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Plasma Technology to Convert Waste

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ABSTRACT: Very hot plasma is formed by ionized gas (i.e. Oxygen, under normal pressure) in the strong electrical arc with the power ranging from 2 to 20 Mega Watts. Temperature of such plasma is very high, ranging from 2 to 6 thousand degrees Celsius. In such high temperature all waste constituents, including metals, toxic materials, silicon, etc. are totally melted forming non-toxic dross. Plastic, biological and chemical compounds, toxic gases yield complete dissociation (required minimal dissociation temperature is in the range of 1500 degrees Celsius) into simpler gases mainly H₂ and CO₂. Simpler gases, mainly H₂ can be used as ecological fuel to generate heat energy and electrical energy decreasing significantly (even to zero) cost of plasma formation and waste utilization. Regained metals from dissociation process can safely return to metallurgic industry, and slag can be used as an additive to road and construction materials. The utilization of municipal waste using this method does not cause the emission of foul odours and does not produce a harmful ash, which is something that normally takes place in an incinerating plant..

KEYWORDS: Plasma torch, Instrumentation, Safety, Control, Waste management, Slag

I. INTRODUCTION

At the most basic level, a plasma waste converter is a plasma torch applied to garbage. A plasma torch uses a gas and powerful electrodes to create plasma, sometimes called the fourth state of matter. Plasma is an ionized gas; in other words, it's a gas with free-roaming electrons that carries a current and generates a magnetic field. On Earth, we can see natural displays of plasma fields in lightning. The temperatures generated by a plasma torch can be hotter than the surface of the sun (more than 6,000 degrees Celsius). At these temperatures, garbage doesn't stand a chance. Molecules break down in a process called molecular dissociation. When molecules are exposed to intense energy (like the heat generated by a plasma torch), the molecular bonds holding them together become excited and break apart. What's left are the elemental components of the molecules. With cyanide, for example, you'll end up with atoms of carbon and nitrogen.

Organic molecules (those that are carbon-based) become volatilized, or turn into gases. This synthetic gas (syngas) can be used as a fuel source if properly cleaned. Inorganic compounds melt down and become vitrified, or converted into a hard, glassy substance similar in appearance and weight to obsidian. Metals melt down as well, combining with the rest of the inorganic matter (called slag).

Unlike incinerators, which use combustion to break down garbage, there is no burning, or oxidation, in this process. The heat from plasma converters causes pyrolysis, a process in which organic matter breaks down and decomposes. Plasma torches can operate in airtight vessels. Combustion requires oxidation; pyrolysis does not.

II. COMPARISON WITH INCINERATOR

Plasma waste converters can treat almost any kind of waste, including some traditionally difficult waste materials. It can treat medical waste or chemically-contaminated waste and leave nothing but gases and slag. Because it breaks down these dangerous wastes into their basic elements, they can be disposed of safely. The only waste that a plasma converter can't break down is heavy radioactive material, such as the rods used in a nuclear reactor. If you put such material in a plasma furnace, it would probably catch on fire or even explode.

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use combustion to break down garbage, requires oxidization for incinerators. In the case of plasma torch there is no burning, or oxidation. The heat from plasma converters causes pyrolysis, can operate in airtight vessels, requires no oxidization, can treat almost any kind of waste.

