PLASMA TECHNOLOGY

Toxic waste is a serious problem for many countries, worldwide. Until the middle of 1980’s waste combustion was widely considered to be the basic method of environmental protection. As a result, the industry of incineration plants and various installations was born. These traditional combustion furnaces lead to further atmospheric pollution with waste such as heavy metals containing ash, soot, sulphur and nitrogen oxides, chlorine compounds and dioxins.

This has triggered the search for alternative technologies requiring less costly purification systems – plasma technology.

Plasma, also called the *Fourth State* of matter, is an ionized gas at high temperature capable of conducting electrical current.

Lightning is an example from nature.
Applications of Plasma Technologies

- Environment/Waste treatment
- Energy Sector
- Plasma Chemistry
- Plasma Metallurgy
- Plasma Processing of Materials
- Construction Materials Technologies
- Manufacturing of Nanomaterials

Plasma arc technology offers a unique opportunity to achieve the “zero waste” goal by providing the capability to eliminate the need for land disposal of many hazardous wastes either in a furnace or in a reactor and also, to recover energy from municipal solid wastes and other organic wastes while producing salable byproducts and eliminating requirements for landfilling of ash or other residual materials.

The main element of plasma technology is a plasma arc torch. A plasma torch uses gas or steam and powerful electrodes to create plasma with a temperature up to 5000 C°, which allows for full decomposition and disintegration of organic components. The same temperatures are capable of melting various non-flammable inorganic components.
Benefits of Plasma Technologies

The main benefits of plasma technologies compared to traditional furnaces can be summarised as:

- Significant waste destruction with the simultaneous decrease of the exhaust gas volume
- Much higher degree of control of the process
- Much lower weight and dimensions of the reactor and the whole installation
- Higher safety
- Less residual waste
- Universality for different type of waste
- Cost competitive
- Environmentally friendly
- Produces no harmful emissions or toxic waste/Slag
- Production of clean alloyed slag which could be used as construction material
- Meets regulatory requirements worldwide
- Produces energy and value - added products
- Simple to operate and requires low maintenance
Plasma Technology Remediation Experience

- Heavy metals
- Radioactive wastes
- Industrial sludges
- Municipal solid waste
- Electric arc furnace dust
- Liquid/solid organic wastes PCB’s
- Asbestos
- High toxic chemical wastes
- Medical wastes
- Plastics
- Used tires
- Other

Plasma technology for treatment of hazardous wastes such as:

**Heavy metals**

**Radioactive**

**Asbestos**

**Medical**

**Highly Toxic Chemicals**
There is a great scorching problem in contemporary, fast growing society: creation of huge amount of noxious wastes which are dangerous to natural environment.

Ecology: Plasma Chemical Pyrolysis and Vitrification of Various Waste

- Safe treatment and disposal of medical and bio wastes
- Processing of organic waste (including waste that high toxic compounds –CWA, its precursors and degradation products
- Treatment and disposal of toxic waste using plasma reactors, including agricultural, defence and industrial waste
- Residual materials (radionuclides, heavy metals, etc.) immobilized in a rock-like vitrified mass which is highly resistant to leaching
- Plasma processing of toxic fly ash originating in waste incinerators and fuel-burning power plants
- Recycling solution for used tires with hydrocarbon production that is to be reused
- Energy production through processing of Municipal Solid Waste (MSW) is effective for furnaces with a capacity to process more than 5 tons of waste / hour
Characteristics of Plasma Technology

- Plasma acts as a resistive heating element that cannot melt and fail
- Produces temperatures of 3000°C to over 7000°C
- Torch power levels from 50kW to 200 MW produce high energy densities (up to 100 MW/m3)
- Torch operates with most gases – not a combustion process
- Elimination of requirement for combustion air
- Reduces gas volume requiring treatment
- Reduces potential for formation of complex organics (i.e., dioxins and furans)
Waste-to-Energy conversion has two objectives:

1 – Disposal of waste by a process to significantly reduces the volume of the waste before final disposal to a landfill or as building material

2 – Recovery energy from the waste that could be used to produce electricity

Plasma technology is the most favorable solution to generate energy from wastes

Waste Destruction Applications

- Melting and vitrification of inorganic materials
- Pyrolysis of organic materials
- Molten metal or glass bath provides heat transfer
- Heat causes breakdown of complex materials into elemental components
- Rapid quenching prevents complex compound formation (dioxins and furans)
- Water gas shift reaction to remove carbon: \( C + H_2O \rightarrow H_2 + CO \)
- Gaseous products are fuel and simple acid gases
- Vitreous residue is resistant to leaching – suitable for aggregate

Recent Applications

- Mixed waste treatment facilities (USA)
- Medical waste vitrification facilities (USA)
- Incinerator ash vitrification facilities – Europe and Japan
- Plasma Arc Shipboard Waste Destruction System (PAWDS)
- U.S. Navy Warships (NSWCCD)
- Plasma Arc Hazardous Waste Treatment System (PAHWTS)
The development of waste-to-energy plants has increased over the last 30 years because of the need to dispose of growing amounts of solid waste and a need to find sustainable energy sources.

