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GLOBAL Gas Turbine News

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ATLANTA, GEORGIA USA • ASME INTERNATIONAL GAS TURBINE INSTITUTE

Register Today for Turbo Expo 2010 Keynote Speakers Announced

TURBO EXPO
Gas Turbine Technical Congress & Exposition
Presented by the International Gas Turbine Institute


Walter Downing


Colin Smith


Peter Christman, Jr.

Event registration and housing reservations for Turbo Expo 2010 in Glasgow are now available online at **www.turboexpo.org**!

Keynote Speakers Announced

Three leaders in the turbomachinery industry will address the theme "Extending Limited Natural Resources Through Energy Technology Innovations" at Turbo Expo in Glasgow.

Peter Christman, Jr., President of Pratt & Whitney Power Systems in East Hartford, Connecticut, USA; Colin Smith, Director of Engineering and Technology at Rolls-Royce plc in Derby, UK; and Walter D. Downing, P.E., Executive Vice President at Southwest Research Institute in San Antonio, Texas, USA, will all speak at the opening keynote on Monday, June 14.

Advancing gas turbine, steam turbine, and other turbomachinery technology is critical to stretch the world's ever decreasing fossil fuel resources while mitigating their carbon greenhouse gas emissions. These keynote speakers will address how turbomachinery manufacturers, universities, consultants, and equipment users are working together currently and may work together in the future to develop the necessary solutions for the energy and aircraft engine industry.

Peter Christman, Jr. was a member of the management team of Energy Services, Inc. (ESI) and Energy Maintenance Corp. (EMC) prior to joining Pratt & Whitney. In 2002, he took management responsibility for the Large Engine Business of Pratt & Whitney Power Systems and then was selected in 2003 to lead the entire business of Pratt & Whitney Power Systems, a division of the United Technologies Corporation.

Colin Smith joined Rolls-Royce as an undergraduate apprentice in 1974. He worked as Chief Engineer on the Trent 700 engine and the Trent 500 engine, Head of Engineering for Compressors and Fans, and Director of Research & Technology. He has served in his current position since 2005 when he also became a member of the Board of Rolls-Royce. Smith is a Royal Academy Silver Medal winner.

Walter Downing serves as the chief operating officer of SwRI, an independent, nonprofit, applied research and development organization that addresses clients' needs in the physical sciences and engineering disciplines. He directs the twelve technical operating divisions and is a member of the SwRI Board. Previous positions at SwRI include senior research engineer in electronics systems and vice president of Avionics and Support Systems.

Don't miss these Turbo Expo events:

TECHNICAL CONGRESS – Turbo Expo has a well earned reputation for bringing together the best and brightest experts from around the world to share the latest in gas turbine technology, research and development, and application. Now, the IGTI community is enhancing its leadership role in turbomachinery as it broadens the program scope to include related topics from wind and steam turbine technology. The 2010 Technical Congress proceedings, alone, are worth the price of admission, as the DVD will contain over 1,000 peer-reviewed publications!

EXPOSITION – Turbo Expo is known for its high-quality, 3-day exhibition of gas turbine products and services, supported by prestigious companies such as ALSTOM, ANSYS, GE, Mitsubishi, Pratt & Whitney, Rolls-Royce, Siemens and many more! New this year is the Do-It-Yourself (DIY) Gas Turbine Booth that will feature some interesting homemade creations including a twin turbo unit and single stationary engine with afterburner. Daily lunches plus afternoon networking receptions in the Expo Hall are included in the registration package for delegates and exhibitors.

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IN THIS ISSUE...

VIEW FROM THE CHAIR

Knox T. Millsaps, Ph.D., Chairman of the IGTI Board of Directors

Greetings to the IGTI community and others reading *Mechanical Engineering Magazine* and welcome to the *Global Gas Turbine News* (GGTN). I hope you enjoy reading this edition and become more aware of all the exciting gas turbine and energy-related activities we offer. Please see the calendar for details.

This year's Turbo Expo will be in Glasgow, Scotland in the UK and will most probably be the largest Turbo Expo in history, with more than 1,000 technical papers. I thank all the authors for their hard work in submitting so many excellent papers. Turbo Expo is rather unique in that all our papers are peer-reviewed by three or more experts in the field from industry, academia, and government laboratories. These papers are then revised and improved. This leads to a paper quality that far exceeds most technical congresses. In addition, typically more than 100 of these papers are recommended for journal publication in ASME Transaction Journals. Successful completion of this process requires the hard work and dedication of a large number of session organizers, reviewers, and our wonderful IGTI staff in Atlanta. I salute them. I also thank Professor Thomas Sattelmayer, the TE Review Chair, and Prof. Karen Thole, the TE co-review Chair, who together read more than 3,000 reviews.

IGTI is a proud part of the ASME family, and we welcome those people who are interested in becoming part of IGTI to visit our website at: http://igti.asme.org to learn more about what we do and how to become involved. Past versions of this newsletter are also available on this website. Also, if you are involved with another division of ASME and want to work with us on a joint conference, educational programs, etc., please contact Mike Ireland, Managing Director of IGTI, or me. IGTI is a community of scholars, practicing engineers, and program managers dedicated to improving gas turbine, steam turbine, turbomachinery, and related energy conversion systems for the betterment of society.

