Utilizing Industrial and Sanitary Waste Water to Generate Electricity

Jalees Asghar Toor, *Member, IAENG*

Abstract- **A new generation of small scale (less than 20 MWe) biomass fueled, power plants are being developed based on a gas turbine (Brayton cycle) prime mover. These power plants are expected to increase the efficiency and lower the cost of generating power from fuels such as wood. The new power plants are also expected to economically utilize annual plant growth materials (such as rice hulls, cotton gin trash, nut shells, and various straws, grasses, and animal manures) that are not normally considered as fuel for power plants.**
This paper summarizes the new power generation concept with emphasis on the engineering challenges presented by the gas turbine component.

I. INTRODUCTION

Sanitary or domestic waste water contains carbon rich organic matter that can be used as fuel to generate electricity. Anaerobic digestion of waste water sludge is the process that produces methane gas (Biogas) in absence of oxygen, CO2 and traces of other 'contaminant' gases. This gas can be used directly as fuel, in combined heat and power gas engines or natural gas grid injection.Many entities worldwide greatly desire improved and more economic methods for using or disposing of biomass in the course of generating electricity. At present, the amount of useable power being produced from biomass is very small relative to the biomass resources available for this use.

Biomass power plants rely on less efficient boiler/steam turbine technology; have a higher installed price per kWe; and draw on fuel supplies that are bulkier, less homogeneous, and more difficult to fire and handle than fossil fuels (especially relative to oil and natural gas which are not solids).The major reasons for consideration of the biomass power option are:

(1) disposal of biomass residues combined with the production of electricity and heat,
(2) power production from abundant indigenous biomass resources,
(3) power for remote locations rich in biomass resources,
(4) it is a renewable energy option. This option has been chosen for many applications.

Manuscript received December 27, 2016; revised January 16, 2017. The base on the paper is to utilize the waste water sludge as source of renewable energy. The author work out to find almost every possibilities to get the suitable results within his professional expertise and the need of sustainable environment development.
Jalees Asghar Toor, is an Electrical Engineer and working as Operation Engineer in Power and Water Utility Company Marafiq for Jubail and Yanbu.Saudi Arabia, Power Generation Department, Telephone:00966-14396-8578; 00966-590829357;email: toorja@marafiq.com.sa ; jaleesasghar@gmail.com

II. ANAEROBIC DIGESTION

It is a collection of processes by which micro organisms like anaerobic bacteria break down biodegradable material in absence of oxygen.

a-Occurs naturally in some soils and in lake and oceanic basin sediments,where it is usually referred to as "anaerobic activity".
b-The process is used to decompose the industrial or domestic waste and produce fuels.
c-This is the source of marsh gas methane as discovered by Volta in 1776.

Anaerobic digestion is widely used as a source of renewable energy. The process produces a biogas, consisting of methane, carbon dioxide and traces of other 'contaminant' gases. This biogas can be used directly as:

1-fuel, in combined heat and power gas engines.
2-upgraded to natural gas-quality bio methane.
3-The nutrient-rich digestate also produced can be used as fertilizer.

III. WASTE WATER TREATMENT PROCESSES

A. Primary Waste Water Treatment

It is removal of debris and suspended solids by screening and settling.It is removal of debtris and suspended solids by screening and settling

B. Secondary Waste Water Treatment

Using of biological processes to breakdown organic material and remove additional suspended solids mostly use in secondary treatment.

C. Tertiary (most effective)

Advanced treatment that uses additional filtering or chemical or biological processes to remove specific compounds or materials that remain after secondary treatment.

IV. MATERIAL AND METHOD

The treatment of wastewater sludge, from both primary and secondary treatment steps, consists of two main phases.In the 1st step, all incoming flows of sludge are combined, and the mixture is heated to a mild temperature (about body temperature) to accelerate biological conversion. The residence time here ranges from 10 to 20 days.