- U.S. Naval Base, Norfolk, VA (Office of Naval Research, Environmentally Sound Ships Program)
- Plasma Ordnance Demilitarization System (PODS)
- Naval Surface Warfare Center, Crane, IN (Defense Ammunition Center)
- Plasma Waste Treatment System (Pyrotechnics and Energetics)
- Hawthorne Army Ammunition Plant, NV (Armament Research and Development Engineering Center)
- Plasma Energy Pyrolysis System (PEPS) Demonstration
- Facility (Medical Waste and Blast Media), Lorton, VA
- U.S. Army Construction Engineering Research Laboratories (CERL)
- Mobile PEPS Demonstration System, U. S. Army CERL
General Process Diagram
Plasma Waste Treatment
Needs for universal and mobile destruction technology

- Large varieties of toxic chemicals (precursors) and reaction masses (waste)
- Remote location
- Absence of commercial waste treatment facilities
- Limited technological and technical capabilities
- Limited timeframe and finance
Hotzone Technologies
Mobile Hazardous Materials Treatment Unit

- Modular design: can be shipped and assembled from parts
- Small footprint: fits standard 20 feet general purpose shipping container
- Final technological scheme can be adjusted to the user specific requirements
- Can be powered from the grid or by diesel generator for complete operational independence

Standard 20-foot shipping container, that can be transported by a trailer to desired location
Flexibility

The MHMTU has been configured and optimised for the destruction and conversion of:

- Solid and/or liquid waste
- Medical waste
- Radioactive waste
- Industrial sludge
- Chemical waste, including: PCBs, mineral oils, plastics, heavy metals, asbestos, pesticides, highly toxic chemicals such as Chemical Warfare Agents (CWA), Toxic Industrial Materials (TIM) etc.

Hotzone Solutions mobile system MHMTU is modular and compact: It can be delivered in parts/modules which, completely assembled, fit into a 20 feet general purpose shipping container. The plant can be mounted on a mobile platform and transported for use at the waste collection point.

Modular and Compact System.
Can be delivered in parts, modules or completely assembled
MHMTU Technological Concept

System designed to provide full and easy access to all pieces of equipment for operations and maintenance.

1- Air Compressor  2 - Plasma Reactor  3 - Burning Chamber
4 – Plasma Torch  5 – Power Supply  6 – Scrubber
7 – Ion Exchange Filter  8 – Smoke Stack  9 – Scrubber Solution Tank
10 – Radiator  11 – Water Supply  12 – Tank with Waste
## Direct Current Plasma Torch Power Design

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Consumed current, A:</td>
<td>110 – 210</td>
</tr>
<tr>
<td>Supply voltage, V:</td>
<td>200 – 320</td>
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<tr>
<td>Power, kW</td>
<td>50</td>
</tr>
<tr>
<td>Total plasma forming gas (air) consumption, m³/h</td>
<td>15 – 18</td>
</tr>
<tr>
<td>Plasma flow temperature, °C</td>
<td>4050–4750</td>
</tr>
<tr>
<td>Efficiency</td>
<td>75%</td>
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</tbody>
</table>

*Torch design extensively tested under several simulations and waste feed compositions*
## Counter Flow Plasma Reactor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity at treated raw material, kg/h</td>
<td>8,0–50,0</td>
</tr>
<tr>
<td>Effective capacity, kW</td>
<td>35–40</td>
</tr>
<tr>
<td>Compressed air consumption on quenching m3/h</td>
<td>~100</td>
</tr>
<tr>
<td>Reactor outlet plasma flow temperature, depends on waste composition: °C</td>
<td>120–500</td>
</tr>
<tr>
<td>Outlet gas speed, m/s</td>
<td>14.7</td>
</tr>
<tr>
<td>Outlet gas amount, m3/h</td>
<td>1265</td>
</tr>
</tbody>
</table>

Plasma unit contains special equipment to control all technological parameters such as:

- Plasma torch power, plasma forming gas consumption, waste consumption, quenching air consumption and others
- Air pressure for plasma unit supplied by autonomous air compressor with fine filter and air-preparation unit. Waste materials are loaded and dispersed by pneumatic injector.
- After burning and cooling of exhaust gases is in the three section quenching module by addition air supplying. Temperature in gas purification system is 150 – 520 °C
Portability of the unit (reactor, gas purification module, supply modules and control system are placed in shipping container) provides ease in transport, minimize installation work.

It also allows correcting technological parameters of the unit to adapt it to any special conditions (waste composition and consumption).
Modular off-gas treatment facilitates operations and maintenance.

Off-gas Treatment

Scrubber – Dust, Acid and Gas

Ion Exchange Filter
Plasma Kiln for Solid Wastes

System Flexibility:

The MHMTU concept provides flexibility to treat different types of wastes – solids and liquids.
Summary

- Depending on the decision taken all chemicals and wastes may be disposed on-site using mobile equipment without complicated transportation of aggressive/toxic chemicals for long distance to the stationary industrial facility.

- Hotzone Solutions Group, Kronenburg and Format MK are able to produce new fully integrated Mobile Hazardous Materials Treatment Units, which can be customized to customer's requirement and purposes.

For more information, please contact:

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