

global Gas Turbine News

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ASME Turbo Expo 2011 Plans Developing; Keynote Theme Announced

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Excitement for ASME Turbo Expo 2011 in Vancouver is building, with a record number of abstracts submitted. The 2011 keynote theme is *Clean & Efficient Turbomachinery Technologies for Future Low Carbon Economies*.

In announcing this theme, Executive Conference Chair Ibrahim Yimer and Conference Chair Thomas Sattelmayer agree that the most essential global challenge today comes from ever increasing energy demand, greater mobility and energy security to sustain current economies as well as meet the growing demand of the new economies. In the context of rapidly increasing public awareness of the environmental impact of non-renewable resources, these challenges present an excellent opportunity to accelerate and develop technological innovations for future low-carbon economies in partnership with government, industry and academia.



Yimer is the Director of the Gas Turbine Laboratory, Institute for Aerospace Research, National Research Council Canada (NRCC). He joined NRCC in 1999 as a Research Scientist, where he spent close to nine years focusing on applied research in emerging technologies, such as low-emission combustion and alternative fuels, to become a well-recognized expert in the field of gas turbine combustion and fuels. IGTI asked Yimer to provide his perspective on efficient turbomachinery technologies and the conference.

Q *Over your career, how has R&D changed to meet the challenges of providing clean, efficient turbomachinery technologies?*

A In addition to a multitude of factors such as reliability, cost and performance, environmental challenges have been a technology driver for some time now, at least since the beginning of my career in the late 80's. Over the past 20 years, I have seen a range of R&D activity intended to minimize noise and emissions of nitric oxide compounds, particulates and unburned hydrocarbons from gas turbine engines. Aero engine combustors, for example, have been optimized for low emissions during operations in and around airports, leading to the current lean burn engine core. This has also allowed the technology to stay ahead of the regulatory curve. Recently however, despite the relatively lower contributions of air transport to the overall anthropogenic radiative forcing, aviation is under unprecedented pressure to reduce its environmental footprint per passenger kilometers. I have seen a shift and a much stronger emphasis to reduce specific fuel consumption and noise emissions while continuing to address air quality concerns. I think now both economic and environmental factors are driving turbomachinery R&D towards more fuel efficiency. As we get closer to the limits of the Brayton Cycle, engine architectures such as the open rotor are being re-explored and refined to maximize propulsive efficiency while managing noise under control. Also driven by the need to reduce green house gases, extending the matured gas turbine technology to other turbomachinery areas such as wind turbines is another trend I am observing. Disruptive technologies that will provide a significant SFC advantage are needed now more than ever. That is why we think these challenges also present an opportunity to accelerate innovations and engage the bright minds of today's young engineers.

Q *Which economies do you see as being at the forefront of supporting and promoting low carbon emissions? How are these economies leading the way for others?*

A Public awareness and government policies in the West will continue to lead and advance the environmental agenda. Specific to aviation, aggressive goals have been set in Europe and the US, more than anywhere else, with significant R&D

TURBO EXPO
Turbine Technical Conference & Exposition
Presented by ASME International Gas Turbine Institute

Keynote speakers from the aeroengine and power generation industry will highlight current development needs and trends in this dynamic environment to stimulate young engineers, foster discussions among the delegates and set the tone of the 2011 conference.

The keynote will feature the following speakers:

- Walter DiBartolomeo, Vice President Engineering, Pratt & Whitney Canada
- Roland Fischer, CEO Business Unit Products Fossil Power Generation, Siemens Energy Sector
- Gary Mercer, Senior Executive in Engineering, GE Energy

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View From The Chair

By Ron S. Bunker, Ph.D., Chairman of the IGTI Board

Ron is a Principal Engineer in the Energy & Propulsion Technology Labs of the GE Global Research Center in Niskayuna, New York. bunker@ge.com.



This issue of the *Global Gas Turbine News (GGTN)*, the quarterly news and events letter of the ASME International Gas Turbine Institute, finds us all in a post Turbo Expo relaxation stage, but gearing up for TE2011 in Vancouver next June.

By now, most readers realize that Turbo Expo is expanding in the near term to encompass and grow technical adjacencies of gas turbines that address our global energy issues. For the TE2011 event we have received 34 abstracts concerning wind turbines, which is about the same as in 2010, but expected to grow as the entire development and deployment of wind turbines grows. Another 27 abstracts have been submitted in the new technical track of fans and blowers, indicating an immediate contribution and interest in a field that accounts for a significant, and perhaps unappreciated, portion of total energy usage. According to a report prepared for the US Dept. of Energy by Arthur D. Little Inc. ("Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation", www.eren.doe.gov/buildings/documents/), fans and blowers are estimated to account for some 1.25 Quads of energy use in the US, that's 1250 trillion Btu or 1320 trillion kJ. And that report was issued in 1999! Clearly this is a turbomachinery area where gas turbine technology can positively impact energy consumption. Last but not least, TE2011 will also launch a new track in solar Brayton and Rankine power cycles, having received 12 abstracts.

