SAND2011-1818P

Determine capability needs for SMU and support capability development through targeted Laboratory-Directed Research & Development projects

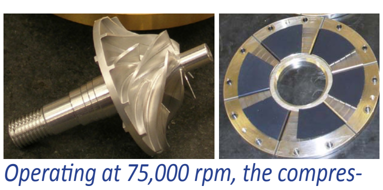
The ECIS investment area focuses on R&D that creates options for its program areas: energy, climate, and infrastructure security and enabling capabilities. Coupling science and technology (S&T) is critical to our SMU's success and a differentiating expertise that we bring to the nation. The ECIS LDRDs seed/initiate transformative approaches that provide real solutions to our key national challenges. The ECIS LDRDs focus on ideas that would be considered too risky for the direct-funded program funding areas. The ECIS LDRDs develop and create products and capabilities to incubate solutions for future program needs.

The ECIS LDRD portfolio supports a number of national-challenge research goals. Future LDRD awards will address priorities where gaps exist in the current investment portfolio. ECIS LDRDs should be revolutionary and span the gap from concept demonstration to prototype demonstration, and in all cases the LDRD must provide and document new knowledge.

ECIS strongly encourages multidisciplinary partnerships that include both S&T and mission technology efforts and that draw on capabilities/expertise from across the Labs such as high-performance computing and engineering testing. Other forms of partnering that are encouraged include external collaborations with key universities, other national laboratories, and other R&D institutions, as well as internal collaborations that pair senior experienced staff with newer Sandians.

Supercritical CO_2 and the Brayton Cycle

Advanced supercritical CO_2 (S-CO_2) Brayton cycle power conversion systems could generate electricity in the next-generation power reactors. The S-CO_2 Brayton cycle uses non-ideal gas behavior at the critical point to achieve efficiencies near 50%—but at only 700 °C. The combination of lower temperatures, high efficiency, and high power density (S-CO_2 is near water's density) allows us to develop very compact, transportable, and affordable systems because they require only standard engineering materials (stainless steel), less material is required, and because the small size allows for advanced, modular manufacturing.



Operating at 75,000 rpm, the compressor wheel (left) in our S-CO_2 test loop can generate 120–150 kW_e with 66% efficiency. We are now testing the gas foil bearings (right).

We demonstrated stable, controllable operation near the critical point using modular, reconfigurable hardware to construct many compression and Brayton-cycle configurations, and also to serve as a test bed for key bearing, seal, and controller technologies. Future testing will measure performance at different compressor inlet conditions (still near the critical point) and explore surge conditions. We will also test gas-foil bearings with different seals to measure their compatibility and to measure seal leakage.

Sunshine to Petrol

Converting sunlight to liquid fuel would be game-changing in the energy and climate arena. A deceptively simple chemical equation captures solar fuels production:

$$\text{Solar Energy} + xCO_2 + (x+1)H_2O \rightarrow C_xH_{2x+2} \text{ (liquid hydrocarbon fuel)} + (1.5x+.5)\,O_2.$$

One can see this as reversing combustion or a simplified expression of photosynthesis. The Sunshine to Petrol (S2P) team is pursuing an unconventional approach to more directly and with much higher efficiency than photosynthesis produce a liquid fuel. The team has a two-step heat engine driven by concentrated (2600 °F) solar irradiation that drives metal-oxide themochemical cycles. The engine converts either CO_2/H_2O to carbon monoxide/hydrogen—synthetic fuels' energy-rich building blocks.

The S2P team has proven the concept in a prototype device, but must solve complex chemical, materials science, heat transport, and engineering challenges associated with thermochemical heat engines and the crucial metal oxides.

The S2P thermochemical engine uses a reactive metal oxide around the outer edge of the counter-rotating rings (a) that are arranged in an insert (b). The CR5 device (c) is placed at the solar furnace's focal point (d).

For more information, contact:

PI/Manager Name, 505-XXX-XXXX, anyname@sandia.gov

SAND2010-xxxxX (Month 2010)

Sandia National Laboratories is a multiprogram laboratory managed & operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

National Nuclear Security Administration

Sandia National Laboratories