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Design and Fabrication of Smart Hybrid Biogas Plant

Puneet Sharma[1*], Varun Panwar[1#], Himanshu Arora[1]

[1]Assistant Professor, Mechanical Engineering, Lovely Professional University, Phagwara, Punjab

Main Author - *puneet.16925@lpu.co.in, Corresponding Author - #varun.17806@lpu.co.in

ABSTRACT -This workaims on design and fabrication of a small-scale biogas digester plant, analysing and reading properties like temperature and pressure of the digester through various installed sensors and develop possible business strategies in the field of renewable energy systems. Different types of properties as temperature, pressure, gas, humidity was read. Methane, Hydrogen, Carbon dioxide, Hydrogen Sulphide were the gases produced from the plant. Methane is the useful gas among all. Development of various business solutions that can be implemented with the help of IoT integration with biogas plant. Integrating the data collected with dynamic data from internet, the relation between temperature and production of gas has been plotted as curves with the help of data analytics and computer programming. Concluded the correlation between both mentioned factors.

INTRODUCTION

Biogasis made by a mixture of various gases produced by the breaking of matter that are organicin the absence of oxygen. Biogas ismadeby the raw materials likewaste from agriculture, municipal wastage, green wastage or food wastage.

Biogas ismade by antiaerobiotic digestion with anaerobic organisms, thatbreaking downthingsin a system with boundaries, or fermentation of degradable waste. Biogas is mainly constituting methane and carbon dioxide withvery lessquantity ofmoisture and hydrogen sulphide. The release of energymakes possiblethe formation of biogas fuel; it isuseful for many heating purposes, like cooking.Biogas is a compressible gas likecompressed natural gas is formed by compressing natural gas, which can be used forautomobiles. In the Europe, biogas canchangearound 17% of vehicle fuel [1]. When biogas is change to bio-methane it can be considered as clean like natural gas. Biogas is a renewable resource because of its production-and-use cycle is endless, and generation of carbon dioxide through it is minimal. Biological material is changed and utilize,it again grows in anendlesslycontinue cycle.Biogas is produced in two waysone of them is landfill gas, that is madethrough the breaking of degradable materials intothe landfill due to microbes and different reaction of them. Projects like NANOCLEAN are helping this generation in findingbetter ways of extracting biogas. This process has the ability to multiply the production of biogas.[2]

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Biogas plants

A biogas plant is an digester that treats farm wastes or energy crops in the absence of oxygen with the help of air tight tanks with different configuration. During the process, the micro-organisms play important role and help in transforming the waste into biogas (methane and carbon dioxide). Wastes can include sewage sludge and waste from food.

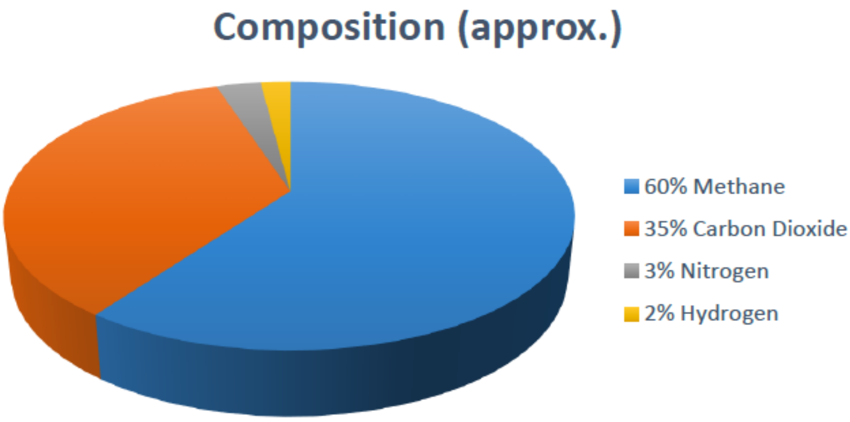

Figure 1. Biogas Composition

The biogas can be used for heating needs at different places using boilers, heaters, or engines. It can alsohelp in saving the electricity and reach to its demand with the surplus electricity to be sold to a regionalcompany [2]. The major resource is of animal dung and slurries from cattle, poultry, fish, fur, etc.

