or simple molecules. At this stage, carbohydrates such as cellulose, lignin and hemicellulose turn into glucose, pentose and hexose, while proteins convert to polypeptides and amino acids. The fat are converted to alcohols, acids and hydrogen. As the hydrolysis of fats occurs very slowly, the hydrolysis step is the stage that determines the rate of biological degradation in anaerobic processes. In the acid formation step, the organic molecules are converted to organic acids such as valeric acid, butyric acid, propionic acid and acetic acid, and methyl alcohol. At this stage, dissolved carbohydrates are converted to ethanol, H_2 and CO_2, amino acids to succinic acid and H2, and fatty acids to acetate and H_2. In the methane formation stage, the organic acids, H_2 and acetate formed during the acid formation phase are used by methane-forming microorganisms and converted into biogas. 70% of the methane formed at this stage is formed by decarboxylation of acetate and the remainder by reduction reactions by methane bacteria using hydrogen [8, 9].

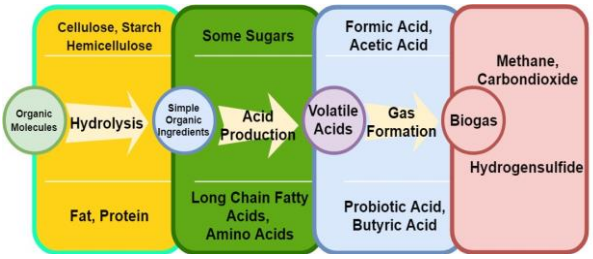

Figure 1. Biogas formation scheme

Biogas technologies include characterization of wastes, determination of the effects of defined parameters in anaerobic fermentation on production, design, optimization and utilization of biogas and require multidisciplinary approach. In the world, biogas technologies have proved their technical and economic competence. Despite the magnitude of potential waste and technological system in Turkey, biogas systems applications could not be implemented except for industrial wastewater treatment plants.
Due to various technical and organizational shortcomings, dissemination efforts, which were initiated by highly demanding, failed. In particular, in rural areas with high waste potential, it is of great importance to provide easy, economical and highly efficient systems that are easy to operate and maintain. These technical conditions are necessary but not sufficient alone. In Turkey, the dissemination of biogas technology and to ensure continuity, it is important for economically and environmentally. In this respect, engineers and technical staff should have sufficient knowledge and experience in this area.

According to data of 2018 in Turkey, 37 energy systems engineering departments and 15 alternative energy sources technology programs are available in higher education. The aim of these departments and programs is to train manpower with high awareness of duty, which can be involved in the use of alternative energy sources and energy efficiency in the public - private sector [10].

In the related biogas courses included in the curriculum of these departments and programs, students will be able to recognize topics such as biomass formation, energy relations, methods and techniques of production and use of biogas from wastes. The aim of the electronic control circuits course is to gain knowledge and skills to use in the types of sensors, their working principles, usage areas and basic electronic circuits. In this study, a simple biogas detector has been designed for practical training in biogas and electronic control circuits courses of related departments and programs. Measurements were also taken from a domestic biogas system with the designed detector.

2. Materials and Method

In terms of biogas production efficiency, biogas production systems need to be controlled regularly and necessary measures are taken against adverse effects. As a result of effective monitoring and control, useful results are obtained such as less waste and high methane content in the biogas production system. Therefore, it is very important to determine the gas formation in biogas plants and make their analyzes. For this purpose, the device for small-scale biogas systems is designed by adding sensors and data loggers positioned on the portable hand-held type. Sensors, data storage module, buttons, LCD display, battery are included in the design. The product has been designed as a portable, programmable and an

updateable device. it is easy to install and use in the desired part due to portable of the device. The detector provides control with an embedded system control card. Methane and carbon monoxide measurements can be made with MQ7 and MQ4 sensors in the detector. In a certain process, the detector can continuously measure and write data to an SD card. The amount of gas can be recorded on the SD card via a computer and analyzed. At the same time, real-time information can be read on the LCD screen on the device.

