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# Effect of Biogas Burners and High Temperature Biofuels Furnaces to the Ceramics Products

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***Abstract:***
This study reports the impact of landfill generated biogas and the scrubbing of biogas on the manufacturing process of high-quality ceramics. To justify this research aim, experimental research based outcomes are generated which concluded that if the potential of the biogas is increased through scrubbing which results in the enhancement of methane value by 92.5% with 7.5% oxygen, and removed the H2S and CO2 gas at the high temperature, then high quality and resistant ceramic material will be generated which is more durable and efficient in its productivity. This experimental statistic proves that the biogas as a fuel is viable alternative energy for high temperature ceramic kin firing and is mostly utilized by the construction industries. In addition, there are some recommendations based on this study outcome like a biogas can be used as a more efficient renewable source for the advanced ceramic production, and also there is a need of chart to utilize this 80% renewable energy for the local efficient ceramic production, which is generated from the landfills of a state.

***Keywords:*** *Biogas burners, High temperature, Biofuels furnaces, Ceramics products.*

## I. INTRODUCTION

The Ceramic word derived from the Greek word meaning “pottery”. The clay-based domestic wares, building products and art objects are quite similar to us, and the pottery is considered as one major part of the ceramic world (I. E. OKONKWO, 2018; Rautureau, Gomes, Liewig, & Katouzian-Safadi, 2017). In the current era, ceramic becomes more expensive and is quite available in the form of advanced ceramics, glass and some other cement system. Well, biogas is the mixture of such gas that is produced by the breakdown of organic material in the absence of oxygen, and usually contains some quantities as methane and other constituents (Löfberg, Kane, Guerrero-Caballero, & Jalowiecki-Duhamel, 2017; U. C. Okonkwo, Onokpite, & Onokwai, 2018). These biogases are usually produced from raw material like municipal waste, agricultural waste, sewage, plant material, food waste or the other green waste. These natural gas plays a significant role in the production mechanism of ceramic products and also consumed in several industrial applications (Atay, 2016; Vargas-Hernández & Jiménez Solís, 2019).

As far as a biofuel is concerned, it is such a cleaner-burning fuel that also produces fewer emissions like carbon monoxide, carbon dioxide and nitrogen oxide (Kesieme, Pazouki, Murphy, & Chrysanthou, 2019; Lei et al., 2016; Tse, 2016). In the current situation, the biodiesel can be utilized in an oil furnace, as a major alternative to typical petroleum-based furnace oil. It's burning at a high temperature is helpful for the development of ceramic products because it's biodegradable, efficiently produces carbon dioxide and also a

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carbon neutral (Martínez-Martínez et al., 2016). In short, these two factors named as biogas burner and the biofuel furnace plays a major role in the development of advanced and attractive shapes and production of ceramics at high temperature. Furnace lining is an insulating and protective layer of heat resistant material that is usually attached inside the hearth, shell, and the tap holes of a furnace (Geselle, 2019; Hameed, Basheer, Iqbal, Anwar, & Ahmad, 2018; Hamid, Shahid, Hameed, Amin, & Mehmood, 2019; Ul-Hameed, Mohammad, & Shahar, 2018). Its most lining materials are metal/ ceramic combination of ceramic compounds. In these ceramic lining materials, the variety of raw materials are used that have some particular strengths, and these are magnesite, aluminum oxide, dolomite and silicon carbide (Atay, 2016; Warlimont, 2018). The major problem statement of this paper is to critically evaluate the impact of the landfill generated simple biogas and the high temperature of biofuel furnaces in the manufacturing of high-quality ceramic products. This research statement is an important approach to investigate the direct influence of these two potentials that plays a productive role in the development of advanced and attractive ceramic products and also give a new direction to this manufacturing field. The major objectives of this informative paper are;

- To examine the properties of biogas and its feasibility to use in the burner, and also to study the guaranty of supply, its homogeneity and its impact on the high product quality (high-quality brick).
- To examine the influence of landfill generated biogas on the production efficiency of the ceramic products in the construction section.
- To examine the influence of biofuel furnace on the production efficiency of the ceramic products in the construction section.
- To evaluate the deployment of biomethane to ceramic kiln firms by providing an alternative and renewable substitute for the traditional fuels at a high temperature.

