

EFFECT OF CATALYST IN THE INTEGRATION OF CAPTIVE BIOGAS PLANT

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

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**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of GANESH. A (35150029), JAI AMAR. V (38150040) who carried out the project entitled "EFFECT OF CATALYST IN THE INTEGRATION OF CAPTIVE BIOGAS PLANT" under my supervision from december 2021 to april 2022.

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DECLARATION

We GANESH. A and JAI AMAR. V hereby declare that the Project Report entitled EFFECT OF CATALYST IN THE INTEGRATION OF CAPTIVE BIOGAS PLANT done by us under the guidance of Dr. J. JAYAPRABAKAR, Associate Professor, Department of Mechanical Engineering, Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering / Technology degree in MECHANICAL ENGINEERING .

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ABSTRACT

Biodegradable waste is the waste that can be decomposed and will be broken down into carbon dioxide, water, methane or simple organic molecules by the action of microorganisms in reasonably less time. Normally, biodegradable wastes are food and kitchen wastes, manure, agricultural wastes, paper waste and textiles. In this research paper, an attempt is made to extract biogas from kitchen waste and a comparison with the effect of catalyst. The anaerobic digestion or bio methanization takes place for the formation of the biogas. The characterization for the gas is done through FTIR and gas chromatography. With this we can obtain the specification of the biogas and calculate the obtained biogas that would an alternative for the LPG that is used for cooking.

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CHAPTER 1

INTRODUCTION

Every day we lead our life with combustion materials. As the day passes there we see a serious threat for the coal and petroleum products. Research leads to the different sources of energy like renewable energy resources. Energy is one of the most important factors to global prosperity in which its importance cannot be over emphasized ranging for domestic and industrial purposes [1]. Also the gradual depletion in petroleum products on earth surface and depletion of ozone layer caused by greenhouse gas emission from fossil fuel usage has necessitated search for a more environmentally friendly alternative source of energy. The challenge of the present world is to harness the various energy sources which are environmentally friendly and ecologically balanced to the environment. In view of these, many researches have done on various sources of renewable energy and one of them is the use of biogas derived from the organic wastes and kitchen wastes. cutting of forest. Also, due to deforestation it leads to soil erosion. Use of dung , firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an eco-friendly substitute for energy.[2]

Kitchen waste is bio-material having the high energy value and calorific value to microorganisms, that's why efficiency of biogas generation can be expanded by several ways of magnitude [3]. The dumping of food waste is the main cause of pollution can be finished in low cost and environment friendly way [4]. Considering cost effective is not the target the dumping of waste must be done in proper way for maintaining hygiene. The disposal of food areas and making the places unhygienic and it needs the solution. Installation of biogas plants give the proper way of utilizing and p roper storage of waste [5]. The process of anaerobic digestion is a key path that allows to efficiently handle a use biofuel (which is comprised of mostly methane and one fourth of carbon dioxide) in order to produce energy.[6]

There is a variation to attain the process of anaerobic digestion because the waste vary to produce energy as well the operating temperature. So production rate of biogas varies for each case [7].

Anaerobic Digestion is one of the method used to treat food waste. In rural areas the commonly used process is “anaerobic digestion of cow dung” but there are factors that limits the production and technical feasibility to continue the process [8]. Some of the factors affecting anaerobic digestion performance include physical structure of plants, the input to these plants and especially the operating temperature. The input feedstock includes size of particle, content of moisture, content of nutrient and biodegradability [9].

1.1 INTRODUCTION TO BIOGAS

Biogas is the mixture of gases primarily consisting of methane and carbon dioxide produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste and food waste. It is a renewable energy

source. In other words biogas is generated through the natural process of bacterial decomposition (anaerobic digestion or fermentation) of organic materials. Components of biogas are as follows

Table 1.1. components of biogas

COMPONENTS	PERCENTAGE
Methane (CH ₄)	50-85
Carbon di oxide (CO ₂)	5-50
Water vapour (H ₂ O)	0-10
Hydrogen (H ₂)	0-1
Hydrogen sulphide (H ₂ S)	0-3
Nitrogen (N ₂)	0-5
Oxygen (O ₂)	0-2

1.2 CHARACTERISTICS OF BIOGAS

Composition of biogas depends upon feed material also. Biogas is about 20% lighter than air has an ignition temperature in range of 650 to 750 deg C . An odourless & colourless gas that burns with blue flame similar to LPG gas. Its caloric value is 20 Mega Joules (MJ) /m³ and it usually burns with 60 % efficiency in a conventional biogas stove. This gas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel, & electricity, depending on the nature of the task, and local supply conditions and constraints. Biogas digester systems provides a residue organic waste, after its anaerobic digestion (AD) that has superior nutrient qualities over normal organic fertilizer, as it is in the form of ammonia and can be used as manure. Anaerobic biogas digesters also function as waste disposal systems, particularly for human wastes, and can, therefore, prevent potential sources of environmental contamination and the spread of pathogens and disease causing bacteria. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen refuse(residuals).

1.3 USES OF BIOGAS

- Production of energy.
- Transformation of organic wastes to very high quality fertilizer.
- Improvement of hygienic conditions through reduction of pathogens.
- Environmental advantages through protection of soil, water, air etc
- Micro-economical benefits by energy and fertilizer substitutes.
- Macro-economical benefits through decentralizes energy generation and environmental protection.

- 1.4 FACTORS AFFECTING YIELD AND PRODUCTION OF BIOGAS

Many factors affecting the fermentation process of organic substances under anaerobic condition are,

- The quantity and nature of organic matter.
- The temperature.
- Acidity and alkalinity (pH value) of substrate.
- The flow and dilution of material.

