Performance analysis of Low Cost Bio digester Using Bio waste

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Abstract - *Jaggery is a sweetener that's becoming popular as a "healthy" replacement for sugar benefits of jaggery include its ability to cleanse your body, act as a digestive agent, sweeten your food in a healthy manner, and provide good amounts of minerals. Jaggery is nutritious and easily available to the rural people. Compared to white sugar, it requires low capital requirement in production and is manufactured at the farmer's individual units itself. Of the total world production, more than 70% of the jaggery is produced in India. While cooking the juice mud is removed and thrown out. This thrown out mud is creating lot of pollution and health hazards to humans and domestic animals. It is becoming an environmental problem in that area. According to primary studies on the waste of the jaggery making units and found that it is viable to produce biogas out of this waste. Biogas technology is best suited to convert the organic waste from agriculture, livestock, industries, municipalities and other human activities into energy and manure. The use of energy and manure can lead to better environment, health, and other socio-economic gain.. Under this work detailed studies will be conducted for utilization of low cost biomass plant for production of biogas and found that the best solution may be achieved by applying biogas technology which provides rural community with energy (biogas) and good organic fertilizer from organic wastes.*

Key Words: Bio gas, jaggery,baggase etc..

1. INTRODUCTION

Jaggery is a traditional Indian sweetener prepared using sugarcane. Farmers make jaggery in their own farms using juice obtained after crushing sugarcane with a crusher. The settled juice is boiled in open pans with continuous stirring and, simultaneously clarificants are added in required quantity. The consistency of the juice becomes thick on concentration by boiling and then it is poured into moulds to make jaggery blocks on cooling. The efficiency of crushing and concentration process is 60% and 14.75% respectively. The low efficiency is due to the use of open pans for concentration and using moulds for cooling. Adopting alternative technologies like a steam jacketed vessel which will get preheated water from the cooling and moulding section. Hot water can also be used in improving the crushing efficiency thereby making the jaggery processing energy efficient. Jaggery is a traditional Indian sweetener with several uses in daily food preparations and it is also used to make many sweet food preparations. According to prevention of food adulteration rules: Jaggery means, the product obtained by boiling or processing juice crushed out of sugar cane. It shall be free from substances deleterious to health and can confirm to the following standard analysis on dry weight basis. 1. Total sugars not less than 90% and sucrose not less than 60%, 2. Extraneous matter insoluble in water 2.0%. 3. Total ash not more than 6% and ash insoluble in HCl not more than 0.5%. 4. Gur or Jaggery other than that of liquid or semisolid variety shall not contain more than 10% moisture. Jaggery is called as Gur in India, Desi in Pakistan, Panela in Mexico, rapadura in Brazil, chancaca in Chile and Peru, Hakuru in Sri Lanka, and Naam Taan Oi in Thailand. Although the word jaggery is used for the products of both sugarcane and the date palm tree, technically, Jaggery refers solely to unrefined form of sugar made from sugarcane juice.

Fig -1: Jaggery unit

In India, jaggery has been used as in the making of traditional dishes like chakkarai pongal, milk pongal, paayasa obbattu, tilgul, kakvi, laddus and puran poli. Jaggery is produced in 25 countries with a world annual production of 11.05 million tones.The manufacture is concentrated in Asia and South America, the major producers being India with 6.89 million tonnes. In India, nearly 35% of about 250 MT of sugarcane produced is crushed for Jaggery preparation .The amount of sugarcane utilized for the Jaggery preparation is being decreased significantly in last decade because of the growing number of sugar mills and market's preference towards more and more refined products. But again due to the increase in the health consciousness of the people, the trend is slightly reversing in the last few years .Jaggery when used daily may increase human life span. In jaggery consuming areas less incidence of diabetes is reported compared to sugar consuming areas .Jaggery from time immemorial has been reported to have many health benefits. Ancient medical scriptures, Sushruta Sanhita , dating back to 2500 years states how Jaggery is useful in purification of blood, prevents rheumatic afflictions and disorders of bile and possess nutritive properties of high order. It supplements the requirement of iron and calcium in women and children, prevents anemia and increases vitality in men and help in digestion. Magnesium in jaggery strengthens the nervous system and potassium conserve the acid balance in the cells and combats acids and acetones. The preventive action of jaggery on smoke-induced lung lesions and the presence of micronutrients in jaggery have antitoxic and an anticarcinogenic property suggests the potential of jaggery as protective agent for workers in industry in smoky environments. In addition, it has potential antioxidant activity owing to the presence of polyphenolic compounds in cane juice Jaggery is marketed in different shapes, colour and texture. The three forms in which Jaggery is available are solid jaggery, liquid jaggery and granular jaggery. Most of the jaggery is prepared in solid form 80% and the remaining 20% is prepared in liquid as well as granular form. Jaggery may be light golden, golden, dark golden, light brown or brown in colour. People from different region have different criteria for the best quality Jaggery. While in north India Jaggery with amorphous texture with slightly lower sucrose content is preferred, in south India crystalline Jaggery with characteristic yellow color is liked. Jaggery manufacturing is done on a small scale by a group of farmers creating employment opportunities to the millions of people in rural areas. From time immemorial, sugarcane crop has been known as a cash crop by Indian cultivators and so also the preparation of jaggery.

