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Modified Stove Burner for Biogas

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Abstract - The study focused on modifying a Liquefied Petroleum Gas (LPG) stove burner to suit for Biogas fuel. Further, it intends to package Biogas technology such that it will be utilized at house hold level. This is to offer an alternative fuel source to various users of LPG which is very expenses nowadays. Also, this is in response to the problem raised by the farmer's Biogas producer that only a part of the cooking burner can burn and release heat and most of the released heat consumed by heating the surplus methane. Biogas producers used (LPG) burner however, LPG is different from Biogas composition, and when burners designed for LPG gas will be used, poor flame produced. Also, the technology's goal is to showcase Biogas stove burner with good combustion in the atmospheric form utilizing hog waste. The technology utilized LPG cooking burner (two burners) which was

modified to fit Biogas burner in atmospheric form. The modification is composed of four parts, nuzzle, air regulation parts, injector and head as similar to a LPG cooking burner, but differ in gadgets. Five trials were done to test the performance of the burner particularly on the length of the flame, color and the pressure. The modified LPG Stove Burner produced blue flame in three layers. No flu gas is coming out from the burner thus fire health and environment hazards minimize.

Keywords - Biogas Technology, experimental research, Ilocos Sur, Philippines

INTRODUCTION

The continued increase on the cost of commercial energy such as Liquefied Petroleum Gas (LPG) caused more household both in rural and urban areas in the Philippines to use other means for cooking their food. Currently the use of wood or charcoal becomes popular among which now become a threat to our environment causing forest degradation. On the other hand, our government is implementing the piggery Biogas project as a means of livelihood and an alternative source of energy through the Department of Science and Technology (DOST). In fact, Biogas technology is now being adopted by many hog raisers all over the Philippines.

Hog raising is very common to Filipino families both in the backyard and in commercial piggery production. It is considered as a source of livelihood to many families in rural areas of the country especially so that easy to raise, and food are readily available such as food wastes from household or other feeding source are also available in the locality. In

Ilocos Sur, farmers usually raised from 2 to ten heads of swine as a means of living while some had already ventured in a medium-scale swine production to cope up the demand of pork and other value adding products such as chicharon, longganisa which are OTOP products of Vigan City.

Animal waste from swine production can be a good source for Biogas even on a backyard scale of production. Biogas is a gas mixture. It consists of methane, carbon dioxide, and a small amount of carbon

monoxide, hydrogen, nitrogen, oxygen hydrogen sulphide and hydrocarbon gases. The volume percentage of each gas in Biogas is not fixed for it varies with raw materials, ration of input materials, fermentation temperature and fermentation stages.

Biogas provide a clean, easily controlled source of renewable energy from organic waste materials for a small labor input, replacing firewood or fossil fuels w/c are becoming more expensive as supply falls behind demand.

Biogas also known as biomethane, swamp gas, landfill gas or disaster gas is the gaseous product of anaerobic digester decomposition without oxygen) or organic matter. In addition, providing electricity and heat, Biogas is useful as a fuel. It usually 50% to 80% methane and 20% to 50% carbon dioxide with traces of gases such as hydrogen carbon monoxide, and nitrogen. In contrast, natural gas is usually more than 70% methane with most of the rest being other hydro carbons (such as propane & butane) and traces of carbon dioxide and other contaminants.

LPG's composition is different from Biogas. Materials are composed predominantly to hydrocarbons, as a mixture of propane, propylene, butanes and butylenes. Burners designed for this gas when used as Biogas burner will not be use. It gives very low efficiency. Flu gases are formed during incomplete combustion.

This study therefore, focused on modifying a LPG burner into a biogas burner to suit the efficient biogas burner.

Thus, this technology development intends to package the use of Biogas technology safety to household consumers. Further, Kyoto protocol on treatment of animal by-products, replacement of fossils to local resources such as an organic fertilizer were some of the utmost reasons that inspired the researchers in conceptualizing this stove burner for Biogas.

FRAMEWORK

The main cooking fuels used in the Philippines include agricultural residues and waste; fuel wood, charcoal, liquefied Petroleum (LPG) and Kerosene.

Liquid Petroleum Gas (LPG) or propane is becoming more popular fuel choice, especially in countries with large urban areas and rising income levels. It is popular with middle and upper income families because it is clean burning and quick cooking compressed gas with an adjustable heat output.

