Design and Analysis of a Digester in a Biogas Plant

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Abstract:-We analysed the digester in a biogas plant using ansys,creo,cfd and obtained the flow of fluids,time of filling and drining and also performed the stress analysis. We calculated the diameter of the digester which helped us to find the load distribution and methane produced. We use floating balloon type digester to easy up the way of finding whether the methane gas is obtained or not. We mount the blades inside the digester horizontally so that we reduce the stress that is distributed in the walls and it does not interrupt with the flow.

Key words: CFD,CREO,ANSYS

1. INTRODUCTION

One of the ways to prevent the effects of global warming is the development of renewable energy sources. According to the data presented by PSE S.A. on 31 Jan 2013, the Polish renewable energy sources are responsible for 9,6% of all the energy produced in the country. One of possibilities for increasing the share of renewable energy could be the agricultural biogas. In practice, biogas is most frequently used in cogeneration when creating heat and electric energy. It is becoming more popular as a source of biomethane. Valuable nutrients obtained in the process of fermentation may be re-used as substitutes for mineral fertilisers. This process results in the lowering of CO2 emissions, allows for conserving fossil fuels and decreasing costs. The process of biogas creation may utilize highly varied technologies. There is a wide spectrum of ways in which the components and technical equipment may be connected. The technical elements of a biogas installation are selected to match the substrates used to produce the gas. The size of individual generators and tank volumes depend on the quantity of the input material. Modern agricultural biogas plants utilize different fermentation chambers. Their construction is mostly dependent on the utilized technology of biogas production.

In practice, biogas is most frequently used in cogeneration when creating heat and electric energy. It is becoming more and more popular as a source of biomethane. Valuable nutrients obtained in the process of fermentation may be re-used as substitutes for mineral fertilisers. This process results in the lowering of CO2 emissions, it allows for conserving fossil fuels and decreasing costs. When planning to build a biogas plant the aspects that are analysed are: location, technology and size of the facility. The most important aspect is selection of substrate from which the biogas will be produced. Agriculture and the communal sphere produces large quantities of waste that can be used for anaerobic fermentation as an energy source.

The analyzed design of a digester biogas tank shall be intended for a biogas plant located on the premises of a college dealing with cattle food and animal waste. The farm shall, instead of storing it in a tank, use the manure in the proposed digester biogas tank and process it into biogas. It was assumed that the place owned 3000litres/day. The substrate for biogas production is cattle slurry. The operation of the biogas plant will be based on a single-stage technology, mesophilic (35°C) utilizing wet fermentation. The fermentation chamber was designed as a vertical one with a balloonat the roof of digester. The fixed dome such as Janata and deenabandhu have been installed in different parts of india , but the performance of the plant depends on the location of installation the fixed dome model consist of an inlet or mixing tank , outlet tank and fermentation chamber or digester pit .In design , there is non separate gasholder and upper portion of the digester pit itself acts as a gasholder . displaced level slurry provides requities pressure foe release of gas for its subsequent use.

II. LITERATURE REVIEW

Sagagi , et al . (2009) presented results of the study on biogas production from fruit and vegetable remains and when they were used as fertilizers (using digested and undigested sludge). It has been observed that the highest weekly individual production rate is recorded for the cow dung (control) slurry with average production of 1554 cm3, followed by pinapple waste which had 965 cm3 of biogas then by organic waste which had 612 cm3 of biogas , lastly pumpkin and spinach wastes had 373 cm3 and 269 cm3 respectively . the results shows that difference in production of biogas to a large extent depends on yhe nature of the substrate . all the substrates used appeared to be good materials for biogas production and their spent slurries can be used as a source for plant nutrients N.Stalin, et al(2007) modified three stage methane fermentation system was developed to digest animal manure effectively. The digester having an effective volume of 200 liter is constructed with central tube filled with burnt bricks .The burnt brick in the central portion of the digester increase the microbial concentration by immobilizing the bacteria on the surface of the burnt bricks .the size of the brick material should not be more than 3 to 5 mm in size the carrier materials used in the digester are 5%,10%,15% and20% of the total volume of the digester and also for each percentage 3.5 kg of cow dung and 3.5 kg of water (1:1) is well mixed and added daily . the reading were taken between biogas generations versus time for each percentage continuously up to 90 days.It was observed that 10 to 15 percentage of carrier material from the total volume for microbial growth gave more gas generation . operational temperature was from 30 to 50 degree Celsius . the study examines the effect of microbe growth , temperature on biogas generation and hydraulic retention time.

