A Study on Small Scale Plasma Gasification of Municipal Solid Waste

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Abstract- *Municipal solid waste (MSW) is one of the major concerns all over the major areas of concern all over the world. MSW commonly known as trash or garbage in us. It is a waste type consisting of everyday items that are discarded by the public. Sources of MSW generated from industries hospitals, Schools, houses and more places.*

Waste Management system (WMS) - a waste management system or waste disposal is a streamlined process that organizations use to dispose of, reduce, reuse, and prevent waste. It is also an approach where companies implement comprehensive strategies to efficiently manage wastes from their origin until their final disposal.

I. TYPE OF SOLID WASTES

- Household hazardous waste (HHW)
- Construction & Demolition Debris
- Industrial / Commercial Waste
- Hazardous waste lamps
- Regulated Medical Waste
- Used Electronic Equipment
- Used Oil
- Waste Tires

Current Municipal Waste Management Methods

- Dumps
- Landfills
- Incineration
- Pyrolysis
- Plasma gasification

Dumps

The simplest, cheapest method of waste disposal is an open dump, which involves piling waste on the ground near the source. Open dumps are sometimes burned to reduce volume and often catch fire as combustibles decompose, producing smoke along with methane gas upon decomposition of organic waste. These dumps are commonly not bottom sealed from chemicals of decomposition leeching into the surrounding water bodies, which are usually close to the communities that fill the dump. Open dumps allow release of the chemicals and decomposition byproducts into the environment. These chemicals often cause health and safety issues for the nearby communities. Higher income countries typically prohibit open dumps. There are many lower income regions of the world where open dumps still exist.

Landfills

Engineered landfills, a more sophisticated type of dump, are typically designed with a bottom lining system and covered or topped every day to minimize pollution released. In European and American landfills, the ground is typically covered with an impermeable or semi- impermeable geomembrane followed by a geotextile and a system of leachate collection pipes laid on top of the geotextile. The leachate collection pipes are then covered in a mineral barrier and finally a drainage layer to allow leachates to reach the pipes. The waste is then laid on top of this liningsystem. The cover is typically made up of the same type of liner placed on top of the waste, withadditional soil on top of the cover. Gas collection pipes are installed to capture the gases produced within the landfill. These gases are collected for use as fuels and typically are composed of 45-55% methane and 40-50% carbon dioxide. Some landfills choose to burn the methane with flares and release methane combustion products directly into the environment.

Incineration

Incinerators for MSW were first built in the US in 1885 as the first level of technology above landfills. This process involves continuously feeding the waste into an incinerator with wasteserving as the fuel source. The trash is burned in a chamber with air continuously injected, allowing for combustion and the high temperature chemical reactions that can form polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and other pollutants. The emissions from MSW incineration often include carbon dioxide, methane, nitrogen oxides, PCDDs, PCDFs,

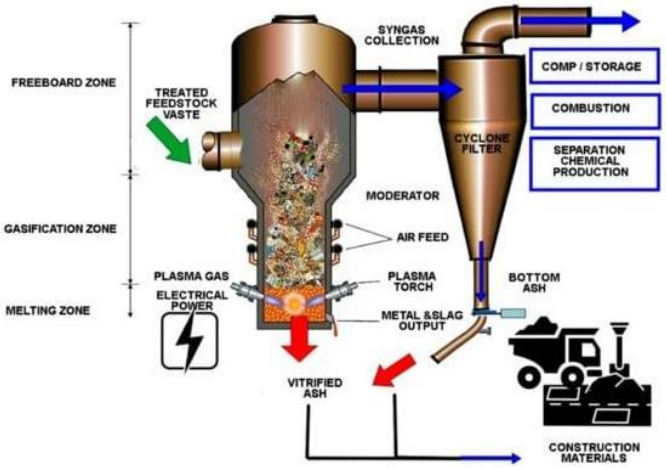
particulate matter including heavy metals, volatile organic compounds (VOCs), and any byproducts formed from the multitude of materials that make up MSW. These systems commonly use air as the source of oxygen for combustion so there is little control over the reactions that form many of the emissions produced during combustion. The byproducts of this process include substantial atmospheric pollution and ash. The ash produced is commonly composed of bottom ash and fly ash, where fly ash includes the fine particles that remain airborne. As MSW can contain anything people throw in the trash, there is a wide range of chemical compounds that can form, which requires extensive emissions controls at each plant. When the Clean Air Act came into effect in 1970, the existing MSW incineration facilities had to either install emission control technology or shut down. In the 1990s, the Maximum Achievable Control Technology (MACT) regulations set forth by the EPA recognizedthe dangers of PCDDs and mercury emissions, resulting in another round of retrofitting emission controls or shutting incineration plants down.