Heat value of the gas produced depends on the amount of methane gas and averages 6.0 kWh/M. Air is heavier than biogas and therefore cannot collect anywhere. On exit the propane mixes with air, and thereby chances of explosion reduced. Biogas ignites at the temperature off 700 °C which is another benefit about the safety in the working with biogas.

Objectives of the Study

Biogas is a renewable energy – gaseous fuel is obtained by the anaerobic digestion of biomass. Organic food waste from institution hostels, different messes, municipal organic waste are not being used for anaerobic digestion which can fetch green profits and can help save environment.Without access to accurate performance data and without the means to analyse the data, operational control, effective customer service and access to the international carbon market and profit control is very limited which can be achieved by software solutions.

Using Internet of Things better efficiency and safety by automated actions for several plants throughout the country or region from single place with data analytics and control will be analysed. The ultimate aim of our project is to develop a prototype model of IoT

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implemented biogas plant, academically known as the "Design and Fabrication of Smart Hybrid Biogas Plant," and to develop business modules out of it.

The project's aim tends towards the implementation of prototype IoT module, with sensor system installed on the digester prototype and demonstrate the readings of factors like temperature etc.

By collecting and coordinating more dynamic data from internet resources with our readings, we plotted graphs and derived some insights based upon it.

Fabrication

The site was selected in the protected cultivation land area under the aegis of department of agricultural science of Lovely Professional University by seeing various benefits to both the parties (student and department). Protected cultivation land area was the remote location of our project due to the availability of electricity, sunlight, crops, raw material, water and a proper environment to use the digestate.

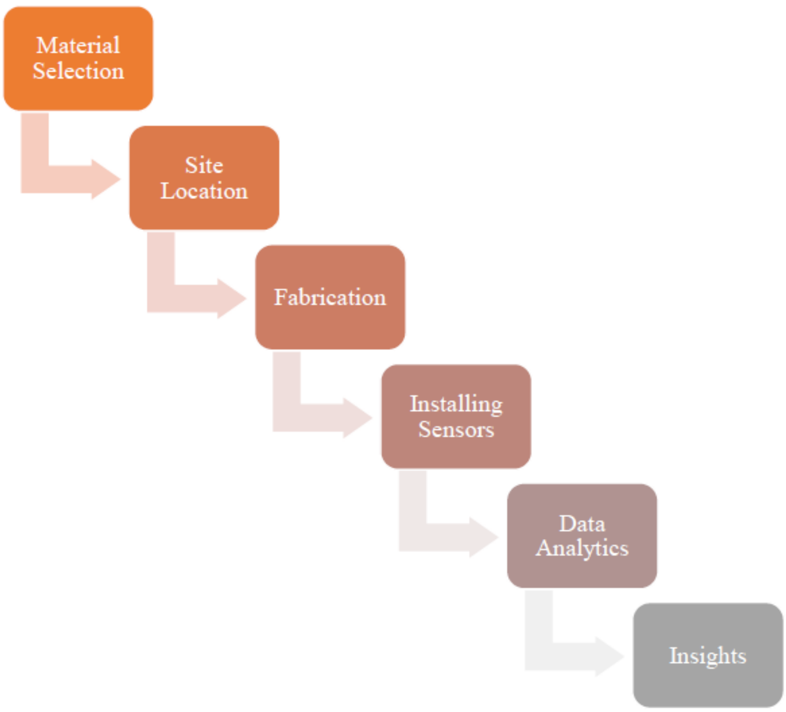

Figure 2. Process Flow Chart

The digestate after the anaerobic process under biogas digester can be used by the agricultural students as organic manure.

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Sr. No.	Type of Waste	% of Nitrogen	% of Phosphorus	% of Potash	BOD in mg/L
1.	Wet Slurry from Kitchen Solid Waste	1.96	0.96	3.32	18
2.	Dry Slurry from Kitchen Solid Waste	0.98	0.84	1.37	-
3.	Cow Dung	0.56	0.35	0.78	30

Figure 3. Manure Detail

Inlet/Outlet Connection:

Two holes on side wall of tank for inlet and outlet are provided for charging and discharging purpose. The inlet joint is at bottom and the outlet on upper side. Along with that pipes are joined to use for inlet and outlet for charge, the L-bow joint to inlet and s-line joint for outlet. For complete fixing of joint glue is used so that there is no leak. The hole is made such that the pipes properly joined but still there is chance of leak, and for properly seal M-seal is used inside out. The whole arrangement was left over for few days with support so that the M-seal and the other joints fix correctly.