Looking to the future, Turbo Expo 2011 will be in Vancouver Canada, and the following year in 2012 Turbo Expo will be in Copenhagen, Denmark.

Thank you for reading the *Global Gas Turbine News*. ✻

CALENDAR OF EVENTS

FEBRUARY 22-26, 2010

ASME International Gas Turbine Institute Training Week
Southwest Research Institute
San Antonio, TX USA

February 22-23, 2010
Introduction to Gas Turbines and Centrifugal Compressors
Instructors: *Dr. Klaus Brun, SwRI and Dr. Rainer Kurz, Solar Turbines*

February 24, 2010
Root Cause Failure Analysis of Gas Turbines
Instructors: *Harold Simmons and David Ransom with SwRI.*

February 25, 2010
Compressor Performance Testing and Dynamics
Instructors: *Dr. Jeff Moore, David Ransom and Marybeth Nored all with SwRI*

February 26, 2010
Machinery Performance Testing and Troubleshooting
Instructors: *Justin Hollingsworth & Dr. Sean Tavares, both with SwRI*

APRIL 4-9, 2010

13th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery (ISROMAC-13)
Sheraton Moana Surfrider Hotel
Honolulu, Hawaii USA

Contact: Prof. Toshinori Watanabe
(University of Tokyo, Japan)
Email: isromac-13@aero.t.u-tokyo.ac.jp

MAY 2, 2010

International Thermal Spray Conference & Exposition 2010
Gas Turbine Metallurgy, Coatings and Repair Technology Workshop
Raffles City Convention Centre
Fairmont Singapore
Instructors: *Jeff Smith, Materials Processing Technology, LLC and Doug Nagy, P.Eng., Liburdi Turbines Services Ltd.*

This course will cover superalloy materials, airfoil manufacture, protective coatings, component damage experienced from service exposure, techniques used to analyze the remaining life of components removed from service, component repair technologies, and quality assurance of repairs. **Contact bartons@asme.org for more details.**

JUNE 12-13, 2010

ASME Turbo Expo Courses
Scottish Exhibition & Conference Center
Glasgow, Scotland, UK

June 12, 2010
- *Thermal Spray and Other Coatings for Gas Turbines Selection and Application for OEM and Maintenance & Repair*
- *Failure Investigation of Gas Turbines*

June 12-13, 2010
- *Gas Turbine Aerothermodynamics & Performance Calculations*
- *Pipeline Engineering for Gas Turbine Industry*

June 13, 2010
- *Basic Gas Turbine Metallurgy and Repair Technology*
- *Film Cooling & Technology for Gas Turbines Workshop*

JUNE 14-18, 2010

ASME Turbo Expo 2010
Scottish Exhibition & Conference Center
Glasgow, Scotland, UK

Visit www.turboexpo.org for all the up-to-the-minute details on this leading global turbomachinery event. Take advantage of the many opportunities for participation, including registration, publications, exposition, sponsorships, and networking.

JULY 25-28, 2010

AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit
Nashville Convention Center & Renaissance Hotel
Nashville, Tennessee USA

The objective for JPC 2010 is to identify and highlight how innovative, green aerospace propulsion technologies are powering both new and evolving systems. Visit www.aiaa.org for more details.

OCTOBER 4-7, 2010

ASME Gas Turbine Users Symposium (GTUS)
Co-located with 39th Turbomachinery Symposium,
George R. Brown Convention Center
Houston, TX USA

With its focus on gas turbine drivers, the GTUS program will complement the excellent technical content pertaining to rotating equipment offered at the Turbomachinery Symposium.

JUNE 6-10, 2011

ASME Turbo Expo 2011
Vancouver Convention & Exhibition Centre
Vancouver, British Columbia, Canada

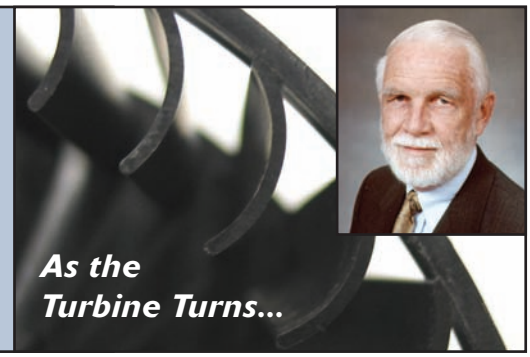
IGTI's flagship event comprises a major gas turbine conference and exhibition.

Featured Column: As the Turbine Turns...

A Bright Natural Gas Future

By Dr. Lee S. Langston, *Professor of Engineering, University of Connecticut*

Langston is a former editor of the ASME Journal of Engineering for Gas Turbines and Power and has served on the IGTI Board of Directors as both Chair and Treasurer.



Modern electric power gas turbines are almost exclusively fueled by natural gas. As an example, take our 25 MW gas turbine cogeneration, combined cycle plant here at the University of Connecticut. The plant's three Solar gas turbines can burn either fuel oil or natural gas, but fuel oil is used only as a backup. Natural gas is cheaper, provides for longer gas turbine life and minimizes exhaust pollutants.

Natural gas, composed mostly of methane, CH_4, has been called the "prince" of hydrocarbon fuels. It has the highest heating value per unit mass (21,520 BTU/lbm = 50.1 MJ/kg, LHV) of any of the hydrocarbon fuels (e.g. butane, diesel fuel, gasoline, etc.). It is the most environmentally benign of fuels, with impurities such as sulfur (hydrogen sulfide) removed before it enters the pipeline.

