PLASMA GASIFICATION

INTRODUCTION

Concern for the environment is increasingly affecting the way we live our lives, and the way we manage our waste has become a major issue.

The considerable increase in the quantity of waste materials generated by human activity and their potentially harmful effects on the environment, have led to an increasing awareness, worldwide, about an urgent need to adopt safe disposal methods.

Today, we are still depositing around 70% of household waste and significant quantities of commercial waste in landfill sites - waste which should either be recycled or potentially put to good use as an energy source.

Landfills not only damage the environment but represent a clear waste of resources as energy becomes an increasingly expensive commodity.

It is obvious that the best method is minimization of wastes generation and maximization of their reuse and recycling.

But the technologies for recovery of energy from wastes will play a major role in mitigating the problems in the future.

Besides of energy recovery, the modern waste utilization technologies will lead to a substantial reduction in the overall waste quantities requiring final disposal.

Most of the Municipal Solid Waste (MSW) is a mix of industrial, household, yard & street wastes containing organic as well as inorganic matter.

The energy present in the Organic Fraction of the MSW can be basically recovered through the following methods:

- Thermo-chemical conversion (Incineration – Pyrolysis - Gasification) - to produce either Syngas, Heat Energy or Liquid Fuel; and
- Bio-chemical conversion (Anaerobic Digestion or Bio-Methanation - Alcohol Fermentation) - to produce Biogas or Alcohol.

The thermo-chemical conversion processes are useful for wastes with very low moisture content.

GASIFICATION

Gasification is a process that has actually been used for many years and involves converting complex organic molecules and carbon, in both the liquid and solid state, to simple gases.

Most of the gases produced are flammable and are therefore used as fuel in processes or applications where flammable gases are required.

The conversion of solids and liquids to gas is usually accomplished by heating the solid, or liquid, in either the presence of very small amounts of air or no air at all. When no air is used the process is called pyrolysis or destructive distillation.

Although gasification is really an old technology, until the invention of plasma gasification in 1995, it was a process that had its fair share of problems and drawbacks.

PLASMA GASIFICATION

Plasma gasification is a technologically advanced and environmentally friendly process of disposing of waste materials converting them to commercially usable by-products.

Plasma is considered a 4th state. It utilizes established technology to convert a wide range of non recyclable wastes into energy in the form of a hydrogen rich syngas.

In plasma gasification the waste is fed to a reactor vessel where electrically generated plasma at a temperature of 14'000 to 20'000 ºC is present.

Plasma is formed by passing an electrical discharge through a gas. Under normal circumstances gases will not conduct electricity, but when a very high voltage is applied the insulating properties begin to break down. As electricity starts to flow through the gas it heats up and it begins to conduct more, it becomes so hot that plasma is formed.

When the waste is exposed to the plasma, it is heated to a high temperature of above 2'000 ºC. This heat causes the organic compounds in the waste to dissociate into very simple molecules such as hydrogen, carbon monoxide, carbon dioxide, water vapor and methane.

These simple molecules in gaseous form are then continuously flowing from the plasma gasifier gas treatment (cooling and cleaning equipment) plant.

Ash and other inorganic material present in the waste are melted down to a complex liquid silicate and metals that flows to the bottom of the plasma gasifier vessel.

The intense and versatile heat generation capabilities of plasma arc technology enable a plasma gasification facility to dispose of all waste (including municipal solid waste, biomedical waste and hazardous waste) in a safe and reliable manner.

The by-products of the plasma gasification process are a combustible gas (syngas) and an inert slag. Plasma gasification consistently exhibits much lower environmental levels for both air emissions and slag leachate toxicity than competing technologies.

Emission and leachate results demonstrate convincingly that plasma gasification represents a far more environmentally friendly method of disposing of waste than does any competing technology.

The syngas from plasma gasifier has a low to medium calorific value, and is therefore suitable as the fuel for a gas fired power & heat generation applications.

Metals that are present in the waste also melt and flow to the bottom of the plasma gasifier vessel, where they can either mix with the silicate, or if present in a large enough quantity, float on the bottom of it as a separate layer.

The liquid melt is allowed to flow continuously from the vessel to a water quench where the liquid silicate melt is cooled to a non leachable, non toxic, obsidian like solid silicate.

Some metals are not melted. Instead, they vaporize and pass out of the plasma gasifier vessel with the gases formed by the organic material. When they enter the cooling equipment for the gases, they condense to fine metal particulates.

Halogen and sulphur compounds present in the fuel are converted to hydrogen halides and hydrogen sulphide, and pass out of the reactor with the other gases.

The plasma gasifier is a refractory lined vessel with the carbon electrode and electrode control equipment mounted at the centre of the vessel roof.

On entry into the plasma gasifier the syngas is forced to swirl around the chamber allowing the maximum amount of time for the gas to be exposed to the high temperatures and intense ultra violet light of the electrode arc before exiting through a refractory lined duct for further processing.

The ash and chars are also treated in the plasma gasifier becoming a molten product which is continually removed, cooled and processed into a recyclable aggregate. Simplified schema of plasma gasifier is shown in the following Figure 1.