The question on many people's minds when they see such growth areas for Turbo Expo, on top of the unprecedented increase in technical papers and sessions of late, is "How can we possibly accommodate this within the framework of a manageable 5-day event?" The IGTI Board recognizes that our volunteers and participants all wish to maintain events with enough time for authors to make presentations of substance, with quality time for interactions and discussions, and without so many parallel sessions as to make full attendance within each subject area impossible. The IGTI Board and staff are actively seeking out opportunities to "spin-off" meaningful and sustainable events in addition to Turbo Expo. Such events may take the form of regional TE's, for example in Asia or the Middle East, and are very likely to be coordinated through teaming with regional technical communities and societies. Whatever the format, it is essential that growth be organic to assure full compatibility with our present organization. At the same time, our community must address the energy challenges that are upon us, and do so globally. To this last point, a special effort was made to increase Asian participation in the organization of Turbo Expo 2010 in Glasgow (many thanks to Prof. Seung-Jin Song, the Incoming Member of the IGTI Board). Thirty session chairs and co-chairs from Asia contributed to TE2010 (compared to about ten for TE2009). This big change represents significant progress in diversifying Turbo Expo participants.

On the topic of our flagship Turbo Expo event, it is essential that we maintain TE as the globally recognized premier venue for all things gas turbine. To this end, you may have noticed or heard of measures to improve and maintain the quality processes used to select technical papers for presentation and also recommendation to journal publication. Our basic review and recommendation process has not changed over the years, but the number of new authors is increasing, as well as the geography of their affiliations, and of course the number of manuscripts. This presents a challenge to all volunteer reviewers and session organizers, many of whom are also new, to maintain the same rigorous evaluation process that defines TE content as "the best technical conference of its kind anywhere." Very soon you will see a new main menu bar item on the TE2011 home page titled "Is My Paper Journal Quality?" This portion of the website will provide guidance to authors about what makes a manuscript journal quality versus conference proceedings, guidance to session organizers and reviewers concerning the quality and content of reviews, and information on the entire manuscript review process. All authors, reviewers, and session organizers are encouraged to reference the new website whether as initial instruction or as a refresher. Your contributions are absolutely necessary to the maintained success and quality of Turbo Expo.

In addition, TE2011 is the first event for which we will be enforcing the new policy of restricting authors of no-show papers from the immediately previous TE event. In an effort to maintain the integrity and quality of the conference for participants and attendees, the IGTI Board instituted a policy to address the issue of no-show authors at Turbo Expo technical conferences. This official policy applies to all authors and co-authors and was first posted on the ASME Turbo Expo 2010 website in September 2009. It states, "Turbo Expo authors that did not register for Turbo Expo, were not present at their session to present their paper, and did not provide for a substitute presenter (i.e., no-show authors), will not be allowed to present at any subsequent Turbo Expo until they have paid the 3-day Turbo Expo registration fee for the Turbo Expo that they missed. Upon payment of the 3-day registration fee, they will receive the DVD of the proceedings of the missed Turbo Expo conference, and they are then cleared to present at Turbo Expo again. This rule will apply to all authors on the no-show paper. Exceptions to this rule can be made by the current Conference Chair." There were nearly 100 no-show papers at TE2009 in Orlando, and another 37 at TE2010 in Glasgow. No-show papers are disruptive to all attendees, add unnecessary strain and burden in the review process, and ultimately increase TE costs for all. The IGTI Board sincerely hopes that a trend of ever decreasing no-show papers will be established.

I look forward to another high quality Turbo Expo in Vancouver next June. As always, your comments and suggestions toward the improvement of IGTI are welcome. *



CALENDAR OF EVENTS

JANUARY 17-21, 2011

Ultra Low NOx Gas Turbine Combustion Course

University of Leeds

Weetwood Hall Conference Centre & Hotel | Leeds, UK

For more details, visit: <http://www.engineering.leeds.ac.uk/cpd> or send an email tocpd@engineering.leeds.ac.uk

FEBRUARY 13-16, 2011

1st Middle East Turbomachinery Symposium (METS)

Sheraton Resort and Convention Center | Doha, Qatar

Organized by the Turbomachinery Laboratory at Texas A&M University and Texas A&M University at Qatar. For more information visit: MiddleEastTurbo.tamu.edu

FEBRUARY 14-18, 2011

Gas Turbine Appreciation Course

Cranfield University | Bedfordshire, UK

<http://www.cranfield.ac.uk/soe/shortcourses/gtc/page4510.html>

FEBRUARY 21-25, 2011

ASME International Gas Turbine Institute Training Week

Southwest Research Institute | San Antonio, TX USA

February 21-22: Introduction to Gas Turbines and Centrifugal Compressors

February 23: Root Cause Failure Analysis of Gas Turbines

February 24: Compressor Performance Testing and Dynamics

February 25: Machinery Performance Testing & Troubleshooting

For more info and to register, visit <http://igt.i.asme.org>

JUNE 4-5, 2011

ASME Turbo Expo Courses

Vancouver Convention & Exhibition Centre | Vancouver, BC, Canada

June 4: Gas Turbine Operation & Maintenance

Technology & Applications of Turbine Coatings

June 4 & 5: Advances in Turbines Aero-Thermo-Mechanical Design & Analysis

Gas Turbine Aerothermodynamics & Performance Calculations

June 5: Basic Gas Turbine Metallurgy & Repair Technology

Introduction to Optimization Methods & Tools for Multi-Disciplinary Design in Turbomachinery

JUNE 6-10, 2011

ASME Turbo Expo 2011

Vancouver Convention & Exhibition Centre | Vancouver, BC, Canada

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

Visit www.turboexpo.org for more details.

