Maintenance Strategies in Biomethanation Plant

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ABSTRACT

The globalisation and libralisation of India economy has build pressure on environment. The black liquor generated during Brown Stock washing contributes more than 80% pollution load and cannot be treated directly in aerobic system, this effluent contains a good source of bio energy, due to good amount of organic biomass it is treated in UASB reactor in absence of oxygen. The state of the art of UASB or biomethanation reactor maintenance is highlighted in the article. The gas liquid solid separator (GLSS) forms an essential part of a biomethanation process or reactor. The article describes the corrosion and other problem and remedy of these problems by the preventive and planned maintenance strategy of GLSS or hood.

INTRODUCTION

Satia Paper Mill is an Agro/waste paper based mill having a capacity of 150 TPD. The pulp mill is equipped with continuous digestor (Pandya type) and Brown Stock washers having a capacity of 100 TPD. The black liquor generated from pulp mill is treated in biomethanation process where methane gas is produced by degradation of black liquor; the produced gas is being used in boilers as a fuel. The biochemical reaction in a UASB reactor takes place in two-reaction zone where upper portion serves as a gas liquid-solid separator (GLSS) device. The GLSS consists of gas dome and setting zone. The reaction zone and GLSS are separated by baffles to guide the gas bubbles in to the zone.

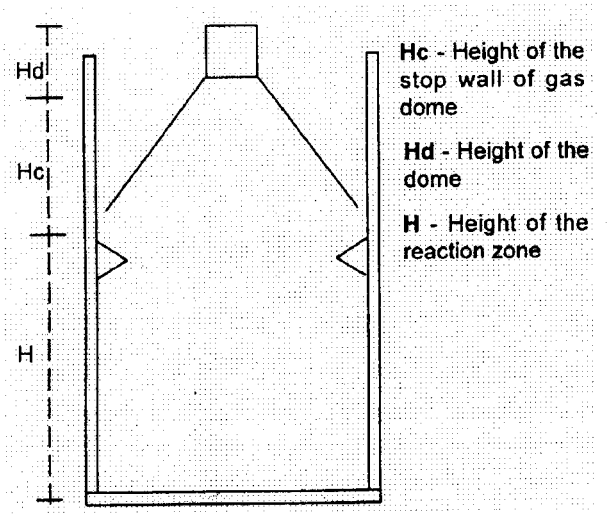

Fig. 1: Gas liquid solid separator layout

The most important features of the UASB concept are mainly for the maintenance purpose, Influent distribution system at the bottom of the reactor. The gas solid separator, which is installed in the upper part of the reactor, Gas piping and recalculation pipe lines. The gas liquid interference area gives the foaming and logging of the gas outlet pipe. Biomethanation is based on anaerobic biological treatment process, the essential component that is needed for maintenance in a UASB plant are as follows:

- An effective equipment of biogas separation called as reactor hood or GLSS.
- Influent inlet network which feeds the waste water in the Reactor.
- Gas piping.
- Recirculation pipe line and inlet pipe line.
- Reactor inlet pump maintenance.

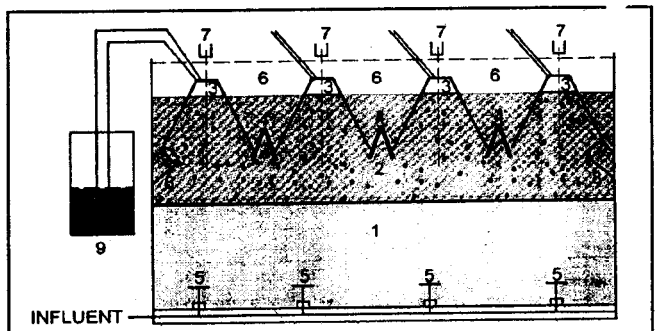

Fig. 2

Structure of GLSS or Reactor hood

Schematic diagram of a full scale UASB Reactor with vertical plates installed Beneath the Gas Collector (1) Sludge Bed (2) Liquid with suspended solid (3) Gas

Bowl (4) Gas Seal (5) Feed inlet distribution system (6) Settler (7) Effluent Launder (8) Gas collector (9) Water Seal.

The reactor hood is mainly constructed of mild steel, It is consisting at upper part of the reactor. The installation of GLSS device in UASB reactor is for effective separation of the biogas from mixed liquor. The design of the GLSS device to some extent will be dictated by the characteristics of the waste water, the type of sludge present in the reactor, the applied loading rate, the expected gas load and the dimension of the reactor.