Vaibhav nasery (2011) presents this report a preliminary study of two highly successful rural biogas models wherein biogas is produced and utilized as a cooking fuel by the villagers . the models studied are the community biogas plant established by SUMUL diary at bhintbudrak, Gujarat and the individual biogas plants established by bhagirathpratisthan (an NGO) in south konkan region of Maharashtra various aspectsincluding design , operation, economics and benefits to the stakeholders have been described .the report ends with the comparison of the two models studied on the basis of their design ,vision,performance, economics and benefits

Bhumeshsingh ,et al.(2011) study on biogas generation from dairy effluent and control of water pollution has been viewed with the aim of control of water pollution through treatment of diary waste as well as generation of biogas envirometal parameters like temperature,pH, biological oxygen demand (BOD) & chemical oxygen demand (COD) was taken in to account . no changes in the average value of temperature and pH was recorded but BOD and COD reduced to the extent of 50 % . All parameters however showed statistically significant differences at 5 % level between inletand outlet point .Gasgenerationfluctuated between . 5m3 / day to maxium 4.5 m3/day with an average of 3 m3/day was recorded

Capela et al (2008) studied the feasibility of anaerobic co digestion of OFMSW, industrial sludge and cattle manure. The increase of OFMSW in the mixture resulted in higher methane production and solid reduction . the co digestion of OFMSW with BS and CM ,significally improved the stability and the process performance with an effective decrease on the need for buffer addition .the mixture with77% of OFMSW and 23% of IS in composition had shown a better performance in term of methane [roduction and solids reduction

Kiely et al (1997)the codigestion of OFMSW with primary sewage sludge, industrial organic sludge and agriculture slurries has been investigated and it was an operational process at full scale in several centralized co digestion plants in Denmark.alsokiely et al (1997) and sosnowki et al (2002) stated that anaerobic co digestion of the organic food fraction of the municipal solid wastes with primary sewage sludge is an attractive method for environmental protection and energy savings point of view.

Neves et al (2009) the behavior of cow manure with food waste by applying increasing concentration oh intermittent pulses of residual oil generated from a canned fish processing industry was investigated by neves . considering the mixture of lipids present in the oily waste ,addition of oily waste at 12 g COD/L enhanced the methane production in the co digestion of cow manure and food waste .

Monou et al (2009) co digestion of different biodegradable waste stream from the food and agriculture industry sector in Cyprus was investigated by monou et al (2009) and a rapid screening sector to optimize the co digestion process was established .

Zhang et al (2011) the role of trace elements in anaerobic co digestion was investigated . the co digestion of food waste with piggery waste water showed a high methane production rate without VFA accumulation . the reason for enhancement of methane production was due to trace elements supplemented from piggery waste water during co digestion with food waste

Gomez et al (2006) studied the anaerobic co digestion of primary sludge and the fruit and vegetable fraction of the MSW in differentmodes of mixing conditions in digesters at an OLR of 2.5-3.6 g VS/d for the primary sludge and 2.5-4.3 g VS/d for primary sludge plus MSW under mesophilic conditions .they found that the absence of agitation resulted in the reduction of specific gas production(SGP) . hence good contact between the substrate and the microbes was needed.

Kapadi , et al . (2004) in this paper reviews the effort made to improve the quality of biogas by scrubbing co2 and the result obtained. There ia a lot of potential if biogas could be made viable as a transport vehicle fuel like CNG by compressing it and filling into cylinder after scrubbing and drying . thus the need emerges for a unifed approach for scrubbing , compressing and subsequent storage of biogas for wider application .

Kumar et al.,(2004) investigated the reactivity of methane . they concluded that it has more than 20 times the global warming potential of carbon dioxide and that the concentration of it in the atmosphere is increasing with one to two per cent per year the article continues by highlighting that about 3 to 19% of anthropogenic sources of methane originate from landfills.

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 on day 1 and day 15 increased the gas production by 55%over unamended cattle dung and addition of teresan of cattle dung:kitchen waste(1:1) mixed residue15%increased gas production Hamad et al [81] compared the performance of modified Indian digester and the Chinese fixed dome models for the conditions

prevailing in Egypt . none of the digesters were suitable for the local conditions ,and for the condition present in Egypt ,the plug flow digester and the digester with a solar heater were reported to be more efficient .biogas production decreased by 70%in the rubber ballon digester compared to 17% in the deenbandhu model during winter . it is not advisable to usethe rubber balloon model in hilly areas as it is affected by the ambient temperature . the fluctuation in temperature changes the microflora in the reactor between lower mesophilic in summer to psycrophilic in winter , affecting the process parameters .compared to the conventional plant (fixed dome digester),rubber balloon reactors in hilly areas maintain 2-3 degreee C lower temperature during the winter and 2-3 degree C higher temperature during summer.
Horiuchi uet al 2002 states that the methane production in a bio gas plant strongly depends on the pH. For selective production of various organic acids from organic waste pH control was effective .the optimum range for methanogens is 6.5 to 8.2
Bouallagui et al (2004) the effect of temperature on the performance of an anaerobic tubular reactor treating fruit and vegetables wastes were evaluated . the higher the degradation efficiency in terms of higher specific biogas production and an improvement of the energy balance of the process were observed in thermophilic conditions when compared with psychrophilic and mesophilic conditions

