Analysis of Thermal Plasma - Assisted Waste-to-Energy Processes

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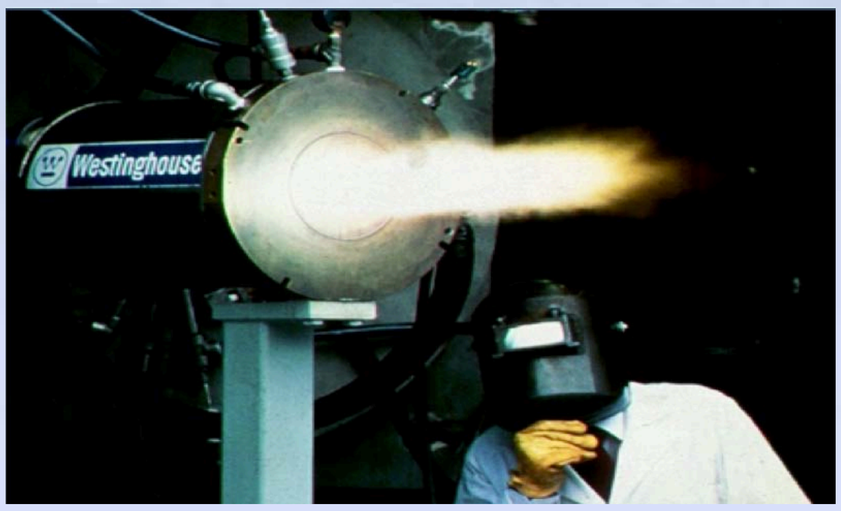
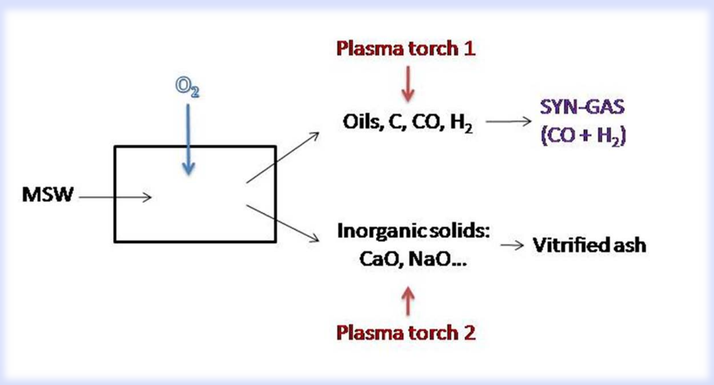
In the last decade, plasma technology has been applied to the treatment of municipal solid waste (MSW). This study examines the potential for some of the thermal plasma processes under development to compete with the dominant grate combustion technology, with regard to a) energy recovery *> 600 kWh of electricity per ton of MSW*
b) capital cost *< $600 per annual ton of capacity*.



Overall process

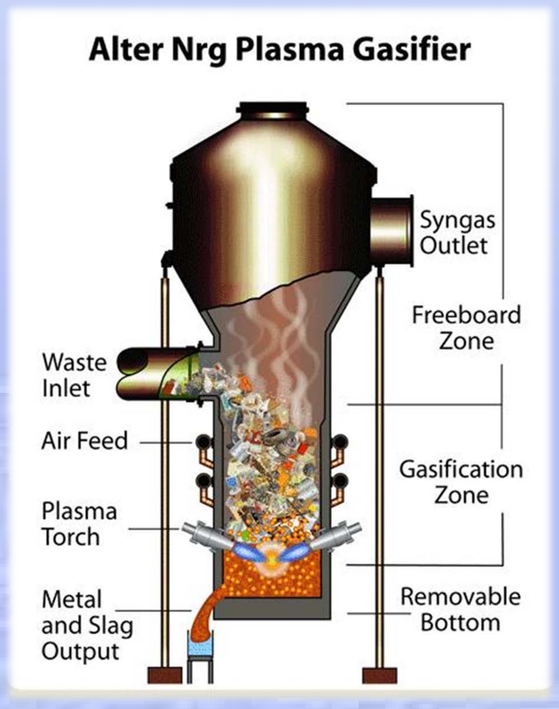
Two plasma-assisted processes are currently developed:
• Combination of plasma torch and partial combustion to gasify the combustible fraction in MSW and vitrify the inorganic fraction. This type of process is the Westinghouse Plasma Corporation process of Alter-NRG.
• Partial oxidation of the waste with air or oxygen, followed by the use of two small plasma torches to "crack" the syngas and vitrify the slag. This type of process is developed by Europlasma (http://www.europlasma.com/) in France, InEnTec in the U.S., and Plasco (http://www.plascoenergygroup.com/) in Canada, as seen in picture below.