NOVEMBER 13-18, 2011

International Gas Turbine Congress 2011

Osaka International Convention Center | Osaka, Japan

The IGTC'11 promises to continue the tradition of nine previous congresses held in Japan, bringing together people from academia, industry, and government. **Abstract deadline is Dec. 31, 2010.**

For more info, visit: <http://www.gtsj.org/english/igtc/IGTC11/index.html>

JUNE 11-15, 2012

ASME Turbo Expo 2012

Bella Center | Copenhagen, Denmark

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



Richard Sessions, programs and membership leader for the ASME South Texas Section Gas Turbine Technical Chapter (www.asmegett.org), arranged a tour of the GE Aero Energy facilities in Houston, TX, for IGTI's Gas Turbine Users Symposium.

ASME Turbo Expo 2011 Plans Developing . . . CONTINUED FROM PAGE 51

collaborations to develop the critical technologies needed. Europe's concerted effort in the Clean Sky and Frame-work programs, and the US Next Gen program are two good examples in that regard. Developing nations have a greater challenge in balancing their relatively fast-growing economies with the environment. Equally challenging is also how to lead or influence in that regard without trampling their economic needs. I do not know the exact answer for this but I do think that leading the way will have to include a mix of S&T, political, and economic co-operations.



Beginning in 2010, ASME Turbo Expo began broadening its scope to include complementary topics relating to steam and wind turbines, fans and blowers and the solar Brayton and Rankine cycle. IGTI asked Sattelmayer, Professor & Chair of Thermodynamics at Technische University in Munich to comment on this development.

Q *How is the scope of Turbo Expo continuing to evolve and what sort of sessions and research are delegates expected to see this year that will make the 2011 conference different from past conferences?*

A The strategy of IGTI is evolving the scope of the IGTI conference to all kinds of turbomachinery and preserving its "home", which is gas turbine technology. Research and technologies in the areas of *steam turbines* and *fans and blowers* have always contributed to the conference program, but the visibility of these areas in the conference program will be increased and the program will be strengthened. Starting with the Glasgow conference, *wind energy technology* sessions have been incorporated in the conference program and this area is expected to grow from Turbo Expo 2010 to Turbo Expo 2011. In Vancouver, participants of Turbo Expo will have the opportunity for the first time to participate in a dedicated program on "Solar Brayton & Rankine Cycles".

For an expanded version of this article, please see <http://igt.i.asme.org/News>

Q *How will broadening the conference scope in 2011 and beyond influence participation? Does the evolving scope affect the status of ASME Turbo Expo as the premier international gas turbine conference?*

A The extension of the activities of IGTI beyond gas turbines has been the most prominent topic communicated over the last two years. For this reason, I would like to emphasize that Turbo Expo will remain first of all the premier conference venue for the knowledge exchange on gas turbine technology and research. We observe a continuous growth of the numbers of papers and sessions in this area, which reflects the high degree of innovation in this area and the increasing role of gas turbines in future energy scenarios with larger contributions of less dependable power than today. The conference provides a unique platform for the fruitful exchange of ideas and information among the participants, which makes the conference the most attractive yearly event for engineers and academics focused on turbomachinery technology. Over 1700 abstracts have been accepted for the Turbo Expo in Vancouver and we expect that between 1000 and 1050 papers will be presented at the conference. With respect to Turbo Expo 2010 we observe an essential increase, although the number of published papers has already grown by 25% between 2005 and 2010. Broadening the conference scope in 2011 has substantially contributed to this success. *

Next Generation of Transport Engines—Very High Bypass Ratio Turbofans vs Open Rotor Engines

By Robert S. Mazzawy, Engineering Consultant, Trebor Systems, Inc (www.treborsys.com)

Engine manufacturers and commercial airlines are looking to the future for the next step in the evolution of gas turbine engines for the industry. Conservation of fuel and reduction in noise are of primary importance in their pursuits. The key to both objectives is improving the fundamental propulsive efficiency of the engine. With subsonic transport applications, this is best achieved by thrusting large quantities of air flow at velocities close to the aircraft travel speed. Two options are to increase the current state of the art bypass ratio level of turbofans (the ratio of air mass flow rate ducted by the fan around the engine core to the engine core airflow) or to eliminate the duct and use an open rotor (advanced prop fan). In either option, the pressure ratio of the fan element has direct influence on the velocity of the air propelled by the engine. Figure 1 illustrates how this fan pressure ratio reduction enhances propulsive efficiency at two levels of flight Mach number. It is evident that reducing exit air velocity has most benefit at lower flight speeds.