Since it has the lowest carbon content per unit mass, combusted methane produces about 30% less carbon dioxide per unit mass than does oil and about 43% less than coal. Combusting it does produce amounts of NOx, with higher combustion temperatures yielding greater amounts. This is usually controlled by injecting ammonia into the gas turbine exhaust, reducing the nitrous oxides to water and nitrogen.

In the last twenty years, simple cycle and combined cycle gas turbine power plants fueled by natural gas have made a huge impact on the world's electrical generation market. With fast starting, simple cycle plants at 40-45% thermal efficiencies and combined cycle plants approaching 60%, governments, utilities and investors have funded their construction in country after country. On a per kilowatt basis, they are far cheaper to construct than a nuclear or hydrocarbon fueled steam plant.

Recently, *The Economist* reported that Britain gets 46% of its electricity from natural gas. The UK's Department of Energy and Climate Change reckons that 75% of the fossil-fueled power stations planned will be gas turbine powered running on gas. If we assume all natural gas used for electrical generation in recent years has been burned in gas turbine plants, the latest U.S. Energy Information Administration (EIA) data shows that in 2007, 22% of U.S. electric power was gas turbine generated. Here in New England it's closer to 40% and in California and Texas, 50%. The EIA also projects that of the estimated 255 gigawatts of additional electric generating capacity to be added in the U.S. by 2030, some 55 percent will be in the form of natural gas fueled gas turbines.

Right now, the future for natural gas supplies are bright. On an energy basis, the global reserves exceed those of oil and the rate of discovery of new gas reserves exceeds that of oil. Historically, natural gas usually trades at prices lower than oil on a per energy unit basis (some 30% lower at 2009's $40 a barrel oil (down from a 2008 high of $145) and $4.50 per million BTU gas (down from a 2008 high of $13)). Natural gas occurrence in the world is more widespread than oil. The EIA defines "conventional" natural gas as that produced from an oil well and "unconventional" as gas not found associated with oil (such as in coalbeds and shalebeds).

Recent exploration in the U.S. in the last few years has produced very large finds of unconventional natural gas. By using new drilling and hydraulic fracturing techniques, extensive deposits of natural gas are being found in underground shalebeds in the eastern and southern U.S., apparently enough to supply the country for many years. One of the finds is in the Marcellus Shale Formation which extends through Pennsylvania, New York, Ohio and West Virginia, close to major markets and pipelines.

More than half of the world's conventional natural gas is found in three nations – Russia, Iran and Qatar. Much of it is in locations far from population centers, at distances that preclude gas pipeline transportation. Gas pipeline lengths are limited by how much gas is needed to power compressors that pump the gas through the line. This brings into play liquefied natural gas, which in a liquid phase is 600 times denser and more easily transportable shipboard, in special LNG tankers. LNG makes natural gas a fungible commodity, like oil. As pointed out in this year's excellent publication *"How the Energy Industry Works"*, piped gas is a commodity for regions, but LNG is one for the world.

In recent years, energy companies have made major investments in LNG trains – very expensive multipart facilities that cool and condense natural gas to a liquid phase. As pointed out in a recent *New York Times* article by Clifford Krauss, six of these plants were due to come online in 2009. This is good news for the world's natural gas users, for these energy companies will be looking for a return on their multibillion dollar LNG train investments. The new natural gas supply should tend to keep gas prices on the low side, as the global economy recovers from the recent downturns.

Given the world's focus on sustainable or renewable energy, how do natural gas fired gas turbines fit in? Consider the case of electrical power generated by wind turbines. At present less than 1% of US electrical power is generated by wind. (At a recent IGTI meeting, an officer from a major German electrical utility told me that 6% or less of their electric load was supplied by Germany's extensive wind turbine system). In Montana, NorthWestern Energy is currently constructing a 200 MW natural gas fired gas turbine Mill Creek Generating Station to provide fast start (and stop) "regulation service" to compensate for the wind's unpredictability. In the company's own words, "Because wind is difficult to accurately schedule…it is more problematic to integrate into the transmission grid. For example, at the Judith Gap Wind Farm, the wind farm has ramped up from zero to 131 MW in 10 minutes and has ramped down from 121 MW to zero MW in a similar time period."

Thus, we can safely conclude that the natural gas fueled gas turbine—be it the heart of a super efficient combined cycle base load electric power plant or be it a quick start supplemental power plant for grid power supply unpredictability—will be around for many decades to come. ✻

PROFESSIONAL DEVELOPMENT

Don't miss this unique opportunity for career advancement by attending one or multiple IGTI courses being offered over the next 12 months!

ASME International Gas Turbine Institute Training Week

February 22-26, 2010 • Southwest Research Institute • San Antonio, TX

A special thanks to SwRI for allowing IGTI to use their facilities for this training week.