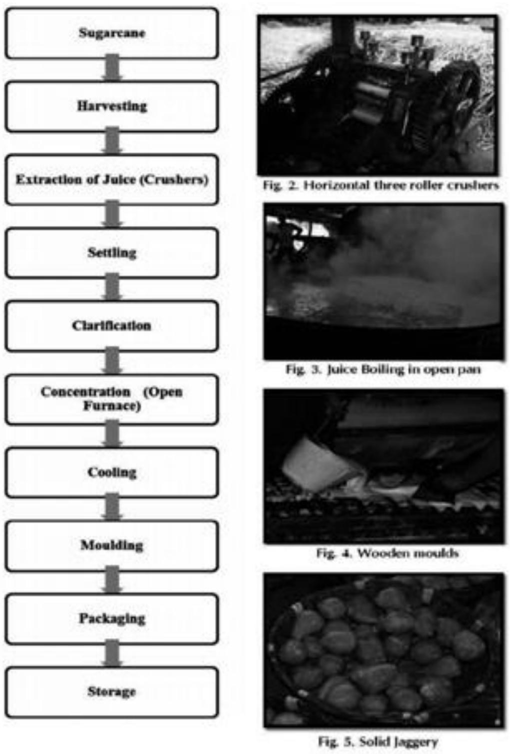

Fig -2: Jaggery manufacturing process flowchart

2. BIO WASTE IN JAGGERY INDUSTRY

2.1 BAGASSE

Bagasse is the material obtained after extraction of juice from sugarcane stalk. It is used as fuel in co-generation plant of sugar mills but is burnt directly in jaggery/khandsari making furnaces. Efficient burning of bagasse depends on its moisture content. Fresh bagasse normally contains 50% moisture and reduction of moisture improves upon its calorific value . It is efficiently dried in sugar industries and in some khandsari units in counter-current type driers whereas, in jaggery units, this is normally sun dried. Variation in moisture content of sun-dried bagasse affects performance of jaggery making furnaces. Determination of moisture content to know its suitability for using it as fuel, therefore, becomes important. Calorific value of bagasse dried to half of its initial moisture content is about 10% higher. So a well-dried bagasse will generate more heat per unit weight[2].

Bagasse consists of three components namely, pith, fibre and rind mixed in different proportions. There is a considerable difference in shapes and sizes of the three components. The rather regular shapes of spongy pith particles with a near unity length/width ratio can be approximated by a spherical shape. The shape of fibres with high length/width ratios can be modelled by cylinders. The large rind materials roughly comprise rectangular particles with high length/width ratios. Some fibres are often adjacent to the inner wall of the rind particles. For each 10 tonnes of sugarcane crushed, a sugar factory produces nearly 3 tonnes of bagasse.

Physical Properties of Bagasse:

a. It is a fibrous matter.
b. It is a low density material with a wide range of particle sizes.
c. It is extremely inhomogeneous material.
d. It has high moisture content, typically 40-50%.

A typical chemical analysis of bagasse might be (on a washed and dry basis):

a. Cellulose : 45-55%
b. Hemi cellulose : 20-25%
c. Lignin :18-24%
d. Ash :1-4%
e. Waxes : <1%

Fig -3: Jaggery Baggase.