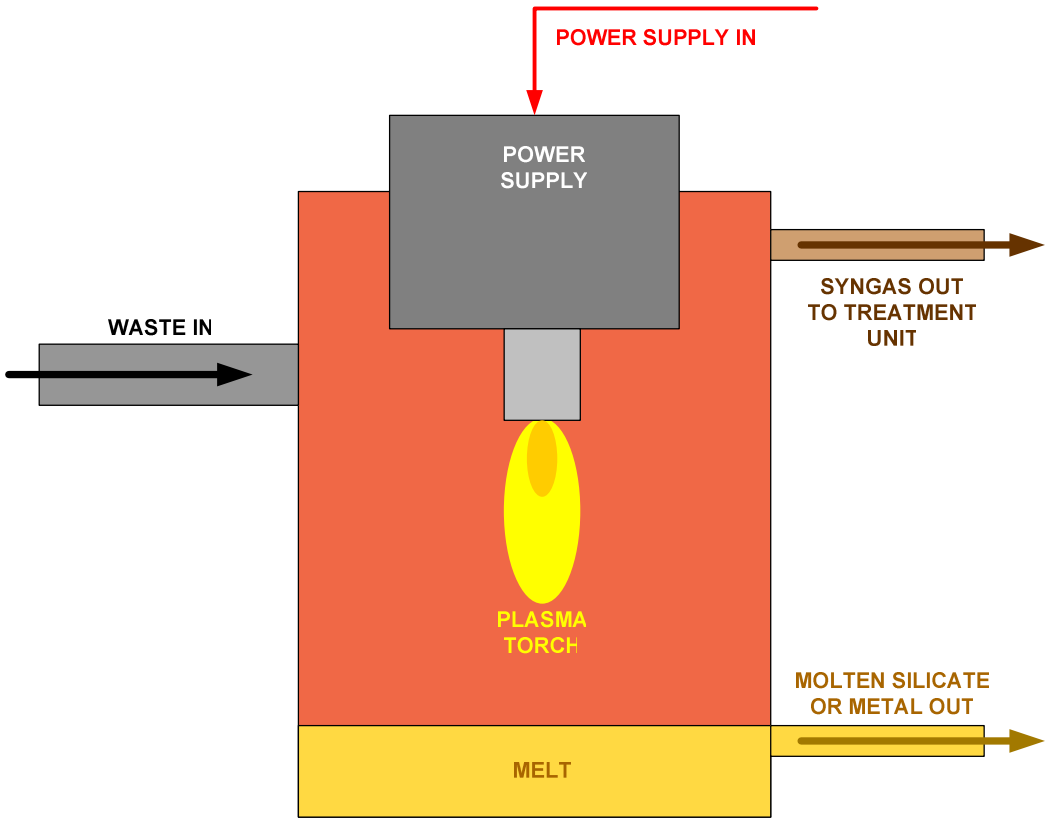

Figure 1 Simplifies Schema of Plasma Gasifier

After leaving the plasma gasifier vessel, the syngas is very hot (>1'200ºC) and still contaminated with a number of undesirable compounds, such as hydrogen chloride and metal particulates, that can cause damage to machinery and the environment.

The syngas is therefore cooled-down and cleaned in the process equipment.

The cleaned syngas, similar in quality to natural gas but of lower heating value, is then fed to syngas storage facility. The most typical use of the syngas is as fuel for power and/or heat generation.

SYNGAS PRODUCTION – POWER GENERATION

A typical block diagram of a plasma gasification system combined with power generation is shown in Figure 2. This identifies the major components of the plasma gasification and power generation (CCGT) equipment.

