BLADES & VANES

Fall 2000

THE NATIONAL ENERGY TECHNOLOGY LABORATORY NEXT GENERATION TURBINE NEWSLETTER

## EVENTS AND CONFERENCES

**November 13:** Turbine Power 2000–This will be an open forum to discuss the direction and R&D needs for NETL's Future Turbine Power Programs. NETL, on behalf of DOE/FE, is developing a strategy that addresses technology, market, and environmental issues for the 21st century. Planning efforts are focused on sensors, controls, health monitoring and life-cycle management. Contact: Abbie Layne, 304/285-4603

**November 14-16:** Mega Session on Advanced Turbine Systems next Generation Turbine Systems Program at PowerGen Conference in Orlando, FL. Contact: Abbie Layne, 304/285-4603

*(Continued on page 2)*

## Parker-Hannifin–NETL Focuses on Duel-Fuel Premixer

As part of a Cooperative Research and Development Agreement (CRADA) effort, NETL and Parker-Hannifin are evaluating the emission levels and dynamic stability of a dual-fuel premixer used in advanced gas turbines. The research is based on Parker-Hannifin's recently patented design and manufacturing technique known as "macrolamination." This fabrication technique allows complex internal flow channels to be formed by fabricating the fuel injectors in layers. As a result, system components like the fuel-flow delivery channels, the spin slots, the swirl changers, and the exit orifices are etched into thin substrates. When these substrates are bonded together to fabricate fuel injectors, they offer advantages in size, atomization and mixing. In addition, this macrolamination technique makes it possible to incorporate air or fuel cooling passages and combustion air passages, into the stack. These fuel injectors are a unique fit for multipoint fuel injection approaches and dual-fuel lean premixed combustor applications. They offer shorter premixer lengths and lower propensity for flashback and autoignition. The experimental testing conducted at NETL has demonstrated the performance of the premixer, paying special attention to pollutant emission levels of carbon monoxide and oxides of nitrogen, as well as RMS pressure levels.

## RamGen® Ignition Tests Successful

RamGen Power Systems has developed an engine system based on an unusual Brayton-cycle configuration. In this unique system, compression, combustion, and expansion are all accomplished in two nearly tangential flow passages within a high-speed rotor, which is 6 feet in diameter and operates at 8,900 RPM. This innovative design represents a substantial departure from the traditional compressor-combustor-turbine arrangement, but has resulted in a drastic reduction in the number of engine parts, and allows quick and easy access to the hot flowpath parts. In May, RamGen conducted ignition tests of its preprototype engine using a modified fuel delivery system. Lightoff was successful and stable combustion was achieved for one-minute and five-minute test runs, at an engine speed of 800 RPM, and a combustor temperature of about 1,200 degrees F° using natural gas as the combustion fuel. RamGen plans to conduct another series of tests that involve increasing the speed and airflow until self-sustaining operation can be achieved with the starter motor off. Longer-term goals are to attain full-speed operation with positive power production and to be synchronized to the local grid. The RamGen® gas-fueled generator set, when successfully commercialized, is expected to offer comparable performance to conventional gas turbine generator sets in its size class at significantly lower capital and maintenance costs.

## EVENTS AND CONFERENCES

**December 4-6:** Advanced Turbine Systems Conference – hosted by DOE's Office of Power systems in the Office of Energy Efficiency and Renewable Energy in Alexandria, VA. Contact: Abbie Layne, 304/285-4603

*For more information on upcoming events, check out www.netl.doe.gov/events.*

## Next Gas Turbine System Feasibility Studies Begin

Forecasts indicate that about half the U.S. demand for gas turbine systems through 2020 will likely be for turbines suitable for both central and distributed power applications. As a result, in April, the Department selected four proposals to study ways to enhance the efficiency and environmental performance of gas turbines in the greater than 30 megawatt range. The Department is contributing about $2.25 million to conduct these feasibility studies for possible "next generation turbine" systems; the participants are adding another $1.24 million to the effort. Winning proposals include the following:

- *Pratt & Whitney*, East Hartford, CT, is studying an intercooled aeroderivative industrial gas turbine that is based on a commercial aircraft engine being developed. Pratt & Whitney's study will address extending turbine materials, improving cooling and efficiency, extending bearing and seal technology, and configuring a dry, low-emission combustor.
- *Rolls-Royce Allison*, Indianapolis, IN, is studying the enhancement and simplification of a gas turbine engine design currently used in U.S. Navy ships. The study involves modifying recuperation and intercooling technologies.
- *Siemens Westinghouse Power Corporation*, Orlando, FL, is pursuing a modular gas turbine that includes new enabling technologies in a single, low-cost system design. The new turbine will be able to operate on natural gas, as well as synthesis gas derived from coal or biomass.
- *GE Power Systems*, Schenectady, NY, will conduct a parametric study to evaluate three categories of gas turbines: aeroderivative, heavy duty, and a hybrid combining components of the other two categories. GE is performing a feasibility study on each turbine configuration selected.

