Design and Development of Multipurpose Smart Biogas Energizer for Generating Electricity

[1]Vinay kumar S B
Assistant professor,Dept of ECE,School of Engineering & Technology,Jain University,Bangalore-562112,India

[2]Harish S
Software Engineer, Infosys, Bangalore, India

[3]Prasanna Kumar C
Associate Professor, Dept of ECE, Sahyadri College of Engineering &Management,Mangalore-55007,India

[4]Monica B V
B.Tech 7th semester in ECE, School of engineering and Technology, Jain University,Bangalore-562112,India

[5]Sachin B M
Assistant professor, Dept of ECE, Bangalore Institute of Technology, Bangalore, India

[6]Ravi U S
Faculty, J V Global Services LLP, Bangalore, India

***Abstract*—As we know that there is a huge growth in the demand for electricity, we have to look into all possible ways of generating electricity mainly renewable sources. It is known fact that methane gas is a major product of the anaerobic digestion. The fermentation caused by this silk worm waste produces the combustion gas. It is used to generate electricity where in rural India especially where the silk warm horticulture exists, usually lots of these anaerobic wastes are used for fertilizers, instead we can use for generating electricity in bio digester as an inlet product. Because of its high combustible nature .In this paper we are trying to present an effective approach to the techniques of calculating the quantity of electricity that can be generated from the waste of silkworm and also process involved in purification. The collective analysis of the acquired data from the sericulture department the analysis of obtainable biomass waste in tones per day from the case study and the biogas accruable of total capacity of running a 60 watts biogas generator, even if the load is in sufficient to produce the electricity requirement it may also use for cooking purpose in rural areas so the Eco balance and deforestation is limited to certain extent. In our paper the monitoring of biogas generation and its further process is controlled through valves and sensors usage in determining the system automation is discussed.**

Keywords— ***Biomass, Renewable Energy, Multipurpose, Controller, Digester.***

I. INTRODUCTION

The conventional sources of fuels which we are using as energy sources are depleting day to day. The consumption of these sources leads to not only pollution but also extinct of non-renewable sources and these fact leading to concentrate on renewable sources so it is nontoxic and also it must be easily cope with present situation. Generally renewable resources are obtained from natural resources which include solar, wind, biogas from biomass [1], which are easily available and also non pollutants. As the population increases the demand of non-conventional resources are increasing so that we need to serve the demand as per requirement and also for future we need to think the use on conventional sources.

In these constraints the biogas usage is cheapest and also most useful for household appliance and also production of electricity, many countries are utilizing the biogas production which not only used for electricity and also solid waste management, in India also if we manage to segregate the biomass usage, the energy factor of resources is developed. The cultivation of biomass presently over million small scale biogas plants serves the rural part of our country.

The feedstock accessibility in India from rural villages basically they use the cattle stock like cow dung which is not only used as fertilizers but also as energy source. The stock available for energy is stored in digester for fermentation and with definite mechanism the electricity is produced. These facility is not only used in rural part but also in urban city's now people are meant to think of renewable sources, by these new process of development is raised they took kitchen waste, cattle waste all of materials which are abundantly available, likewise the silk worm waste is the another manure used as a biomass in the silk worm harvesting. This waste is eco-friendly and also the production of biogas is high.

As the technology developed the methodology in determining the work and its methods of operating things are also changing ,now people needs everything to be monitored and decision taking performance should be automatic and must consume less power these are the present demands which also consider here most of the digester are manually controlled some are automatic , In India the council of renewable energy and technologies are implementing and supporting to cultivate these biogas plant across the country, not only by government but also many organization are developing these concepts.

The biogas basically contains the methane which is a biogas, but as per it concern the digester produces the gas with constituents of other gases like sodium oxide, Sulphur, hydrogen, nitrogen, carbon dioxide etc. in that they have to produce pure methane which is quite effective, and it must be done in order to work engine properly else its performance in working is caused due to these inert gases. The main objective of this paper to study the rate of biogas production in biogas digester of concrete made plant which we are using a poultry

waste as a source of energy production with various ratios of poultry waste and their composition ratio's under various temperature over a period of detrained also analysis of maximum production of biogas production from poultry waste with the other source and comparison of it in order to use to production of electricity and also for cooking purpose and also the methodology in monitoring the system in controlling of valves and data transfer in order of measurement in the production of biogas in biomass plant with a communication technology.