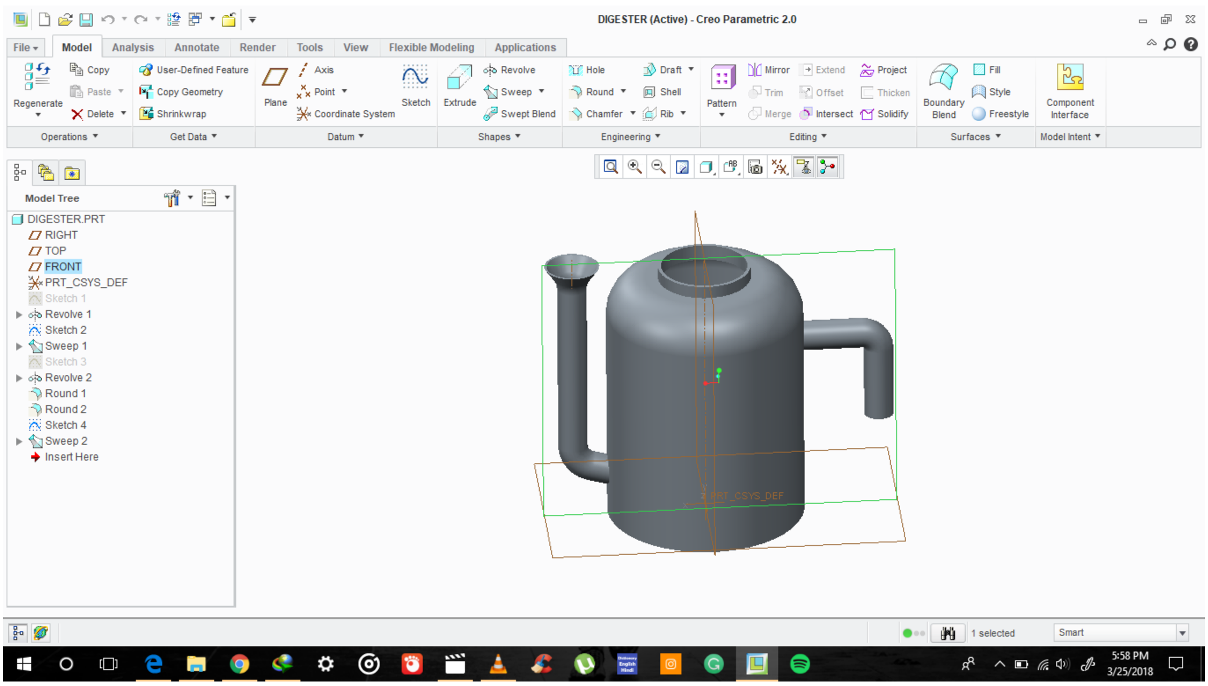

Figure 4. Design in Creo Software

Exit Connection for Gas: Then we made a hole for exit of gas. Cut the pipe in pieces join them with L-bow for the joint. The hole was made on the cap of tank with the help of nipple. Than on the horizontal portion of L-shaped pipe we fix the valve and on other side add a nozzle that we generally use to connect two water pipes, at the end of nozzle a small pipe also added.

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Figure 5. Gas Outlet

Temperature and Pressure Sensor

On the inner side of the tank cap mount all the sensors for this we made three small holes on the cap of the tank by the help of drilling machine so that the wires of the sensors easily taken out of the tank and available for the connection with Raspberry Pi. At the project site we have a sensor control there we settle the screen and the Raspberry Pi. The connection of these with sensors we use plastic tubing for electrical conduct.

The Gas Sensor with name MQ2is used to checkleakage of gas in houses and commercially as well.[5]These sensors useheater with anelectrochemical sensor. This sensor isvery responsivewithvarious gasses that are used inside,at an ambient temperature. The final resultwill be an analog signal Raspberry pi is used to read it.