Liquefied Petroleum gas also called LPG, GPL, LP gas, or liquid propane gas is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles. It is increasingly used as an aerosol propellant, and a refrigerant, replacing chlorofluorocarbon in an effort to reduce damage to the ozone layer.

Varieties of LPG bought and sold include mixes that are primarily propane (c3 H3), butane (C4 H10) and most commonly mixes including both propane and butane, depending on the season, in winter more propane, in summer more butane. (http://www.ofdc.energy.gov/afdc/). Propylene by butylenes are usually also present in small concentration.

Agricultural residues and waste include Biogas. Like LPG, Biogas can also provide a clean, easily controlled source of renewable energy from organic waste materials for small labor input, replacing firewood or fossil fuels (w/c are becoming more expensive as supply falls behind demand).

Biogas is a product of decomposing organic matter, such as sewage, animal by products, and agricultural, industrial, and municipal solid waste. It is usually 50% to 80% methane and 20% to 50% carbon dioxide with traces of gases such as hydrogen, carbon monoxide, and nitrogen. In contrast, natural gas is usually more than 70% methane with most of the rest being other hydrocarbons (such as propane and butane) and traces of carbon dioxide and other contaminants. (http://www.afdc.energy.gov./afdcl).

The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows Biogas

to be used as a fuel. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is used in a gas engine to convert the energy in the gas into electricity and heat.[2] Biogas can be compressed, and used to power motor vehicles. In the UK, for example, Biogas is estimated to have the potential to replace around 17% of vehicle fuel.[3] Biogas is a renewable fuel, so it qualifies for renewable energy subsidies in some parts of the world. Biogas can also be cleaned and upgraded to natural gas standards when it becomes Biomethane (*en.wikipedia.org/wiki/**Biogas***).*

According to Robert Wilhelm Bunsen, a German chemist, combustion in atmosphere form is a part of air is mixed with Biogas before Biogas combustion and let primary air coefficient more than zero but less than one. The ways of air pre-mixed up can be mechanical air blow and also inhalation by Biogas own pressure.

The flame of combustion in atmospheric form is compost of three layers, Bunsen added, its most interval layer is inner flame. It is formed by combustion after Biogas mixed with primary air, and a cone in shape and blue in color. Outer flame is outside inner flame. It is formed by unbury Biogas from inner flame area which is differing and mixing with the surrounding air. It is purplish blue, and its tip is a bit round in shape. The outer flame is surrounded by an invisible high temperature film. The highest point of flame temperature is at the place which is outside, but was the tip of inner flame. (The Biogas Technology in China. December 05, 1989).

The aforementioned literature dealt on the modification of an LPG stove burner for use in Biogas fuel, also known as Biomethane, swamp gas, landfill gas, or digester gas, a gaseous product of anaerobic digestion (decomposition w/out oxygen) or organic matter.

OBJECTIVE OF THE STUDY

The study focused on modifying LPG stove burner to suit to biogas fuel for efficient utilization at the household level.

MATERIALS AND METHODS

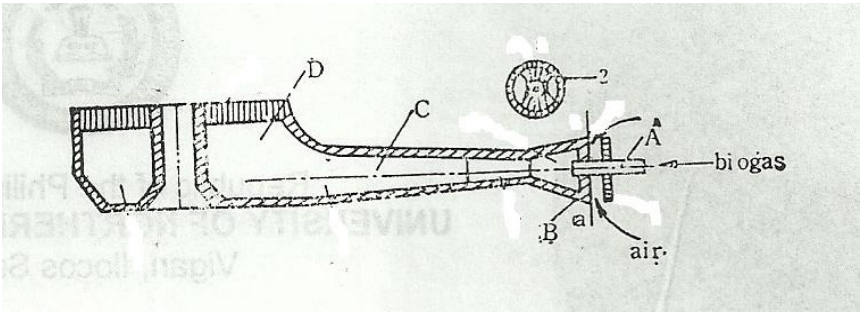
This study made used of experimental type of research utilizing LPG stove burner to test for the use of biogas as fuel. It involves the design and development of a modified stove burner for Biogas and the qualitative testing to identify the good combustion output of the burner. Several trials were conducted to determine the effective utilization and to test the functionality of the modified LPG stove burner for Biogas.

