GLOBAL Gas Turbine News

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ASME Turbo Expo 2010 Taking Shape; Keynote Theme Announced

Plans for ASME Turbo Expo 2010 in Glasgow are in full swing, with a record number of abstracts submitted. The 2010 keynote theme is ***Extending Limited Natural Resources Through Energy Technology Innovations.***

In announcing this theme, Executive Conference Chair Graham Hopkins and Conference Chair Klaus Brun agree that 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. Future power generation plants, oil & gas production and distribution equipment, and aircraft engines must operate at higher efficiencies with much reduced air pollution and lower noise levels to meet regulatory, customer and consumer needs. Alternative energy technologies such as wind turbines, tidal generation, fuel cells, geothermal power plants, solar thermal power plants, and other energy storage devices provide great opportunities for scientific and engineering improvement that will make them more viable and cost efficient. Research, development, and teaching in these technology areas is imperative so that future generations can have continued access to low cost energy, fuel, and a clean environment. Original equipment manufacturers, universities, consultants, and equipment users must work together to develop the necessary solutions for the energy and aircraft engine industry of the future.

Hopkins is the Director of Engineering & Technology, Defence Aerospace, Rolls-Royce. He has been with Rolls-Royce plc in the Aerospace Group since 1979. In his current position since 2005, he provides strategic direction and leadership for all business sector engineering activities. IGTI asked Hopkins to provide his perspective on the turbomachinery industry and the conference.

Q Over your career, have you seen any changes in the focus of turbomachinery research and development?

A In the last few decades there has been a significant change in the focus of R&D (including R&T) investment within the Defence business of Rolls-Royce. During the era of the Cold War, predominantly in the 70s and 80s, the MoD typically contracted RR via 'cost plus' contracts to design, develop and produce *Gas Turbines*. The requirements for such gas turbines were primarily focused upon space envelope (i.e. the physical envelope space allocated for the gas turbine in the airframe), performance (mostly dry and reheated thrust, power and transient response) and to a lesser degree, weight. Specific Thrust was more of a focus than SFC. The holistic or *Systems Engineering* approach in the identification of requirements for the gas turbine by the customer/'*airframer*' during this Cold War era was immature, resulting in a lack of understanding of the implications of platform architectures on gas turbine thrust/power and electrical generation and vice versa.

The increased pressure on Defence budgets and the recession of the early 90s encouraged MoD to adopt smart procurement initiatives and 'fixed price' contracts. At a similar time heavy investment in Computational Methods started to demonstrate that more and more elements of technology maturation could be verified via the various software packages as opposed to rig and engine testing, thus reducing cost, time and risk to programmes.

The increased focus on Through Life Capability Management (TLCM) has resulted in more emphasis on increasing fuel efficiency (which drives the requirements for hotter thermodynamic cycles, which in turn require advancements in aerofoil aerodynamics, cooling architectures and higher temperature capable materials) and reduced through life costs. Research programmes have focused on how to optimise the design of components ('design for process excellence initiative' which allows parametric studies to demonstrate impacts via chosen cost functions) at initial concept stages as opposed to undertaking various iterations via rig tests through the technology maturation phase as was often experienced in the 70s and 80s. The focus on reduced through life costs have focused research to increase the life and reliability of components – particularly those at the hot end.

The increased focus on power density has resulted in a significant R&D investment into blisks, blings and composites (for rotatives as well as structures).

...continued on page 7

IN THIS ISSUE...

VIEW FROM THE CHAIR

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

Welcome to the second quarter edition of the Global Gas Turbine News (GGTN) for 2009-2010. The content of this publication has improved significantly over the last couple of years, and with the inclusion of GGTN in the ASME *Mechanical Engineering Magazine,* the circulation has increased to nearly 135,000. However, we will continue to improve this publication. The best way to do this is for you, the membership, to become involved, primarily through writing short articles for it. If you have something that you think our readership would like to know about in the gas turbine area, please contact the editorial board.

IGTI is an exciting and vibrant organization, and I will outline some of the events occurring this year and highlight some new aspects of IGTI.