CHAPTER 2

LITERATURE SURVEY

To supply biogas for cooking, ARTI - appropriate rural technology of India, pune in 2003 has developed a compact biogas plant in which waste food rather than any cow dung is used as feedstock. The plant is compact and used in urban households and as well as rural house holds. About 2000 plants are currently in use at maharashtra. This simple yet powerful experimental technique for the plant, has won ARTI the Ash den Award for sustainable Energy in the Food Security category of the year 2006. Dr. Anand Karve (President Appropriate Rural Technology of India, pune ARTI[10],[11] developed a compact biogas system that uses starchy or sugary feedstock material and the analysis shows that this new system is 800 times more efficient than conventional biogas plants. Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days to complete the reaction.. Thus, overall, the new system is 800 times as efficient as the conventional biogas system.

Hilkiah Igoni[12] (2008) studied the Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester. The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process. They investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding.

Shalini sing, sushil kumar, M.C. Jain, Dinesh kumar (2000), [13] carried studies on cattle dung and their residues insemination with kitchen waste and found that the increased biogas production using microbial stimulants.

Shalini Singh et al.(2000) studied the increased biogas production using microbial stimulants. They studied the effect of microbial stimulant aquasan and teresan on biogas yield from cattle dung and combined residue of cattle dung and kitchen waste respectively. The result shows that dual addition of aquasan to cattle dung on day 1 and day 15 increased the gas production by 55% over unamended cattle dung and addition of teresan to cattel dung : kitchen waste (1:1) mixed residue 15% increased gas production[14].

Lissens et al. (2004) completed a study on a biogas operation to increase the total biogas yield from 50% available biogas to 90% using several treatments including: a mesophilic laboratory scale continuously stirred tank reactor, an up flow biofilm reactor, a fiber liquefaction reactor releasing the bacteria *Fibro bacter succino* genes and a system that adds water during the process. These methods were sufficient in bringing about large increases to the total yield; however, the study was under a very controlled method, which leaves room for error when used under varying conditions[15].

Thomsen et al. (2004) found that increasing oxygen pressure during wet oxidation on the digested bio-waste increased the total amount of methane yield. Specifically, the yield which is normally 50 to 60% increased by 35 to 40% demonstrating the increased ability to retrieve methane to produce economic benefits .

As Taleghani and Kia (2005) observed, the resource limitation of fossil fuels and the problems arising from their combustion has led to widespread research on the accessibility of new and renewable energy resources. Solar, wind, thermal and hydro sources, and biogas are all renewable energy resources. But what makes biogas distinct from other renewable energies is its importance in controlling and collecting organic waste material and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations or requires advanced technology for producing energy, nor is it complex or monopolistic.

He has also outlined the economic, and social benefits of biogas production.

The economic benefits were as follows:

- Treatment of solid waste without long-term follow-up costs usually due to soil and water pollution. Increased local distribution of fertilizer, chemical herbicides, and pesticide demand.
- Generation of income through compost and energy sales (biogas/electricity/heat) to the public grid .
- Improved soil/agriculture productivity through long-term effects on soil structure and fertility through compost use .
- Reduction of landfill space and consequently land costs.

Tjong Won Kang et al (2010) studied the On-site Removal of H₂S from Biogas Produced by Food Waste using an Aerobic Sludge Bio-filter for Steam Reforming Processing. They show that abio-filter containing immobilized aerobic sludge was successfully adapted for the removal of H₂S and CO₂ from the biogas produced using food waste to produce economic benefits.

The social and health effects associated with biogas include:

- Creation of employment in biogas sector
- Improvement of the general condition of farmers due to the local availability of soil improving fertilizer
- Decreased smell and scavenger rodents and birds

2.1 SUMMARY OF THE LITERATURE REVIEW:

A set of literature reviews were referred and a valid course of action was determined and used in the current research work. The arrived conclusions are:

- Biogas will be the best alternative for Liquified Petroleum Gases
- Since it is a renewable resource it is eco-friendly.
- The source for the biogas is easily available.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

- Bio gas production through kitchen waste with and without catalyst.
- Check for the components of the gases using FTIR and gas chromatography.
- The comparative study is done between the resultant biogas for the gas components.
- Check the ignition of the gas produced from the experiment.
- Comparing the resultant gases with Liquified Petroleum Gas.

3.2 SCOPE

There is a vast scope to convert these energy sources into the biogas. Biogas production is a clean low carbon technology for efficient management and conversion of fermentable organic wastes into clean, cheap and versatile fuel and bio/ organic manure.

CHAPTER 4

MATERIALS AND METHODS

The process for the experimental method are as follows

- Bio waste collection
- Anaerobic digester
- Gas handling

4.1 BIO WASTE COLLECTION

For our project we have collected bio waste or kitchen waste from market. Vegetable waste and poultry waste are mixed together for the bio waste collection. Different containers of volumes 5 L to collect the wet waste, stale cooked food, waste milk products. The vegetables refuse like peels, rotten potatoes coriander leaves collected in bags. This waste is crushed by blender and slurry was prepared mixing with water.

This slurry and water is mixed for 1:15 ratio so that the methanogenesis takes place with the help of active microorganisms.

4.2 ANAEROBIC DIGESTION

It is also referred to as biomethanization, is a natural process that takes place in absence of air (oxygen). It involves biochemical decomposition of complex organic material by various biochemical processes with release of energy rich biogas and production of nutritious effluents.