Maintenance problems

Corrosion

Corrosion of gas piping reactor hood or GLSS recirculation pipe line and inlet pipe network was noticed, after 3 years of operation following to which anticorrosive paint was applied to reduce the corrosion and some of the parts were replaced. Normally the composition of the biogas generated from biomethanation of black liquor constitutes 80-85% methane, 15-20% CO_2 and 1-8%% H_2S. The presence of CO_2 in biogas does not affect the fuel quality. The H_2S causes corrosion problem in the system itself thus reducing the life of reactor hood (GLSS) and pipe line

Bacteria are prominent actor in corrosion of iron and steel in water with an aerobic corrosion being due to sulphate reducing bacteria. H_2S produced by this microbes react directly with iron and cause corrosion forming between the cell iron sulphide and metallic iron. Reducing zone of metallic iron acts as anode towards other area which is connected with oxygen containing area so that dissolution of iron ensures.

Pipe Corrosion by H_2SO_4

When H_2S as a gas or in water comes in contact with air the sulphide is oxidized to sulphuric acid. It often causes destruction of concrete and stone structure even leading to a collapse of the roof of collection sump. The experience with full scale reactor teaches that corrosion can represent a major problem. The biggest problem occurs in the upper part of the reactor where H_2S is oxidized to sulphate by air or oxygen. This can lead to very low local pH value. Both concrete and steel will be affected by this corrosion due to dissolved CaO_2 because Calcium oxide from concrete may dissolve of the presence of carbonic acid and depending on the construction material used, some corrosion at the settler plates may also occur.

Remedy

Corrosion problem can be prevented with corrosion resistant construction material e.g. stainless steel, for which proper coating have to be applied. Removal of H_2S: The removal of H_2S by the metal oxides e.g. ZnO, CuO. Fe_2O_3 etc. are useful in removing H_2S at relatively high temperature. H_2S can be removed at room temperature, mostly by passing through solution containing the appropriate removing agent. Some of the methods used are illustrated here.

Using sponge iron

Sponge iron absorbs H_2S at ambient temperature and can be regenerated by heating the sponge. The drawback in using sponge iron is that it can not be regenerated after a few cycles.

Using silica gel

Highly porous silica gel can be used to absorb H_2S at ambient temperature. The preperative method of silica gel and the regenerating temperature are critical. In this method regeneration of this material releases H_2S.

Using Cu+Ion in the solution

The process of removing H_2S from the gas stream comprises of :

a) Passing the H_2S containing gas through an aqueous solution of Cu++ to convert H_2S to CuS

$$Cu^{++} + S = CuS$$

b) regenerating the Cu++ solution from the CuS by treating with conc. HNO_3

$$CuS + 4HNO_3 = Cu(NO_3)2 + 2NO_2 + S + 2H_2O$$

Using Fe_3 + ION

This method is the based on the principle of reduction of Fe_3 + to Fe_3 + by H_2S. By stabilising the Fe_3 + formed it is possible to use this technique for the process of H_2S removal. Once Fe_3+ is stabilised, it is easy to oxidise it to Fe_3 + by passing air to regenrate Fe_3+

$$2\ Fe_3 + S\ 2- = 2\ Fe_3+ +$$

$$2Fe_3+ + 1/2O_2 + H_2O = 2\ Fe_3+ + 2OH$$

The regeneration of Fe_3 + could be used for the H_2S removal purpose.

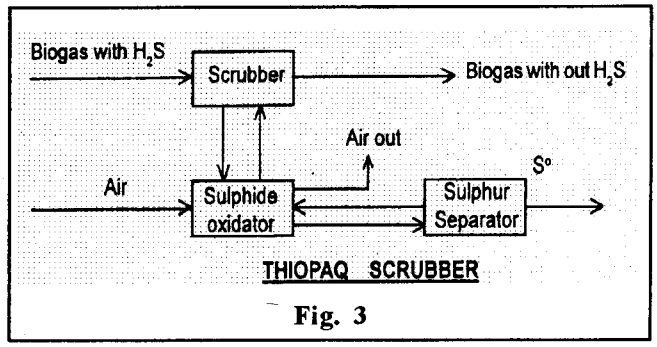

Fig. 3

Purification of Biogas before gas holder

The chemical scrubbing of H_2S from biogas has been found to be expensive. The process has been developed at Wagnening Agricultural University, Neitherland and commercialised by paq at industrial water. This scrubber (Thiopaq) process as it is popularly known is based on

the biological oxidating sulphide into elementry sulphur. In that process sulphur is not formed in the scrubber itself but outside the scrubber. The removal efficiency of H_2S in thio scrubbing process is more than 99% and has high operational sefety as there is no risk of blockage which is advantagious compared to other conventional methods.