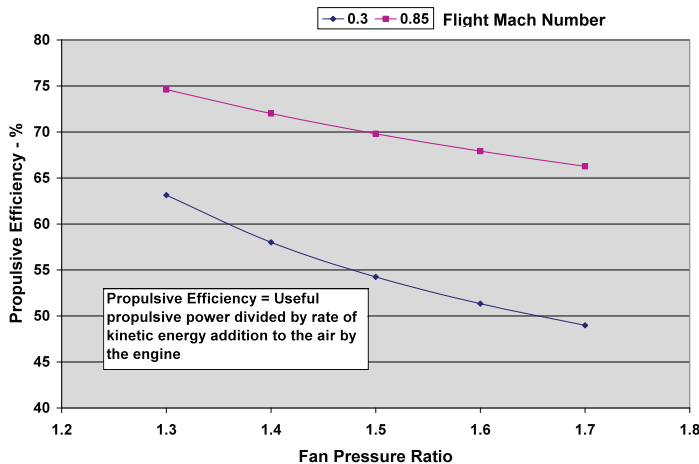


Figure 1. Engine Propulsive Efficiency related to increase in air pressure by engine fan.

Each engine option has its pluses and minuses to consider. The very large bypass ratio turbofan engine maintains the proven capability of containment of blade failures, is inherently quieter due to ability to incorporate acoustic treatment in the fan duct and is not subject to high fan tip losses associated with direct exposure to higher cruise level flight speeds. The duct does not come for free, however, and installed weight becomes a primary concern as the increased bypass ratio drives up the engine diameter. Additionally, the fan is subject to higher local airfoil incidence when the fan nozzle un-chokes at low flight speed. The open rotor engine can achieve potentially greater improvements in propulsive efficiency than a turbofan but lacks the containment and noise reduction benefits of a duct. The rotor is also exposed to flight speed, driving up tip losses at today's accepted cruise flight speeds.

Different engine manufacturers are currently developing advanced turbofan and/or open rotor engines, and making claims to be the correct choice for the future. Without specific details on any particular

engine geometry or technology, it is difficult to assess the individual options, but it is possible to do a "first cut" comparison. To do this, we will confront the major performance issue of each engine. For the turbofan, it is the installed weight and drag associated with the large duct. For the open rotor, it is the performance loss at higher flight speeds.

This evaluation considers two engines of similar technology and thrust size. The turbofan engine incorporates a gearbox to enable the optimum combination of low rotor speed of the fan and high rotor speed for engine core components. It also includes the latest state of the art compact variable pitch mechanism to adjust fan blade incidence at low flight speed. Based on *installed* performance evaluation, this engine optimizes at a fan pressure ratio of 1.3 and a bypass ratio in the range of 12 to 13. The comparable open rotor engine has an effective "bypass ratio" level in excess of 20. Each engine will be compared with today's nominal turbofan engine having a bypass ratio of 6 and a fan pressure ratio of 1.67 on the basis of fuel burn at different flight speeds.

The results of this assessment are provided in Figure 2. [Note that the open rotor engine fuel burn does not include a debit for installation effects associated with the weight of required local hardening of the aircraft for blade loss which is difficult to evaluate for this level of comparison.] As one might anticipate, the open rotor engine is a clear winner at low flight speeds, but loses this advantage as flight speed is increased beyond a flight Mach number of 0.7. With current cruise speeds in the range of Mach 0.8 and higher, the very high bypass ratio engine the scale tips in favor of the very large bypass ratio turbofan. In either case, whether the application is for short cruise segments with extended loiter where the open rotor fits best or for extended high speed cruise where the very high bypass ratio engine excels, the future engines offer substantial fuel savings over today's engines. *

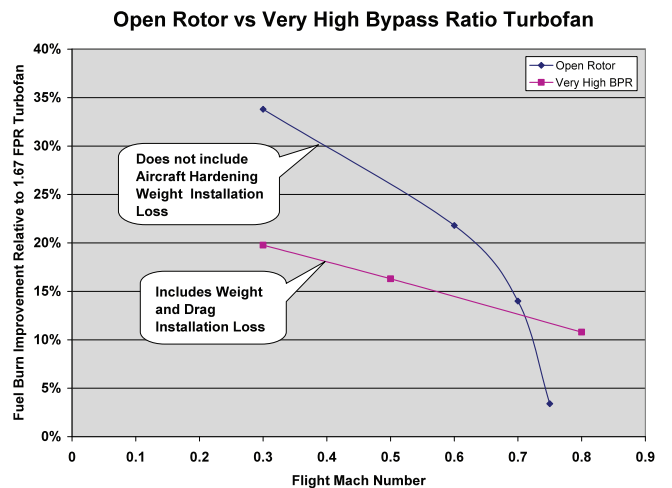


Figure 2. Fuel Burn Improvement for Very High BPR Engine and Open Rotor Engine.



