Application of Plasma Arcs for the Pyrolysis of Mixed Solid/Liquid Waste Material

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The Naval Research Laboratory (NRL) is investigating the application of plasma arc technology for the on-board remediation of waste material generated by sea faring ships. A 100 kW transfered arc torch has been set up at NRL for research on the pyrolysis of liquid and solid material. The operation of this demonstration torch will be presented. The scientific challenge lies in improving the energy efficiency for conversion of waste to a molten slag, in developing an exhaust gas treatment facility suitable to the limited confines of a ship, and in formulating on-line process controls. The approach to these issues involves numerical simulation as well as systematic experiments.

The NRL plasma arc has been analyzed with both optical emission spectroscopy and through the voltage-current characteristics of the arc. Spectroscopy offers the potential of a non-invasive diagnostic to eventually be used for on-line process control. The feedstock gas is nitrogen (N_2) or argon but a small admixture of hydrogen (H_2) is introduced within the gas flow for diagnostic purposes. The emission lines from the hydrogen in the arc are generated by electron excitation followed by spontaneous radiative decay. The ratio of two Balmer lines from atomic hydrogen reveals information on the electron temperature. Synthetic spectra were calculated from a cylindrically symmetric simulation code for the arc torch geometry and input plasma properties. Contour levels of the intensity ratio in the temperature versus electron density plane have been generated. Experimental measurements can be directly plotted on these figures thereby obtaining information on the plasma properties, primarily electron temperature. In addition, the relation between the arc voltage and arc length provides information on the plasma's conductivity. The latter rate is strongly dependent on the plasma temperature. A comparison of these two methods for estimating the electron temperature indicates that the arc gas is in near equilibrium conditions (heavy particle temperature equal to electron temperature) at ~6000°K. There is also a variation in the temperature with supplied current. A general discussion of the anticipated materials to be treated and the associated problems arising in shipboard pyrolysis with a plasma torch will also be presented.