This experimental research is an informative approach in front of the related field scholars and construction companies to understand the importance of the biogas burner and the biofuel furnace in the manufacturing of advanced ceramic items in the current advanced technological environment. Also, this paper covers the gap of the previous researches because no one majorly worked on considering the combination of these two biogases and biofuels in the development of advanced pottery items. Last scholars majorly worked on exploring the potential of biogas as fuel for high temperature based ceramic kiln firing (E Abubakar & Sadiq, 2018; BU et al., 2019), utilization of its biogas, development of biogas combustion in combined power and generation, etc (Hosseini & Wahid, 2013, 2014). But nobody major worked on the combined chemical reaction based experiment of both biogas and biofuel furnace at different temperatures and circumstances for the new pottery design, which is specifically covered by this paper. This experiment-based outcome will enhance the information regarding the in-depth analysis of biogas for advanced ceramic products.

## II.PROCESS DESCRIPTION

As this is an informative and challenging experimental approach to understand the impact of the biogas with moderate temperature and the biofuel furnace with high temperature on the efficiency of the ceramic product manufacturing, so differentially two experiments will be performed to justify the point that which process is an appropriate one to enhance the productivity of these advanced ceramic items. No doubt, the major difference between both the processes is based on their temperature and related working condition like the landfill generated biogas caused production of ceramic items. While the high temperature oriented biofuel results in the ceramic kiln firing. Their process description based application in this manufacturing mechanism is mentioned below;

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### *2.1. Application of Landfill generated Biogas to Ceramic Products Manufacturing*

In the manufacturing of high-quality ceramic products, a biogas burner plays a significant role to make a desirable outcome. Well, the biogas constitutes a fuel source that is homogeneous throughout the landfill's life. This landfill originated biogas is majorly based on (40-50%) of carbon dioxide and (50-60%) of methane gas. While, the technical validity study of this project shows a series of biogas characteristics in the landfill which means it is conditionally used in the kiln burners in the ceramic factory in the form of variable production, high humidity, low calorific power, impurities content and variable pressure. The varied composition based variable production causes a major difficulty in the continuous processes that require a stable and constant fuel supply. According to its in-depth study, a gas production curve is plotted to provide a minimum guarantee for the feasibility use in plants. In such ceramic product manufacturing, the lower heating capacity (50% of natural gas) is used in this biogas characteristics. Also, the dual-energy designed to fuel the kilns is continuously processing. This low heat producing fuel helps to retain this continuous process without affecting the final ceramic product by specifically installing and designing a dual heat supply system. It means that a ceramic kiln could be used as a combination of both natural gas and biogas that will automatically be adjusted to fulfill the heating requirements (Gómez, Calleja, Fernández, Kiedrzyńska, & Lewtak, 2019; Nahar, Mote, & Dupont, 2017). While, siloxanes and H2S based impurities can destroy the final product of ceramic so they had to be eliminated, minimized or identified.

Well, the experimental studies regarding the biogas properties and the methane recovery based composition have been made. On the other side, the impact of biogas properties on the ceramic manufacturing process and its final product appearances and properties will be important in this case. In the previous studies, the supply requirements of the ceramic products were based on continuous operation (more than 8000 h/year) and high availability, low humidity, impurity-free biogas and constant supply pressure.

### *2.2. Application of Biofuel Furnace to the Ceramic Kiln Firing Products Manufacturing*

As the ceramic Kiln firing hitherto is majorly dependent on the unreliable and erratic sources of energy like fossil fuels and electricity which is not environmental friendly. Therefore, the global shift towards the application and the usage of sustainable fuel of the best available technique (BATs) in the production have changed the research paper consideration in the ceramic fuel and the firing technology to make a use biogas oriented renewable fuels. Well, the biogas has already been applied to the ceramic kiln firing in the United States, Spains and Nigeria (Ayats, Jiménez, & Cabré, 2007; Sadiq, 2004). But that applications were restricted to the temperature of 700°C and 900°C due to the absence of hydrogen sulphide (H2S), carbon dioxide (CO2), moisture (H2O) and the other trace elements. In this case, the experimental temperature of 900°C is not enough to derive a needed mechanical strength and the stony character of a ceramic ware which have the power to retain any pressure in daily usage. So, there is a need to fire a ceramic ware beyond the temperature of 900°C where that high gas needs to be effectively cleaned for enhanced calorific value. The application of the previous biogas implication to ceramic kiln firing is shown in the following table.

