A REVIEW PAPER ON DOMESTIC BIOGAS PLANT

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ABSTRACT

In today's fast-growing world, the speed of energy consumption is rising at unexpected rates with each passing day. Development of renewable and sustainable energy source is that the best solution to the country's energy demands. In this context, Biogas generation must be given proper attention. Biogas is one type of renewable source of energy. Biogas is the combination of different gases produced by the breakdown of organic matter in the absence of oxygen, primarily consisting of methane and carbon dioxide. It can be used as alternative fuel instead of LPG for household cooking. But the technology needs to improve for the production of biogas at a higher-efficiency. The problem occurs during the biogas generation is that the temperature inside the digester is not constant because of the seasonal variation in weather as a result production rate of biogas is decreased. In this study we only use green waste for the production of the biogas. To overcome this problem we used aluminium digester along with the heating system to control the temperature variation inside the digester and also we used some inorganic additives to enhance the production rate furthermore.

INRODUCTION

Biogas is the combination of different gases produced by the breakdown of organic matter in the absence of oxygen, primarily consisting of methane and carbon dioxide. Biogas can be produced from organic matter such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Anaerobic digestion (AD) is a widespread technology to treat organic waste streams with clear environmental benefits including generation of methane as renewable energy, which implementation has been steadily increasing over the last years [3]. Kitchen waste is the best alternative for biogas production in a community level biogas plant. It is produced when bacteria degrade organic matter in the absence of air. Biogas contains around 55-65% of methane, 30-40% of carbon dioxide [1].

In today's available technology some problems are faced during the biogas generation are the systems used in the production of biogas are not efficient. There are no new technologies yet to simplify the process and make it abundant and low cost [6]. Biogas generation is additionally laid low with the weather. The optimal temperature bacteria must digest waste is around 37°C. In cold climates, digesters require energy to take care of a continuing biogas supply [6]. The design of the digester is most intricate. pH dropped due to feeding rate is too high or variable, operating temperature have changed and agitation is not working properly.

Although biogas acts an ecofriendly source of energy but the constraints faced is that its production rate doesn't meet the daily requirement and thereby reducing its popularity in the consumer section so in order to make it market viable we have to increase its efficiency by different methods without affecting the basic functioning of biogas and also maintaining cost factor.

In this paper, an attempt has been made to increase the production rate of biogas and control the temperature variation inside the digester with the help of aluminium digester along with heating system and inorganic additives. So that we can make compact assembly which can be installed individually in houses for cooking purposes.

LITERATURE REVIEW

1. Ravi P. Agrahari (2013), The aim of this research paper is to make a digester capable of maintaining internal temperature by incorporating aluminium as the raw material for digester and further painting it with black paint, painting will also increase its life by preventing corrosion from slurry.
2. Yadvika (2004), The aim of this research paper is to enhance production of biogas from solid substrates using inorganic additives that improve gas production. The addition of iron salts at various concentrations [FeSO4 (50 mM), FeCl3(70 μM)] have been found to enhance gas production rate, also it has been observed that Nickel ions (2.5 and 5 ppm) enhanced biogas up to 54% due to the activity of Ni-dependent metallo-enzymes involved in biogas production.
3. M.S. Romero-Güiza (2016), The aim of this research paper is to implement Micro-nutrients supplements which have shown good results. Use of inorganic and biological additives in anaerobic digestion systems has become an important topic due to their capacity to increase reactors performance in terms of process stability, biogas production and treatment capacity.
4. Samson Nnaemeka Ugwu (2020), The aim of this research paper is to observe the reviewed capacity of various iron-based additives which enhance biogas production, improve digester process stability, achieve better substrate treatment, and increased pathogen reduction. Iron-based additives have been found advantageous of being effective in H_2S toxicity control, nutrient supplementation, enhancement of methane content, facilitation of substrate solubilization.
5. E. Abdelsalam (2015), The aim of this research paper is to observe the effect of different trace metals such as $CoCl_2$, $NiCl_2$ and $FeCl_3$ additives on biogas and methane production and the statistical analysis indicated that the biogas production increased with the addition of trace metals by the order Ni>Co>Fe.