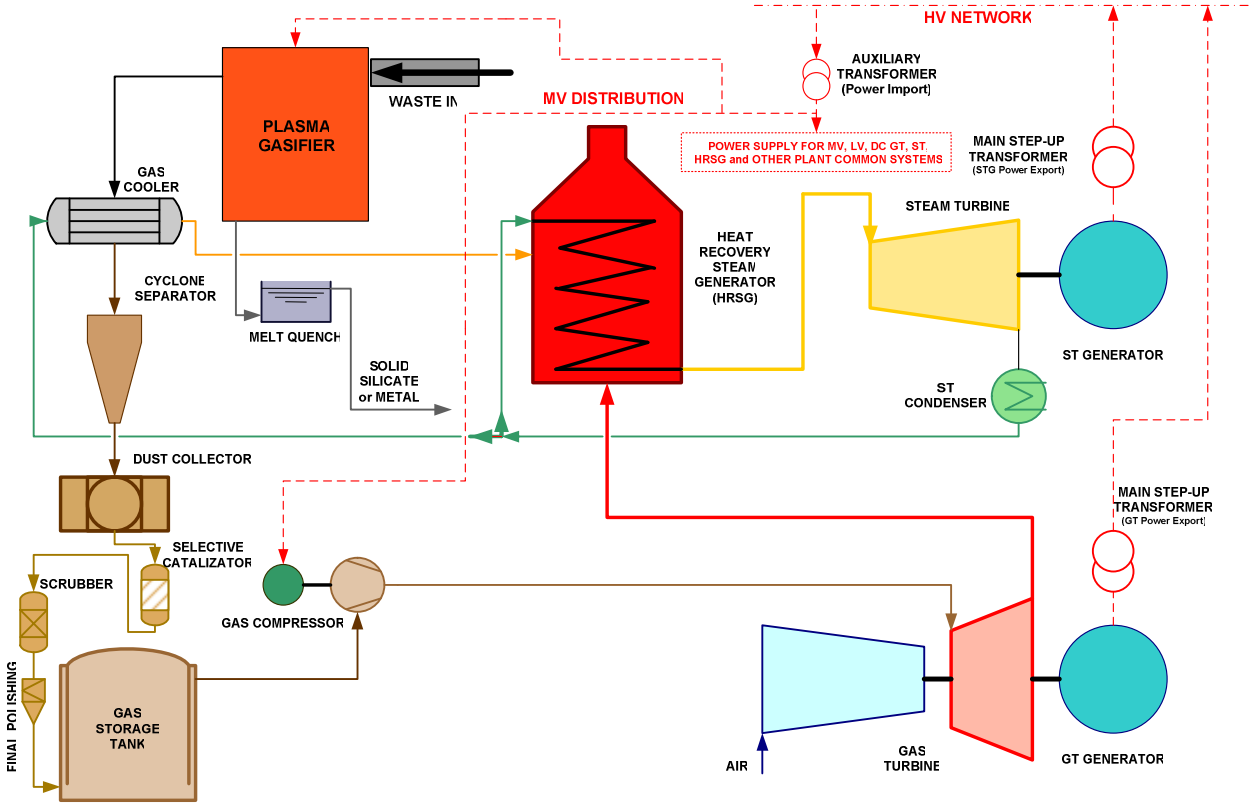

Figure 2 Typical Flow Diagram – Plasma Gasification for Power Generation

The gas cooler is required to reduce the temperature of the syngas for processing purposes, and also to stop the formation of dioxin by de-novo synthesis.

The hot syngas exits from the plasma converter at approximately 1'200 ºC and is then cooled in a water tube heat exchanger to reduce the gas temperature to around 200ºC.

During this process, energy is recovered in the form of low-pressure steam and a proportion of the steam is used in power- & heat generation process.

The cyclone and the dust collector (multiple-stage gas filter) remove the majority of larger and small particulates that are carried over with the syngas.

Due to the high temperature in the plasma gasifier vessel, nitrogen compounds react to form oxides of nitrogen. These unwanted compounds are removed by selective catalysator.

In the packed column scrubber, acid gases such as hydrogen chloride are removed by dissolving them in water or a caustic solution.

Any particles remaining in the gas are also removed in the scrubber.

The final syngas polishing, before storage and/or direct utilization is done in the activated charcoal gas polishing plant.

Electric power can be exported to the HV transmission & distribution network.

SUMMARY

Benefits of plasma gasification technology can be summarized as follows:

- Plasma gasification provides for efficient and sustainable waste solution (i.e. with no pollution problems) for all types of waste streams, including wastes with high moisture contents, municipal solid waste (MSW), hazardous wastes, and even radioactive waste, which delivers tangible economic and environmental benefits.
- The main product, the syngas, can be used for power and heat generation.
- Plasma gasification does not produce hazardous bottom ash and fly ash.
- Plasma gasification technology is well proven with more than one hundred plasma gasification plants worldwide.
- The most efficient way is the combination of syngas production with combined cycle gas turbine power generation.
- Syngas can be also efficiently used in trigeneration application (simultaneous production of electric cooling and heating energy).
- Syngas can be also used for ethanol production.
- The silicate produced in plasma gasification is non leachable and non toxic, and therefore has re-saleable value.
- Metals which are easily recoverable from plasma gasification process can be collected and recovered for further use.
- Hydrogen sulphide in the plasma converted gas can be extracted from the syngas and can then be converted to elemental sulphur.
- Comparing to classic gasification, the plasma gasification process produces fewer emissions and treats certain types of waste better.
- The remaining solids are entirely the inert fraction of the waste, typically resulting in a 125:1 volume change for municipal solid waste.

- Plasma gasification technology is more expensive, comparing with classic gasification process. However, under consideration that the plasma gasification technology produces valuable syngas and byproducts (silicates, metals, sulphur) the overall economics for plasma gasification is better than classic gasification in many situations, even though the capital cost is higher.
- Plasma gasification consistently exhibits much lower environmental levels for both air emissions and slag leachate toxicity than competing technologies. Emission and leachate results demonstrate convincingly that plasma gasification represents a far more environmentally friendly method of disposing of waste than does any competing technology.
- The extremely high process temperature decomposes any organic toxins in the waste (Polychlorinated Biphenyls –PCB-, dioxins, etc.).
- A plasma gasification plant can be constructed on a reasonably small site. For example, plasma gasification plant which can handle around 300 ton MSW per day can be can be constructed on a 100m x 100m site.