Pyrolysis

One solution to reducing the emissions from incineration is to reduce the concentration of oxygen in the combustion chamber. An oxygen starved high temperature process is called pyrolysis. The byproducts of pyrolysis include a low sulfur liquid similar to fuel oil, char, a fraction of water, and gaseous emissions. This process has reduced gaseous emissions as compared to traditional incineration due to the lack of air in the heated chamber. The gaseous emissions from atmospheric pressure pyrolysis include carbon monoxide, carbon dioxide, hydrogen, C1 to C7 hydrocarbons and small amounts of water vapor and methyl chloride. The composition of the byproducts is approximately 40 wt.% oil, 35 wt.% char, 10% gases and 15% water. The oil produced from pyrolysis is typically used as fuel oil for energy production as the oils are composed of many sizes of molecules and depend highly on the MSW feed material.

Plasma gasification

Plasma Gasification defined as a method in which the raw material molecules are broken down into their elements at elevated temperature and atmospheric or elevated pressures. The complex process mentioned must be carried out in the presence of a gasifying agent as steam, air, O2, CO2 or even mixtures of these. Exposure of the raw material to the substoichiometric oxygen level leads to the production of synthesis gas that mainly involves hydrogen, carbon monoxide, methane, carbon dioxide, branched hydrocarbons, tars, and a negligible amount of nitrogen. This gas has applications, such as combustion in engines to produce electric energy, heat generation, and as a raw material in chemical synthesis, among others. Tars are condensable organic compounds formed in the gasification process. Tar species is a wide range of hydrocarbons that are mainly comprised of single-ring to five-ring aromatic hydrocarbons. Below figure shows more information on the plasma gasification technical aspects.

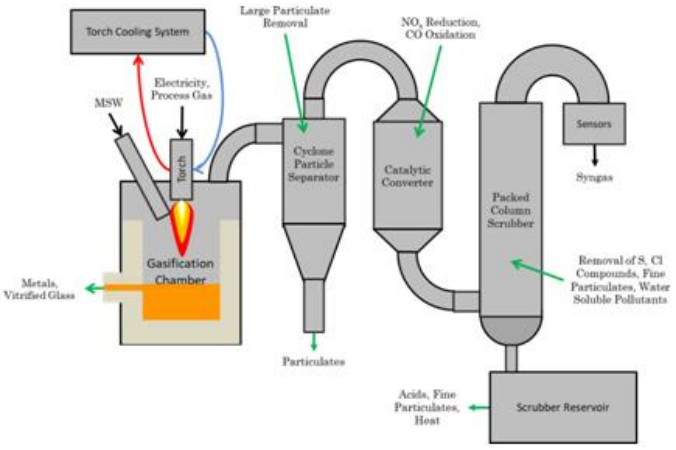


Plasma is composed of high-temperature ionized gases that provide fast and efficient heat transfer. Plasma's ability to transfer calories to incoming organic raw materials allows it to simultaneously pyrolyze them and provide thermal energy to conduct endothermic vapor reform reactions. This double benefit has been implemented with great success in systems such as US Patent No. 5.666.891, showing a variety of particularly useful configurations for arc electrodes. Here, the organic compounds contained in waste are destroyed by pyrolysis, caused by the high temperatures of the plasma breaking bonds in the organic molecules. When introducing steam into the process chamber, these constituents are converted into synthesis gas, a clean-burning fuel that consists mainly of CO, CO2, and H2, through the steam reforming reaction. Other constituents of waste, which do not volatize, are transformed into a molten state, which then cools to form a stable vitrified glass. Controlling the vitrification process, the resulting vitrified glass has stability against chemical and environmental components, with high resistance to leaching of the dangerous components bonded to the glass, showing interesting downstream utilizations.

Plasma is the fourth state of matter and constitutes more than 99% of the universe. It is composed of electrons, ions, and neutrals that are in fundamental and excited states. From a macroscopic point of view, plasma is electrically neutral. However, it does contain free charge carriers and is electrically conductive. Plasma is created by applying power

to a gas to reorganize the electronic structure of species (atoms, molecules) and produce excited species and ions. This energy can be thermal or carried by an electric current or by electromagnetic radiation.

Plasma gasification process schematic.



An overview of waste treatment technologies is provided to show how plasma gasification applied as a waste treatment/materials recovery option has the potential to greatly reduce the emissions and other environmental damage caused by antiquated waste management methods. This project investigates whether a small, low cost plasma gasification system can produce closeto zero emissions with the proper controls. In order to explain the reasoning for the particular emission control systems chosen in this project, a background of air quality regulations is provided. A review of the technologies that are currently in use is also provided to show the relative costs and benefits of each technology and reasons why each may or may not be viable in a small-scale system. With the background in air quality controls, a more detailed description of the plasma gasification system used in this project can be appreciated. The plasma gasification system designed, built, and used for this project includes a gasification chamber, particle separator, catalytic converter, packed column scrubber and a set of sensors to test pollutants passing the emission controls. The tests of the components in this system are discussed, along with recommendations for improvement.