3. Results

The gas measurements were carried out through Arduino Uno R3 to enable students to meet and practice Ardunio, which became popular in the electronic world due to its easy programmable and feasible application. Arduino has a broad support community on the internet, an easy way to get started with embedded electronic devices. The Arduino consists of a programmable circuit board (microcontroller) and a piece of software or IDE (Integrated Development Environment) that runs on a computer and is used to write and load the sd card into the physical panel. Arduino Uno R3 is a micro controller card based on a removable ATmega328 AVR microcontroller. It has 20 digital input-output pins and 6 of them can be used as analog input and 6 as PWM output (Figure 2) [11-12].

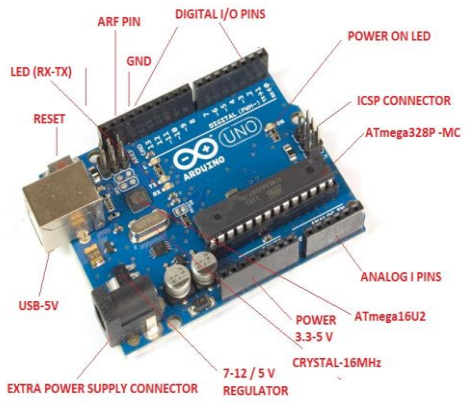

Figure 2. Arduino Uno R3

Figure 3. MQ-4 and MQ-7 sensor

The MQ-4 sensor (Figure 3a.) is a gas sensor that can detect methane in the environment. It gives an analog output according to the gas density in the environment. The gas detection range is 300 - 10000 ppm. The sensor is mounted on a board to make it easier to use. It is supplied by 5V. Both digital and analog output can be output from the sensor. In this way, the gas can be determined either in the presence of gas or not. Sensitivity adjustment can be done with the pot behind the module. It can be used easily with Arduino, Raspberry Pi or other microcontrollers. MQ-7 (Figure 3b.) carbon monoxide gas sensor detects Carbon monoxide in 10ppm and 10,000ppm concentrates. Like other MQ sensors, this sensor outputs analog voltage based on the density of the gas as output. suitable for gas leakage capable of detection in the range of 10,000ppm and 300ppm. By supplying 5V to the H pins, the sensor is warmed up sufficiently to ensure that it works precisely and accurately. It is necessary to wait for the sensor to warm up for 20-30s so that it can operate fully. Applying 5V voltage to pin A or pin B causes an analog voltage to be transmitted through the other pins of the sensor [13-15]. The recording is done by writing the values of the detected gases in ppm and percentage by creating a file with txt format. Thanks to the 16x2 LCD screen, values can also be read on the device. The detector (Figure 4) has been developed as a step-by-step method in the application parts of biogas and electronic control circuits courses. Students followed the steps of the application with curiosity and interest. Figure 4 shows the general view and connections of the biogas detector.

Figure 4. The general view and connections of the biogas detector

In Figure 5, a biogas system fed with bovine animal waste which was developed in Bucak Emin Gülmez Vocational High School was given a 20-day period methane gas obtained by the detector [8]. Methane values (the left-axis arbitrary unit in the graph) are the mean values for the 3 values received every day. With time, the rate of methane formation decreased

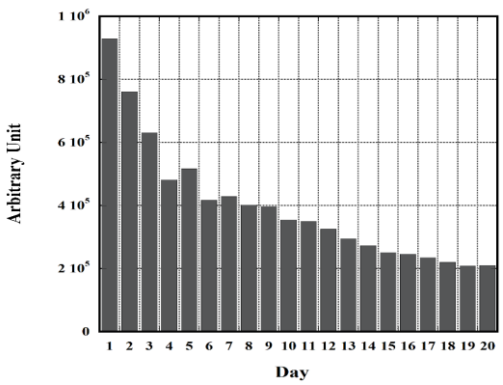

Figure 5. Methane values obtained by biogas detector

4. Conclusion

In this study, a simple hand-held biogas detector has been developed for students training alternative energy sources technology and energy systems engineering. Such devices can be used for gas analysis in domestic biogas systems. The device can be easily used by anyone. The user can take instant and daily measurements from the system so that he can make plans for the system and production. Such studies can be used as an application of courses related to electronic control circuits, sensors and biomass. Applied training reduces the risks of making mistakes, students will become technicians or engineers who are self-confident when they graduate and can practice theory and practice at the same time. This is an extended version of the study entitled "Küçük ve Orta Ölçekli Biyogaz Tesisleri için Gaz Dedektörü Tasarımı" presented at the Techno-Science 2018 [9].

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