Cheng –nan change et al (2002) demonstrated ORP as a controlling parameter in waste activated sludge hydrolysis process and a relation between change of ORP value and increase in SCOD was developed with the help of models .

III. DESIGN

DIGESTER CALCULATION :
Known values :
Design considerations :
People = 400
Sludge content per capita per day = 0.068 Kg
Moisture of the sludge = 94%
Specific gravity of wet sludge = 1.02% & 3.5% of digester volume daily filled with fresh sludge which is mixed with digester sludge.
Solution :
Dry sludge content produced by 400 people = 0.068 × 400
= 27.2 Kg per day

94% moisture content means that 6Kg of dry sludge will produce 100 kg of wet sludge.

27.2 kg of dry sludge produces wet sludge $= \frac{100}{6} \times 27.2$

= 0.453 t per day

Volume of wet sludge produced $= \frac{mass\ of\ sludge}{density\ of\ sludge}$

$= \frac{0.453}{1.02}\ m^3$ / day

= 0.444 m^3 / day

(Density of sludge in t/m^3 = specific gravity × density of water

= 1.02 × 1

= 1.02 t / m^3

0.444 m^3 /day of fresh sludge is added to the tank daily to fill 3.5% of the digester capacity

$\frac{3.5}{100}$ capacity of digester = volume of fresh sludge produced daily

= 0.444m^3

Capacity of digester required = $\frac{0.444 \times 100}{3.5}$

= 12.698 m^3

Providing 30% additional required capacity for fluctuation we have , the required digester capacity

= 12.698 × 1.3

= 16.5079 m^3

Now Providing 6m depth of cylindrical digestion tank, we have
The cross sectional area of the tank = $\frac{16.5079}{6}$

= 2.75163m^3

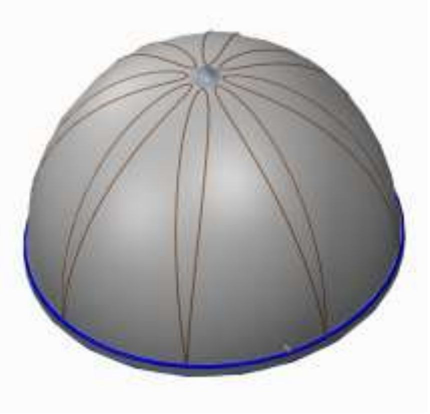
Diameter of the tank = $\sqrt{\frac{2.7513}{\frac{\pi}{4}}}$

= 1.87 m

MODELLING

- *BALLOON*

THICKNESS	DIAMETER
0.005 m	2.3m



BLADE

Blade (mm)	Diameter (mm)
350x150x50	600

DIGESTER TANK

Outer dia	Inner dia	Length right side	Length left side
2.3m	2m	2.5m	3m

ASSEMBLED VIEW

IV. CONCLUSION

Biogas technology has significant potential to mitigate several problems related to ecological imbalance, minimising crucial fuel demand, improving hygiene and health, and thus, resulting in an overall improvement in the quality of life in rural and semi-urban areas. Biogas obtained by anaerobic digestion is a type of bacterial degradation of organic matter that occurs in the absence of oxygen and produces primarily, methane and carbon dioxide. It is evident from the above discussion that efficiency of anaerobic digestion essentially depends on intensity of bacterial activity, which is influenced by several factors such as ambient temperature, temperature of digester material, loading rate, hydraulic retention time, pH value of digester content etc. Therefore, for efficient performance of a biogas plant, it is necessary to regulate all the above factors suitably. The rate of biogas production also depends on the ambient temperature of a particular region. The fluctuation of temperature is very high in northeastern India. During winter, the temperature of the region falls below 15°C, thereby reducing the gas production. Based on the information in published literature, and investigations carried out at IIT Guwahati, a novel duplex model of digester has been designed and developed. This duplex model is found to be very effective to provide a consistent biogas production provided the operating parameters are regulated to the suitable levels.

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