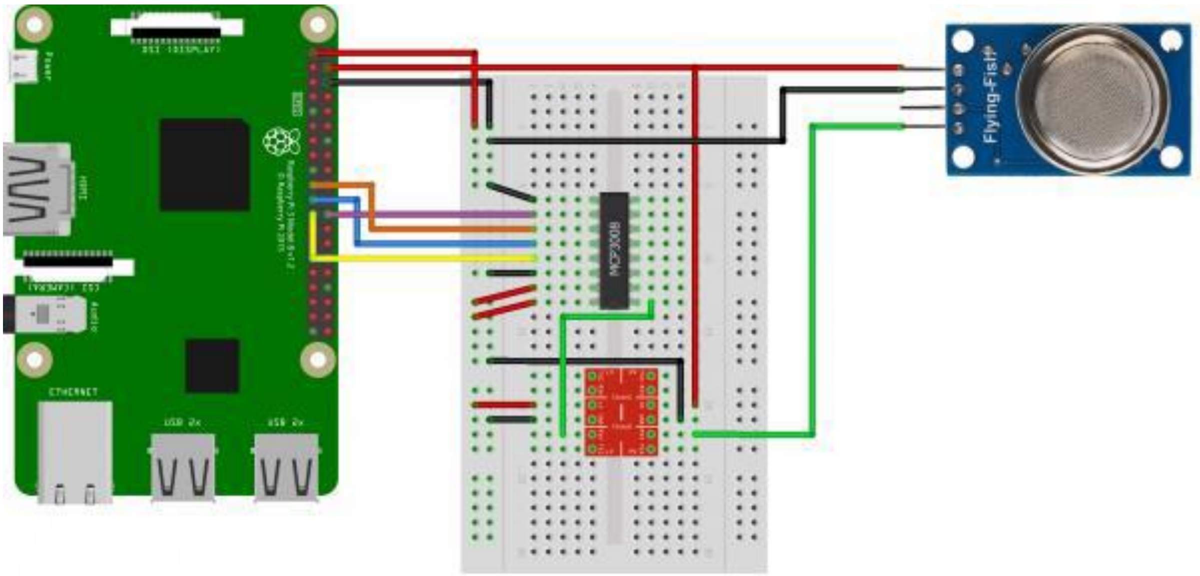

Figure 6. MQ-2 Configuration

Program Sample:

Frommq import*

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```
import sys,time
try:
    print("Press CTRL+C to abort.")
    mq= MQ();
    while True:
        perc=mq.MQPercentage
        sys.stdout.write("\j")
        sys.stdout.write("\033K")
        sys.stdout.write("LPG: %g ppm, CO: %g ppm, Smoke: %g ppm" % (perc["GAS_LPG"], perc["CO"], perc["SMOKE"]))
        sys.stdout.flush()
        time.sleep(0.1)
except:
print("\nAbort by user")
```

Thepressure sensor BMP 180 is used as a barometric sensor used to measure pressure. It is used to measures the pressure fluctuatewith theenvironmental conditions and height.The DHT11 temperature sensor is used in the project and it is a cheap digital temperature and humidity sensor.

Results

The prototype model of smart hybrid biogas plant has been fabricated. It has been installed with the sensors which read different data such as temperature and gas production. The data which has been used in this analysis is dynamic and referenced from various internet resources. The data comes from the DHT-11 and MQ-2 sensor.

The collected data has been saved in a CSV format in an excel file. **File name:** Biogas.csv

In [13]: df.describe()

Out[13]:

	temp	pro
count	63.000000	63.000000
mean	37.603175	0.076190
std	8.984825	0.039856
min	20.000000	0.010000
25%	30.000000	0.040000
50%	39.000000	0.070000
75%	44.500000	0.100000
max	50.000000	0.150000

Here, it can be noticed the various aspects of the data related to the biogas digester.
Number of data is 63, mean, standard deviation, minimum and maximum values, percentage distribution of both temperature and production data.

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To watch over some data from upper and lower side, the following commands can be used respectively.

df.head()and df.tail()

Out[15]:

	temp	pro
0	20	0.01
1	22	0.03
2	22	0.03
3	22	0.03
4	22	0.03

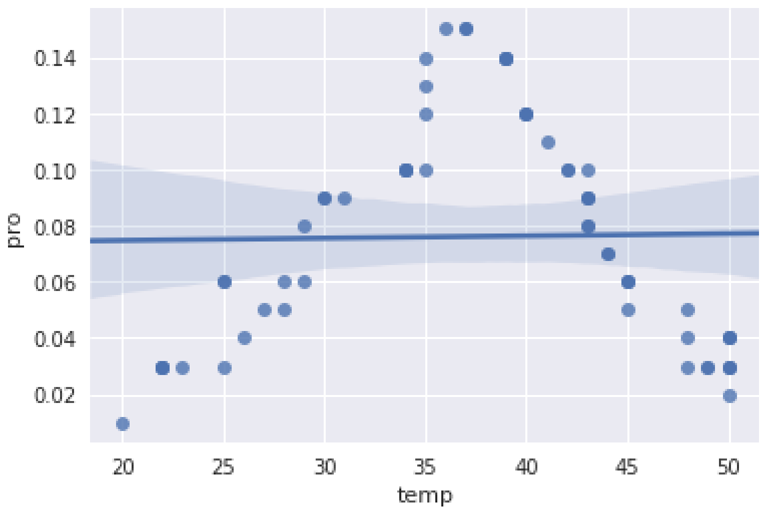

Figure 7. Temperature vs Pressure

INSIGHT 2

It can be clearly seen from the above output graph that the production of biogas first increases with increase in temperature and then starts to decrease if uncharged. Maximum production of gas is between 35 degree centigrade and 39 degree centigrade.

Hence the most favourable temperature for production of biogas in this region for the current weather lies between 30 degree centigrade and 38 degree centigrade.

INSIGHT 3

Production of biogas is not truly depending on temperature at the time of experiment. It fluctuates. To prove this, correlation between both the features can be analysed.

Correlation: It is a statistical concept which determines the strength of a relation between the two factors. It is often used in data analytics. If the result of “r” is closer to zero, it means that

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both the factors are mostly independent of each other.Here, a python function has been designed to calculate the Pearson's r mathematically.