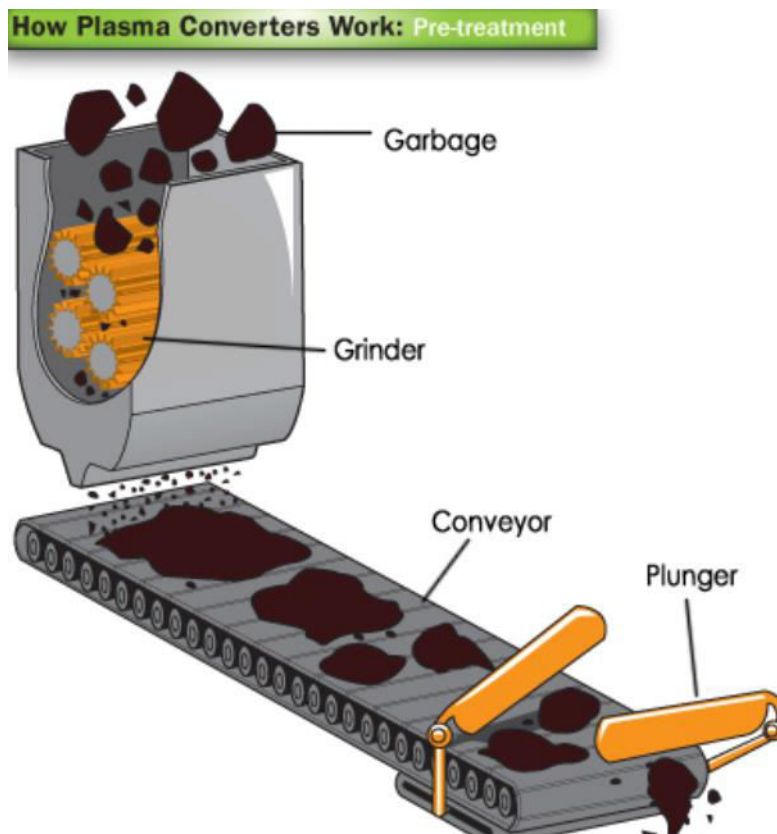
III. THE ANATOMY OF A PLASMA CONVERTER

Currently, plasma plants aren't standardized. Many different companies are designing plasma facilities, and for the moment each facility is essentially custom-built. Still, most converters have the following components in common:

Conveyor system

In order to feed garbage into the converter, almost all plasma facilities have a conveyor system. Garbage is loaded on the conveyor and is pushed into the furnace (or pre-treatment system if the plasma facility uses one) by a plunger.

PRE-TREATMENT MECHANISM



Although a plasma torch can break down waste without any special pre-treatment, most plasma facilities employ some sort of pre-treatment process to make the entire system more efficient. Some designs use grinders or

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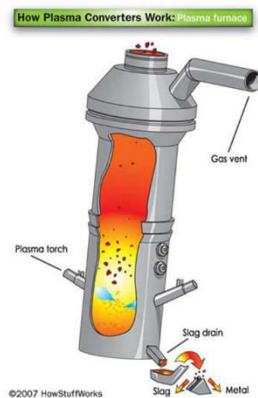
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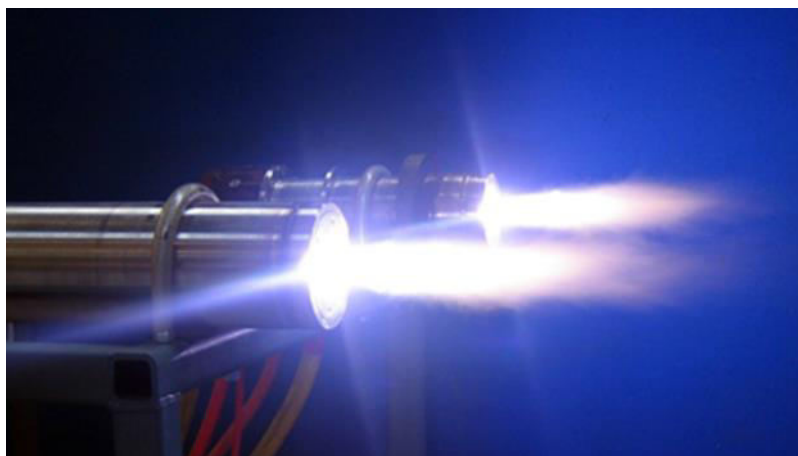
crushers to reduce the size of the individual pieces of garbage before moving in to the furnace. The plasma torch can break down the smaller pieces faster.

Furnace



Here's where the magic happens. Furnaces have an airlock system to allow garbage to come in while preventing the hot gases in the furnace from escaping into the atmosphere. The furnace houses at least one plasma torch; many furnaces have multiple torches to break down all the matter. These torches are usually placed a little lower than halfway down the furnace. The furnace also features a drainage system to tap off the slag as it accumulates and a vent system to vent out the gases. In order to withstand the intense heat, furnaces are lined with refractory material and often have a water-cooling system as well.

PLASMA TORCH



The plasma torches used in these facilities are custom-built. The amount of energy they consume, the lifespan of the electrodes it uses, the gas used for ionization (most torches just use ordinary air), the downtime it takes to replace an offline torch and the size of the plasma field it generates all depend on the specific manufacturer. Plasma torches are water-cooled.

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Slag drainage

Molten slag pools at the bottom of the furnace and helps maintain the high temperature inside the gasification chamber. Occasionally slag must be drained from the furnace. Some furnaces have drains positioned at a certain height, others use a tap system. Either way, slag drains away from the furnace and cools in a separate chamber.

Gas ventilation

The furnace also has a vent system to allow gasified components to pass into another part of the system (either an afterburner or a gas cleaning chamber).

Afterburner

Gases can pass through a secondary chamber where natural gas flames combust any remaining organic material in the gases. These extremely hot gases then pass through a Heat Recovery Steam Generator (HRSG) system, where they heat water to form steam. This steam then turns a steam turbine to create electricity.