Kankyo Cleantech (India) Pvt. Ltd, Chennai

- Kankyo Cleantech India Pvt. Ltd. was established in 2017.
- Kankyo Cleantech India Pvt. Ltd. operates from Chennai.
- The company is mapped in Mixed Waste Technology Magnoplas, biogas stove, composting machine, organic waste composter, etc.
- Kankyo Cleantech (India) Private Limited is an unlisted private company incorporated on 05 October, 2017. It is classified as a private limited company and is located in Thiruvallur, Tamil Nadu. It's authorized share capital is INR 10.00 lac and the total paid- up capital is INR 1.00 lac.
- Kankyo Cleantech (India)'s operating revenues range is INR 1 cr - 100 cr for the financial year ending on 31 March, 2022. It's EBITDA has increased by 186.18 % over the previous year. At the same time, it's book net worth has increased by 37.31 %.
- The last reported AGM (Annual General Meeting) of Kankyo Cleantech (India) Private Limited, per our records, was held on 30 September, 2022. Also, as per our records, its last balance sheet was prepared for the period ending on 31 March, 2022.
- Kankyo Cleantech (India) Private Limited has three directors - Devanand, Chellappa Sriram, and others.
- The Corporate Identification Number (CIN) of Kankyo Cleantech (India) Private Limited is U74999TN2017PTC118931. The registered office of Kankyo Cleantech (India) Private Limited is at 114, SIDCO AIEMA TOWER, 1ST MAIN ROAD, AMBATTUR,,CHENNAI, Thiruvallur, Tamil Nadu.

It is India’s one of the leading Solid Waste Management company. Established Solution Provider for

- Waste Management in Various segments like Solid Waste Management
- Water & Wastewater Treatment
- Waste to Energy
- Bioremediation and Air Pollutio3
- Control
- Solid Waste Management

Kankyo’s Solid Waste Management System




Kankyo's Plasma Gasification

Kankyo's plasma gasification technology can accept all types of waste. Energy & construction material are Byproducts. The real improvement in gasification has come with introduction of our plasma technology into the process. Plasma in simple language means a eld of intense radiant energy. This could be created by passage of high voltage current b/w two electrodes when plasma arcs like lighting produced. The temperature in plasma gasification chambers may go upto give thousand degrees Celsius. The process is thus capable of disintegrating almost all types of waste materials with exception of nuclear waste. If converts organics to syngas & inorganics to slag syngas produced is cleaner than in conventional gasification process & could be used for power generation after filtering & scrubbing. Slag, the black glassy liquid by product could be used as construction material & be made into concrete, bricks, paving stones or insulating rock-Wool. These products are unreachable & thus there is no fear of their adding to pollution of any bind during use.

INCINERATION

- Oxidizing reaction
- Temperatures 850°C - 1200°C
- Excess air for complete combustion
- CO2, H2O and heat

GASIFICATION [PYROLYSIS]

- Reducing reaction
- Temperatures 400°C - 900°C
- Air < stoichiometric air [Pyrolysis - thermal decomposition in absence of air]
- CO, CO2, H2 H2O CH4 and some heat
- Partial combustion provides heat to sustain process

PLASMA GASIFICATION

- Reducing reaction
- Temperatures 1500°C - 5000°C
- Air < stochiometric air
- CO, CO2, H2 H2O CH4 and heat
- Requires electricity input (1200 – 1500 MJ / tonne of waste), 15% - 20% of gross output energy

EMISSIONS

PARA METERS	UNITS	USEPA STANDAR DS	EPA STANDA RDS	PLASMA EMISSION
NOX	ppmvd	150	250	35-40
PM	Mg/dscm	20-24	34	<5
SO2	ppmvd	30	55	<2
HCL	ppmvd	25	15	<10
CO	ppmvd	100	40	<20
Hg	Micro g/dscm	50-80	55	<2
PCDD/PCDF	Nano g/dscm	13-30	25	0

SLAG -EPA's TCLP Limits and Compliance of Plasma Technology

METAL	PERMISSIBLE CONCENTRATION (MG/L)	MEASURED CONCENTRATION (MG/L)
Arsenic	5.0	**<0.1**
Barium	100.0	**<0.5**
Cadmium	1.0	**<0.02**
Chromium	5.0	**<0.2**
Lead	5.0	**<0.2**
Mercury	0.2	**<0.01**
Selenium	1.0	**<0.1**
Silver	**5.0**	**<0.5**

II. CONCLUSION

Plasma gasification/ vitrification is a technologically advanced and environmentally friendly method of disposing of waste, converting it to commercially usable by-products. This process is a drastic non-incineration thermal process, which uses extremely high temperatures in an oxygen-starved environment to completely decompose input waste material into very simple molecules. The intense and versatile heat generation capabilities of plasma technology enable a plasma gasification/ vitrification facility to treat a large number of waste streams in a safe and reliable manner.