```
In [21]: def correlation(temp, pro):

             temp_std = (temp-temp.mean())/temp.std(ddof=0)
             pro_std = (pro-pro.mean())/pro.std(ddof=0)

             corr = (temp_std*pro_std).mean()
             return corr

         temperature = df['temp']
         production = df['pro']

         print (correlation(temperature, production))

0.018230875583327096
```

As the Pearson's r = 0.018230875583327096, it is nearer to zero. Hence it has been proved that some fluctuations are occurring in temperature and production.

Conclusion

a. Measurement of average temperature:

- The digester isset at a fixed temperature of 35°C, it is known as a normal body temperature for warm-blooded organisms who feed upon bacterial activity for their nutrition to break down food.
- In winter biogas plant becomes inefficient due to temperature lower than 30 Celsius, which can be avoided by heating the digester by heating blankets.
- This can be triggered remotely by software collecting the data of temperature by temp. Sensors.
- Hence plant can achieve constant max. Efficiency in low ambient temperatures too.

b. Measurement of Pressure & ensuring safety:

- Monitoring of pressure in digester and container equipment through pressure sensors.
- This will help in maintaining constant gas regulation at burner.
- Mechanical systems can be actuated remotely in order to do so.
- Continuous data of pressure and temperature will also help triggering safety release valves and alarm systems.

c. Regulation:

- Electronic Regulators will provide the data of continuous gas regulations from digester to storage as well as to burners and gas wastage in case of safety release or other condition.
- It can be coordinated with other data for commercial payment control.

d. Online Billing and taxation:

- Based on all collected data from all the remote biogas plants, automated bill and tax calculations can be done.
- Costumer can get automatic SMS alerts or e-bill via emails.

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- Online payment systems can be generated.
- Automatic Billing

e. Commercial Payment Control:

- Supply of Gas can be stopped by remotely actuating mechanical electronic systems in a plant in case of any payment default.
- Instant activation of gas regulation upon successful payment.

Future Aspects

- Municipal Waste Management System
- District Power Generation Plant (4 to 5 MW)
- District Gas supply Line
- Home Equipment Consultancy (Direct Biogas Use)
- On Grid Power Plants (Municipal as well as can be private)
- Domestic Cylinder Filling Station
- Manufacturing of Noise-less Generator IC Engines for Hotels

The following objectives are accomplished during the work:

- Fabricated the prototype
- Charged the digester
- Installed sensors
- Setup of IoT system
- Configuration of Raspberry pi
- Data Scrapping
- Data Analytics and Insights

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