II. System Architecture

Many parameters like temperature, humidity, and constituents of mixture of waste manure are involved in determining the production of biogas, as the above mentioned all this parameter also resembles the fermentation process to go smoothly, here in the internal process in digester is measured in daily basis these data tells the production of gas building in digester. In the inlet valves are controlled by sensor in order to determining the digester is full and once the digester gas is produced the outlet valves open and stores in a storage tank ,

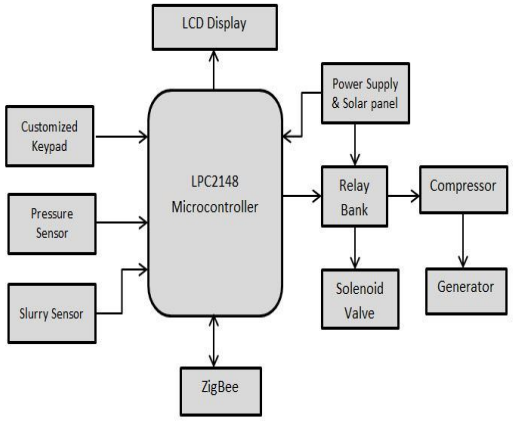

Fig. 1. Block diagram of Controller System to a proposed system for Biogas Energizer

these tank is filled with mixed amount impure methane which is removed by scrubber and these pure methane is passed through compressor tank and then subjected to generator meanwhile the pressure is measured by the pressure sensor which is noted by controller which in turn triggers the generator to produce electricity. The pressure sensor also determines the pressure of gas while passing to either for cooking purpose or for electricity generation and respective valves is open accordingly and communication devices like ZigBee, GSM the information of biogas production in energy plant is passed to main station. All this process is evaluated and monitored by the micro controller based systems. And also the overall power to operate the system is utilizing the solar energy by solar panel and DC batteries.

The measurement of temperature variation in day is analyzed and observed in slurry in bio chamber the fermentation duration and under various ratios the deposition of waste. The production of methane at rate in the influence of different temperature ranges is observed in experimental setup done in Bangalore, India

A. *Arm Controllor*

The LPC2148 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU with Real-time emulation and embedded trace support that combines the microcontroller with embedded high speed flash memory ranging from 32 KB to 512 KB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

B. *ZigBee*

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE802 standard for personal area networks The DigiXbee 802.15.4 modules are the easiest to use, most reliable and cost-effective RF devices we've experienced. The802.15.4X bee modules provide two friendly modes of communication-a simple serial method of transmit/receive or a framed mode providing advanced features. These modules can communicate point to point, from one point to a PC, or in a mesh network

C. *Solar panel*

The solar panel is renewable source where the solar cells in panel is absorbed converted the solar energy into the electrical energy the cells contains the small silicon cells which are made of and the photo voltaic cells convert into light energy as the more intensity increases the generation of conductivity.

D. *Rechargeable Battery*

A boost converter (step-up converter) is a DC-to DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

E. *20X4 LCD*

LCD is an output device using this device we can display a character or a text through microcontroller. So the LCD is connected in the port pins of microcontroller. Those ports are initialized as output port. We are using a 4 line LCD display. In one line we can display 16 characters. So totally we have 32 characters display in our LCD.

F. *Solenoid Valves*

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid in the case of a two-port valve the flow is switched

on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design

G. Relay

The Relays are devices which allow low power circuits to switch a relatively high current/voltage ON/OFF.A relay circuit is typically a smaller switch or device which drives (opens/closes) an electric switch that is capable of carrying much larger current amounts.

H. Pressure Sensor

The pressure sensor MPX5010DP that operates the signal by detecting pressure in air as well vacuum and also it monitors the temperature in the digester which intake capacity of biogas passage through pipeline operates at range with 5 watt power and 5V supply with 5mA, with minimal sensitivity of sensitivity and accuracy of 85%with response time of 1ms, with full scale output and full scale span is measured.