IGTI Training, Awards and Scholarships

By Shirley Barton, IGTI Professional & Member Development Manager

FY2011 Training Events Scheduled:

- In FY2011, IGTI will deliver 12 short courses/workshops and several webinars.
- IGTI continues its successful partnership with Southwest Research Institute to offer four hands-on training workshops. The "Training Week" will be held February 21-25, 2011 at the SwRI facility in San Antonio.
- IGTI will also continue its successful partnership with the von Karman Institute (VKI) to offer two new workshops: *Advances in Turbines Aero-thermo-mechanical Design and Analysis* and *Introduction to Optimization Methods and Tools for Multi-disciplinary Design* in conjunction with Turbo Expo 2011 in Vancouver.
- Turbo Expo 2011 in Vancouver will also be the venue for four other workshops. *Gas Turbine Operation and Maintenance* and *Technology and Applications of Turbine Coatings* are both new this year. Back by popular demand, IGTI will offer *Gas Turbine Aerothermodynamics & Performance Calculations* and *Basic Gas Turbine Metallurgy and Repair Technology*.
- This past October, two courses were held in conjunction with the Texas A & M Turbomachinery Symposium in Houston. A new course titled, *Gas Turbine Combined Cycle Primer*, and the highly recognized *Basic Gas Turbine Metallurgy and Repair Technology workshop*

If you have a topic you think will be of value to the turbine industry and would like to present it in a webinar format or a "face-to-face" format, please contact Shirley at bartons@asme.org.

Young Engineer Travel Award

IGTI offers several travel awards to students and young engineers employed in industry or government to attend ASME Turbo Expo to present papers of which they are authors. Please visit the IGTI web site at <http://igti.asme.org/> for more detailed information.

\$4,000 Scholarship Award

Each year ASME awards a \$4,000 scholarship from IGTI based on superior academic performance and demonstrated interest in the gas turbine, propulsion, or turbomachinery industries. Applicants must be ASME Student Members in good standing at the time of application.

Applications are accepted online each year only from January 15 through March 1. Application forms and detailed instructions may be found at: http://www.asme.org/Education/College/FinancialAid/Details_Requirements.cfm

Congratulations to our Past Winners!

2008 Winner: Gregory Bond with Baylor University
 2009 Winner: Tejas Chafekar with Birla Institute of Technology & Science, Pilani, India
 2010 Winner is Stephen Clark with Duke University

For detailed information on up-coming training events and webinars for the gas turbine industry, please visit the IGTI web site at <http://igti.asme.org/> *



Dr. Dilip Ballal named Pratt & Whitney Chair in "Gas Turbine Engineering"

By Professor Knox Millsaps, Past Chair, IGTI Board

Dr. Dilip R. Ballal has been named the first Pratt & Whitney endowed (Visiting) Chair Professor in Gas Turbine Engineering in the Department of Aerospace Engineering at the Indian Institute of Science (IISc) in Bangalore India. He will assume the Chair position starting in January 2011. IISc is India's top "Research Institute" in engineering and science.

Dr. Ballal is the Head of the Energy and Environment Engineering Division and the Hans von Ohain Distinguished Professor at the University of Dayton. He is a world-renowned scholar in Gas Turbine Propulsion, Combustion, Emissions, and Synthetic and Alternative Fuels. The Pratt & Whitney Chair is expected to provide intellectual leadership to spearhead an applications-driven and

science-based research program related to gas turbine engineering. Pratt & Whitney and IISc envisage a collaborative research program that looks to the Chair as a resource for R&D as well as technical counseling.

In conjunction with his appointment, Ballal expects to give a keynote address on gas turbine technology at the biennial "Aero India 2011" Air Show held during 9-13 February in Bangalore, India.

Ballal, a former Chairman of the IGTI Board, is currently ASME's Senior Vice-President of Institutes. He is also Editor-in-Chief of the *ASME Journal of Engineering for Gas Turbines and Power*. *

IGTI Staff Visits GE Facilities in South Carolina



The staff of the ASME International Gas Turbine Institute participated in a tour of GE Energy's Greenville, SC, campus this summer. GE Energy is a consistent supporter of IGTI activities and is a Platinum Sponsor for ASME Turbo Expo 2011.

The GE tour was arranged by Dr. John Blanton, chief consulting engineer, Heat Transfer, GE Energy, and Judy Osborn, Senior Program Manager, Events and Member Services. Following a presentation by Blanton and other GE representatives, IGTI staff was led on a tour of the manufacturing plant, research and design facilities, and repair development center. *





Low Emission Gas Turbine Technology for Hydrogen-rich Syngas:

EU Research Project on Developing Gas Turbines to pave the way for commercial deployment of efficient, clean, flexible and reliable IGCC plants with CCS by 2020

By Christer Bjorkqvist, Project Coordinator and Managing Director of ETN

For further information about the H2-IGCC project please contact the Project Coordinator at info@etn-gasturbine.eu

In November 2009 the four-year H₂-IGCC research project kicked-off, co-funded by 24 partners, from both the academic and industrial sector, as well as the European Union (EU), under the Seventh Framework Programme for Research and Development (FP7).

The project focuses on developing gas turbine (GT) technology optimised for the next generation Integrated Gasification Combined Cycle plants with Carbon Capture and Storage (IGCC-CCS).

The H₂-IGCC project is coordinated by the Brussels-based European Turbine Network (ETN) – an association with members of all stakeholders across the GT technology development value chain (power generation, mechanical drive and marine applications). ETN promotes environmentally sound gas turbine technology with reliable and low cost operation.

The objective of the H₂-IGCC project is to provide and demonstrate technical solutions for state-of-the-art, high efficiency, low emissions GT technology that can be employed to IGCC applications. More specifically, the goal is to enable combustion of undiluted hydrogen-rich syngas with low NO_x emissions and also allowing for high fuel flexibility. The challenge is to operate a stable and controllable GT on hydrogen-rich syngas with emissions and processes similar to current state-of-the-art natural GT engines. The H₂-IGCC project aims to tackle this challenge as well as fuel flexibility, by enabling the burning of back-up fuels, such as natural gas, without adversely affecting the reliability and availability.