Mechanism

1) washing solution -- caustic absorbs H_2S from gas phase

$$H_2S^+ OH^- = HS^- + H_2$$

2) oxidation of sulphide ion in to sulphur by bacteria and regeneration of hydroxides

$$HS^- + 1/2O_{2-} = S^- + OH^-$$

The performance of thio paq system has been highly satisfactory as the H_2S level has been reported to decrease 95 to 98% in biogas after bioscrubbing.

Maintenance strategies in biomethanation

We may try to evolve and implement the various maintenance strategies in biomethanation. The production of biogas is joint venture between operation and maintenance.

The following equipment becomes under maintenance in biomethanation plant.

1. Pumps, 2. Influent pipe line, 3. Gas pipe line, 4. Gas holder, 5. Blower, 6. Hood or GLSS.

For the performance or good efficiency of the plant, good maintenance incorporates following :

Preventive maintenance

Routine maintenance of pumps: In the routine maintenance, the lubrication cleaning and inspection is the first step of maintenance of pumps. This step takes care of small problems before they cause equipment outage, the inspections may reveal deterioration that can be repaired through the normal planned and scheduled work order system.

Preventive maintenance infact should be done on regular basis and following points need to be checked:

1) Drive Motor or Cable joints
2) Electronic Devies like as flow meter
a) Waste water flow meter, b) Gas flow meter
3) Pump bearing lubrication.
4) Pump leakage due to gland.
5) Belt and V Belt
6) Gear box lubrication
7) HCI dosing tank leakages
8) Gas blower
9) Gas leakage (most important for the energy saving and cost effectiveness).

Preventive maintenance is very effective, it is followed religiously. It will avoid break down maintenance and in turn will lead to higher productivity.

Planned/shut down maintenance

The biogas contains H_2S which is most effective for the corrosion. The reactor hood may be damage due to the corrosion and gas pipe line blockage due to the scaling. When we installed a new bio methanation plant, we were using so many anti corrosive paint but after three year of operation again anti corrosive paint was applied to reduce the corrosion according to the equipment condition and some parts were replaced.

a) cheaper item can be replaced keeping their life in to account because the repaired cost can be high and it may lead to a break down.
b) In biomethanation plant, the need to new equipment

Table 1: Daily preventive maintenance & lubrication schedule

Place	Name of the Equipment	Month / Days													
1. Lift Pump	SP 6L Pump No. 1 SP 6L Pump No. 2	1	2	3									29	30	31
2. Feed Pump	SP 6L Pump No. 1 SP 6L Pump No. 2														
3. Floculator Mixtur	Gear Box														
4. Clarifier	Sludge Pump Gear Box														

(Hood, gas pipe line, pump, etc.) is installed as a replacement. Planned maintenance seems expansive but always cost effective. Planning must be made prior to shut down the plant. In Satia Paper Mill the maintenance of reactor hood was done due to the leakage. It is a planned or shutdown maintenance for energy saving.

Benefit of good quality maintenance

The first full scale high rate biomethanation plant based on UASB cofiguration has been successfully working as a congenerating unit of biogas as agro residue based mill and is running successfully for the last five years. The biogas production is 10,000 m^3/day. It is used as fuel and is fired along with rice husk in boiler for the production of steam. The 15 to 20% of total energy requirement of the mill is met by utilization of biogas as fuel in the boiler. Before few days, the leakage of biogas through the hoods was observed which is loss of energy.

Table 2: Effect of biogas utilization on carbon content in boiler ash

	Carbonmatter in boiler Ash (%)
1. Before Biogas Firing	12.8
2. After Biogas Firing	3.20
3. Reduction in Residual Carbon	75.0

Table 3 : Potential bioenergy generation from black liquor of 100 TPD pulp mill

Black liquor flow m^3/Day	2500
Average COD Load MT/Day	53.5
Biogas Generation m^3/Day	10,000
Methane Content of Biogas %	80
Calorific Value of Boigas K Cal/m^3	7000
COD Removal MT/Day	30-40
COD Removal Efficiency %	40-55
BOD Removal efficiency %	75-80

We have done planned maintenance of reactor hood, the good quality maintenance is directly related to environmental pollution and cost effectiveness for the company.

Environmental pollution

When we fire rice husk in the boiler, the unburnt carbon is emitted but when we fire rice husk with biogas the combustion is increased and the efficiency of rice husk is evidenced by around 75% i.e. reduction in unburnt carbon in boiler ash.

CONCLUSION

It has been observed that by adopting the planned maintenance strategy the break down can be minimised with reduction in cost and production can be maximised. The condition monitoring with proper maintenance system helps to improve the running of the plant and prevents expensive break down to a great extent. By adopting planned maintenance strategy, we are able to increase the life of equipment and the production efficiency has also gone up with reduced maintenance cost.

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