## June 6th Stakeholder Forum in Washington, D.C., Refines Goals of the Next Generation Turbine Systems Program

Cohosted by NETL and the Gas Turbine Association (GTA), the stakeholder forum was an opportunity for representatives from the user community, manufacturers, the financial and insurance communities, and other interested parties, to discuss issues, such as: Financial Risk; Reliability, Availability, and Life-Cycle Cost; and Modernizing Environmental and Regulatory Conditions. Participants agreed that future turbine development efforts should focus on improving the durability and reparability of turbine parts, and making sure future engine models are capable of burning alternative fuels. Participants also expressed concern that regulators need to recognize that modern gas turbines have extremely low emissions relative to other large systems, such as coal-fired power plants and automobiles. In addition, participants pointed out that the financial and insurance backing for gas turbine projects is dynamic with stock market trends affecting the willingness of insurers to be involved and the willingness of equity investors to accept risk. Participants want the NGT program to focus on eliminating the risks associated with purchasing and operating a Next Generation Turbine System. In addition to these discussions, Ellan Brown from the U.S. EPA, Policy Office of Air and Radiation, spoke regarding recent permitting issues for combined-cycle gas turbines. Since the meeting, EPA/DOE discussions have led to draft guidance being issued in the Federal Register on August 17, 2000. The guidance suggests that Selective Catalytic Reduction may not necessarily be the Best Available Control Technology for dry, low $NO_x$ Clean Coal Technologies. Copies of the proceedings are available by contacting Cynthia Kish at 304/285-4232, or by email: cynthia.kish@netl.doe.gov.

## SOLICITATIONS

**Hybrid Power Systems**

Development of hybrid systems to produce affordable, safe, and environmentally acceptable electric power at 70+ percent efficiency is the goal of this solicitation. Issued on May 12, 2000, awards are scheduled for December 31, 2000.

**Development of Technologies and Capabilities for Developing Coal, Oil and Gas Energy Resources—Round 1**

This broad based financial assistance solicitation includes areas in coal and environmental systems, fuel processing, oil technologies, and natural gas technologies. Solicitation will be available on or about December 1, 2000 and pre-applications will be due on December 20, 2000.

## CONTACT POINT

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## Materials and Manufacturing Technology Research Focuses on Single-Crystal Airfoils

Funding from NETL enables Oak Ridge National Laboratory (ORNL) to manage research to modify and improve the alloys traditionally used to produce single-crystal (SX) airfoils. In 1994, ORNL issued a solicitation to develop the manufacturing technology for SX airfoils used in industrial and large utility gas turbines. Howmet Corporation and PCC Airfoils examined improvements in SX furnace design, mold design, grain orientation control, ceramic core and mold materials, mold and core removal, mold and core cleanup techniques, and in-line and post-manufacturing quality assurance, and associated inspection techniques. A second solicitation was issued to identify, develop, and demonstrate alternative manufacturing processes at more cost-effective yields. Howmet Corporation received an award to improve current Vacuum Induction Melt furnace capability and control, addressing deficiencies in shell systems, and investigating novel cooling concepts to improve thermal gradients. General Electric's award involves evaluating and implementing liquid–metal cooling, and the adaptation of new alumina core segment formulations. Siemens Westinghouse is casting and subsequently assembling smaller single-crystal segments in transient liquid-phase bonding.

## GE H-Class Turbine Undergoes Full-Speed No-Load Test

Development of the H-class advanced turbine system (ATS) continues as part of an eight-year partnership between DOE and General Electric Company (GE). This advanced engine is expected to achieve greater than 60 percent efficiency operating at the combined cycle mode, while maintaining single-digit nitrogen oxides emission levels. At the heart of the GE concept is steam cooling of the first two power stages. Innovative steam cooling allows the turbine to operate at inlet temperatures of 2,600°F, which is 200°F higher than the now-commercial F-class. A high inlet temperature equates to high efficiency. This versatile technology serves as the foundation for the power modules of the Vision 21 energy plants and will be integrated into coal-gas fired system.

## Developing the 21st Century Gas Turbine

As part of the Advanced Turbine Systems (ATS) Program, in September 1995, Siemens Westinghouse Power Corporation was awarded a cooperative agreement to design and develop a 21st century gas turbine. The goal of the project was to develop a system that would significantly increase the efficiency of combined–cycle power plants using natural gas as their primary fuel. Efficiencies were to exceed 60% on a lower heating value basis for a natural gas-fired utility system.

The Siemens Westinghouse 501 ATS four-stage engine was designed using the latest three-dimensional design philosophy. To date, the project has involved, detailed compressor redesign, generator development engineering, manufacturing verification testing, turbine engine development engineering, adaptation of the turbine to coal and biomass fuels, engine verification testing, and manufacturing engineering.

Most recently, as part of manufacturing engineering efforts, Siemens Westinghouse has validated the steam-cooled component and the aerothermal design. In addition, a full-scale combustor test was performed with a new adaptive noise control algorithm. Siemens Westinghouse used a dry, low $NO_x$ combustor with the active noise control actuator on the pilot-fuel stage and then on one of the premixed fuel stages. The algorithm was able to determine the appropriate phase for control on both.