The EU has conceded that to reach its 20% emissions reduction target by 2020 (which will possibly be increased to 30%) it will require carbon capture and storage (CCS), the only technology available to mitigate emissions from large-scale fossil fuel usage. CCS is also a vital pillar in the European Commission's Strategic Energy Technology Plan (SET-Plan), which seeks to meet the emissions reduction goals while building a low carbon economy with reduced dependence on external fuel supply.

The target year of 2020 for CCS deployment in the EU is only achievable if different parts of the efficiency chain are improved in building near zero emission power plants. The technology for the next generation of IGCC plants with CCS is promising but still requires development and demonstration of hydrogen GT technology as well as overall process integration. This process integration approach used in the H₂-IGCC project will enhance confidence and significantly reduce deployment times for new technologies and concepts developed in this project.

The H₂-IGCC project brings together 24 partners from industry and academia with the common goal to increase gas turbine efficiency and fuel flexibility without affecting the reliability and availability in a pre-combustion IGCC-CCS plant configuration. A successful outcome of this project will be an important step towards opening up the market for a commercial implementation of IGCC-CCS technology.

The H₂-IGCC project addresses the technical challenges related to GT in 4 Sub-Projects (SPs):

COMBUSTION (SP1)	MATERIALS (SP2)
<p>Safe and low emission combustion technology for undiluted, hydrogen-rich syngas will be developed and demonstrated.</p> <p>In order to achieve this, problems resulting from the differences in combustion properties of hydrogen and natural gas need to be addressed and solved. These are higher flame speed, higher adiabatic flame temperature, drastically reduced auto-ignition delay times and the large increase in volumetric fuel flow rate of hydrogen compared to natural gas.</p>	<p>Cost-effective materials and coatings technologies will be developed to overcome the component life-limiting problems of overheating and of hot corrosion resulting from the higher temperatures and residual contaminants in the syngas, including validation of materials performance data, life prediction and monitoring methods.</p> <p>Simulation tools for estimating performance and lifetime of materials systems will also be enhanced to suit the new operating environments.</p>
TURBOMACHINERY (SP3)	SYSTEM ANALYSIS (SP4)
<p>Modified compressor, turbine and turbine cooling designs will be delivered. Compressor stable operation should enable the switch between fuels without compromising efficiency with the increased fuel mass flow rate that could lead to compressor instability.</p> <p>Turbine design has to cope with a different enthalpy drop, while the turbine cooling system has to cope with the higher specific heat of the exhaust gases. This will result in increased operating temperatures of the components in comparison with natural gas-fired gas turbines. Potential turbine vibration problems will also be addressed.</p>	<p>System analysis will evaluate the optimum IGCC plant configurations and set up guidelines for optimised full scale integration providing a detailed system analysis that generates realistic techno-economical results for future gas turbine based IGCC plants with CCS.</p> <p>The compatibility of the combustion technology with the materials and turbo-machinery requirements will be optimised.</p>

In the fields of combustion, materials and turbomachinery, academic research and industrial testing activities have begun, while common terms for boundary conditions were identified in order to work towards the optimum IGCC plant configurations. In the first six months of the project, reports on state-of-the-art IGCC technologies, kinetic mechanisms and plant modelling resources have been published on the project website.

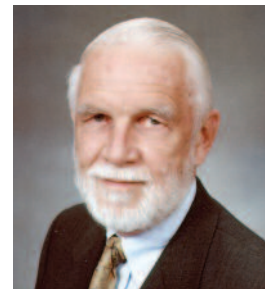
Over the past decade, a number of initiatives on clean coal technology and IGCC have started around the world. Successful mitigation of climate change requires global efforts. Therefore, international knowledge sharing is essential to significantly reduce the time and the cost of bringing CCS to the market. In order for industry to invest in the next generation of IGCC plants with CCS systems, both technical and commercial risks need to be quantified and minimized, especially those associated with the GT. To further this process, the public research findings and results drawn from the H₂-IGCC project will be disseminated at international conferences and on the project website: www.h2-igcc.eu. *



Featured Column: *As the Turbine Turns...*

The Elephant in the Room – Gas Turbine Power

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



In the last 30 years, advances in gas turbine technology have almost doubled the thermal efficiency of new electric power plants.

Modern gas turbine combined cycle (CCGT) power plants^[1] are producing electric power as high as half a gigawatt with thermal efficiencies approaching the 60% mark – almost twice the efficiency of power plants I learned about as an undergraduate ME student.

In a CCGT power plant the gas turbine is the key player, driving an electrical generator. Heat from the hot gas turbine exhaust is recovered in a heat recovery steam generator (HRSG, a.k.a., a boiler), to generate steam, which drives a steam turbine to generate more electrical power. Thus it is a combined power plant (the gas turbine or Brayton cycle and the steam turbine or Rankine cycle) burning one unit of fuel to supply two sources of electrical power.

