Microwave Plasma Hydrogen Recovery System

This method can efficiently recover hydrogen from natural gas.

Marshall Space Flight Center, Alabama

A microwave plasma reactor was developed for the recovery of hydrogen contained within waste methane produced by Carbon Dioxide Reduction Assembly (CRA), which reclaims oxygen from CO_2. Since half of the H_2 reductant used by the CRA is lost as CH_4, the ability to reclaim this valuable resource will simplify supply logistics for long-term manned missions. Microwave plasmas provide an extreme thermal environment within a very small and precisely controlled region of space, resulting in very high energy densities at low overall power, and thus can drive high-temperature reactions using equipment that is smaller, lighter, and less power-consuming than traditional fixed-bed and fluidized-bed catalytic reactors. The high energy density provides an economical means to conduct endothermic reactions that become thermodynamically favorable only at very high temperatures.

Microwave plasma methods were developed for the effective recovery of H_2 using two primary reaction schemes: (1) methane pyrolysis to H_2 and solid-phase carbon, and (2) methane oligomerization to H_2 and acetylene. While the "carbon problem" is substantially reduced using plasma methods, it is not completely eliminated. For this reason, advanced methods were developed to promote CH_4 oligomerization, which recovers a maximum of 75 percent of the H_2 content of methane in a single reactor pass, and virtually eliminates the carbon problem. These methods were embodied in a prototype H_2 recovery system capable of sustained high-efficiency operation.

NASA can incorporate the innovation into flight hardware systems for deployment in support of future long-duration exploration objectives such as a Space Station retrofit, Lunar outpost, Mars transit, or Mars base. The primary application will be for the recovery of hydrogen lost in the Sabatier process for CO_2 reduction to produce water in Exploration Life Support systems. Secondarily, this process may also be used in conjunction with a Sabatier reactor employed to stockpile life-support oxygen as well as propellant and fuel production from Martian atmospheric CO_2.

This work was done by James Atwater, Richard Wheeler, Jr., Roger Dahl, and Neal Hadley of Umpqua Research Co. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32769-1.