The principle in the anaerobic digester

- Hydrolysis
- Acidification
- Acetogenesis
- Methanogenesis

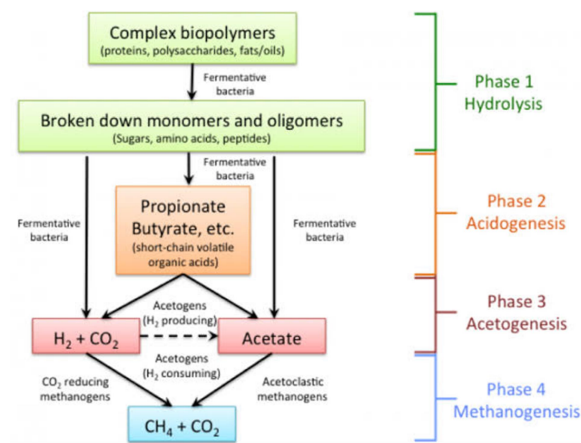


Fig 4.1. Schematic representation of anaerobic digestion

4.2.1 HYDROLYSIS:

In the first step the organic matter is enzymolysed externally by extracellular enzymes, cellulase, amylase, protease & lipase, of microorganisms. Bacteria decompose long chains of complex carbohydrates, proteins, & lipids into small

chains. For example, Polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids.

4.2.2 ACIDIFICATION:

Acid-producing bacteria, involved this step, convert the intermediates of fermenting bacteria into acetic acid, hydrogen and carbon dioxide. These bacteria are anaerobic and can grow under acidic conditions. To produce acetic acid, they need oxygen and carbon. For this, they use dissolved O_2 or bounded-oxygen. Hereby, the acid-producing bacteria creates anaerobic condition which is essential for the methane producing microorganisms. Also, they reduce the compounds with low molecular weights into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical point, this process is partially endergonic (i.e. only possible with energy input), since bacteria alone are not capable of sustaining that type of reaction.

4.2.3 ACETOGENESIS

Acetogenesis is the third step followed by the acidification which results in the formation of CO_2 and H_2 and is completed through the carbohydrate fermentation which can be utilized by the methogens to form methane.

4.2.4 METHANOGENESIS

(Methane formation) Methane-producing bacteria, which were involved in the third step, decompose compounds having low molecular weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, CH_4 producing microorganisms occur to the extent that anaerobic conditions are provided, e.g. under water (for example in marine sediments), and in marshes. They are basically anaerobic and very sensitive to environmental changes, if any occurs. The methanogenic bacteria belongs to the archaeobacter genes, i.e. to a group of bacteria with heterogeneous morphology and lot of common biochemical and molecular-biological properties that distinguishes them from other bacteria's. The main difference lies in the makeup of the bacteria's cell walls.

4.3 SYMBIOSIS OF BACTERIA:

Methane and acid-producing bacteria act in a symbiotical way. Acid producing bacteria create an atmosphere with ideal parameters for methane producing bacteria (anaerobic conditions, compounds with a low molecular weight). On the other hand, methane-producing microorganisms use the intermediates of the acid producing bacteria. Without consuming them, toxic conditions for the acid-producing microorganisms would develop. In real time fermentation processes the metabolic actions of various bacteria acts in a design. No single bacteria is able to produce fermentation products alone as it requires others too.

To create the anaerobic digester for our experiment

- we have put all slurry with mixed proportion sealed the collection barrel using sealant.
- To create an anaerobic setup we have buried the sealed collection barrel underground.
- For the gas collection a nonreturn valve is fixed so that the atmospheric gas will not mix with the biogas obtained.
- To avoid excess gas pressure in the digester a drain plug is fitted.
- Pressure gauge with regulator valve is installed to discharge side of the digester.
- Since we have to setup catalyst added anaerobic digester for comparison we have made another anaerobic set up with yeast and silica gel.

4.4 YEAST AND SILICA GEL AS CATALYST

Yeast has the characteristics of osmotic pressure resistance, acid resistance and high metabolic efficiency, which is widely used in the treatment of high-concentration organic wastewater, including the treatment of toxic and refractory pollutant-containing waste water (16). It has been proved that yeast can accelerate reaction rates in the hydrolysis stage of organic matter and promote the hydrolysis of Food waste (17). FW contains high enough levels of proteins, amino acids and trace elements from the hydrolysis and breakdown of food-stuffs, and can provide sufficient nutrition for the growth of yeast [18]. In the process of anaerobic digestion of food waste, yeast can convert the degradable organic matter of substrates into neutral ethanol instead of acid propionic acid or butyric acid (19, 20). Through the addition of yeast to the FW substrate for ethanol pre-fermentation before AD, a large amount of ethanol is produced, and ethanol is gradually converted into acetic acid, which in turn can be easily used by methanogens, thereby increasing methane production, reducing the effect of acidification on the system and enhancing the stability of Anaerobic digester (21,22).



Fig 4.2. Addition of yeast

On the other hand we have also used silica gel as catalyst. Silica gel was also used as a catalyst to increase the gas production [23]. Silica gel was chosen as a catalyst because of its cheapness and availability. According to a previous study [24], silica gel acts as a good catalyst for biogas production because the catalytic and absorbing effects of silica gel are used for the removal of undesired gases such as CO_2 .

Since brewer's yeast would make the water content more while the production of gas, we have also opted for the second catalyst silica gel that cuts down the water content and makes the gas production faster.



Fig 4.3. Addition of silica gel

In our research, we have made an attempt of two experiments biogas production without any catalyst and biogas production with yeast and silica gel as catalyst and we are ahead to compare results.

4.5 GAS HANDLING

- For the gas to be collected from the digester, through the nonreturn valve the gas is collected to a LPG cylinder.
- The same is made for all the anaerobic digestors with catalysts to collect the gas obtained.

4.6 MATERIALS

The following are the materials used for the experimental set up and are fabricated.

4.6.1 FABRICATION

Cutting is the separation or opening of a physical object, into two or more portions, through the application of an acutely directed force.

Cutting is a compressive and shearing phenomenon, and occurs only when the total stress generated by the cutting implement exceeds the ultimate strength of the material of the object being cut.