TABLE I:
Summary of Biogas Application to Ceramic Kiln Firing based on different

| Research (s) | Reactor | Methods | Place | Year | Temperature | Substrate |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Sadiq (2004) | Landfill | Anaerobic Digestion | Nigeria | 2004 | 900 | Wet Cow Dung |
| Cabre (2007) | Landfill | Anaerobic Digestion | Spain | 2007 | 900 | Municipal Waste |
| Harnetty and Baker (2008) | Landfill | Anaerobic Digestion | USA | 2008 | 700 | Municipal Waste |

The above table based on previous experimental biogas applications which shows that now this paper is strategically based on scrubbing and bottling of the biomethane at the high temperature of ceramic kiln firing.

## III. MATERIAL AND METHOD

In the case of manufacturing the simple ceramic item, there is a need of continuous supply of fuel with a low calorific power without any impact on the final product. It was done by effectively incorporating a duel heating system in kilns which majorly based on natural gas and biogas based on heating requirements. The specific characteristics of the biogas of this new burner and the fuel injector is based on low heating capacity, pressure, and the different air-gas stoichiometrics. This specific burner has to perform equally by using either the fuel type (natural gas or biogas) and to perform dual regulations. In this testing mechanism, a software program is automatically adjusted for the different working usage of temperature and gas pressure. The facilities used in such ceramic production is based on the horizontal burner, vertical burner and the pilot light system to ignite the biogas. After this, the major equipment facilities are based on the compression group and biogas cooling system. In this experimental mechanism, the gas transport network is designed between the manufacturing plant and landfill for the gravity-based collection of the condensates produced by the temperature change within the supply stoppages and caused by breakdown and maintenance. These condensates are usually channeled to landfill blowers' points that facilitate pumping and collection. Before this testing mechanism, a detailed study was conducted on the topography and route between both facilities.

Well, in case of manufacturing the ceramic kiln firing based product, there is a need of material which having 1000L capacity synthetic plastic tank, 21L transparent plastic bucket, 100L capacity plastic drum, gas regulator, ½ inch flexible rubber pipe, 1 x 20kg & 2x 12.5kg LPG cylinders, gas regulators, 3.5 horsepower Peugeot compressor and 2L urine pouch. In this situation, the strong biogas is generated through anaerobic digestion, scrubbing by using the water displacement technique and then bottling the biomethane for the high temperature of kiln firing. In this manufacturing process, the pretreated substance is mixed in the ratio of 1:7 (cow dung: water, as already discussed by Sadiq (2004) and then charged into a 1000L based capacity plastic digester. Well, the 632 liters of the slurry is charged by leaving 368 headspaces for the excessive gas collection. Overall the 127L raw biogas is collected over the 28 days based digestion period. The generated biogas is then subjected to a simple flame test that helps to evaluate its combustibility and then critically analyzed before and after the scrubbing of composition. The picture-based description of 1000L capacity plastic digestion is mentioned below;

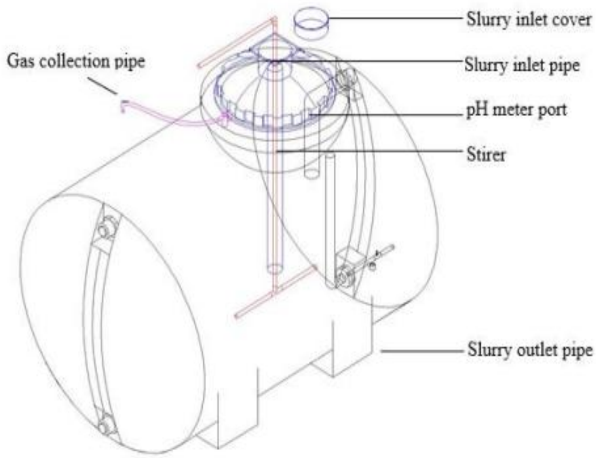

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FIGURE I:
1000L Capacity Plastic Digester

According to the above figure, the slurry inlet covers are used to protect the digestion chamber from any dirt, while the slurry inlet pipe is helpful to charge substrate into the digestion. This slurry outlet pipe is helpful for the removal of the exhausted substrate from the digester, while the pH meter port is used to monitor the level of acidity or alkalinity of the digestion process (Ezra Abubakar, Sadiq, Umar, & Wuritka, 2019). Well, its gas collection pipe is useful to channelize the generated gas into the scrubber for the purification, and the stirrer is used to mix the substrate and create a microbial activity based efficient biogas generation. This water scrubbing process is based on high solubility of H2S and CO2 in water that results in passing of the raw biogas from the digester to water column in an inverted 21L plastic bucket directly. This inverted transparent plastic bucket is immersed into the plastic drum with 100L capacity and these H2S and CO2 based gas bubbles are stripped off through the water-filled column. The Archimedes principle-based gas and water displacement is followed in this experiment. Well, its methane gas was initially collected over water and passed through the silica beds to remove the moisture.