In the 2nd tank, the mixture is allowed to undergo further digestion. There is no longer active mixing in order to promote separation, and there is no need of heating as the process generates its own heat. In further processes (not shown on the diagram) the settled sludge is dewatered and thickened. The goal is to separate as much water as possible to decrease the volume of material. Finally, a phase known as *sludge stabilization* reduces the level of pathogens in the residual solids, eliminates offensive odors, and reduces the potential for putrefaction

Low calorific value (LCV) gas will fuel the gas turbine. Table I contains the LCV gas composition and Table II contains the LCV gas characteristics as produced .

The block diagram of Figure below shows a pressurized air-blown fluid bed reactor with fuel injection from a biomass pressurization and metering unit. The air is supplied to the reactor from a booster compressor which in turn is fed from the turbine compressor final stage. The product gas is passed through a hot gas cleanup system followed by injection into the turbine combustor. Electricity is produced from the generator which is powered by the output shaft of the gas turbine. One major challenge to overcome in making this type of power plant possible is designing a gas turbine fuel and combustion system that will accept and burn hot LCV gas. An EGT Typhoon gas turbine has been designed to operate on gas of 5 MJ/scm (134 Btu/scf) at a fuel injection temperature of 400EC (752EF)

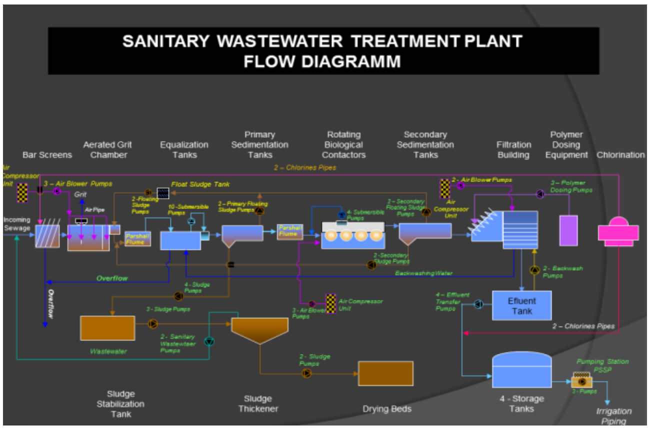

Fig 1: Yanbu (KSA) Industrial and Sanitary Waste Water Treatment Plant, Sanitary Waste Water Treatment Flow Diagram

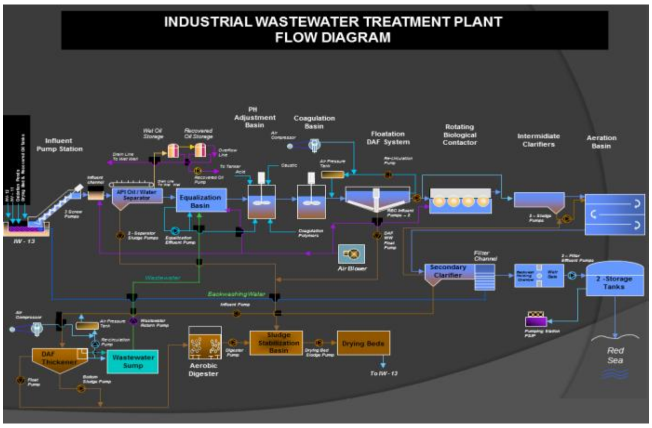

Fig 2: Yanbu (KSA) Industrial and Sanitary Waste Water Treatment Plant, Industrial Waste Water Treatment Flow Diagram

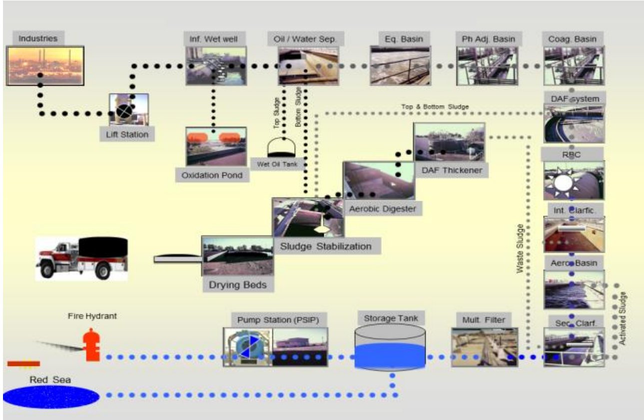

Fig 3: Yanbu (KSA) Industrial and Sanitary Waste Water Treatment Plant, Over all Process View