Most of these CCGT plants burn natural gas, which has the lowest carbon content (less CO₂) of any other hydrocarbon fuel. Their near 60% thermal efficiencies lower fuel costs by almost half compared to other gas fired power plants. Their installed capital cost are the lowest in the electric power industry (\$1000–1200/KW compared to a modern nuclear plant at \$4500/KW (or higher) and lower by half than a fossil fueled steam power plant). Environmental permits, necessary for new plant construction, are much easier to obtain for CCGT power plants. Another environmental advantage is that less than half of the power plant output requires water cooling (to condense steam). This is an important consideration in many parts of the world, where cooling water may be in short supply, and air-cooled condensers may be needed.

And yet, it has been to my astonishment that I hear almost no reference to these superstar power plants in the general public, energy-commenting media or at two recent U.S. national energy forums I attended. The CCGT power plant is truly the “elephant in the room.”... ignored by many energy affectionatos, through perhaps ignorance or nearsightedness.

Two years ago I attended the US National Academies Summit on America’s Energy Future, a conference held in Washington D.C., March 13–14, 2008. The two day summit featured some 26 presentations providing an overview of recent influential energy research studies and initiatives. Speakers included three secretaries of energy: James Schlesinger (he was the first under President Carter), Samuel Bodman (then in office under President Bush) and 1997 Nobel Prize winner and director of the Lawrence Berkeley National Laboratory, Steven Chu (subsequently appointed by President Obama).

This year I attended the US Department of Energy’s March 2–3, 2010 Energy Innovation Summit, held just

south of Washington, D.C. This conference, with about 1700 attendees, served to introduce and give a progress report on DOE’s newly formed Advanced Research Projects Agency – Energy (ARPA-E), patterned after the US Department of Defense’s well-renowned ARPA. Presentations given over the two days included those by DOE Secretary Steven Chu, General Electric CEO Jeff Immelt, New York Times columnist Tom Friedman, retired Lockheed Martin CEO Norm Augustine and Daniel Yergin (well-known energy consultant and author of *The Prize*, the story of oil).

However, in both of these major energy conferences, there was a complete lack of serious discussion of the important role of electric power gas turbines, in America’s and the world’s energy future. In discussions often centered around the “hydrogen economy” and “renewable energy” the actual role that gas turbine technology has and will play in the world’s energy picture was benignly neglected or ignored. If mentioned, it was referred to as a transitional means to the employment of some future, immersing energy converter (e.g. the fuel cell, solar energy plants, or wind turbine farms).

Consider the track record of some of the energy converters featured at these energy summits. Fuel cells have been around since 1839 and while research has greatly improved their performance, they always seem to be “the promise of things to come.” Wind turbine technology goes back 1000 years and, however efficient, suffers from the intermittent nature of wind.

Contrast this with the progress^[2] made with gas turbines in less than four score years. The very first electrical power plant gas turbine was built and tested by Brown Boveri in 1939. It was installed at Neuchatel, Switzerland and had an output of 4MW, a thermal efficiency, η , of 18%, a firing temperature (turbine inlet temperature) of 998°F (357°C) and a relatively low exhaust temperature of about 530°F (277°C). Compare this very first power plant gas turbine to today’s Mitsubishi Heavy Industries (MHI) M701G2 heavy frame “G Class” gas turbine, with an output of 334 MW, an η of 39.5%, a firing temperature of 2732°F (1500°C) and a much higher exhaust temperature of 1089°F (587°C), eminently suited for combined cycle steam production.

With the much higher exhaust temperature, the MHI CCGT power plant has an overall on-site thermal efficiency of 59.1%, yielding an aggregate output of 500MW. Currently, three of these units with a combined output of 1500MW are replacing six conventional steam powered plants (43% efficiency) with a total output of 1050MW, in one third of the plant area, at the Tokyo Electric Power Company (TEPCO) Kawasaki Thermal Power Station in Japan.

The largest combined cycle gas turbines are the H class machines made by GE and Siemens. A new Siemens H class gas turbine, the SGT5–8000H, is rated at 340MW, making it the world’s largest gas turbine. The turbine underwent testing in 2009 at Irsching, Germany, and is the heart of a new 530MW combined-cycle plant. Siemens expects to exceed 60% thermal efficiency for this new H machine.

Last February, in this column^[3] I outlined the bright future for natural gas as a fuel for gas turbine power plants, based on new discoveries and the growth of liquefied natural gas facilities. It was also pointed out that the U.S. Energy Information Administration (EIA) projects that of an estimated 255 gigawatts of additional electric generating capacity to be added in the U.S. by 2030, 55% will be in the form of natural gas fueled gas turbine plants. This “elephant in the room” has a bright future – that could be made brighter by directing more gas turbine technology and research funding to push way beyond the unmatched 60% efficiency mark, now established. *

References

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2. Langston, Lee S., 2008, “Efficiency by the Numbers,” *Mechanical Engineering Magazine*. Website, Web Exclusives, pp. 1–3.
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Annual Insight Into Blade Mechanics In The Foothills Of The Swiss Alps

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A rotating turbine or compressor blade is a piece of engineering art that brings various scientific disciplines together to convert as much thermo-dynamic energy into mechanical work as possible.