Test trials were conducted at the Guzman Piggery owned by Engr. Mario Guzman, a Professor and a Biogas digester designer at Tapao, Sinait, Ilocos Sur. Performance of the stove burner was measured in terms of complete combustion.

Development Process of Modified Stove Burner

Structure of Stove Burner

Biogas burner in atmospheric form is composed of four parts: nozzle, air regulation parts, injector and head as similar to a liquefied petroleum gas cooking burner, but differ gadgets. Actually the burner for liquefied petroleum gas cooking burner was modified.



A. Nuzzle
A. Air Regulation
B. Injection
C. Head

1. Nozzle controls the flow amount of Biogas which converts

Biogas static pressure to potential energy to its kinetic energy. Its shape influences the thermal load of burner and inhalation of primary air amount. It is made up of a copper tube material with high temperature.

2. Air regulation parts play a role of regulating air amount, fixing nozzle and keeping their concentric with the injector. These are the some subcomponents: a.) air shutter, b.) nozzle support and c.) short tube.
3. Injector is reducer; throat and diffuser that serve air inhalation reducer. It plays a role of reducing the resistance to inhaled air. Its function is to cause an extraction force to mixer. Most importantly, to convert a part of kinetic pressure to static pressure in order to inhale air amount needed for combustion and further mix Biogas with air homogeneously.
4. Head is compost of chamber and flame parts. Chamber is used to distribute the mixture.

RESULTS AND DISCUSSION

Performance Testing of Modified Biogas Burner

The modified Stove Burner for Biogas undergone a series of Trial to test the different operation on the nozzle and air blending. For the nozzle test, the length of the flame, the color and pressure of the flame coming out were evaluated. Also, the diameter for the passage of the Biogas was tested using the different size of the nozzle. Air mixture or blending was also tested at the injector, to test the co9mbustion and quality of the flame produced using the Biogas as showed (table I).

Table 1. Results of modification trials of an LPG burner use for biogas fuel

Trials in Modification of the Burner	Result
Trial 1- Unmodified LPG burner	No flame at all
Trial 2- Insert nozzle a one centimeter diameter.	Low Flame not suitable for cooking. Low efficiency . Part of the burner can burn. Most of the release heat consume by heating a surplus methane.
Trial 3 Insert Nozzle one centimeter diameter ad close air regulator.	Improve the flame a yellow in color. Excessive carbon black that comes from the burner and form at the burner due to incomplete combustion. It is Hazard use for cooking and could pollute the environment.
Trial 4 Close air bend at the injector	Flame are long and weak a combination of yellow and blue flame. No inner flame of the burner as can be seen using the LPG stove. Flame lift off every now and then.
Trial 5 Close air bend at the injector and open air regulator as to the original use for LPG gas.	The flame is purplish blue and its tip is a bit round in shape. The outer flame is surrounded by an invisible high temperature film. The highest point of flame temperature is at the place w/c is outside but was the tip of inner flame.

Test on functionality and modified stove burner

After many trials, the researchers came up on developing the stove burner for Biogas after a series of trials. The LPG stove burners were the only part that was modified. Other gadgets such as the casing, housing and the hose were not. Also, the modified stove burner is not using the LPG regulator and the electronic igniter.

In modified stove burner using Biogas, blue flame was produced. The flame is composing of three layers. It was purplish blue and its tip and a bit round in shape. The outer flame was surrounded by an

invisible high temperature film. The highest point of flame temperature is at the place which is the outer flame, but located at the tip of inner flame. The mixture of methane and air (oxygen) produced a blue flame and producing a large amount of heat energy. Generally, the flame is safe, no more flu gas coming out from the burner that is hazardous to our health and could pollute the environment.