The WPC process of Alter-NRG

The Westinghouse Plasma Corporation process was bought by Alter NRG (http://www.westinghouse-plasma.com/).

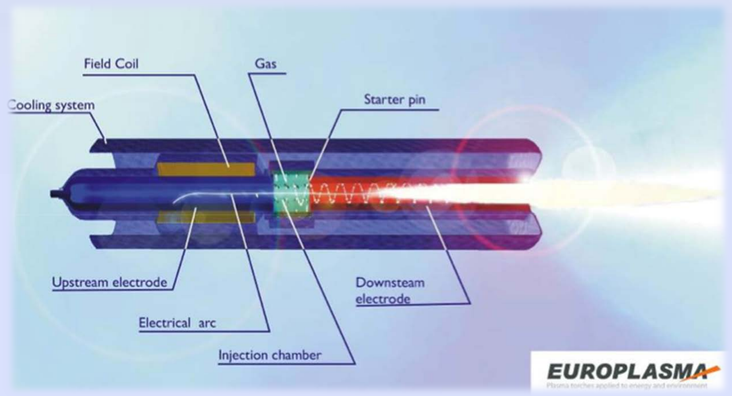
The process uses a gravity-fed cupola where the heat for gasification is provided by the plasma torches and also partial combustion of the MSW. Syngas exits at the top of the cupola and is quenched and then passes through an air pollution control system. The molten slag and metal exit at the bottom of the cupola.
Metallurgical coke (4% by weight of MSW) is also fed to the gasifier and forms the "bed" on which the MSW rests as it is gasified. The process can use wide range of feedstock.



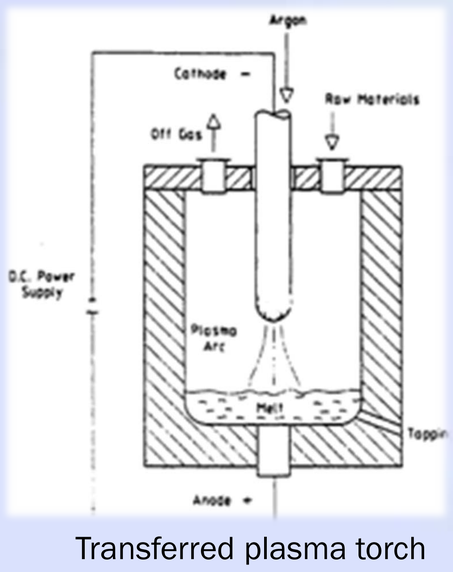
Plasma, called the "fourth state of matter", is a mixture of electrons, ions and neutral particles. The plasma plume can reach temperatures up to 5000°C and break down any chemical bond.

Plasma Torches

Plasma torches are of either the "transferred" or "non-transferred" arc type. Most of the torches used in WTE processes under development are of the non-transferred type, where electricity is transformed into thermal energy by means of electric discharges between two electrodes. The torch body is water cooled.
In a transferred arc plasma, electricity is converted to heat within the gas column between the graphite torch and the molten slag/metal bath beneath it. The graphite pipe is gradually consumed and needs to be replaced.



Non-transferred plasma torch



Transferred plasma torch

The two steps of the overall process can be described as follow:
• *Gasification by means of partial combustion with oxygen (assuming no reactor heat loss):*
$C_6H_{10}O_4+3O_2 = 3CO + 3CO_2+ 4H_2 + H2O + 1300$ *kWh per ton of MSW*
• *Gas turbine combustion (assuming no turbine heat loss):*
$3CO + 4H_2 + 3.5O_2 = 3CO_2 + 4H_2O + 1500$ *kWh*

The InEnTec process of WMI

InEnTec (http://www.inentec.com/), has developed a plasma-assisted system for gasifying MSW and other solid fuels. It is composed of three units:
• a downdraft gasifier where most of the gasification takes place
• a Plasma Enhanced Melter where the remaining carbon char is gasified and the ash/metals are melted by means of a plasma torch.
• a Thermal Residency Chamber designed to free the syngas of hydrocarbons.