Syngas cleaning

Alternatively, the gases from the furnace enter a chamber where they are cooled and scrubbed, usually by water. The gases pass through a spray of water, which scrubs the gases of pollutants and particulates. A filter system containing a base filter neutralizes acid gases. The acids in the gases and the bases in the filter combine to form inert salts. The cooled and clean gases continue through the system, which in most cases involves a gas turbine connected to an electricity generator. Some systems also harness the heat from these gases to generate steam, similar to the afterburner method mentioned above.

If the plant uses an afterburner, the remaining gases must be cleaned thoroughly to get rid of any hazardous material. Many designs include a dry scrubber system. In this system, powdered carbon is injected into the gases to strip away mercury, a poisonous element. Gases also pass through a fabric or bag filter to remove any other dangerous particulates, like lead. Once the gases have been cleaned they move to the stack, where they are released into the atmosphere.

Byproducts of the Process

There are three main byproducts that are a result of the plasma gasification process: synthetic gas (syngas), slag and heat. Let's look at each of these byproducts in more detail.

Syngas is a mixture of several gases but mainly comprises hydrogen and carbon monoxide. It can be used as a fuel source, and some plants use it to both provide power for the plant and sell excess electricity to the power grid. Garbage contains a great deal of potential energy; the gasification process enables engineers to convert the potential energy into electrical energy. How much gas is generated by a plasma converter? That depends on what you put into the furnace. If the garbage contains a lot of carbon-based material (in other words, organic waste), then you'll get more gas. Waste with a lot of inorganic material won't yield as much gas. Because of this, some plasma facilities sort through garbage before feeding it into the system.

IV. PLASMA CONVERTER CHALLENGES

First, they are a new technology. New technologies are expensive. Until very recently, land costs were so low that it was cheaper to use landfills than to build and maintain a plasma waste facility. Environmental concerns often take a back seat to economic realities. Any major revolution in waste management faces critics and opposition from those that benefit from the status quo. As environmental pressures increase city and county governments are more willing to explore alternate strategies to handle waste.

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V. THE FUTURE OF PLASMA CONVERTERS

In-situ facilities .One method is the creation of a portable plasma gasification system to treat existing landfills without building an entire plant. Instead of a stationary furnace and gas treatment facility, it is suggested to create boring holes into existing landfills, sticking a plasma torch into the hole, and capping the hole with a gas capture system. The landfill itself would act as the furnace vessel. Since plasma gasification is not a combustion process, the landfill contents would either gasify or vitrify, with no danger of fire.

Co-location with existing power plants .Another option is the co-location of the plasma gasification chamber with a pre-existing power facility. Coal and oil power plants use the same processes as plasma plants to treat gases and generate power. The gases from the plasma furnace would combine with the gases in the coal or oil furnace. The relatively clean gases from the plasma furnace would help boost efficiency and reduce the amount of coal or oil needed to generate power.

Decontamination .The intense heat from plasma torches can completely neutralize the hazardous components found in diseased livestock or contaminated soil. Incineration of such hazardous material doesn't always destroy all the contaminants, or produces ash that is also hazardous waste. Plasma gasification would destroy or render inert any harmful material

VI. CONCLUSION

Plasma method utilizes efficiently all four types of hazardous, toxic or lethal waste because of high temperature, capable of disassociating molecular bonds.

Plasma waste utilization method takes place in a close system, without releasing ashes, waste remnants, dusts and toxic gases into environment.

Regained metals return to metallurgic industry and created slag is used as an additive to road construction materials.

Non-toxic gases, which are created, are stored in special containers (gas cylinders) and used as fuel and energy creators. Plasma technology allows converting large quantities of municipal waste in the range of 10 to 500 tons a day.

This method of waste reduction is the only method available to reduce electronic waste, which does not undergo biodegradation.

The costs of using plasma technology are significantly reduced as a result of creation of ecologic by-products.

Contaminates in slag and gases created during plasma utilization with elements such as mercury, cadmium, sulphur, SO₂, HCL, dioxins, selenium, chromium, lead, barium, arsenic, radioactive elements are strictly controlled by usage of special water or dry scrubbers and filters.

Using this method elements are considerably minimized below environmental standards.

The remainder of the pollutants sink into glassy slag and can be treated further in close system, which is a major distinction to conventional incineration.

The ashes that are formed as a result of conventional incineration can be burned down to further using plasma technology to make them harmless.

Contemporary plasma converters are computer controlled, safe, quiet and can be stationary or mobile.

Plasma waste utilization will improve public health and safely achieve "total and irreversible destruction of hazardous and toxic compounds", "lethal viruses, bacteria and prions that are so dangerous to our health."

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