Introduction to Gas Turbines and Centrifugal Compressors

Monday, February 22 & Tuesday, February 23, 2010

Instructors: Dr. Klaus Brun, SwRI & Dr. Rainer Kurz, Solar Turbines.
Fee: Member $1045 – Non-Member $1195

OVERVIEW:

This two day class is a unique opportunity to join the experts to learn what you need to know to apply and operate gas turbines and gas compressors in your operation as well as to interact and network with your peers in the field of turbomachinery applications. There will also be an opportunity for hands-on learning using Southwest Research Institute's gas turbines and compressors. In addition to the theoretical presentations, real life case studies will be presented by the instructors in an interactive forum which will further enhance the students' skills in troubleshooting gas turbine and gas compressors issues. Acquiring and perfecting these skills will enable them to go back to the workplace and perform their job with a much higher level of performance and accuracy.

Root Cause Failure Analysis of Gas Turbines

Wednesday, February 24, 2010

Instructors: Harold Simmons & David Ransom with SwRI.
Fee: Member $595 – Non-Member $695

OVERVIEW:

Root cause failure analysis (RCFA) is the process for identifying the fundamental root cause of a particular failure. The objective of RCFA is to establish firm evidence that can be used to set a course for corrective/preventive action. A thorough RCFA investigation involves utilizing multidisciplinary expertise of metallurgical examination, fluid-structure interaction, fatigue and fracture analysis, corrosion assessment, thermodynamics, and structural dynamics. ***The course will show how the information gained from each discipline can be combined to reach conclusive determination of the root cause of common gas turbine failures.***

Compressor Performance Testing and Dynamics

Thursday, February 25, 2010

Instructors: Dr. Jeff Moore, David Ransom & Marybeth Nored all with SwRI.
Fee: Member $595 – Non-Member $695

OVERVIEW:

This interactive, hands-on course will focus on Rotordynamics, Vibration Analysis, and Gas Turbine Compressor Performance Testing. Students will have the unique opportunity to practice what they have learned by taking part in a live demonstration on rotordynamic issues and characterization of key instabilities in the gas turbine laboratory at SwRI. They will also be participating in a hands-on test at the SwRI Natural Gas Closed-Loop Facility. Real life case studies will further enhance the students' skills in trouble-shooting rotordynamic issues, vibration analysis, and gas turbine compressor performance testing. Acquiring and perfecting these skills will enable them to go back to the workplace and perform their job with a much higher level of performance and accuracy. ✲

Machinery Performance Testing and Troubleshooting

Friday, February 26, 2010 (HALF-DAY COURSE)

Instructors: Justin Hollingsworth & Dr. Sean Tavares, both with SwRI.
Fee: Member $285 – Non-Member $385

OVERVIEW:

This course will provide a practical introduction to gas turbine and compressor performance and vibration testing. The course includes both a lecture as well as hands-on testing and data evaluation of performance and vibration data of a small gas turbine driven compressor. Topics that will be covered are:

- Field instrumentation
- Compressor performance measurement parameters
- Compressor and gas turbine vibration parameters
- Performance and troubleshooting diagnostics
- Data evaluation and interpretation

New courses and Interactive Webinars will be offered in the coming months. For an up-to-date calendar of these new training events, please visit our website at: http://igti.asme.org or contact Shirley Barton at: 404-847-0072 ext. 1647 • E-mail: bartons@asme.org

International Thermal Spray Conference & Exposition 2010 Singapore

RAFFLES CITY CONVENTION CENTRE • FAIRMONT SINGAPORE

Sunday, May 2, 2010

Gas Turbine Metallurgy, Coatings and Repair Technology Workshop

Instructors: ***Jeff Smith, Materials Processing Technology, LLC and Doug Nagy, P.Eng., Liburdi Turbines Services Ltd.***

This course will cover super alloy materials, airfoil manufacture, protective coatings, component damage experienced from service exposure, techniques used to analyze the remaining life of components removed from service, component repair technologies, and quality assurance of repairs. The seminar includes many case study examples, and the last section of the seminar is devoted to a workshop where attendees develop component repair solutions. Participants are encouraged to contact the instructors prior to the course with potential applications or problems that can be discussed as case studies.

After completing the course the participants should be able to explain:

1. *What makes super alloys especially suited for gas turbine components*
2. *Understanding of the distinction between conventional casting and directional solidification*
3. *How different damage mechanisms (oxidation, corrosion, erosion) affect the component*
4. *Advantages & disadvantages of the many types of protective coatings*
5. *How high cycle fatigue & low cycle fatigue damage is caused, prevented, and repaired*
6. *Various heat treatments used in repairs, and why they are important*
7. *Critical quality control steps in component manufacture and repair*
8. *How to reliably extend the service life of valuable components*

Registration info will be available soon. If you are interested in registering for this course, please contact bartons@asme.org.

A "giant" gas turbine sets new benchmarks

Siemens H Class Turbine, the SGT5-8000H Ready for the Market

SIEMENS

By Willibald J. Fischer, *Program Manager 8000H, Siemens Energy Sector, Erlangen, Germany*

Over thirteen meters long, five meters high and weighing 444 metric tons – these are the vital statistics of the world's largest gas turbine developed by Siemens with the type designation SGT5-8000H. Purely on the basis of its dimensions it has been included in the *Guinness Book of Records*.