COMPONENTS OF BIOGAS PLANT

Digester:

In general terms, digesters consist of the digestion tank as such, which is thermally insulated, plus a heating system, mixer systems and discharge systems for sediments and the spent substrate. Biogas digesters receive organic matter, which decompose in an exceedingly digestion chamber [7].

Piping system:

The piping system connects the biogas plant with the biogas appliances. it's to be safe, economic and may allow the desired gas-flow for the particular gas appliance. Most prominently, the piping system has to be reliably gas-tight during the lifespan of the biogas unit. In the past, faulty piping systems were the most frequent reason for gas losses in biogas units [7].

Valve:

The main gas valve has to be installed close to the biogas digester. Sealed T-joints should be connected before and after the main valve. With these T-joints it is possible to test the digester and the piping system separately for their gas-tightness [7].

Gas Collector:

Biogas is not typically produced at the time or in the quantity required to satisfy the conversion system load that it serves. When this occurs, storage systems are employed to smooth out variations in gas creation, gas quality, and gas consumption. The storage component acts as a reservoir, allowing downstream equipment to operate at a constant pressure. Gas collector is a tank which collects gas from the digester with the help of piping system [7].

Heating system:

To achieve the optimum biogas yield, the anaerobic digestion needs constant environmental conditions, preferably close to the process optimum. The digester temperature is of prime importance [7]. In order to maintain the temperature we incorporated heater.

METHODOLOGY OF BIOGAS PLANT

Aluminium made digester along with heating system

As biogas plant is set up outside in the surrounding it has to face the harsh environment changes caused due to seasonal changes which also includes temperature variations, but as we know that temperature is an important factor determining the production rate so in order to cope up with the sudden changes in temperature the factors that can be changed are the thermal conductivity of the material used to make digester so we used aluminum as the material because its thermal conductivity lies at the optimum range. Aluminum is also better alternative on the basis of biogas production and also safe for the environment because it can easily be disintegrated by microorganism, but plastic creates a lot of environmental problem due to its non-biodegradable nature. In overall observation, we got, metal absorbing more sunlight to increase the temperature inside the digester in comparison to plastic made biogas plan [1]. Sometimes temperature can drop to a certain point where the bacterial colony can be affected and maybe result in the wipe out of entire bacterial colony so to overcome this problem we have used heater as a source providing constant heat and thereby maintaining the internal temperature of digester.

Addition of inorganic additives

Biogas is formed by series of bacterial reactions catalyzed by different bacterial enzymes. As enzymes are biological chemicals their viability is very less and they denature easily so to maintain their functioning and enhance their process speed several cofactors can be added they can be either in the form of biological entities or inorganic additives in the following part we focus on the inorganic part. Several inorganic additives that improve gas production have also been reported, that higher concentration of bacteria could be retained in the digester by the addition of metal cations since cations increase the density of the bacteria, which are capable of aggregating by themselves [2]. Researchers found that the addition of iron salts at various concentrations $FeSO_4$, $FeCl_3$ have been found to enhance gas production rate [2]. But their addition is to be exercised properly or else negative impact can take place on the production rate.