2.2 SUGARCANE PRESS MUD

Sugarcane press mud is the residue of the filtration of sugarcane juice. The clarification process separates the juice into a clear juice that rises to the top and goes for manufacture, and a mud that collects at the bottom. The mud is then filtered to separate the suspended matter, which includes insoluble salts and fine bagasse. There are 3 types of filter: the press filters (used in carbonization factories), mechanical filters and rotary vacuum filters.. The yield of filter cake is variable, from 1 to 7 kg (wet basis) per 100 kg of cane. With a conservative yield of 2% and a total production of 1700 million t in 2009 , the world output of fresh filter press mud can be estimated to be about 30 million ton.This industrial waste is mostly used as soil conditioner, soil fertilizer and for wax production. Other industrial applications are reported (cement and paint manufacturing, foaming agent, composting aid for bagasse, etc.) and it has been used as human food by resource-poor families. In animal production, it has been used as feed ingredient, notably for ruminants, because of its sugar and mineral content, and as a compacting agent for ensiling.

3. BIOGAS PRODUCTION FROM JAGGERY WASTE

Biogas can be produced by anaerobic digestion of organic matter. Potential raw materials available on a large scale are cow dung, municipal wastes, kitchen waste and specially grown plants for this purpose like water hyacinth, algae, and certain types of grasses. The main advantage of bio gas is that it can be produced in rural areas from readily available materials. Biogas mainly consists of 55-65% methane, 30-40% carbon dioxide and rest being impurities (H2, H2S and some N2). Its calorific value is low but its knock resistance is high and ignition quality is low. In dual fuel type diesel engine the gas is mixed with the incoming air and ignited by diesel fuel injection. This engine suffers a fall in efficiency compared to the diesel engine but has a good efficiency at full power output.

Biogas originates from bacteria in the process of bio-degradation of organic materials under anaerobic conditions. The natural generation of biogas is an important part of bio-geochemical carbon cycle methanogens are the last link in a chain of micro organism, which degrade organic materials and return the decomposition products to the environment. In this process biogas is generated as source of renewable energy. Each year some 590-880 million tons of methane are replaced worldwide into atmosphere through micro bios. About 90% emitted methane drives form biogenic source i.e., from the decomposition of bio mass. Anaerobic fermentation involves the activity of three different bacterial communities. The process of biogas production depends on various factors. However only homogeneous and liquid substrates can be considered for simple biogas plants waste and waste water from processing industries are only suitable for simple plants if they are homogeneous and in liquid form.

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.Very often microorganisms are not as efficient in natural surroundings as one would expect them to be and therefore artificially multiplied cultures of efficient selected microorganisms play a vital role in accelerating the microbial processes in soil.[4]

Use of biofertilizers is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. They can be grouped in different ways based on their nature and function.

PROCESS PARAMETERS

Each of the various types of bacteria responsible for the three stages of methanation is affected by the above parameters. Since an interactive effect between various determining factors exists no precise quantitative data on the gas production as a function of the above factors are available.

Substrate temperature: Anaerobic fermentation is in principle possible between 30 C and approximately 700 C. The rate of bacteriological methane production increases with temperature however the amount of free ammonia also increases with temperature bio digestive performance could be inhabited or even reduced as a result in general unheated biogas plants perform satisfactory only when mean annual temperature are around 200C as about or where the average daily temperature is at least 180C within the range of 20-280C mean temperature. The gas production will be so slow that the biogas plant is no longer economically feasible. The process of bio methanisation is very sensitive to changes in temperature.

Available nutrients: In order to grow, bacteria need more than just a supply of organic substances as a source of carbon and energy. They also require certain mineral nutrients. In addition to the carbon, oxygen and hydrogen, the generation of biomass requires an adequate supply of nitrogen, sulphur, prosperous, potassium, calcium, magnesium and number of trace elements such as iron, manganese, molybdenum, zinc, cobalt, selenium, tungsten, nickel etc., higher concentration of an individual substance usually as inhibitory effect normal substrates such as agricultural residues and municipal sewage usually contain adequate amount have about mentioned elements.

Retention time: Batch type and continuous plants; the retention time can only accurately defined in batch type facilities for continuous system. The mean retention time is approximately by dividing the digester volume by the daily influent rate depending on the vessel geometry, mixing etc. The effective retention time may vary widely for the individual substrate constituents. If the retention time is too short the bacteria in the digester are washed out faster than they can reproduce so that the fermentation practically comes to standstill. Biogas production is optimum for a retention time of 30, 40, 55 days.

pH value: The methane producing bacteria live best under neutral to slightly alkaline conditions. Once the process of fermentation has stabilised under an anaerobic conditions, the pH will normally take on a value between 7 and 8.5. Due to buffer effect the carbon dioxide bicarbonate (CO2-1+CO2) and ammonia-ammonium (NH3-NH4) pH level rarely taken as a measure of substrate as its and potential biogas yield. The digester contain higher than normal pH value. If pH value drops below 6.2 medium will have toxic effects on the methanogenic bacteria.