Even more impressive than the dimensions is the performance achieved by the turbine, which is capable on its own of meeting the power demand of a city the size of Hamburg, Germany, with its over 1.7 million inhabitants. However, the most important thing is that this turbine sets completely new benchmarks both in terms of operating economy and ecology: Based on the data acquired in simple cycle operation, a power plant efficiency in combined cycle exceeding 60 percent is expected. With the new gas turbine, fuel can be saved and less carbon dioxide will be emitted. In combined cycle power plants, the energy is first converted into power in a gas turbine and subsequently the thermal energy of the hot exhaust gas is used in a heat-recovery steam generator to raise steam for a steam turbine. Compared to a combined-cycle power plant of the previous designs with a comparable output, combined-cycle power plants with the new gas turbine can achieve CO_2 savings of more than 43,000 metric tons per year. This is the equivalent of the CO_2 emissions produced by more than 23,000 middle class cars driven 20,000 kilometers per year.

The H class gas turbine is the first new frame developed since the merger of Siemens and Westinghouse. It combines the best features of the two established product lines with advanced technology. The functional and mechanical design of the new engine was built on the experience gathered with the predecessor 50-Hz and 60-Hz engines. Proven design features were applied wherever possible, and "Design for Six Sigma" tools were used resolutely to deliver a competitive product focused on meeting requirements in terms of life-cycle costs, performance, serviceability, flexibility, reliability, and low emissions.

The engine concept was selected from quite a number of potential air-cooled engine designs after completing a comprehensive feasibility analysis during the conceptual design phase. The air-cooled concept selected offers maximum added value by virtue of its higher operational flexibility – an essential prerequisite in the deregulated power generation market environment with increasing need for compensation of volatile green power like wind and solar.

The most important gas turbine design features are:

- Single tie-bolt rotor comprising individual compressor and turbine disks with Hirth facial serrations,
- Hydraulic clearance optimization (HCO),
- Axial 13-stage compressor with high mass flow, high component efficiency, controlled diffusion airfoils (CDA) in the front stages and high performance airfoils (HPA) in the rear stages, variable guide vanes and cantilevered vanes,
- High-temperature, air-cooled can annular combustion system,
- Four-stage air-cooled turbine section,
- Advanced, on-board variable secondary air system, with no external cooling system,
- Advanced, high-efficiency, high-pressure and high-temperature combined cycle process with a Benson boiler design based on the high mass flow and exhaust temperature of the new engine.

A 60-Hz version is now under development using a direct aerodynamic scaling approach, thereby minimizing operational risks for customers.

Tried, tested, and trusted

For minimization of customer risk during the introduction of a new product, a comprehensive test and validation program was set up. This already included tests on prototype parts during the design phase, followed by subsystem validation such as atmospheric and high-pressure combustion testing as well as full-scale 60-Hz compressor validation.

The individual component, subsystem and then engine tests were performed in the Siemens Berlin test center and at several other suitable test facilities. In addition, it has been decided to test the entire gas turbine in a real power plant. The partner for this extensive validation project is E.ON Kraftwerke, a major German utility.

The crucial phase of validation was engine operation under real power plant conditions. Preparation for this phase commenced back in 2005 with the installation of about 3000 sensors in and on the engine during manufacture of the prototype. In addition to the standard instrumentation of the I&C system, these sensors measure temperatures, pressures, strain, flows, acceleration, and vibration encountered during part-load and base-load operation. It also enables the engineering to compare the design models with the real engine response. Two telemetry systems located at the turbine rear end and at the compressor front end of the intermediate shaft delivered some 600 additional signals from the rotor.

During engine installation, a considerable range of additional instrumentation such as externally mounted blade vibration sensors, pyrometers, tip clearance and flow field probes as well as two infrared turbine blade monitoring cameras was installed.

Concurrent with erection of the power plant, test facilities including the extensive data acquisition system (DAS) were added. The DAS setup was not limited to the Irsching site. A dedicated encrypted data network between the Irsching Test Center and the engineering headquarters in Muelheim, Germany and Orlando, Florida was established. This network enabled 100 additional engineers to have a live view of engine operation without the need for on-site presence and contributed both to testing operations and engine safety.

Cold commissioning of the gas turbine was successfully completed in December 2007. A four-phase structured testing operation commenced with a successful first firing on December 20, 2007. The first test phase was mainly driven by auxiliary and startup commissioning steps. The startup and protection settings were optimized. In addition, mandatory full speed no load (FSNL) tests such as speed sweeps for compressor and turbine validation and generator protection testing were also conducted. Test phase 1 ended with first synchronization with the grid on March 7, 2008.

Test phase 2 included the first loading to full speed full load (FSFL) and all related tests for optimizing the loading schedule for the four stages of variable guide vanes as well as the five fuel gas stages of the combustion system. Test phase 2 culminated in achieving base load for the first time on April 24, 2008.

