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The Plasma Method for Waste Treatment

Cultural Concern

For years, much attention has been directed at environmental issues. Many developing industries are now following “green”-oriented policies. New generations are becoming more aware of their responsibilities to protect the environment. Government agencies are supporting research and development for new sources of energy that are environmentally friendly. The waste-treatment industry in particular is concerned with environmental issues. Recycling and composting, for example, are important common everyday practices. The ways in which society handles waste has significant implications for lifestyles and living standards. The government may be used to discourage waste generation; i.e. there may be limits to the amount of garbage allowed per household.

Many large organizations are associated with the waste industry. Government institutions and private industries are actively searching for innovative and effective programs to deal with waste. An appealing solution is Plasma Waste treatment.

Problems of Landfills

In the early period of waste management, especially in the United States, there was little consideration for the long-term consequences of dumping waste in landfills; rather, officials focused on what was most economic. According to recoverednergy.com, the average person in the United States generates 2-5 lbs of waste/day. Over years, large amounts of waste accumulate in landfills and subsequently contaminate the environment. Nearby cities and towns are significantly affected. Ground water and acquifers, for example, are contaminated; biodegradable waste decomposes to produce global-warming gases such as methane in the air. As a result, government officials have to spend more money to maintain environmental safety standards and to transport waste to other domestic or foreign landfills. Despite increasing recycling and compost programs, the problems of current landfills remain. In an attempt to solve these problems, society is now looking for long-term stability that may be found in more environmentally-friendly alternatives.

Plasma Waste Treatment

Plasma waste treatment utilizes plasma arcs, which use powerful electrodes of opposite charges that pass electrical energy. An electric arc is generated between the tips of electrodes to break molecular bonds and produce an ionized gas. This ionized gas is called Plasma; it consists of ions and free-roaming electrons at temperatures between 3,000 to 7,000 degrees Celsius. Plasma arcs which shoot the plasma from a nozzle are called plasma torches. At these high temperatures, waste is broken down into elemental gas and solid waste. Through secondary treatments (discussed below), the elemental gas can be released to the atmosphere, and the solid waste can be utilized as a resource. In principle, following the plasma waste treatment, there is no leftover waste for transport to landfills.

Notable advantages of Plasma waste treatment include: any type of waste (except heavy radioactive or nuclear waste) is treatable, and requires no or minimal pretreatment; more than 99 mass % of Carbon-based waste is broken down into Hydrogen gas and Carbon Monoxide, as shown in Figure 1; gases produced by the process can be used to vaporize water into steam that can then be utilized to produce electricity to power the Plasma treatment system; therefore, the Plasma system uses self-sustenance as its main source of power. Molten solid and gas byproducts can also be salvaged as fuel sources, materials for roads, and recycled glass-like insulation material.