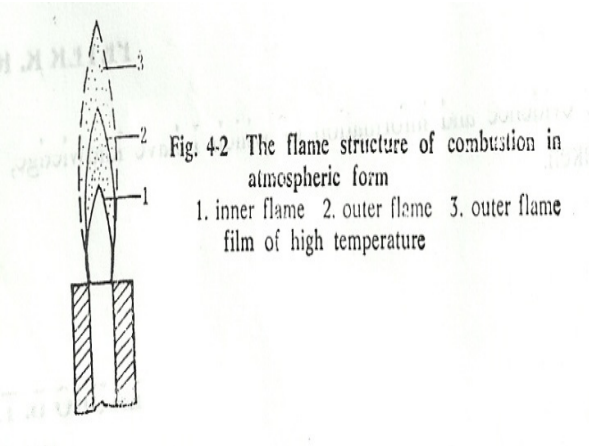


Fig. 4-2 The flame structure of combustion in atmospheric form
1. inner flame 2. outer flame 3. outer flame film of high temperature

Working Principle Of The Designed Technology

Biogas is supplied from conduit to nozzle and gets out of the nozzle. Then, it has kinetic energy by itself. Furthermore, injection took part of it where in, air is inhaled to reducer from the opening of air shutter.

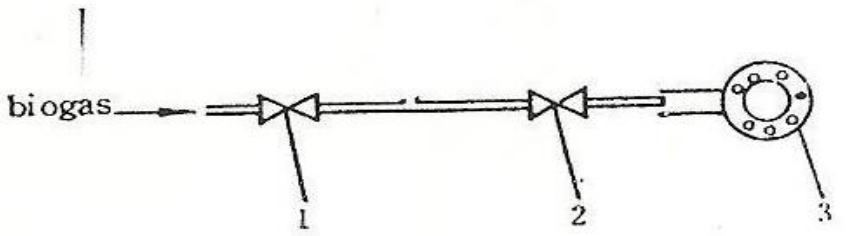
Biogas and a small amount of air are inhaled and mixed well while flowing towards and then enter to the chamber. Mixed Biogas and air in chamber escapes from ports and burns under the condition of seemed air existence. The flames appeared in double layers of inner and outer shape while the inhaled primary air amount is controlled by regulating air shutter.

Manipulation

To Operate a Burner

There were many ways to obtain a good result of combustion as similar to the liquefied petroleum gas burner. The technical know-how for operating a burner must be mastered by trail and error adjustments.

1) Control inlet pressure. When Biogas is used, open the valve before the burner, regulate the pressure equal to rated inlet pressure and the regulating result can be achieved to meet the combustion requirement.
1) Regulate the opening of air shutter. When methane content is high, required primary air amount shall be more and vice versa. If methane content is high, but air amount is less, it will cause incomplete combustion.
2) Keep flame ports clean. Flame ports are easy to be choked by vegetable and rice soup, and corroded by in Biogas. When the ports are choked, it will affect the injection of primary air seriously, cause incomplete combustion, flames of some burners will wave, and flame left off will happen at the ports in outer circles of most burners.



Troubleshooting

Troubles will often occur during the use of Biogas burners. Here are the common troubles and the remedies listed for reference or as a guide to Biogas adaptors.

Table 2. Common troubles and remedies for stove burner using biogas

Trouble	Causes	Remedies
1.Pressure indicated at biogas digester is high, but the fire is not strong	➢ The bon of the valve is for small and the biogas supplied to the burner is not enough ➢ The nozzle is choked	➢ Clean the bone of the valve or change of valve ➢ Clean the nozzle
2. Strong fire and all of a sudden weak and even goes out	➢ There is accumulated water in the conduit, which affects the normal transportation of biogas	➢ Remove the accumulated water in the conduit
3. Flames of perishes, but no flame in the middle	➢ The injection of primary air is not enough. ➢ The parts are too near to the pot bottom.	➢ Lift the pot bottom so that to cut a proper distance between the ports and pot bottom
4. The flames are weak. Flames and noise occur at nozzle	➢ The parts are larger. After a certain time of combustion, the ports are too hot. It causes back fire, when biogas pressure is low	➢ Adopt rationally designed burner ➢ Properly increase the height of pot supports. Decrease the temperature of ports ➢ Increase inlet pressure of biogas
5. Flame are long and waving	➢ The primary air is not enough	➢ Open the air shutter or open it wider

Economic Evaluation

Cost Efficient Fuel

Putting up a Biogas is an expensive one which cost up to Php 83, 266.00 depending on its size. It can be utilize for 2 to 5 years depending upon the mode of usage. However, the adoption of the technology provides cost saving to household expenditure and a means of mitigating climate change since it's pro-environment.