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Southwest Research Institute Holds 2nd Annual Climate Change Mitigation Technology Lecture Series

By Klaus Brun & Vishwas Iyengar, *Southwest Research Institute*

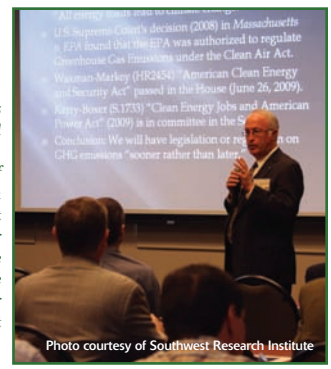
For the second year in a row, Southwest Research Institute (SwRI) held a one-day expert lecture series and forum to discuss technologies for the reduction of carbon and other greenhouse gas emissions from power-plants and other industrial sources. About 130 scientists and engineers were in attendance at the event which was held on the 1200 acre SwRI campus in San Antonio, Texas on November 18th, 2009. This year the lecture series had 10 distinguished speakers whose focus topics were:

- Technology Solutions to Greenhouse Gas (GHG) Emissions
- Power Diversification Strategies
- Energy Efficiency Gains
- Carbon Capture, Conversion and Storage (CCCS)

The proposed greenhouse gas emissions regulation is a looming challenge to many energy producers, large industrial users, and transmission pipeline companies. With the inevitable need to reduce carbon emissions on a global scale, the United States must address increasing energy demands and the challenges of using its current infrastructure and resources more efficiently and effectively. Technologies must be developed to solve today's energy-related carbon emissions while at the same time addressing tomorrow's energy needs. The SwRI lecture series covered a wide variety of technologies that are at the forefront of making a difference in the climate change challenge.

"At Capitol Hill, all energy roads lead to climate change," said Danny Deffenbaugh, the Vice President of SwRI's Mechanical Engineering Division, as he gave the welcome speech to speakers and participants. While emissions in the United States fell by 3 percent last year, they jumped 2 percent worldwide, most of the increase coming from China. The U.S. and China are the world's largest carbon emitters. The climate change problem is multifaceted. The challenges are not just technical, but also the economic and political.

As Deffenbaugh rightly said, any economic impacts are heavily dependent on the successful commercialization of technologies, the rate of adoption and the political system. As the man-made carbon emissions continue to increase despite the global recession, managing carbon emissions is essential. Tim Fout from the Department of Energy (DOE) proposed three options that could be utilized to manage carbon emissions. First, reduce carbon intensity by either switching fuels or by using renewable energy. Second, increase the efficiency of the operating system, which would thereby reduce the carbon emissions. And finally by sequestering the carbon, i.e. capture and store the carbon for future use. All efforts at the Department of Energy (National Energy Technology Lab) indicate that in order for these options to succeed, all the three options need to affordably meet energy demands and more importantly address the environmental objectives.



Danny Deffenbaugh, vice president of SwRI's Mechanical Engineering Division, gives an overview of near-term research efforts to attendees at the Technologies for Climate Change Mitigation lecture series, held November 18 at Southwest Research Institute.

LIST OF SPEAKERS

Paul Barham | CPS Energy
Steve Bridges | Zachary International
Eloy Flores III | SwRI
Timothy Fout | DOE NETL
Jeff Moore | SwRI
Stephen Pavel | Ivanhoe Energy
Charles Roberts | SwRI
Gary Walter | SwRI
John Waycuilis | Marathon Oil Company

On the other end of the spectrum, a staggering amount of global warming pollution comes from U.S. vehicles. Data showed by Charles Roberts from Southwest Research Institute indicates that in 2004, the carbon dioxide (CO_2) emissions from personal vehicles totaled 314 million metric tons. He said that the best way to get a big reduction in CO_2 reduction for IC Engine applications is by "squeezing out" as much efficiency as possible because fuel economy means reduced greenhouse emissions. Roberts reports that a typical good diesel engine produces only 40% useful work, while the other 60% are losses associated with the various operations of the IC engine. This leaves plenty of room for improvement in areas such as combustion, thermal cycle, exhaust waste heat, friction and engine cooling within the IC engine. Assuming that in the years to come improvements are made in each of these each category areas, then a typical IC engine can potentially be 60% efficient, which can help the carbon emissions considerably.

While CO_2 is the largest contributor to greenhouse emissions, John Waycuilis from Marathon Oil said that Methane (CH_4), Nitrus Oxide (N_2O), Halocarbons, and 03 levels in the atmosphere have also risen abruptly in the last century or so. These greenhouse gases each contribute to "radiative forcing" but CO_2 has the largest contribution. Waycuilis showed that the rate of change of "radiative forcing" is apparently much steeper than during any period in the record, back at least 650,000 years. In 2004, although GHG emissions from energy supply (~26%) & industrial production (~19%) were the biggest sources, forestry and deforestation/clearing were also significant contributors (~17%). "Look outside the box," said Waycuilis, while presenting some alternative concepts (Un-Usual Suspects) to tackle the climate mitigation problems -

- Air capture – remove CO2 from air and capture it
- Water splitting - H2 is produced for direct use as fuel (displacing CO2 emitting sources),or is available for hydrogenation of CO2
- CO_2 splitting - combined with water splitting, can produce "solar syngas" for production of chemicals or fuels
- Electrosynthesis - CO_2 can be electrolyzed to various chemicals or fuels using a renewable energy source
- Artificial Photosynthesis

As the world continues to search for alternative fuels to fuel our vehicles and heat our homes, many different opportunities are being explored, including converting Municipal Solid Waste (MSW) and Landfill Gas (LFG) to energy, which can displace fossil carbon sources and reduce GHG emissions. Gary

Walter from Southwest Research Institute spoke on the new opportunities for beneficial use of MSW and LFG. His research says that, with some exceptions, MSW buried in landfills release methane (CH_4), which is 21 times stronger than CO_2. One of the ways to use MSW is by gasification, where the waste is converted into fuel gas or synthetic fuels. LFG Methane can be liquefied to liquid fuels for beneficial uses in grid electricity and pipeline quality gases.