III. DESIGN OF DIGESTER

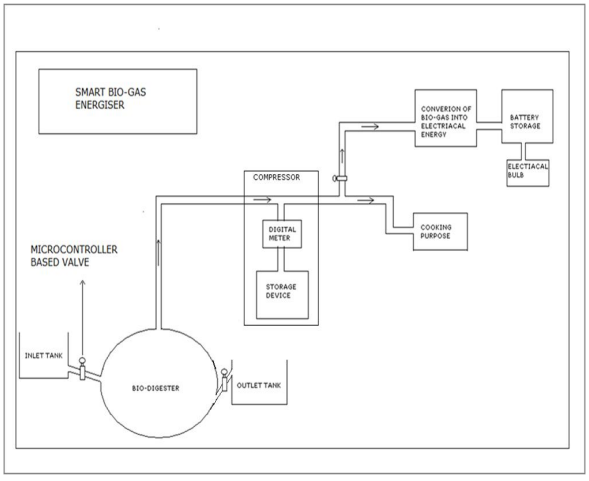

Fig. 2. Proposed System of a Smart Biogas Energizer

As shown in figure.2 the plug flow digester is a big narrow concrete tank with a top most sealed with a flexible and convenient way of capturing the biogas. The tank is heated by the source of internal insulated coil so the fermentation across the digester is meant to occur faster rate, and also it is built fully below the ground level to access the heating requirement, so that it is functioned in mesophyll range and it is most compactable and suited for cattle waste and poultry waste, the waste manure is mounted in the digester in a proportionate ratio's. the movement of waste in the inlet is allowed in the digester in there inlet valve and deposited in the digester tank where the inner mixer with constitute spread mix the ingredients for fermentation process these manure will be start producing the biogas in the 1 or 2 days in order to increase the fermentation process the artificial agents like yeast ,drum stick fibers, fermented curd etc. which are added so that the biogas is produced, and also the new waste are added, it displays the equal volume of outlet ,hence it is called plug flow in to the digester.

IV. FUNCTIONAL DISCRIPTION FLOW CHART

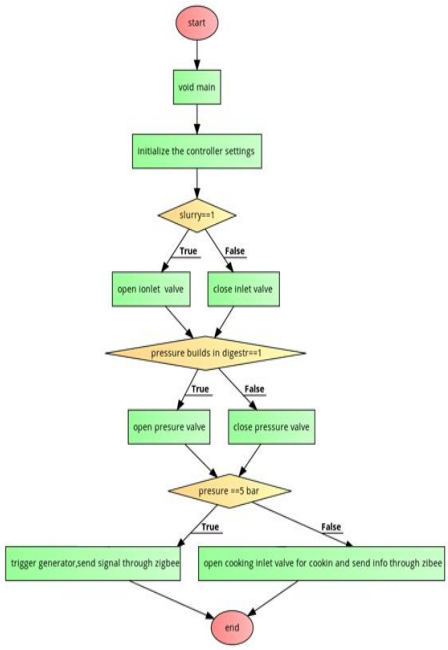

Fig. 3. Flow chart of operation involved in a proposed system

As soon the inlet open the controller sends the signal to serial communication channel devices of the solenoid valves it triggers by letting slurry to the digester the valves is open with the predefined values set by the timer in the controller system, if the storage tank is fill completely by the biogas then the outlet sensor detects and triggers the outlet valves and the pressure sensor will detect the pressure built in the storage tank and according to the predefined valve usually 5 bar pressure, greater than the atmospheric pressure if it exceeds the pressure then it connects to the compressor , the compressor thoroughly simplify the mechanism and connects to the generator terminal for the engine to get run once engine triggers then the electricity is transformed through lines of electric poles and also it may store the electric energy in chargers, if the pressure is to low and if it too high then it bifurcate from valves to cooking purpose connect valves is opened and it is utilized further. (As shown in Figure.3), All these every process is communicate through ZigBee from energy plant to base station. Since everything is monitored by controller. All the data is transferred as frames in the communication medium and also each process involved in

storing and transforming of biogas to various units is stored in memory for further evaluation.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

V. Results and Discussions

The results of the following analysis and description of various methods in generating the biogas is shown in tables and graphs the purification and scrubbing process in digester is shown n table 1,and composition of gas mixture while formed during fermentation is shown in table2.

In the overall observation in analysis done under biogas production in day to day the slurry of waste manure is added in different units at once and observed in production of biogas by factor of temperature and the intensity of light i.e. solar energy and atmospheric moisture and humidity in biogas plant and compared by varying the mixture of slurry. According to factor in an experimental research the poultry waste of definite amount is taken in different ratios and also an anaerobic bacteria called innocullum[1] along with mixture of yeast in the digested slurry which is responsible for production of biogas here various ratios of added mixture is shown in table.