DESIGN AND CONSTUCTION

Design

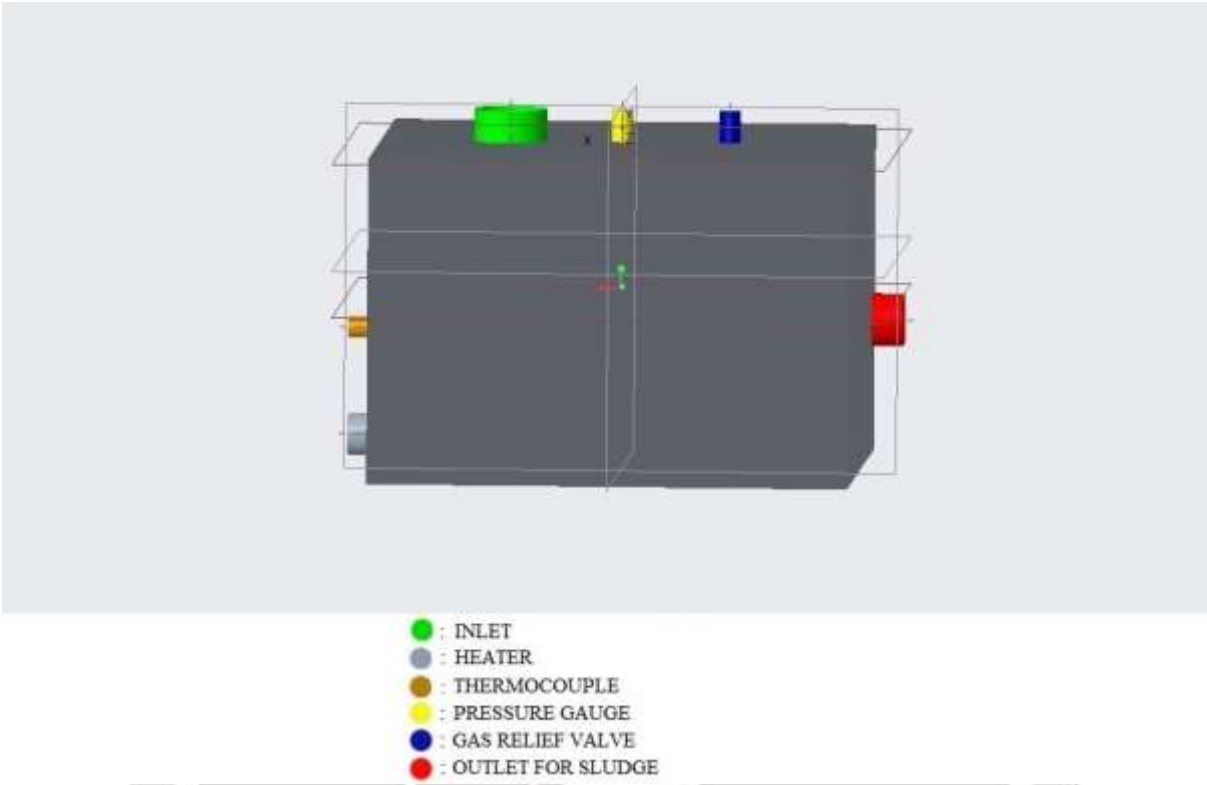

Figure 1: Creo Design

Figure 2: Actual Model

Construction

Digester is constructed by welding 6 aluminium sheets thus forming a cuboidal geometry. Welding is carried out in such a way that the whole assembly is air-tight. The top portion of digester contains inlet for waste, outlet for biogas and pressure gauge. On one side of the digester we made proper arrangement for sludge removal. An internal heater is fixed at the bottom of the digester. Thermocouple is connected to the digester in order to measure the internal temperature of digester and we also used sensor system for automatic operation of heater.

WORKING

First step in the process of biogas formation is collection and segregation of green waste, after that it is mixed with water in ratio of 1:2 and then it is fed to the digester through inlet. For the first run of digester, we put adequate amount of green waste thus forming inoculum for future purposes. After this green waste has to be added on daily basis, bacterial colony will slowly start growing in the digester and thereby ensuring production of biogas. Biogas is produced from organic wastes by concerned action of various groups of anaerobic bacteria through anaerobic decomposition [1]. Anaerobic decomposition is a two stage process as specific bacteria fed on certain organic materials [1]. In the first stage, acidic bacteria dismantle the complex organic molecules into peptides, glycerol, alcohol and the simpler sugars [1]. When these compounds have been produced in sufficient quantities, a second type of bacteria starts to convert these simpler compounds into methane [1]. Biogas formation requires about 30-40 days time interval. As it's a series of biochemical chain reaction it is very sensitive to outer environment condition and substrate composition so to maintain and steadily increase rate of production, we have to add inorganic additives such as $FeSo_4$ and $FeCl_3$ at a periodic interval in appropriate amount. As mentioned above bacterial colony require optimum condition for biogas production, temperature plays a key role so to regulate it we incorporated a heater fixed at the bottom of digester. For self-regulation of internal temperature of digester, we also connected heater with sensing system and thereby maintaining a constant internal temperature automatically. After the complete decomposition of substrate, formation of sludge takes place which is ideal as fertilizer for plants and is taken out through sludge outlet.

CONLUSION

We developed the methodology to increase the production rate of biogas and control the temperature variation inside the digester with the help of aluminium digester along with heating system and inorganic additives. We make an assembly such that it can be installed individually in houses for cooking purposes.

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