Within this process of compressing the methane into the cylinder, scrubbed biogas is collected into a 12-20 gauge vehicular tube (named as plate 2) from the above scrubbing process, and then passed through a 3.5 Horse Power (HP) compressor, as mentioned below;

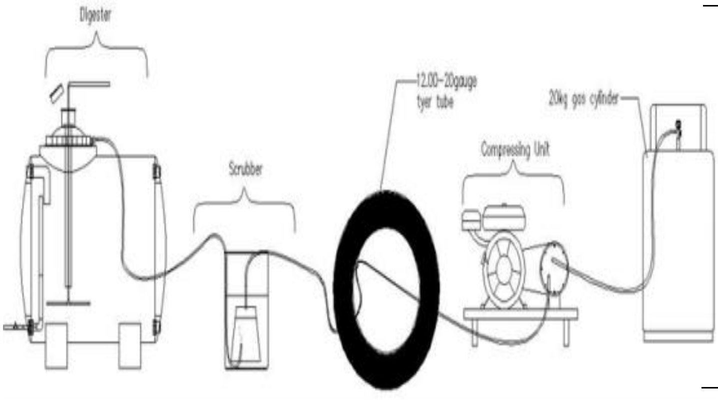


FIGURE II:
Biogas Scrubbing and Compressing Process

## IV. EXPERIMENTAL RESULTS AND DISCUSSION

In case of biogas oriented ceramic plate production, all the obtained average values do not exceed the guaranteed values. Well, the quality of produced brick shows no major difference from the natural gas wherein the reddish glazes, the efficient use of biogas results in the intense coloring as compared to browner, the darker once as obtained with natural gas. Also, the alkaline damage to the kiln refractory that may damage the kiln element in the short run. In this process, there is a higher content of sulphur component as compared to natural gas. Well, the average and guaranteed values-based description are mentioned below;

Table II:
Average Values Obtained

| Average Values Obtained | |
|---|---|
| Humidity | 0.6% |
| Methane | 45% |
| Oxygen | 1.5% |
| Nitrogen | 11% |
| Carbon dioxide | 39% |
| Ammonia (NH4) | 70 mg/Nm3 |
| Hydrogen Sulphide (H2S) | 550 mg/Nm3 |

TABLE III:
Average Values Obtained

| Guaranteed Values | |
|---|---|
| Humidity | ≤ 0.75% |
| Methane | ≤ 43% |
| Oxygen | ≤ 3% |
| Nitrogen | ≤ 15% |
| Carbon dioxide | ≤ 45% |
| Ammonia (NH4) | ≤ 150 mg/Nm3 |
| Hydrogen Sulphide (H2S) | ≤ 1,500 mg/Nm3 |

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According to the previous studies data, the four years of continuous operation result in desirable outcomes in this research, like the fuel is changed and developed high satisfactory results. Well, in the final product quality, no reduction occurs in the overall production capacity and the final product quality. The project's technological novelty of this project lies in the biogas valorization for this industrial application. The environmental impact is reduced by performed two companies like valorized the high polluted gas at a low cost and the fossil energy is substituted by the landfill biogas (Bose et al., 2019; Gandiglio et al., 2020). This renewable energy plays a significant role in the manufacturing of ceramic items by reducing 48% $CO_2$ emission and result in the reduction of 83% consumption of fossil fuels. The relationship between the volume of biogas and temperature for the efficient production of ceramic items is given below;

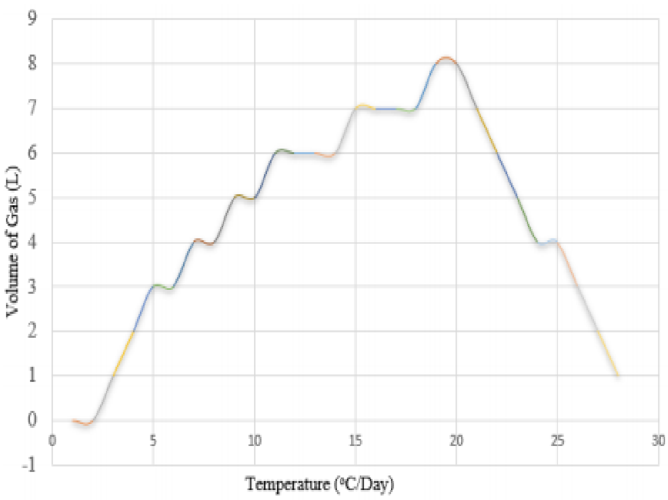


FIGURE IIIL:
Relationship between Volume of Gas and Temperature

Well, the scrubbed biogas based outcomes caused some major changes in the peak values of oxygen, carbon monoxide and methane with 6%, 0.0005% and 93.98%. This high volume of methane results in the complete removal of $H_2S$ and $CO_2$ from the gas stream by reacting $CO_2$ with water to generate a weak acid (carbonic), while the $H_2S$ is mostly lower than 2% when reacted with $H_2O$ and becomes changed into hydronium ion (0.000 PPM).