The co-operators previously consumed a tank LPG in just 20 days for his one-burner stove for daily cooking which is equivalent to Php 17, 100 per year. At present, a tank of LPG costs Php 950.00.

Table 3. Payback period of the biogas project

Modes of Biogas Fuel Usage	Cost of Biogas Digester and Burner	Number of LPG Tanks consumed	Cost of LPG Consumed per year	Payback period (years)
Household Fuel use only	Php 83, 266.00	1 Tank for 1 month @ P950.00/tank	P17, 100.00	4.87
Household and Food Processing ventures such as production of: • Chicharon (bagnet) • Longganiza • Etc.	Php 83, 266.00	4 Tanks for 1 month @ P 950.00/ tank	P45, 600.00	1. 83
Dual Household Fuel use only	Php 83, 266.00	2 Tanks for 1 month @ P950.00/tank	P22, 800.00	3.65

Financial analysis of the project using payback period showed that to be able to compensate the incurred expenses for the Biogas digester and Biogas stove, 4.87 years payback period was computed if utilized for household consumption only. If the stove burner using Biogas

will be utilized both for household and for business ventures such as processing of "bagnet" chicharon production, a cost saving for LPG amounting to P 45,000/ per year thus manifested a computed payback of 1.83 a year. However, if utilized by dual household fuel a cost saving of 22, 800 per year and having payback period of 3. 65 years.

Other Benefits Using Biogas as Energy Source

Environmental Benefits

1. A means of mitigating climate change by reducing the atmospheric methane concentrations.
2. Treatment of wastes reduces water and air pollution, odor and destroys pathogens that may cause disease to human and other animals.
3. Application of digestive or sludge fulfils the phosphorus requirements of crops and completes the nitrogen requirement from mineral fertilizer.
4. Displacement of fossil fuels reduces CO2 emissions.

Farming Benefits

1. Diversification of farming activities.
2. Reliable energy production and utilization.
3. Additional earning from wastes treatment on production of energy Biogas and fertilizers.
4. Improvement of the mechanical and nutrition properties of manure.

CONCLUSIONS

The preliminary trials of the design of the Biogas burner were the performance of little flame heat efficiency were not suitable for cooking because of an excessive carbon black due to incomplete combustion. The third designed and developed Biogas burner composed of four parts, namely the nozzle, air regulation parts, injector and head. A liquefied petroleum gas cooking burner was used, but it was modified in some parts like in the nozzle, air regulation parts and in the

injector. This design was found effective for Biogas as substitute for LPG. Payback computation showed that, 4.87 years payback period was computed to recover the cost of Biogas technology if utilized for household consumption only. If the stove burner using Biogas will be utilized both for household and for business ventures such as processing of "bagnet" chicharon production summed up to Php 45, 600 per year thus manifested a computed payback of 1. 83 years. However, if utilized by dual household fuel a 3. 65 years payback period was computed.

Stove design for biogas is cost effective, an alternative fuel source, and saves forest by not using firewood or charcoal for cooking. The technology is health and environment friendly.

RECOMMENDATIONS

Diversification of farming is always encourage among farmers to increase revenue generation. Adoption of technology is also highly recommended to farmers through piggery project whether on backyard or commercial scale.

Utilization of Biogas is encourage when one engage in piggery production as alternative fuel source since commercial energy particularly LPG cost very high in the market today.

Users of Biogas are encourage to convert stove burners that will fit to the use of biogas to avoid hazards that might occur in the future since commercial stove burner found in the market today are designed for liquefied petroleum gas alone.

LITERATURE CITED

Storage and Handling of Liquefied Petroleum Gases Hand out 2008 Retrieved from:***www7.dleg.state.mi.us WebORRGSA/1000_39_AdminCode.pdf***

The Biogas Technology in China, Chengdu Biogas Research Institute of the Ministry of Agriculture Retrieved from: **ftp://ftp.fao.org/docrep/fao/008/ae897e/ae897e04.pdf**

Guzman, M.
2011 Biogas Digester Designer. Interview topics of the type of burner used and the quality of fire produced using biogas Alternative Fuels Data Center. US Department of Enery. Retrieved from: *http://www.ofdc.energy.gov/afdc/*

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