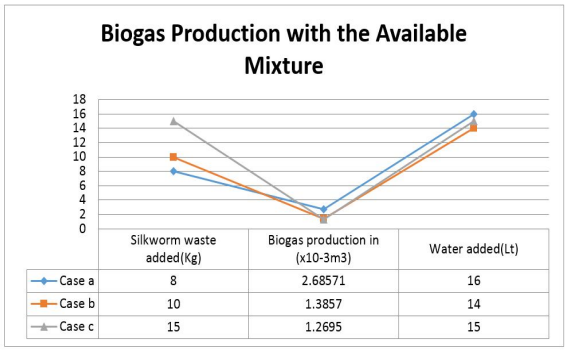

Fig. 4. Analysis of mixture added to the Manure

In these chart it explains the three cases which we deployed to various approach in generation of biogas, in these cases we can see the amount of amount of waste manure added with different quantities of water mixture added and available biogas in m3.Here case b is produced with the max production of biogas with the least ingredient compared to other cases.

In case a the volume of mixture added is proportional to the water added in the predefined ratios so that the production of biogas is varied accordingly as shown in figure. 6 and also by maintaining this ratio constant the availability as stock is used in predefined manner.

The extra added fermentation chemicals like inoculums is maintained constant because the overall mixture will be calibrated as more acidic or base's in nature which contributes the added mixture in proportionate to raw materials which added to digester for fermentation process. In figure .5 it shows the production of gas as well as the ph. values of the mixture produced after fermentation which could be justified the amount of gas production.

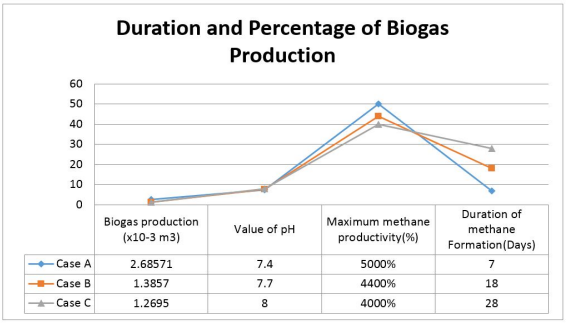

Fig. 5. Analyses of biogas production

In above graph it shows the overall days involved in production of biogas and also the amount of gas generated in the digester and also the chemical composition of the biogas is shown, where the case a generates the acceptable amount of biogas formation in least days and the overall percentage of half of the generation is involved, compared with case b with case a the efficiency and duration is varied but the production of gas is formed is durable as shown in table 1 that the phenomenon of the biogas production is more in the analysis that the materials and their composition evolved in production in various approaches as a result the 50% production of gas is produced in analysis of case A compared to other composition of mixtures, thus this production is passed to next stage of observation.

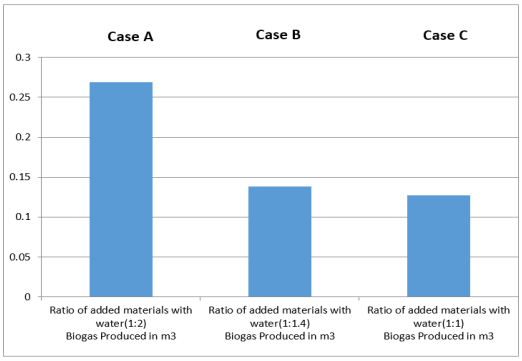

Fig . 6. Graph of production of biogas with pre-determined ratio

(* 6 liters of inocullum used as artificial Agent in all cases for fermentation process)

The above graph shows the ratio of ingredients and mixture of water added to the waste manure so the biogas is produced to its maximum level, so the production is fast to conduct the electricity. In these cases the case b production is faster with water along with chemical of inoculums with 1:2 ratio but other two cases the mixture produced is not diluted to form the sufficient amount of biogas, the process involved here is the proper amount of combining mixture is important in order to get the biogas as shown in table 1 the various ratio

amount of mixture and other chemical added and term of days in production of the biogas in large quantity is shown below.

By this factors of analysis the biogas production and formation of it is mentioned in table I. The next stage is the chemical composition of gas present while formation, this gases will also determines the combustible nature of biogas the gases present in that mixture is shown in table II, here it shows the percentage of gases and its amount present in it. So the graphical analysis if this mixture is analyzed and with various reactions and observation the amount of composition of mixtures like carbon dioxide, nitrogen, potassium, methane is been shown in graphs and in table II.

The overall process of purification of gas and its process is shown in figure.9 where the materials each stage of its nature involved is shown and the various purification process is listed.