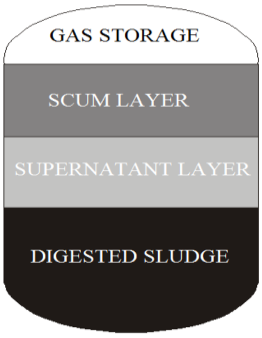

Fig 4: High Rate Anaerobic Digester

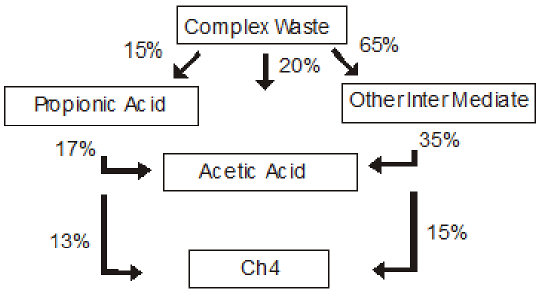

Fig 5: Metabolic Pathways of Anaerobic Digestion

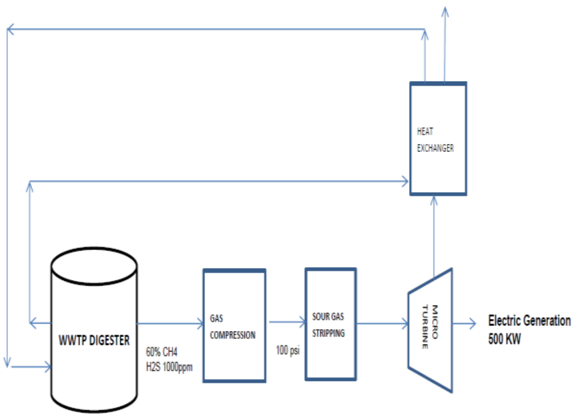

Fig 6: Block Diagram

ISBN: 978-988-14047-7-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Table I : LV Gas Consumption

Components	% mole fractiopn
H2	10.4
CH4	3
C2H4	1
C2H6	0.3
CO	17
CO2	15.3
N2	41
H2O	12

Table II : LV Gas Characteristics

Molecular weight: 26.2
Gas temperature: 700C (1292F)
Chemical energy of gas: 5.18 MJ/scm (139 Btu/scf)
Sensible energy of gas: 1.05 MJ/scm (28 Btu/scf)
Solid particle concentration < 6 ppm with max particle size of 3 μm
Tar content was not measured.

V. RESULTS AND CONCLUSIONS

1. Overall, the process converts about 40% to 60% of the organic solids to methane (CH4) and carbon dioxide (CO2). The chemical composition of the gas is 60-65% methane, 30-35% carbon dioxide, plus small quantities of H2, N2, H2S and H2O. Of these, methane is the most valuable because it is a hydrocarbon fuel (giving 36.5 MJ/m3 in combustion).

2. The residual organic matter is chemically stable, nearly odorless, and contains significantly reduced levels of pathogens.

3. The suspended solids are also more easily separated from water relative to the incoming sludge or aerobically treated sludge (such as in outdoor pond).

REFERENCES

[1] "Standard Methods of Examination of Water & Waste Water" 14th ed, American Public Health Association New York 1976.

[2] "Oxygen Theory in the biological treatment plant design & discussion" By Mueller, James A, Journal Environmental Engineering Division Proceeding American society of Civil Engineer.

[3] "Process Design Manual for Sludge Treatment and disposal" U.S Environmental Protection Agency.

[4] Mina, T., G.S. Robinson, and A. Seamer. “Gas Turbine System Development to Meet the Requirements of a Dual Fuel Biomass/Diesel Oil Application."Proceedings of the Sixth National Bioenergy Conference, p. 463-470, Reno/Sparks Nevada. October 2-6, 1994.

ISBN: 978-988-14047-7-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)