Organic Waste → Syngas

$$C + O_2 \rightarrow CO_2$$

$$C + H_2O \rightarrow CO + H_2$$

$$CO + H_2O \rightarrow CO_2 + H_2$$

$$CH_4 + H_2O \rightarrow 3H_2 + CO$$

$$Cl_2 + 2H_2 \rightarrow 2HCl + H_2$$

Figure 1: Chemical Reactions in Plasma Waste Treatment

Basics of Plasma Treatment Process

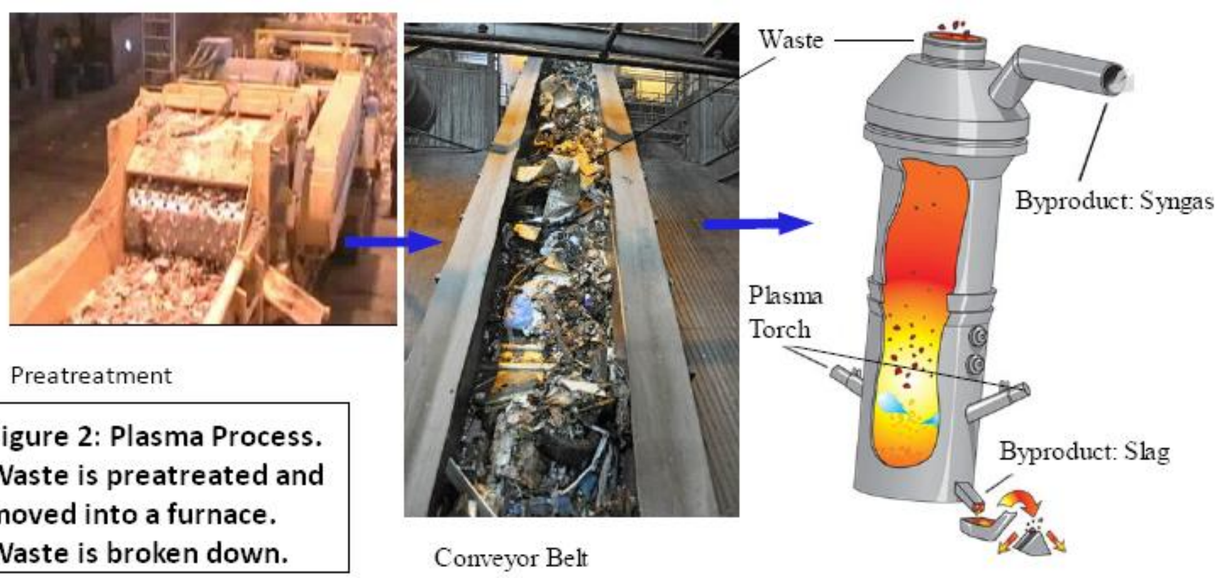

Figure 2: Plasma Process. Waste is preatreated and moved into a furnace. Waste is broken down.

As shown in Figure 2, waste first enters the system by a conveyor belt. Pretreatment is optional. If waste is appropriately sorted into categories i.e. by metallic or organic material; and reduced to a small, evenly distributed size by a shredder the waste can be treated at a much faster rate. From the conveyor belt, waste is placed into a vacuum furnace, where torches or powerful electrodes of opposite charge produce a highly ionized gas (Plasma). Unlike combustion, there is no burning. Organic material is broken down into elemental gas, syngas (Figure 1), a mixture of several gases but most abundantly of Hydrogen and Carbon Monoxide. The inorganic and metal substances melt to a small fraction (~5%) of the initial volume and combine to form molten solids, or slag. Slag and syngas are separated by ventilation and drainage systems, where optional secondary processes are applied. For example, Figure 3 shows potential secondary processes for syngas. Many Plasma Torch systems include an Afterburner that applies natural gas flames to burn the organic material in syngas. Syngas enters this secondary chamber, and combusts. The hot gases may subsequently enter a gas-turbine system, or enter a steam generator, where water is vaporized. The steam or gas can pass through turbines to produce electricity that can be used to power the electrodes used in the Plasma torch. The amount of electricity produced depends on the amount of entering syngas, the extent to which the syngas is combusted, and on the efficiency of the turbine system. Although the combustion process is not essential, this "recycled" electricity is used as the primary source of power for many current Plasma systems.