TABLE I. LIST OF ANALYSIS IN A BIOGAS GENERATION

Parameters	Case a	Case b	Case c
Silkworm waste added	8kg	10kg	15kg
Water added	16 lt	14 lt	15 lt
Inoculum with yeast	6 lt	6 lt	6 lt
Ratio of added materials with water	1:2	1:1.4	1:1
Biogas production in ($x10^{-3}m3$)	2.68571	1.3857	1.2695
Value of pH	7.4	7.7	8
Maximum methane productivity	50%	44%	40%
Duration of methane fraction production in days	2-12	15-20	25-30

After treating biogas with iron sponge and activated carbon and passing to solutions of potassium sodium and calcium hydroxides the average upgraded methane formed with 70 to 80% of pure form in overall method about 5-7% of hydrogen sulphide 58-65ppm were removed this method is implemented in this paper.

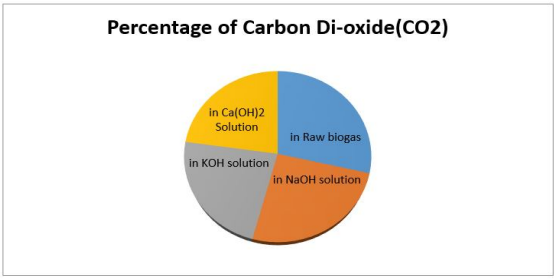

Fig. 7. Graph of composition of carbon dioxide in various scrubbing process.

In the above graph we can see that amount of carbon dioxide content in the mixture when it forms in digester and also the amount of passing into various chemicals the removal from the mixture is shown while over these chemicals while reactions combine to form oxides and water so the mixture of percentage available in biogas purification is shown.

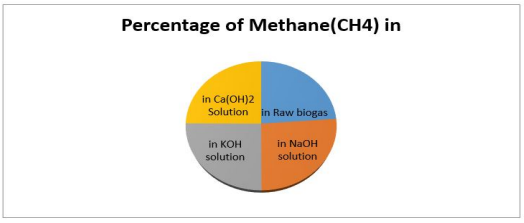

Fig. 8. Graph of methane composition in various scrubbing process

In these charts we can predict the available methane after purification process involved so that the scrubber process involves of series of chemical passage into the biogas flow. Here various constraints of available resources which contribute the biogas formation are shown and percentage of gas sustained in various processes is shown. Here in raw biogas the availability of biogas is less but after passing to various solutions the amount of gas generation is shown.

TABLE II. LIST OF PARAMETERS INVOLVED IN SCRUBBING PROCESS AND PRODUCTION OF PURE BIOGAS

Parameters	Normal raw biogas	NaOH solution	KOH solution	Ca(OH)2
CO_2 (%)	40.67	36.34	32.69	32.34
CH_4 (%)	59.06	64.86	62.45	61.89
H_2S(ppm)	100	38.64	37.42	57.73

A. Evaluation Factors

The power generated from the biogas plant can be calculated by means of this equation

$$P_{ge} = \frac{Qb.(LCV\ CH_4).(Cm).(n_{motor}).(n_{generator}).Fc}{ckw}$$

Where , P_{ge}=generated power (kW);

Qb =amount of biogas (m^3/h);

LCV CH_4-lower calorific value of methane ($kcal/m^3$);

Cm- percentage of methane in biogas (%);

nM –engine efficiency (%);

nG- generator efficiency (%);

Fc- correction factor (%);

Ckw- kcal conversion in kWh.

B. Experimental Setup

Different types of scrubbers were used for the up gradation of biogas, since the silkworm waste is used as input to the digester for production of biogas. Once the biogas of pure methane is formed it is send for further process, in actual production the many other mixture of gasses is formed in that major content is carbon dioxide and nitrous oxide, ammonium , and hydrogen sulphide in that hydrogen sulphide and scrubbers are installed when gas is passed through these it contains iron sponge and charcoal for removal of hydrogen sulphide and carbon dioxide respectively and later these gas is passed through various solution of sodium hydroxide(NaOH) calcium hydroxide are prepared and these meant for up gradation process[2].

C. Conversion of Electricity from Biogas

Basically biogas can be converted to electricity using a combustible fuels like diesel and kerosene etc. by means of combustible engines which converts mechanical energy into electrical energy. Many appropriate generators available according to usage and requirement, usually prefer which is maintained simpler it can be either 1-phase or 3-phase generators. But it needs skills in order to meet the challenges involved in design and manufacturing of these engines and also its efficiency matters.

