Inductively Heated Plasma for Waste Treatment

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Technology abstract

High enthalpy plasma sources have originally been developed for testing heat shield materials used for space reentry vehicles, to characterize the hostile environment during reentry flight or for electric space propulsion. Such plasma sources have been miniaturized successfully and can now be used for decentralized inductively heated plasma waste treatment systems.

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Plasma Wind Tunnels using high enthalpy plasma sources have been developed over decades and are widely used in space systems engineering. Plasma Pyrolysis is a known method for waste treatment. Its use is still limited by the lack of availability of qualified plasma sources.

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Technology Description

Plasma sources have been in development at the Space Systems Institute (IRS) of Stuttgart University for decades. Typical applications are emulating atmospheric entry for the qualification of heat shield materials (in so-called plasma wind tunnels) or electric space propulsion. High-power steady-state Magneto Plasma Dynamic (MPD) sources (max. 1 MW), thermal arc jets (max. 100 kW), hybrid systems, e.g. TIHTUS (max. 300 kW) and inductively heated plasma sources (IPG) are developed (max. 200 kW). Pulsed MPD and thermal plasma sources are also developed.

For space propulsion, a benefit is created from the fact that electrical energy is fed to the propellant such that significantly higher exhaust velocities can be achieved in comparison with chemical propulsion given that an adequate acceleration technology (based on electro-hydro-dynamic or magneto-hydro-dynamic effects, based on thermal expansion, or a combinations of the three) for the propellant is applied.

Some of the sources can solve problems for terrestrial applications. In the past decade, plasma-coating processes, treatment processes for turbine blades such as plasma shock peening were assessed on the basis of the plasma technologies at IRS. This also led to the development of corresponding inductively coupled plasma sources and associated advancements and miniaturization e.g., by Concept Evolutions in cooperation with Baylor University.

Plasma-based decomposition, in general, is a theme with rather widespread specific applications. However, the plasma sources used are almost as diverse as the respective applications. Dielectric barrier discharges are in use, e.g. for pesticide degradation, decomposition of dichlorobenzene or NOx removal. For inductively coupled plasma sources (ICPs), applications come from either high energy density and/or high-power requirements due to, for example, high mass flow rates of waste. The classical application for spectral analysis is still a valid option as well. However, the plasma-based treatment of wastes is a clear focus.

Innovations & Advantages

Using plasmas for waste treatment offers numerous advantages in comparison with conventional thermal treatment methods. First of all, plasma provides high mass specific enthalpies and therefore, high heat flux densities and temperatures (thermal plasmas can reach temperatures of up to 20,000?C, whereas only 2000?C can be achieved by burning fossil fuels). This allows rapid heating and reactor start-up, rapid shutdown times and high heat and reactant transfer rates. In addition the required size of an installation for a given waste throughput is significantly smaller than for conventional incinerators. Furthermore, the temperature generated by plasmas makes the melting of high temperature materials and the destruction of toxic molecules possible. Due to both the high temperatures and the high temperature rates organic material can be reduced in volume by more than 99% after the release of ultraviolet radiation. And finally, the steep thermal gradients in the reactor facilitate high quench rates (> 106 K/s). This enables the generation of non-

equilibrium compositions or metastable materials.

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Further Information

Reference: Environmental Technology, 2014 (http://dx.doi.org/10.1080/09593330.2013.875066), ?Inductively heated plasma waste treatment for energy recovery?, Authors: G. Herdrich, S. Schmalzriedt, R. Laufer, M. Dropmann and R. Gabrielli, Concept Evolutions UG (limited liability), Am Glockengarten 6, Esslingen, 73733, Germany.

Current and Potential Domains of Application

High enthalpy plasma sources have originally been developed for testing heat shield materials used for space reentry vehicles, to characterize the hostile environment during reentry flight or for electric space propulsion. For space propulsion, a benefit is created from the fact that electrical energy is fed to the propellant such that significantly higher exhaust velocities can be achieved in comparison with chemical propulsion. Some of the plasma sources solve problems for terrestrial applications. In the past decade, plasma coating processes, and treatment processes for turbine blades such as plasma shock peening were assessed on the basis of the plasma technologies at IRS. This also led to the development of corresponding inductively plasma sources and the respective advancements and miniaturizations e.g., by CE in cooperation with Baylor University.