Compact Fuel Reformers – kW to MW Scale

Jeff Weissman, Christian Junaedi, Subir Roychoudhury
Precision Combustion, Inc. (PCI), North Haven, CT

PCI is developing logistics fuel processors for PEM, solid oxide and molten carbonate fuel cell systems. The fuel processors are designed for reforming diesel or JP-8 and are currently sized at from 2 to 250 kilowatts, with larger scales reactors in the offing. The fuel processors include fuel preparation, CPOx, ATR or SR reactor, steam generator, sulfur remover, WGS (as necessary), and BOP components. The initial applications targeted are for Army tactical gen-set applications and vehicle APU's and Navy Ship APU's. PCI is also developing natural gas and liquid hydrocarbon fuel processors to support industrial needs. This program has been supported by numerous DOE and DOD SBIR and industrial partners.

Recent developments towards commercial viability will be discussed, including demonstrate of water neutral reformer operation, development and optimization of a low pressure drop fuel injector/nozzle, which permits stable, steady state operation and good mixing as evidenced by reactor product yield and selectivity, while significantly reducing parasitic energy losses. Equivalent performance with "bio-fuels" will also be discussed, along with integration efforts into 1-5 MWth systems. There will be a brief look at compact efficient and moderately sulfur-tolerant steam reforming, and finally a look at the benefits of using PCI's catalyst technology for nearly methane-free WGS operations.

PCI has developed a compact, lightweight and high efficiency catalytic reactor design offering performance and cost advantages over conventional reactors. These advantages are derived from an ultra-short channel length substrate structure, Microlith®, combined with advanced catalyst coatings. The Microlith catalyst substrate is very thin and has short metal channels resembling screens or meshes. As a consequence, these reactors have low pressure drop, enabling design of a high cell density, low thermal mass device which simultaneously leads to a smaller, lighter and higher efficiency catalytic reactors. Rates of both mass and heat transfer are significantly increased by the design, allowing more rapid reactor response to gas temperatures as well as improved rates of reactant contact with the surface. The substrate is coated utilizing proprietary methods with a variety of materials including catalysts or adsorbent materials which provide a unique and superior approach to heterogeneous catalytic reactions.

Fueled by natural gas, PCI's CPOX technology, using the Microlith approach, has demonstrated steady operation at up to 16 atm. and power densities up to 30 MW/liter. Fueled by liquid fuels, PCI's CPOX technology has demonstrated excellent performance in the mission critical areas of cold start-up and sulfur tolerance. PCI's ATR technology has demonstrated complete conversion of liquid fuels at low S:C ratio (~1), multi-fuel capability, and sulfur tolerance. PCI's steam reforming technology has demonstrated complete conversion of low-sulfur (up to 15 ppm) liquid fuels into high hydrogen content syn-gas. PCI's fuel reforming catalytic reactors have many desirable attributes including: 80% reforming efficiency (LHV basis); projected catalyst lifetimes of thousands of hours; operation at low steam to carbon ratios for reduced water needs; high power densities, ~160 kWel for liquid fuels and ~1000 kWel for natural gas; high specific power, ~200 kW/kg for liquid fuels, ~1000 kW/kg for natural gas; fast start-up (<30 seconds); and fast transient response (~3 seconds).