D. Energy Generation from Slik Worm Waste

The collected silkworm waste is fed into anaerobic digester .the digester is built in to collect it for a certain period over the production of biogas. The biogas engine which turns spins the generator to create electricity as and when the silkworm waste can produce the enough electricity to glow up two 100 watt electric bulbs for 24 hours per day. And also if the production is sufficiently available it can be the extension for distribution to customers,[2] here in a plant if the farmers are ready to give the silkworm waste in per kg as a source the same by utilizing the manure in return we can generate electricity in a stored form and can be utilized further , the biogas in slurry is composed of 1.8-2.4%nitrogen,1-1.2% phosphorus, 0.6-0.8% potassium and 50-75% organic humus,60-70% methane and 30-35% carbon dioxide.

As per survey about one cubic meter of gas may be generated from one pound of silkworm waste at around normal temperature of 28^0C. Is enough to cook a day meals for 4-6 people in rural India about 1.6 cubic meters of biogas is equal one litter of gasoline. since Gas engines requires about 0.6 of methane per horse power per hour some attentive responsibility must be taken with lubrication of engines because it is dry in nature of the fuel else simpler conversion will occur and performance is caused.

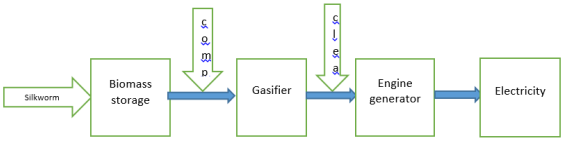

Fig. 9. Process of Stages involved in biogas generation electricity

E. Solar Cell for Controller

Sun rays are available abundantly around the globe it is most preferred energy with nontoxic and easily available source lots of solar cell are been installed in many power plant as source in this paper we set up the cell for operating a control system of monitoring in the biogas generation plant as new implementation it costs are included with cables and charge controllers, cost of PV panel with the set up cost include for 1kw generation if the resource are support full and also the normal controller can operate up to 12 volts and 5 watts to 3.3 watts, Thus it operating frequency of controller is 1Mhz is also operate in solar cell of constant DC source.

F. Purification Process of Methane

Many techniques are available in purification of methane in a biogas generating process according to which type of source it depends. these techniques include high pressure water scrubbing, chemical reactive process, absorption method, cryogenic separation etc. all these process is subjected to various levels in order to mixture of gases is removed in order to get the pure methane many researches are done in removal of and H_2S separate collective research is done in the applications of generating power [3].

Shannon, 2000 worked for the technique of physical absorption. Bhattacharya et al, In 1988 also worked for the process called water scrubbing , and he succeeded by 100% of pure methane generation with the other factors like size, water cleanliness, streaming speed, pressure of gas. Vijay, In 2004 he designed a accessible packing materials for scrubbing mechanism which has removed 30-35 and CO_2 in his system ,khapre, 1989 introduced a scrubber system whose pressure bars is 0.48 bars at rate of $1.764m^3$ and water flow rate was $0.6704m^3$ it will remove 30% of carbon dioxide from the gas. Wellinger, 1999, used a water scrubbing system in manure combustion slush type biogas plants in France [3], America. Around 20-30% of carbon dioxide is removed in biogas from this method. In membrane separation process a thin membrane layered is fixed to the valves when gas is passed on these due to thickness and partial size of mixture it keeps on hold and these pressure with minimal appearance is passed cryogenic process of purification involves the mechanism of partial condensation and distillation at appropriate temperature as it output of purification involves in a liquid form so it is flexible in transportation but high investment required.

As the requirement is high the nominal of absorption in a system is also needed since in chemical process the removal of other sulphides and carbon materials is easier [2] but precaution is to be taken because these may cause the reaction in chemical process in the form leakage which is toxic. And also in water scrubbing process if more amount of carbon and sulphides and hydrogen is to be removed then more water is to be provided and it may form hydroxyl form and cause to form acids but methane does not mix with water.

VI. Conclusion

In the above overall analyses we observed that the production of biogas using silkworm wastes is acceptable and the

approach of determining the overall results obtained in this research it shows clear indication that silkworm waste is capable of biogas production and it is a renewable energy, since it is used as manure earlier now it can also use as fuel, the chemical analyses of biogas is feasible of production of energy and due to the anaerobic reaction the slurry also used as fertilizer, the electricity produced in this process may produce large quantity, if it is placed in large poultry or silkworm sericulture farm lands, so the waste manure is available abundantly. These kinds of plants is reasonable to cultivate small power plants which is suitable in rural areas so production is equally act as a parallel source of energy.

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