After this, the flame test is implemented on the raw and scrubbed biogas, where the plate 3 is initiated raw biogas and plate 4 shows the scrubbed biogas, as mentioned below;

Plate 3: Raw Biogas Plate 4: Scrubbed Biogas

While the difference in the flame strength is attributed to high methane content by 92.5% of the scrubbed biogas, as shown in the following figure 4.

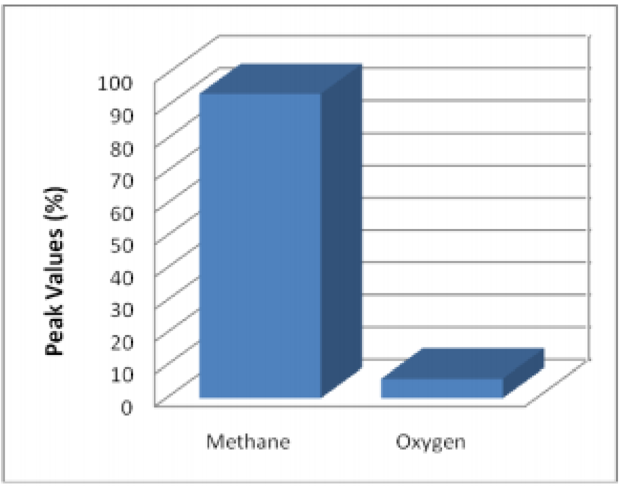


FIGURE IV:
Gas Constituents and Peak Value in Scrubbed Biogas

After this, methane is bottled into the LPG cylinder by using a single-stage compressor, and then a 127L of biogas is generated from the aerobic digestion process which is lasted for 28 days. After this, the generated volume of biogas translates the energy of 1143 Mega Joule and the British thermal unit of 1,08,358.26 energy (BTU = required temperature x nature of insulating material). The 91200 BTU is required to fire a 0.161M3 ceramic kiln at 150 degree-centigrade in 1hr. If this temperature increased to 1350 degree-centigrade with 9hrs, then non-stop hiring at constant temperature is required because of their linear relationship. When these outcomes are compared to Ward's model, then the maximum volume of biogas is generated that are enough for the fire ceramic wares at high temperature. Two major assumptions of this theory are that 1) there is no loss in biogas during scrubbing, and 2) the temperature rise was constant at 150 degree-centigrade/hour throughout the firing period (E Abubakar & Sadiq, 2018).

## V. CONCLUSION AND RECOMMENDATION

Thus, after performed the experimental based descriptive research, it becomes concluded that 80% of biogas production can be recovered from landfills. Well, fossil fuel based biogas recovery can be converted into a renewable energy source. The maximum production of biogas for simple ceramic production required 83% of the renewable energy source as opposed to 0% beforehand. Also, the technological enhancement in the efficient development of ceramic items through biogas burner is majorly dependent on energy improvement, which makes it possible to manage the generated gas effluent at the landfill sites. After this, the produced biogas can more efficiently use in the production of ceramic kiln firing and then developed and upgraded the biogas at a high methane content by using a simple technique. Well, the devices of such experimental technique are simple automobile compressor and scrubbing technology. According to the above mentioned experimental outcomes, at a higher temperature oriented kiln firing, the excessive gas needs to be scrubbed for enhanced heating value. The generated volume of this study shows that there is more than enough capacity to fire a ceramic kiln at a high temperature. This shows that biogas is viable alternative energy for the high temperature based ceramic kin firing. These processes result in the development of such high-quality ceramic floor tiles, utensils etc, have a quite hard protective top layer that has a capability to resistant in the high humidity condition and more impervious to water and other material. Based on these outcomes, there are some recommendations for the use of biogas as a renewable source and the exploration of the other renewable energy sources for the ceramic kiln application. This paper must recommend the state's policymakers to make a chart regarding the usage of sustainable and renewable energy in businesses and homes.

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