C/N ratio: This is also an important factor that effects the biogas production. The biogas production is optimum for a C/N ratio between 25:1 to 30:1

4. INSTALLATION OF BIOGAS PLANT

Three main types of simple biogas plants can be distinguished:

- Balloon plants
- Fixed-dome plants
- Floating-drum plants

BALLOON PLANTS:

A balloon plant consists of a plastic or rubber digester bag, in the upper part of which the gas is stored. The inlet and outlet are attached direct to the skin of the balloon. When the gas space is full the plant works like a fixed-dome plant - i.e., the balloon is not inflated; it is not very elastic[3].

The fermentation slurry is agitated slightly by the movement of the balloon skin. This is favorable to the digestion process. Even difficult feed materials, such as water hyacinths, can be used in a balloon plant. The balloon material must be UV-resistant. Materials which have been used successfully include RMP (red mud plastic), Trevira and butyl.

Advantages: Low cost, ease of transportation, low construction, high digester temperatures, uncomplicated cleaning, emptying and maintenance.

Disadvantages: Short life (about five years), easily damaged and does not create employment locally, little scope for self-help group.

Here a balloon type of biogas plant is installed. The main advantage of this is that it is of low cost and the space required is less. Also a plastic digester bag is used here instead of sintex tank. These are cheaply available rather than sintex tank or concrete based biogas plants.

Various processes involved in the installation of biogas plant are as follows:

STEP 1: Selection of plastic sheet

A plastic digester bag of size of 18m*30m is selected. A nozzle is fitted at the centre of the bag for the purpose of gas output.

STEP 2: Selection of suitable place

The site where the plant has to be installed must be identified .This must be very close to the sugarcane crusher .Also the bagasse must be in the form of fine paste which isdone with the help of a cutter.

STEP 3: Digging the pit

A pit of suitable size must dug. Then some amount of ash is spread over the pit to protect the plastic sheet from the insects. This is the place where slurry is stored inside a plastic digester bag.

Fig -4 Digging of Bio Digester.

STEP 4: Installation of digester bag

A plastic digester bag is inserted into the pit. At both the ends of the bag, a PVC pipe of 3inch diameter, 3feet length is fitted. Then the bagasse in the form of fine paste is fed into the digester bag along with some amount of jiggery residues (maddi).

Fig -5 Installing inlet chamber

5.UTILISATION OF BIOGAS IN JAGGERY PLANT

Biogas production from sugarcane waste has large potential for energy generation, however, toenable the optimization of the anaerobic digestion (AD) process each substrate characteristic should be carefully evaluated. In this study, the kinetic Challenges for biogas production from different types of sugarcane waste were assessed. In jaggery industry produced biogas can be used is more economical to run diesel engine.figure-7 showing utilization of biogas to run disel engine[5].

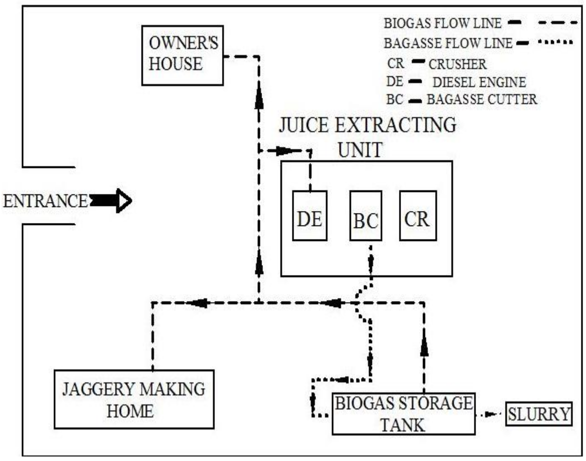

Fig -6: Usage of biogas in Jaggery plant

Fallowing tables demonstrates the specification of biogas plant and daily and annually basis of biogas production details.