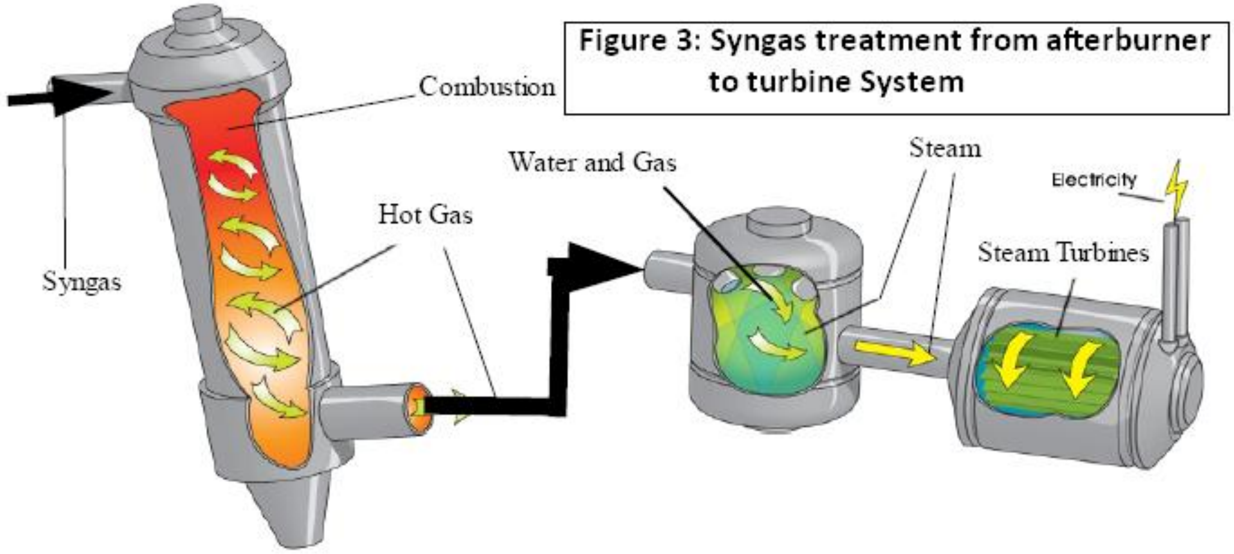

Figure 3: Syngas treatment from afterburner to turbine System

Alternatively, before release into the atmosphere, syngas and afterburner gases may experience further treatment. There may be a chamber, for example, where water can be used to scrub out some pollutants and harmful particulates. A subsequent filter system can neutralize acids (i.e. HCl) in the syngas, and may allow gaseous components to combine and produce salts. For afterburner gases, a dry scrubber using powdered carbon can strip away poisonous gases such as mercury. Fabric filters can subsequently remove remaining harmful particulates such as lead.

There are several potential treatments of slag. Slag may be air-cooled to form a rock-like material for concrete or asphalt. Similarly, water-quenching can produce glass-like fragments for roads. Metals can be filtered and subsequently recycled for other purposes for construction or for making automobiles.

A notable alternative treatment blows compressed air over the molten slag. A light, gray material called Rock-wool is produced. Rock-wool is an efficient insulation material and absorber, and is less dense than water. Rock-wool has many potential applications, i.e. it can be used to control oil spills. Many of these products contribute to the economic viability of Plasma treatment. For many of these processes, the hazardous components are kept to a minimum. For example, exposure to toxic material and pH limits are controlled.

Case Study: Utashinai, Japan

A commercial Plasma-torch plant in Utashinai, Japan was built in 2002. The initial projected rate of waste treatment was 170 tons of waste per day; however, currently, the facility runs at a capacity of about 300 tons of waste per day. Using several of the secondary processes noted above, the plant also generates 7.9 Megawatt; about half of the electricity is sold, and the other half is used for self-sustenance. Three plants already exist in Japan. Due to Plasma treatment's current overall success, future facilities are planned for several countries including the United States, China, and the United Kingdom.

Future Policies and Long-term Effects

Waste treatment is essential to maintain our standard of living. Plasma treatment has only recently been shown more economic than landfills. Government policies may subsidize waste transportation to Plasma treatment plants. Alternatively, mobile Plasma plants can travel to landfills. Because of numerous optional secondary processes and because there are different types of plasma torches, there is no standard model for Plasma treatment plants. Regrettably, this lack of uniformity may deter potential investors. Inevitably, there is also opposition from skeptics, those afraid of change, and those who benefit from the status quo. However, as society continues to require new, alternative waste-treatment methods that provide long-term benefits, Plasma waste treatment merits consideration.

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