Implements commonly used for cutting are the knife and saw, or in medicine and science the scalpel and microtome. However, any sufficiently sharp object is capable of cutting if it has a hardness sufficiently larger than the object being cut, and if it is applied with sufficient force. Even liquids can be used to cut things when applied with sufficient force (see water jet cutter). Cutting has been at the core of manufacturing throughout history. For metals many methods are used and can be grouped by the physical phenomenon used.

Chip forming – sawing, drilling, milling, turning etc. Shearing – punching, stamping, scissoring Abrading – grinding, lapping, polishing, water-jet Heat – flame cutting, plasma cutting, laser cutting

Electrochemical – etching, electrical discharge machining (EDM)

Every method has its limitations in accuracy, cost, and effect on the material. For example, heat may damage the quality of heat-treated alloys, and laser cutting is less suitable for highly reflective materials such as aluminum. Laser cutting sheet metal produces flat parts and etches and engraves parts from complex or simple designs. It is used over other cutting options for its quick process and customizabilities.

In our project we initially started the fabrication with the cutting process.

The digester is cut open in the top with hacksaw in order to fit in the gas holder (i.e) the barrel.

The digester is made of barrel with capacity of 200litre, it is also cut open at the top.



Fig.4.4 Cutting

4.6.2 DRILLING

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips (swarf) from the hole as it is drilled.

In rock drilling, the hole is usually not made through a circular cutting motion, though the bit is usually rotated. Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements. The hammering action can be performed from outside the hole (top-hammer drill) or within the hole (down-the-hole drill, DTH). Drills used for horizontal drilling are called drifter drills.

In rare cases, specially-shaped bits are used to cut holes of non-circular cross-section; a square cross-section is possible

Drilled holes are characterized by their sharp edge on the entrance side and the presence of burrs on the exit side (unless they have been removed). Also, the inside of the hole usually has helical feed marks.

Drilling may affect the mechanical properties of the workpiece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the workpiece to become more susceptible to corrosion and crack propagation at the stressed surface. A finish operation may be done to avoid these deterioration conditions.

For fluted drill bits, any chips are removed via the flutes. Chips may form long spirals or small flakes, depending on the material, and process parameters. The type

of chips formed can be an indicator of the machinability of the material, with long chips suggesting good material machinability.

When possible drilled holes should be located perpendicular to the workpiece surface. This minimizes the drill bit's tendency to "walk", that is, to be deflected from the intended centre line of the bore, causing the hole to be misplaced. The higher the length-to-diameter ratio of the drill bit, the greater the tendency to walk. The tendency to walk is also prompted in various other ways, which include:

Establishing a centering mark or feature before drilling, such as by:

- Casting, molding, or forging a mark into the workpiece
- Centerpunching
- Spot drilling (i.e., centre drilling)

Spot facing, which is machining a certain area on a casting or forging to establish an accurately located face on an otherwise rough surface.

Constraining the position of the drill bit using a drill jig with drill bushings

Surface finish produced by drilling may range from 32 to 500 microinches. Finish cuts will generate surfaces near 32 microinches, and roughing will be near 500 microinches.

Cutting fluid is commonly used to cool the drill bit, increase tool life, increase speeds and feeds, increase the surface finish, and aid in ejecting chips. Application of these fluids is usually done by flooding the workpiece with coolant and lubricant or by applying a spray mist.

In deciding which drill to use it is important to consider the task at hand and evaluate which drill would best accomplish the task. There are a variety of drill styles that each serve a different purpose. The sub-land drill is capable of drilling more than one diameter. The spade drill is used to drill larger hole sizes. The indexable drill is useful in managing chips.

In our digester tank we drilled the holes in different types in order to fit different dimensioned pipes, etc.

It is done with heating the cylindrical shaped metal and by applying force on the tank due to sharp heated edge the hole is cut for the required dimension.

One hole is provided for the inlet of the feed stock and the other for its outlet.



Fig. 4.5 Drilling

4.6.3 FITTING

A fitting is used in pipe systems to connect the straight pipe or tubing sections, adapt to different sizes or shapes and for other purposes, such as regulating (or measuring) fluid flow. "Plumbing" is generally used to describe the conveyance of water, gas, or liquid waste in domestic or commercial environments; "piping" is often used to describe the high-performance (high-pressure, high-flow, high-temperature or hazardous- material) conveyance of fluids in specialized applications. "Tubing" is sometimes used for lighter-weight piping, especially that flexible enough to be supplied in coiled form.

Fittings (especially uncommon types) require money, time, materials and tools to install, and are an important part of piping and plumbing systems. Valves are technically fittings, but are usually discussed separately.

The material with which a pipe is manufactured is often the basis for choosing a pipe. Materials used for manufacturing pipes include:

Carbon (CS) and galvanized steel Impact-tested carbon steel (ITCS) Low-temperature carbon steel (LTCS) Stainless steel (SS) Malleable iron

The bodies of fittings for pipe and tubing are most often the same base material as the pipe or tubing connected: copper, steel, PVC, chlorinated-polyvinyl chloride (CPVC) or ABS.

Any material permitted by the plumbing, health, or building code (as applicable) may be used, but it must be compatible with the other materials in the system, the fluids being transported and the temperature and pressure inside (and outside) the system. Brass or bronze fittings are common in copper piping and plumbing systems. Fire hazards, earthquake resistance and other factors also influence the choice of fitting materials.



Fig.4.6 Fitting

The following are the materials used for our experiment.

- Barrel

A barrel or cask is a hollow cylindrical container with a bulging centre, longer than it is wide. They are traditionally made of wooden staves and bound by wooden or metal hoops. Barrels have a convex shape and bulge at their centre, called bilge. This facilitates rolling a well-built wooden barrel on its side and allows the roller to change directions with little friction, compared to a cylinder. It also helps to distribute stress evenly in the material by making the container more curved. Barrels have reinforced edges to enable safe displacement by rolling them at an angle (in addition to rolling on their sides as described).



