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Plasma Arc Torch Technology

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PLASMA ARC TORCH TECHNOLOGY

THE NEED

For many years, in-situ thermal vitrification has been recognized as one method to remediate contaminated soils and help stabilize land fills. However, the complexity of the process and the uncertainty of the results have limited the use of this remediation technique. Major technological advances in plasma arc technology now permit the in-situ transformation of all soil, rock, and waste types into vitrified, rock-like material, similar to obsidian, that is durable, strong, and highly resistant to leaching.

THE TECHNOLOGY

A plasma is a gas that has been ionized by the electric arc of a plasma torch and can therefore respond to electrical and magnetic fields. Plasma arc technology can create plasma using almost any type of gas (oxygen, nitrogen, carbon monoxide, air, etc.) and in a wide range of pressures (vacuum to 20 atmospheres). The flame of the plasma torch is actually an energized arc, similar to lighting (see Figure 1).



FIGURE 1 PLASMA ARC SYSTEMS' ABILITY TO EFFECTIVELY TRANSFORM WASTE INTO INERT END-PRODUCTS

The plasma arc has a wide spectrum of temperatures ranging from 1500°C to over 7000°C, or approximately 1000°C hotter than the surface of the sun. The plasma arc torch uses copper electrodes to create a non-transferred arc. The plasma torch and electrodes are water-cooled and the average life of the electrodes ranges between 200 to 500 hours of operation. A DC power supply unit provides the electrical requirements





of the torch and commercial units are available in power levels ranging from about 100 KW to 10 MW capacity.

Conceptually, a plasma arc torch can be lowered into a borehole to any depth and operated to melt contaminated materials into a type of magma or lava, which cools into a zone of vitrified material. Subsequently, the plasma torch is slowly raised and operated at progressively higher levels to thermally convert a mass of soil into a vertical column of vitrified and remediated material called slag. It can be left in place on the landfill to seal the site, or more garbage can be piled on top. The vitrified material can also be removed and used as gravel in roadway projects, molded into products like bricks or used as concrete aggregate. Gases released through devolatilization or combustion reactions will be able to move freely to the surface through a subsidence zone and open pipe for treatment. Water, CO₂, and air are expected to be the predominant gases released during processing. At sites containing significant organic matter, H₂ and CO are also produced. Thus, secondary combustion of these gases would be required within the remediation process. Because process similarities, the plasma remediation technology appears to be easily adaptable to existing ISV off-gas technology.

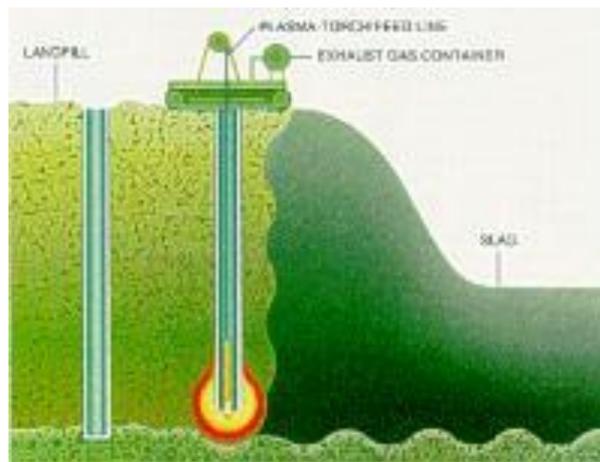


FIGURE 2 PLASMA TORCH MAY BE A SOLUTION TO LEAKY AND OVERFLOWING LANDFILLS

THE BENEFITS

The process of plasma remediation of in-situ materials could provide a rapid, highly efficient, cost-effective, reliable and simple controllable technique to selectively melt, vitrify and remediate essentially any contaminated or buried volume of soils, materials or objects at any depth underground. It appears to overcome most of the limitations present with thermal vitrification techniques using fossil fuels and electric heat sources.



The much higher temperatures, greater flexibility, simplicity of use and the high efficiency of the plasma torch makes it a viable means of in-situ thermal vitrification for contaminated soils and burial pits (mixed wastes and contaminants such as hazardous/toxic waste, heavy metals and low level radioactive wastes, organics, concentrated waste sediments and sludges, sanitary landfills, radionuclides, underground storage tanks) by applying the technique over a systematic grid pattern.

The consolidation and remediation process could extend the life (to an average of 100 years) of landfills and increase by a factor of five the capacity by melting solid waste down (Plasma arc technology reduces landfill volume to one fifth of the original size or by 80%, the remaining 20% is the glassy by-product). Another very important benefit is that it is a promising tool for melting asbestos fibers converting them into safe material.

The plasma torch offers two to three times the heating value of fossil fuels with less air or oxygen and far fewer emissions and, these can be collected and used as fuel-grade gas. The process is about 90 percent efficient in energy usage. Plasma heating systems can be placed on flatbed trucks for a mobile configuration. It complements in-situ vitrification (ISV) technology by overcoming several ISV limitations. It is readily adaptable to the existing equipment developed by DOE for the ISV program permitting rapid commercialization. It has the potential to fundamentally improve current industrial and commercial concepts of buried waste remediation in terms of effective treatment, reduced cleanup time, and significant cost savings.

STATUS

The technology has begun to emerge as a commercial tool in the waste disposal sector as well as other industries such as steelmaking, and precious metal recovery. France and Japan are already using the plasma torch for waste and ash disposal. Major research programs for the study of the basic science of plasma heating and development and implementation of models and prototypes for different applications are being conducted around the world (U.S., Japan, Canada, Russia, France, Switzerland).

BARRIERS

Cost and public approval are presently a barrier to wide acceptance. Apparently the commercial success will be tightly linked to legal authorization to reuse the vitrified end-product. However, there is no way to estimate the long term effect and neutrality of such material. The cost-effectiveness of in-situ plasma remediation will be highly dependent on several variables relating to site location, geological conditions, and the type of plasma torch system used for the process. The economics of the process are currently its biggest drawback for landfill utilization. Pyrolysis (using the plasma torch) is still about twice as expensive for municipal waste, but for biologically or chemically hazardous waste is about the same cost.



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REVIEWERS

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