With a vision for long-term research, Mike Miller from Southwest Research Institute spoke about how the scientific analysis now favors to define CO_2 limits not as GT/year, but rather as total mass of fossil carbon released during the "industrial" time span—geologically short. He stressed the fact that CO_2 emissions must start to decline by 2020, if we are to have any chance of mitigating CO_2 emissions on climate change. Miller said that scientist and industry experts need to dedicate their resources wisely to fundamental problems, especially problems like marine acidification and atmospheric chemistry which have not been studied extensively. Excessive reduction in sulfates and nitrates in the atmosphere may actually make matters worse.

One of the problems with carbon capturing and sequestration (CCS) is the cost associated with it. Jeff Moore from Southwest Research Institute stated that the current cost of carbon capturing is \$30-90 /tCO_2, most of which is due to the significant compression power required to boost pressure to pipeline levels for storage/transportation. Moore's work has shown that CO_2 capture has a compression penalty as high as 8-12%. He said that the cost of CCS can be reduced significant by reducing the power requirements. His research aims to achieve double-digit reduction of compression power for CO_2 capture technology by utilizing two concepts, isothermal compression and liquid CO_2 pumping. Preliminary results for both concepts show promising results.

Presenting an electric utilities perspective, Paul Barham from CPS Energy talked about how energy efficiency was one of the key areas for the utility industry in order to control greenhouse gas emissions. Some of the key areas that CPS Energy are focusing on include retrofit technologies, cost reduction in renewables and improving grid integration/control issues.

It is clear that all future projections assume there is a set of technical solutions that is globally consistent. Renewable technologies are assumed to be generally competitive. However, these technologies require redundant generation or energy storage capacity to be reliable. Investments in new technologies run the risk of becoming stranded, especially if more economical alternatives become available in the future. Only minor improvements in efficiency are forecasted, however, enhanced efficiency technology could provide dramatic cost-effective solutions.

As world governments met in Copenhagen in December 2009 to map future strategy to contain global warming, and the U.S. Congress continues to debate legislation to reduce carbon emissions, evidence continues to accumulate that the threat is accelerating. To meet future GHG goals, there may be no single energy winner; many technologies must advance and survive concurrently. With continuing research and technology in climate change mitigation, Southwest Research Institute is strategically placed to perform the required multidisciplinary research in order to discover cost-effective solutions for future challenges. ✲

Siemens H Class Turbine . . . *CONTINUED FROM PAGE 51*

The primary focus of test phase 3 was the mapping of aerodynamic and thermodynamic performance at part load and base load as well as final combustion tuning to meet emissions requirements. Test phase 3 also included tests with preheated fuel at various loading rates and also load rejection tests. Pyrometers were utilized to gain a more comprehensive picture of the surface temperatures of the rotating turbine parts. Flow probes were installed in the diffuser and in the turbine flow path to determine the flow fields.

In addition, a comprehensive thermal paint test was conducted at Irsching 4. Thermal paints, also known as temperature indicating paints, are a simple and effective means of obtaining a permanent visual record of the temperature variations over the surface of components. Thermal paints do not modify the thermal behavior of a component during testing and can be applied to surfaces with small-diameter cooling holes without affecting the cooling effectiveness. For this test, two extensive outages involving uncovering the machine were required.

During the first eight-week outage, several parts with thermal paint were installed in the combustion and turbine sections. After reassembly, the engine was started and loaded straight to base load for 10 minutes. Consequently, the thermal painted parts were removed again. The color changes were evaluated and very valuable temperature profiles over the entire surface of the hot gas path parts determined.

Having completed test phases 1-3, all specific operational tests were successfully concluded. During these 15 months of testing, frequent inspections were conducted and valuable service and outage experience was also gained.

Test phase 4, the so-called Endurance Test had the following main purposes:

- Collection of further mid-to-long-term operating experience, starts and hours under semi-commercial conditions,
- Confirmation of "readiness for commercial service", based on the load regime required by the grid operator,
- Operation by staff without special qualification (other than standard GT O&M experience), and
- Recording of test sensor data will be continued, however the prime focus is no longer on testing.

The operating parameters are set and the engine is operated 24 hours for extended continuous periods as well as on a daily start-and-stop basis in line with load dispatch requirements.

The test phase was completed end of August 2009 and has become a success story in gas turbine validation. Key parameters such as the compressor pressure ratio and aerodynamic efficiency, temperatures of hot gas path parts, combustion dynamics behavior, as well as engine output, vibration and emissions have been validated and demonstrated.

The key performance parameters of the SGT5-8000H after 1500 operating hours, 1200 at full load, met or even exceeded expectations and the engine has convincingly proven its capability as a 400-MW-class gas turbine.

With impressive key performance data ready for the market

Siemens Energy is now in a position to offer the 8000H system to the power generation market for commercial applications. Following evaluation of the measured data, the machine's original rated output of 340 megawatts (MW) was raised to 375 MW in simple cycle duty. In combined cycle operational output it will increase by 40 MW to more than 570 MW. These 40 MW are sufficient to supply a further 220,000 people with electricity. Expansion of the plant to a combined cycle station has in the meantime commenced. In 2011, E.ON will take over the world's most environmentally friendly fossil-fueled power plant. ✲

TURBO EXPO
Gas Turbine Technical Congress & Exposition
Presented by the International Gas Turbine Institute

ASME Turbo Expo 2010 Short Courses

SCOTTISH EXHIBITION & CONFERENCE CENTRE, GLASGOW, SCOTLAND

Visit www.asmeconferences.org/TE10/ShortCourses.cfm for more details.