Fig. 4.7 Barrel

- PVC pipe

PVC pipes are made from a special plastic, chemically known as Chlorinated Polyvinyl Chloride, commonly known as CPVC. PPR Pipes and Fittings - Vectus PPR pipes and fittings are manufactured using Polypropylene Random Copolymer (PP-RC), which is the most reliable polymer in the piping system industry.

The most common gas piping is black steel. Galvanized steel, copper, brass or CSST (Corrugated Stainless Steel Tubing) also can be used in some areas, but some utilities specifically prohibit the use of copper. In other areas, the use of copper is widespread. Black pipes are also called steel pipes and are used to carry water and gas from their sources to the end users. It is the pipe that is used by businesses and homes to convey their supply of natural or propane gas. It is also used for fire sprinkler systems because of its strong resistance to heat.



Fig. 4.8 PVC pipe

- Pressure gauge

Pressure gauges are instruments designed to measure the pressure of media in a system. Measuring the pressure in our system is a critical quality step to ensure consistency of a product and safety check to be aware of leaks or building pressure in a system. The correct pressure gauge can be determined based on selection criteria, to accurately measure the pressure within the system. Pressure represents the amount of force applied perpendicular to a surface per unit area. In a stagnant liquid or gas, this is the amount of force applied to the wall of the container at a given point.

Static pressure is uniform in all directions. However, a moving fluid applies additional pressure in the direction of the flow while having negligible impact on the surfaces parallel to the flow direction. This additional pressure is called dynamic pressure. The total pressure of a flow (also called stagnation pressure) is the sum of static and dynamic pressure in that flow.

Bourdon tube gauges come in a variety of designs and specialties to serve a diverse range of applications. The pressure range of bourdon tube gauges varies from 0 to 0.6 bar to 0 to 1600 bar with an accuracy class of typically between 0.1 and 4.0.



Fig. 4.9 Pressure guage

- TEE Joint

A tee, the most common pipe fitting, is used to combine (or divide) fluid flow. It is available with female thread sockets, solvent-weld sockets or opposed solvent-weld sockets and a female-threaded side outlet. Tees can connect pipes of different diameters or change the direction of a pipe run, or both. Available in a variety of materials, sizes and finishes, they may also be used to transport two-fluid mixtures. Tees may be equal or unequal in size of their three connections, with equal tees the most common.



Fig 4.10 TEE joint

- End cap

Caps, usually liquid- or gas-tight, cover the otherwise open end of a pipe. A cap attaches to the exterior of a pipe, and may have a solvent-weld socket end or a female-threaded interior. The exterior of an industrial cap may be round, square,

rectangular, U- or I-shaped, or may have a handgrip. If a solvent-weld cap is used to provide for a future connection point, several inches of pipe must be left before the cap; when the cap is cut off for the future connection, enough pipe must remain to allow a new fitting to be glued onto it.



Fig. 4.11 End cap

- Elbow joint

An elbow is installed between two lengths of pipe (or tubing) to allow a change of direction, usually a 90° or 45° angle; 22.5° elbows are also available. The ends may be machined for butt welding, threaded (usually female), or socketed. When the ends differ in size, it is known as a reducing (or reducer) elbow.

A 90° elbow, also known as a "90 bend", "90 ell" or "quarter bend", attaches readily to plastic, copper, cast iron, steel, and lead, and is attached to rubber with stainless-steel clamps. Other available materials include silicone, rubber compounds, galvanized steel, and nylon. It is primarily used to connect hoses to valves, water pumps and deck drains. A 45° elbow, also known as a "45 bend" or "45 ell", is commonly used in water-supply facilities, food, chemical and electronic industrial pipeline networks, air-conditioning pipelines, agriculture and garden production, and solar-energy facility piping.

Elbows are also categorized by length. The radius of curvature of a long-radius (LR) elbow is 1.5 times the pipe diameter, but a short-radius (SR) elbow has a radius equal to the pipe diameter. Short elbows, widely available, are typically used in pressurized systems, and in physically tight locations.

Long elbows are used in low-pressure gravity-fed systems and other applications where low turbulence and minimum deposition of entrained solids are of concern. They are available in acrylonitrile butadiene styrene (ABS plastic), polyvinyl chloride (PVC), chlorinated polyvinylchloride (CPVC), and copper, and are used in DWV systems, sewage, and central vacuum systems.



Fig. 4.12 Elbow joint

- Ball valve

A ball valve is a shut off valve that controls the flow of a liquid or gas by means of a rotary ball having a bore. By rotating the ball a quarter turn (90 degrees) around its axis, the medium can flow through or is blocked. They are characterized by a long service life and provide a reliable sealing over the life span, even when the valve is not in use for a long time. Ball valves are also used as a control valve. This application is less common due to the relatively limited accuracy of controlling the flow rate in comparison with other types of control valves. To understand the working principle of a ball valve, it is important to know the 5 main ball valve parts and 2 different operation types. The valve stem (1) is connected to the ball (4) and is either manually operated or automatically operated (electrically or pneumatically). The ball is supported and sealed by the ball valve seat (5) and there are o-rings (2) around the valve stem. All are inside the valve housing (3). The ball has a bore through it, as seen in the sectional view in Figure 1. When the valve stem is turned a quarter-turn the bore is either open to the flow allowing media to flow through or closed to prevent media flow.