Table -1 Basic details of biogas plant

Input to the plant	20to 25 kg of bagasse per day
Built up Area	20 x3 sq.ft
System Elements	Plastic digester bag, Input and output pipes, Nozzle, Gas flow pipe line
Application	Biogas for running diesel engine, slurry as bio-fertilizer for agriculture purpose

Table -2 Daily basis biogas and bio fertilizer production

Daily biogas and bio fertilizer production	Generation of biogas per day	8 m3
	LPG equivalent of biogas per day	4.8 kg
	Savings through LPG per day	Rs. 528
	Savings through bio fertilizer per day(20kg/day)	Rs.50
	Total returns per day through biogas and manure	Rs.578

Note: 1m3 biogas is equivalent to 0.6 kg of LPG.

Cost of 1kg commercial LPG is assumed as Rs. 110.
Gas generation rate of 8 m3 per day is under ideal conditions

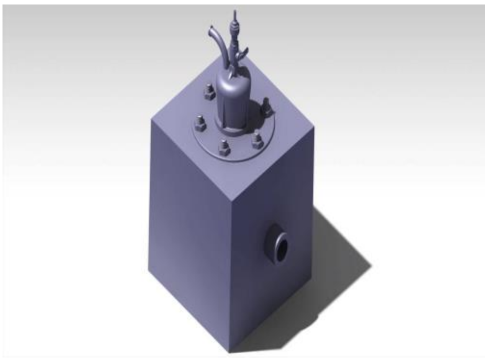

Fig -7 Air box for supply biogas to engine

The biogas plant is fed with fresh slurry to aid the production of biogas. Biogas is supplied to the air inlet by connecting one end of a flexible pipe to the outlet of the biogas plant and the other end to the bottom inlet of the air box[7]

Table -3 Biogas output for various types temperature

Date	Temperature (OC)	PH value	Biogas output (m)3	Power (KW)
Day 1	28	6.8	2.5	1.875
	30	7	3.2	2.4
	29	6.9	2.3	1.725
Day 2	29	7	2.3	1.725
	31	7.1	3.3	2.475
	30	6.9	2.4	1.8

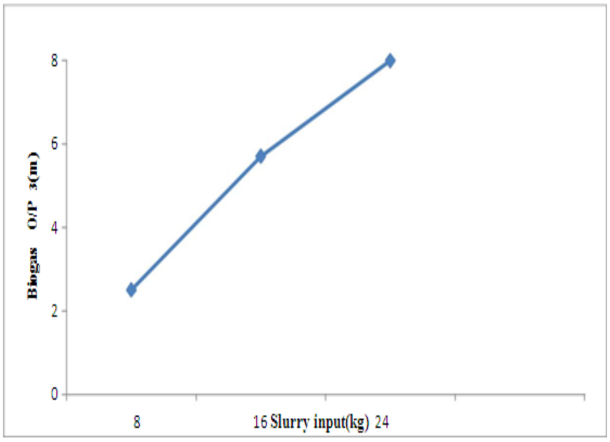

Chart -1: Biogas output v/s Temperature

Table-3 shows biogas production with respect to temperature and chart-1 explains when increases the temperature, increase the biogas production.

6. COST ANALYSIS

Table 4 shows the cost analysis details of low cost biogas plant.

Table -4 Cost of biogas plant

Sl. No	Description	Cost (In Rs.)
1	Digging of the pit(labour)	2000
2	Plastic digester bag	4,600
3	Nozzle	100
4	PVC pipes and gas intake pipe	700
5	Thermometer	250
6	pH scale	350
7	Air tank	1500
8	G.I pipes and fittings	300
	Total	10,000

7. CONCLUSION

The objective to meet electricity demand of village can be achieved by making proper utilization of biomass resources. The two major problem of managing the residue left after harvesting and inconvenient electricity supply of villages could be well overcome by utilizing the existing resource of village and making itself sustainable in its energy requirements. In this paper conclude that Biogas plant is installed at low cost by using plastic digester bag. The anaerobic treatment of sugarcane bagasse has been adjudged the best technology to produce energy in terms of biogas. It is eco friendly process. It gives enriched slurry which can be used as manure for gardening. It is a best technology for rural areas. Instead of diesel alone, biogas is used as fuel to run a crusher in jaggery industry. The cost analysis predict in spite of having huge capital and installation cost renewable energy sources prove to be more reliable and environmental friendly source to provide electricity in remote or off grid areas.

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