National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Environment

Advanced Supercritical Water Oxidation Reactor

Based on a Hydrothermal Flame-Piloted Vortex Flow

Innovators at the NASA Glenn Research Center, in conjunction with Case Western Reserve University, have designed the Supercritical Water Oxidation - Flame Piloted Vortex (SCWO-FPV) Reactor. The SCWO-FPV Reactor operates at temperatures and pressures above the thermodynamic critical point of water, enabling organic material to become highly soluble, effectively oxidizing all carbonaceous waste in liquid material introduced into the reactor. NASA's new technology addresses problems that have long plagued SCWO-based systems by implementing an innovative design to limit temperatures on the reactor walls, which minimizes the typical issues of scaling, corrosion, and fouling of heat transfer surfaces. While the SCWO-FPV Reactor is being considered for space exploration missions, it has great potential for a variety of terrestrial applications across many industries, especially for water reclamation, water treatment, and waste destruction in liquid waste streams.

BENEFITS

- Offers significant advantages over typical closed-loop systems for water-processing: The SCWO-FPV Reactor has improved recovery efficiency over classic closed-loop systems, eliminates all residual microbial contamination, and avoids typical limitations due to waste stream preconditions
- Eliminates wear on reactor components in conventional SCWO systems: The use of controlled regions in the reactor minimizes scaling and eliminates much of the need to protect the inner surfaces from the highly corrosive nature of supercritical water, allowing the reactor vessel to be constructed from thinner and more common materials than typical SCWO systems
- Provides a "green" design: The SCWO-FPV Reactor separates inorganic materials, oxidizes essentially all organic materials, and eliminates microbial contamination. It does not produce pollutants that require further scrubbing, such as NOx or SOx, whereas previously designed SCWO systems occasionally released pollutants due to unstable heating mechanisms

THE TECHNOLOGY

NASA's Supercritical Water Oxidation - Flame Piloted Vortex (SCWO-FPV) Reactor implements a unique design where heating is primarily supplied by the energetics of the waste stream through the control of a hydrothermal flame in the core of the reactor with the injection of fuel and oxidizer. Once the hydrothermal flame is initiated and stabilized, an outer-core "wash" stream, consisting primarily of water, is injected near the walls at the base of the reactor. This "wash" stream maintains subcritical conditions at the reactor walls, while also dissolving and/or flushing from the reactor any precipitate and non-soluble inorganic materials generated from the supercritical reactor core. Mixing between the core region and the outer subcritical flow region is largely eliminated due to the great differences in density and viscosity. The flow configuration is further stabilized by the generation of a vortex using internal structures on the inside of the reactor wall. An aspirator assembly is positioned at the top of the supercritical core region to extract treated water and un-extracted material is recirculated through the reactor. The rate and amount of aspiration will be determined by product monitoring and will depend on waste stream content and overall operating conditions. Key aspects of the technology have been demonstrated and a prototype reactor is under development.

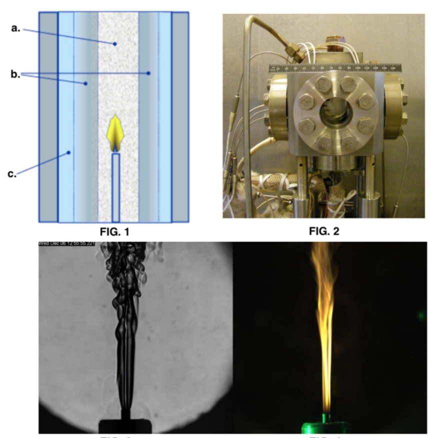

FIG. 1: Conceptual diagram of the SCWO-FPV Reactor (a. supercritical region; b. transcritical region; c. subcritical region); FIG. 2: Experimental Set-up: SCWO-FVP Test Cell; FIG. 3: B&W camera (shadowgraphic image) of the fuel/water solution being injected into the SCWO test cell filled with air and water at supercritical temperatures and pressures; FIG. 4: color camera view of the hydrothermal flame taken at the same time as FIG. 3.

APPLICATIONS

The technology has several potential applications:

- Aerospace: water processing and reclamation for human spaceflight
- Agriculture: treatment and reclamation of agricultural runoff
- Manufacturing: treatment of waste streams from making chemicals, pharmaceuticals, semiconductors, paper, and food
- Marine: treatment of discharge to conform to international treaties
- Military: destroying hazardous waste during weapons demilitarization
- Oil, Gas and Power: treatment and reclamation of water used for fracking and treatment of radiation contaminated organic waste streams
- Purification: water treatment and reclamation (e.g., desalination of unusable aquifers, treatment of algae blooms in freshwater lakes, etc.)
- Waste Management: sewage processing and water treatment and reclamation

PUBLICATIONS

Patent No: 10,954,152; 11,505,485

"Spontaneous Ignition of Hydrothermal Flames in Supercritical Ethanol Water Solutions," M.C. Hicks, et al., April 23, 2017, https://ntrs.nasa.gov/search.jsp?R=20170006847

"Hydrothermal ethanol flames in Co-flow jets," M.C. Hicks, et al., December 11, 2018, https://ntrs.nasa.gov/search.jsp?R=20190030838

More Information

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