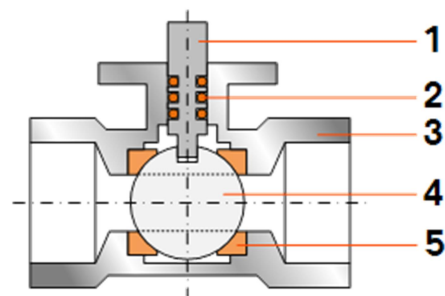


Fig. 4.13 Ball valve

- Epoxy resin

Epoxy resin is known for its strong adhesive qualities, making it a versatile product in many industries. It offers resistance to heat and chemical applications, making it an ideal product for anyone needing a strong hold under pressure. **Epoxy**

resin is also a durable product which can be used with various materials, including: wood, fabric, glass, china or metal. It's important to note, however; epoxy resin is not considered to be water resistant. Repeated moist or wet conditions can cause deterioration over time which will affect durability. The strong-properties of the epoxy allow for structural and engineering adhesives. Commonly, epoxy resin is used in the construction of vehicles, snowboards, aircrafts and bicycles. But epoxy adhesives aren't limited to only structural applications.



Fig. 4.14 Epoxy resin

- Discharge hose

Hoses are also sometimes called pipes (the word pipe usually refers to a rigid tube, whereas a hose is usually a flexible one), or more generally tubing. The shape of a hose is usually cylindrical (having a circular cross section). Hose design is based on a combination of application and performance. Common factors are size, pressure rating, weight, length, straight hose or coilhose, and chemical compatibility. Applications mostly use nylon, polyurethane, polyethylene, PVC, or synthetic or natural rubbers, based on the environment and pressure rating needed. In recent years, hoses can also be manufactured from special grades of polyethylene (LDPE and especially LLDPE). Other hose materials include PTFE (Teflon), stainless steel, and other metals.

Dredge rubber hoses have a long story, which features high strength and flexibility. A flexible dredging hose widely used in dredgers to convey silt or gravel. It is resistant to abrasion and wear to ensure long service life. Types of flexible dredge hose include the floating rubber hose, discharge hose, suction hose, armored hose and ceramic hose. To achieve a better pressure resistance, hoses can be reinforced with fibers or a steel cord. Commonly used reinforcement methods are braiding, spiraling, knitting and wrapping of fabric plies. The reinforcement increases the pressure resistance but also the stiffness. To obtain flexibility, corrugations or bellows are used. Usually, circumferential or helical reinforcement rings are applied to maintain these corrugated or bellowed structures under internal pressure.



Fig. 4.15 Discharge hose

CHAPTER 5

Table 5.1 COST ESTIMATION

S.NO	MATERIALS	AMOUNT
1	PVC pipe (3 inch)	620
2	PVC pipe (1 inch)	260
3	Tee joint	70
4	Elbow joint (1 inch)	35
5	Female adapter	70
6	End cap	140
7	Male adapter	56
8	Ball valve	430
9	M-seal	160
10	Epoxy resin	30
11	Discharge hose	450
12	Compact cylinder	950
13	Barrel	1700
14	Elbow joint (1.5 inch)	70
15	Nipple	45
16	Yeast	30

17	Silica gel	160
18	Miscellaneous cost	700
19	Pressure gauge	230
20	Fabrication cost	300

FINAL COST = 6506

CHAPTER 6

CHARACTERISATION

The resultant gas formed is characterised at Fourier Transform InfraRed (FTIR) spectroscopy and Gas chromatography (GC).

6.1 Fourier Transform InfraRed (FTIR) spectroscopy:

For the sample without catalyst, FTIR characterisation is taken. The broad wide rounded band with frequency (3218.6/cm) RO–H indicates the presence of alcohol. The band (2890.3/cm) implies the presence of the major functional group SP³, C–H band. (C=C) alkenyl stretch is shown at frequency of broadband (1659.1/cm). The broadband frequency of (1401/cm) reveals the presence of methylene C=H bending vibration which implies that the substrate is a potential source of methane.

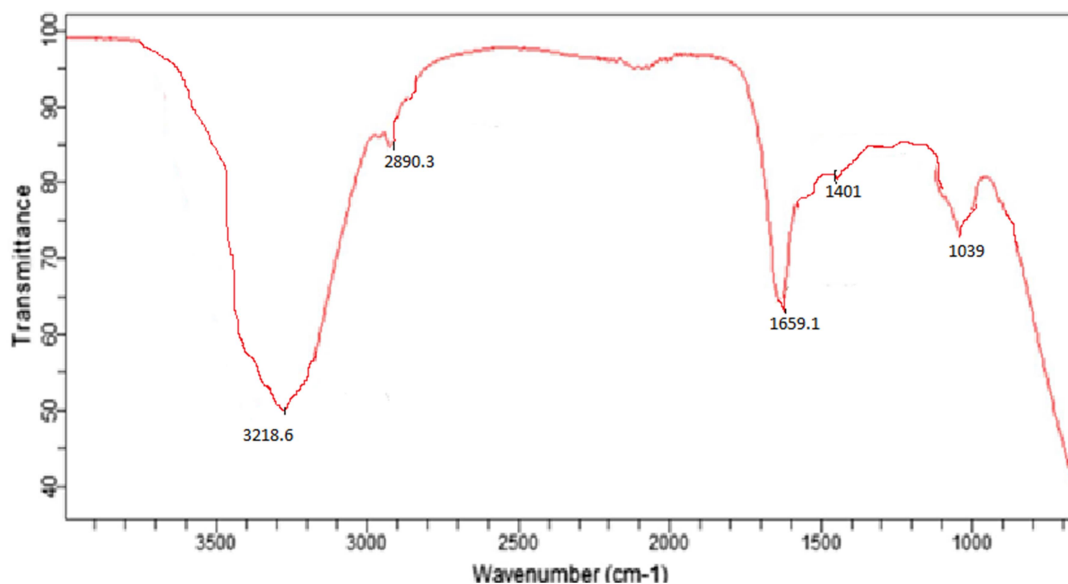


Fig. 6.1 FTIR for biogas without catalyst

For the sample with catalyst, FTIR characterisation is taken. The broad wide rounded band with frequency (3390.4/cm) RO–H indicates the presence of alcohol.