This work drives the generator, producing electricity that has been an essential source of economic development and a better quality of life for over 100 years.¹ Over 100 years of design experience have been incorporated in various design criteria to prevent blades from failing in service. From the mathematical point of view, the reliable operation of the rotating blade stands for meeting the aero-, thermo- and structural dynamics principals as an integrated solution explicitly given in the blade geometry and material.

Today's market requirements for higher engine performance drive the further development of the blade design towards 3D-blading technologies, sophisticated cooling schemes, new alloys and better thermal barrier coatings. These technical challenges do not conform with the conservative design criteria, which have to be elevated to a higher level of the engineering knowledge. Therefore, computational techniques are being employed to accelerate the research and development process. Modern clusters linking a hundred computers are able to simulate realistically the unsteady fluid-structure behaviour of the cooling process or of excitation, providing better understanding of the physics involved in the blade mechanics. New results and findings of these numerical and experimental studies are being published in hundreds of technical papers every year. The conference proceedings of international congresses, like the ASME Turbo Expo, become a huge database shared in many thousands of papers. A literature survey facilitates leveraging the individual knowledge, detailing what is most important for each company.

Indeed, the knowledge exists in both tacit and explicit form. Tacit technical knowledge is difficult to pin down because it is rooted in the expertise of individual engineers or researchers with many years of work experience. Different manners of sharing knowledge, such as design guidelines, lecture series, workshops, or seminars help to identify the existence of tacit technical knowledge. This knowledge is routinely exploited in product development. The antipode is the explicit technical knowledge associated with comprehensible numerical analyses and experiments. Those investigations are triggered by the distinct needs of product development. Therefore, the explicit technical knowledge is easier to articulate than the tacit one. Or in other words, the tacit and explicit technical knowledge, respectively, correspond with the "personal" and

"collective" knowledge of product. Both need to be managed in a way allowing the selection of the most competitive technologies to meet market and business requirements in the best way possible.

Focussing on the common need for knowledge base analyses, the Blade Mechanics Seminar, hosted annually in Winterthur by Zurich University of Applied Sciences (ZHAW) and co-organized by the Swiss Section of the ASME, offers a platform for know-how and experience exchange between engineers from various turbomachinery companies. The Blade Mechanics Seminar aims to answer the participants' needs that arise in their daily work regarding axial and radial bladed discs of aero-engines and industrial turbines. A one-hour keynote speech given by an expert from the industry opens the one-day seminar that also includes a few presentations followed by comprehensive discussions on the understanding of the presented problems and their solutions. As a discussion forum, this seminar highlights many dimensions of the state of the technology and methodology applied to blade analysis. Long coffee breaks allow for various bilateral discussions or visits to the sponsors' booths. In 2010, non-destructive testing of component properties was demonstrated at Alstom's booth (Fig. 1), providing practical experience for finite element analysts. Now, the Blade Mechanics Seminar is a local engineering event with a global footprint because in 2009 and 2010 one hundred engineers representing 21 companies and 5 universities from 12 countries took part in this event (Fig. 2).



Fig. 1 During the coffee break of the 15th "Blade Mechanics Seminar," the demonstration of NDT capabilities for the evaluation of the material properties of turbine blades.

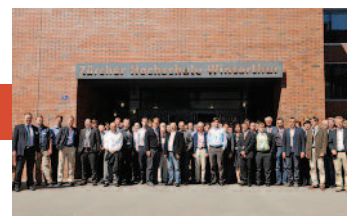


Fig. 2 100 participants of the 15th "Blade Mechanics Seminar" on 1 September, 2010, representing 21 companies and 5 universities in 12 countries.

The seminar location in Winterthur, in the foothills of the beautiful Swiss Alps, is not incidental. This Swiss town is the cradle of turbocharger technology invented in 1905 by the Swiss engineer, Alfred Buechi. In 1908, the American Chadwick racing car was first equipped with 'Zoller rotary compressors' (a centrifugal compressor) developed by the Swiss engineer, Arnold Zoller of Winterthur. 100 years ago in 1910, Joseph J. Murray constructed the first mechanically supercharged two-stroke aircraft engine for the Murray-Willat Company (see 'Early Flight exhibition' in 'National Air and Space Museum', Washington DC). The adjacent Swiss city of Zurich (30 km from Winterthur) became the cradle of the gas turbine technology engineered by Prof. Aurel Stodola. In 1939, the first gas turbine with a power output of 4 megawatt and an efficiency of 17.4 percent was installed in the municipal power station in Neuchâtel, Switzerland. This oldest machine, which has been restored by Alstom in Birr (70 km from Winterthur), is recorded in the ASME historic landmarks.² Participants of the 16th Blade Mechanics Seminar,³ to be held on 14th September 2011, can also visit spectacular dammed lakes (e.g. Lake Grimsel) in the Swiss Alps that provide the water to drive 543 turbines of hydropower plants, generating 56% of the electricity in Switzerland. *

References

1. The 100 years are based on Parson's steam turbine innovation in 1884 and the first patent for a gas turbine by British inventor John Barber in 1791, but the idea of using water or steam kinetic energy dates back to the ancient times.
2. www.asme.org/Communities/History/Landmarks/
3. <http://project.zhaw.ch/de/engineering/blade-mechanics-seminar/>