Saturday, June 12, 2010

Thermal Spray and Other Coatings for Gas Turbines - Selection and Application for OEM and Maintenance & Repair

Instructor: **Robert C. Tucker, Jr.**, FASM, TS HoF, The Tucker Group LLC

IGTI is proud to be partnering with ASM International

Failure Investigation of Gas Turbines

Instructor: **Maxine Watson**, Quest Reliability

Saturday & Sunday, June 12-13, 2010

Gas Turbine Aerothermodynamics & Performance Calculations

Instructor: **Syed Khalid**, Rolls-Royce North America

Pipeline Engineering for Gas Turbine Industry

Instructors: **Tom Hausfeld,** GE Energy; **Andre Concalves** and **Aaron Hasnip**, Penspen, Limited

Sunday, June 13, 2010

Basic Gas Turbine Metallurgy and Repair Technology Workshop

Instructors: **Lloyd Cooke,** and **Doug Nagy**, with Liburdi Turbine Services; **Warren Miglietti**, Power Systems Mfg., LLC (an Alstom owned company)

Film Cooling & Technology for Gas Turbines Workshop

Instructors: **Dr. Ron Bunker,** Thermal Systems Lab-GE Global Research Center; **Dr. David Bogard**, UT at Austin; **Dr. Tony Arts**, VKI; and **Sumanta Acharya**, LSU

IGTI is proud to be partnering with the von Karman Institute to offer a workshop modeled from one of their week-long lecture series on Film Cooling.

Keynote Speakers Announced . . .

CONTINUED FROM PAGE 47

CAREER DEVELOPMENT COURSES – Taking place just before the conference begins, our Turbo Expo short courses provide focused, fundamental training. See box at left for more details and visit www.turboexpo.org to register.

ANNUAL WOMEN'S DINNER – Women working in the turbomachinery industry who register for Turbo Expo are eligible to attend our women's networking reception and dinner. The dinner will be held during Turbo Expo on Tuesday evening, June 15, 2010. Registered female delegates will receive an RSVP email from IGTI later this spring. Be sure to respond promptly! This year the dinner is generously sponsored by both Pratt & Whitney and Siemens.

SPECIAL NETWORKING EVENT FOR YOUNG ENGINEERS – The ASME International Gas Turbine Institute (IGTI) provides invaluable professional development benefits for early career engineers and students! Featuring the top experts and leading companies in the field of turbomachinery, there is no better place for young engineers to be than Turbo Expo! While attending Turbo Expo 2010, young engineers won't want to miss a ***special networking event on Wed., June 16, for rising engineers.*** This special networking event will give young engineers the opportunity to meet a variety of representatives from the turbomachinery industry as well as members of IGTI's technical committees. Come and meet potential mentors and seek advice from industry experts during Turbo Expo in Glasgow! **Visit www.turbo.expo.org today for more details and to register**. Students qualify for discounted registration. ✲

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Cranfield University Holds Gas Turbine Events and Courses

By Dr. Yiguang Li, *Professor of Mechanical Engineering, Cranfield University*

Cranfield University MSc students in the Department of Power and Propulsion organize annual Gas Turbine Systems Symposiums as part of their study. Every year the students prepare and present around 100 technical papers which cover different aero and industrial gas turbine engines manufactured by major gas turbine companies and most gas turbine components and subsystems. It is an ideal venue for young engineers and university students whose jobs are gas turbine related or who see gas turbine engineering as their potential career to have an overview of the technology, the products and the industry. The Symposiums will be held in both March and August 2010. The next Symposium will be at Cranfield in the week commencing 8th March 2010. For more information, please contact Dr. Yiguang Li at i.y.li@cranfield.ac.uk.

In addition, Cranfield University offers Continuous Professional Development (CPD) courses which provide state-of-the-art information for people in gas turbine industry, gas turbine user industry or related organizations. The courses are taught by experienced university professors and industry experts. See the list at right for upcoming courses. For more information, please contact Claire Bellis at c.bellis@cranfield.ac.uk or visit http://www.cranfield.ac.uk/short/courses.jsp?subjectid=1015. ✲

Cranfield UNIVERSITY

Introduction to Fatigue & Fracture Analysis
15 Mar 2010 - 17 Mar 2010

Fundamentals of Aircraft Engine Control
22 Mar 2010 - 26 Mar 2010

Gas Turbine Design and Performance
19 Apr 2010 - 30 Apr 2010

Mechanical Integrity of Gas Turbines
10 May 2010 - 14 May 2010

Gas Turbine Performance
07 Jun 2010 - 11 Jun 2010

Gas Turbine Transient Performance
07 Jun 2010 - 11 Jun 2010

Combined Cycle Gas Turbines
21 Jun 2010 - 25 Jun 2010

Gas Turbine Combustion
21 Jun 2010 - 25 Jun 2010

Gas Turbine Technology for Operations & Maintenance Engineers
22 Nov 2010 - 26 Nov 2010