The band (2851/cm) implies the presence of the major functional group SP³, C–H band. (C=C) alkenyl stretch is shown at frequency of broadband (1639.7/cm). The broadband frequency of (1460.3/cm) reveals the presence of methylene C=H bending vibration which implies that the substrate is a potential source of methane.

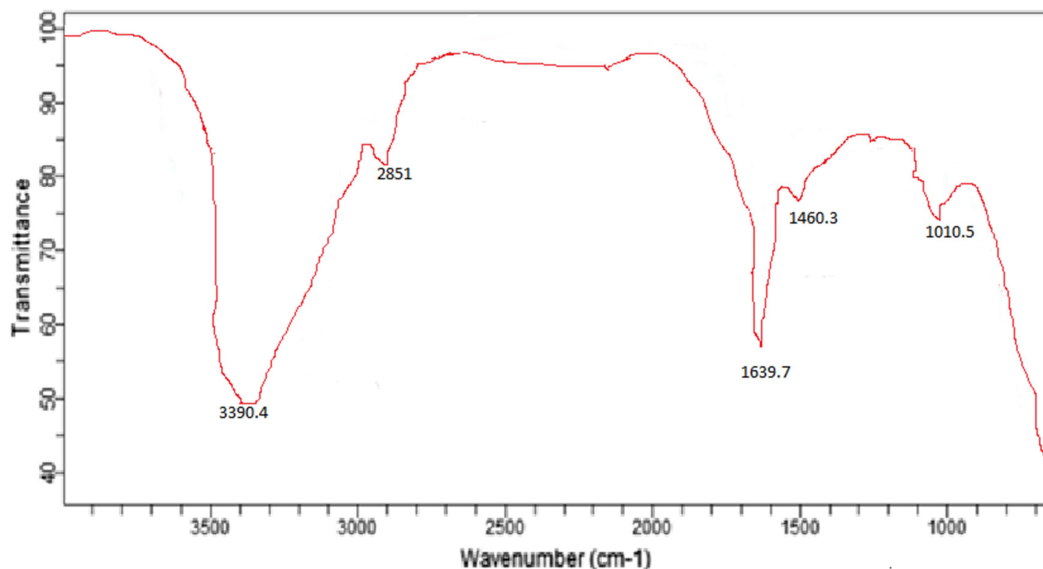


Fig. 6.2 FTIR of biogas sample with catalyst

On comparing our results with the FTIR Spectra of poultry dropping Evaluation of biogas production from co-digestion of pig dung, water hyacinth and poultry droppings by [Wdse Zjup](#), [Akindele Oyetunde Okewale](#), [Olusola Adesina](#), the broad wide rounded band with frequency (3291.2/cm) RO–H indicates the presence of alcohol. The broadband (2851.4–2922.2/cm) implies the presence of the major functional group SP³, C–H band. (C=C) alkenyl stretch is shown at frequency of broadband (1636.3/cm). The broadband frequency of 1461.1/cm reveals the presence of methylene C=H bending vibration which implies that the substrate is a potential source of methane.(25)

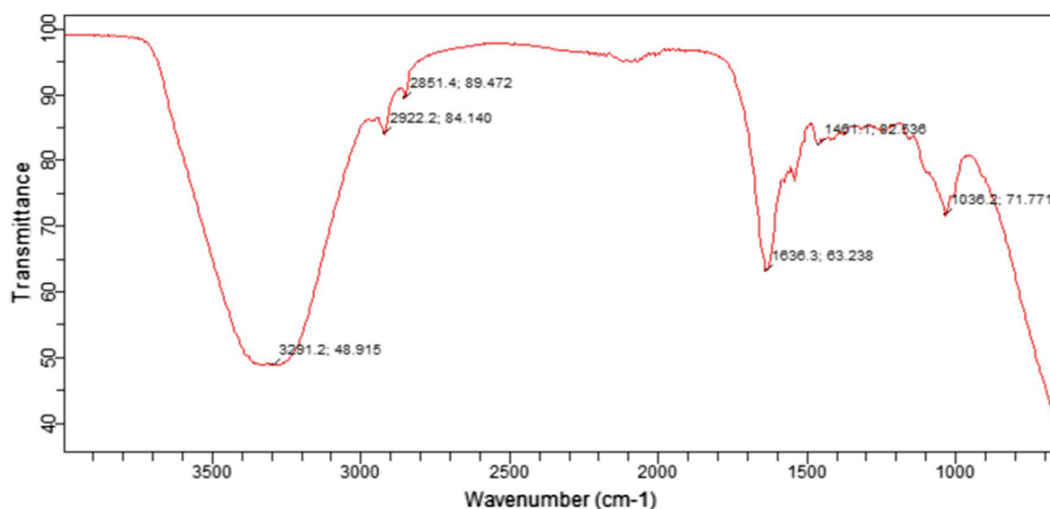


Fig. 6.3 FTIR spectroscopy of poultry dropping evaluation of biogas production from co-digestion of pigdung, water hyacinth and poultry droppings

We could see our results overlapping with the results of biogas production with the co digestion of pig dung, water hyacinth and poultry droppings in FTIR. Thus we prove to have the required biogas contents through FTIR.

6.2 Gas chromatography

Table 6.1 Analysis of biogas generated in digester C3

ELEMENTS	GAS COMPONENTS WITHOUT CATALYST (wt%)	GAS COMPONENTS WITH CATALYST (wt%)
Methane (CH ₄)	56.13	64.33
Carbon di oxide (CO ₂)	22.44	21.59
Ammonia (NH ₃)	2.00	1.59
Hydrogen sulphide (H ₂ S)	2.98	1.99
Oxygen (O ₂)	0.98	1.3
Nitrogen (N ₂)	6.98	5.00
Water (H ₂ O)	7.94	3.98

CHAPTER 7

RESULT AND DISCUSSION

From the experiment conducted, we have derived a timeline tabulation which shows the experiment conducted days and the yield.

