Microwave Plasma Hydrogen Recovery System

This method can efficiently recover hydrogen from natural gas.

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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 CO₂. Since half of the H₂ reductant used by the CRA is lost as CH₄, 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 H₂ using two primary reaction schemes: (1) methane pyrolysis to H₂ and solid-phase carbon, and (2) methane oligomerization to H₂ 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 CH₄ oligomerization, which recovers a maximum of 75 percent of the H₂ content of methane in a single reactor pass, and virtually eliminates the carbon problem. These methods were embodied in a prototype H₂ 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 CO₂ 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 propel-lant and fuel production from Martian atmospheric CO₂.

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