Table 7.1 TIMELINE TABULATION

No. of days	Biogas obtained without catalyst per kg	Biogas obtained with catalyst per kg
1	4.5	6
2	4	5.8
3	3.9	5.8
4	4.4	6.1

From timeline tabulation we could see that we have the yield of about 16.8kg of biogas from the without catalyst experiment and 23.7kg of biogas from with catalyst experiment. About 6.9 kgs ahead of the without catalyst experiment.

The following is the graphical representation of the timeline tabulation.

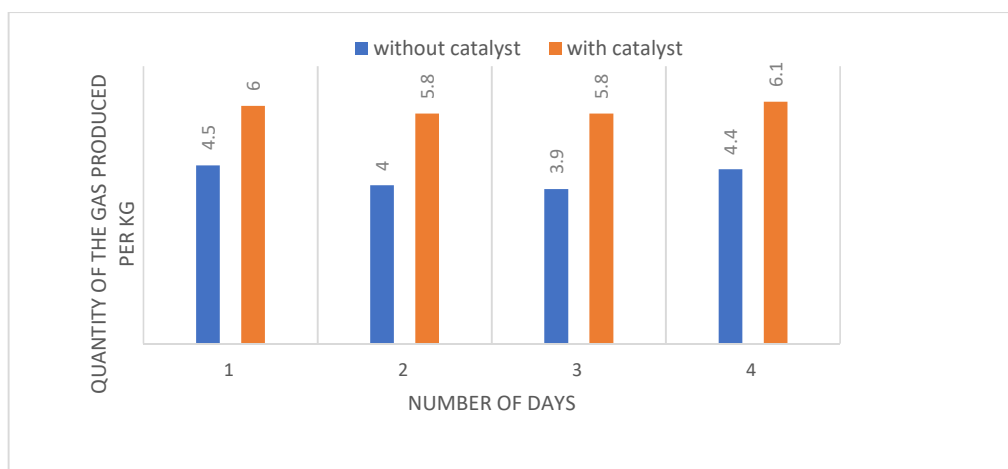


Fig. 7.1 GRAPHICAL REPRESENTATION OF TIMELINE TABULATION

From the FTIR spectrum, we can able to find all the contents in our specifically observed in resultant biogas. And from the gas chromatography we could

see the production of the methane is higher when comparing yeast/ silica gel biogas sample to the without catalyst sample.

The production methane is 64.33% in with catalyst sample and 54.13% in without catalyst sample showing 8.2 % greater production than the without catalyst sample. Likewise we could find water content showing greater difference .7.94 % in with catalyst and only 3.98% in with catalyst showing nearly 3.96% serious difference.

The below graph shows the comparative study of all components in with and without catalyst samples generated from the gas chromatography.

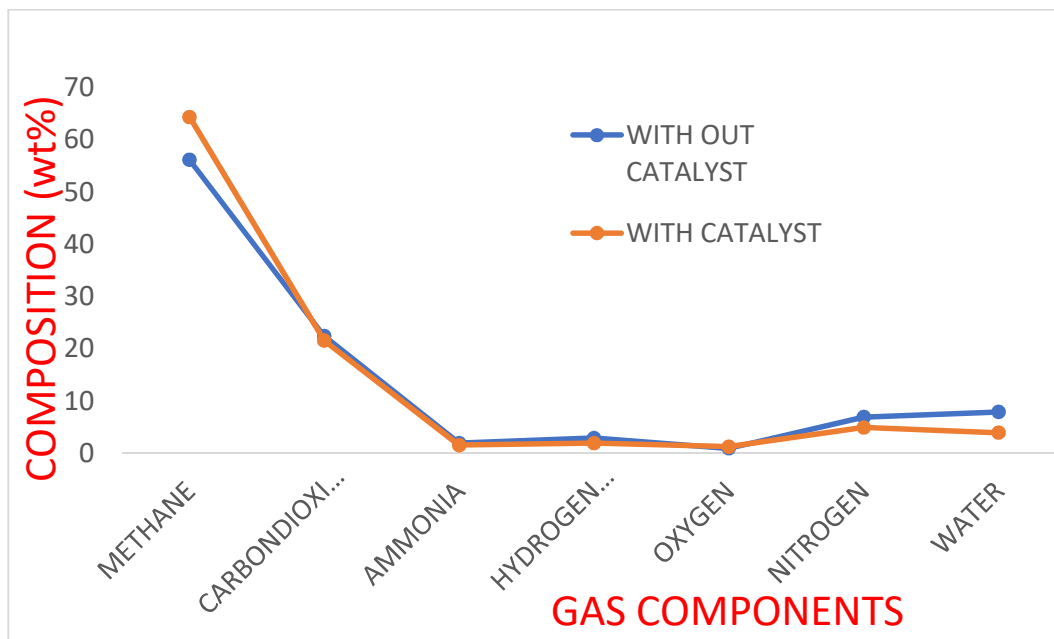


Fig. 7.2 COMPARITIVE STUDY OF COMPONENTS WITH AND WITHOUT CATLYST SAMPLES

Therefore from the above results, we can conclude,

Per day gas production without catalyst

Gas produced per day =4.2kg

Gas produced per year=4.2*365=1553kg

1 cylinder capacity (Lpg)=18kg

85 cylinders in a year.

Likewise for the experiment with catalysts yeast and silica gel,

Gas produced per day = 5.9kg

Gas produced per year= 5.9*365= 2153.5kg

1 cylinder capacity (Lpg)=18kg

119 cylinders in a year.

Nearly 34 cylinders extra production can be done with the effect of catalyst experiment. And this would be more helpful for the alternative source for the LPG.

CHAPTER 8

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