First and foremost IGTI is famous for our Turbo Expo, and this year's event in Glasgow, Scotland, promises to be the largest one ever, and we are thinking one of the best. We are expecting more than 1,000 papers, so it will be a very busy late Fall and early Winter reviewing all of these papers.

While the nature of the event will remain the same, there are a couple of new and exciting additions to the conference. First, IGTI is expanding our scope to respond to ASME's "Grand Energy Challenge" and like last year will have more papers, dedicated sessions, and panel discussions on Steam Turbines. I thank Dr. Anestis Kalfas for his leadership in organizing the steam turbine sessions in several committees, including Turbomachinery, Heat Transfer, and Structures and Dynamics. There will also be Wind Turbine sessions for the first time, and I thank Harold Simmons from SwRI who is organizing this new area. IGTI intends to welcome these new areas into our conference since we have the technical expertise to make contributions in these areas, and our members find these areas interesting.

Along with Turbo Expo there are many exciting activities offered by IGTI, including educational and workforce development. IGTI is responding to the needs of our community by offering Short Courses. This year we repeat our Training Week at Southwest Research Institute, in San Antonio, TX, February 22-25, 2010 with three (3) courses and have four (4) courses on the Saturday and Sunday before Turbo Expo 2010 in Scotland. We also plan to have a number of webinars on special topics. See the **Calendar of Events** for details and visit our website (http://igti.asme.org) for updates.

IGTI will continue to support young career engineers through scholarships and travel grants to attend our conference.

Thank you for participating in IGTI, and I look forward to continuing to work with you to maintain the preeminent position IGTI holds in the gas turbine world. ✻

CALENDAR OF EVENTS

JANUARY 4-7, 2010
48th AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition
Orlando World Center Marriott
Orlando, Florida USA

A forum for scientists and engineers from industry, government, and academia to share and disseminate scientific knowledge and research results with a view toward new technologies for aerospace systems. **Visit IGTI in booth #1013!**

JANUARY 18-22, 2010
Ultra Low NOx Gas Turbine Combustion
Weetwood Hall Conference Centre & Hotel
University of Leeds

Contact: CPD Unit, 0113 343 2494
Email: cpd@engineering.leeds.ac.uk
Web: www.engineering.leeds.ac.uk/cpd

FEBRUARY 22-25, 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.*

ASME International Gas Turbine Institute Training Week...continued

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 Troubleshootng
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

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***

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.

AUGUST 8-13, 2010
14th Int'l Heat Transfer Conference (IHTC)
Omni Shoreham Hotel
Washington D.C., USA

For more details, visit:
http://www.asmeconferences.org/IHTC14/

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.

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

ASME Turbo Expo 2010 Short Courses

SCOTTISH EXHIBITION & CONFERENCE CENTRE, GLASGOW

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

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

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.

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

Gas Turbine Prognostics: A Key to Successful Condition Based Maintenance Programs

By Michael J. Roemer, Ph.D. , *Director of Engineering , Impact Technologies • www.impact-tek.com*

Predicting the future is difficult. This is certainly true in most aspects of life and predicting gas turbine faults or failures is no exception. Of course, in the cases when we can make such fault predictions accurately, we are able to gracefully schedule our maintenance actions and never have to deal with costly downtime due to unforeseen events. That is what the Prognostics and Health Management (PHM) and Condition-Based Maintenance (CBM) engineering communities have been working to accomplish for decades now. Although the success stories are numerous, the truth is that we still have some way to go, especially when we focus on the prognosis piece. But with proper management of the risk and uncertainties involved with making such predictions, gas turbine operators are beginning to make better decisions, which in turn is saving them money over the life cycle of their machines.

Today, many maintenance programs are still managed based on a combination of existing reliability data and operational and maintenance experience to help provide insight into their machine's health for scheduling maintenance actions. However, more progressive operators are combining their experience with the latest information coming from automated monitoring systems available in the market today. Coupled with software packages that can be used to automatically detect, classify and in some cases predict faults or failures, operators are in a much better position to manage their assets. Data-driven fault detection models, automated classification techniques and advanced models for predicting structural, performance and mechanical related faults are just a few of the methods currently being implemented in next generation condition-based maintenance programs.

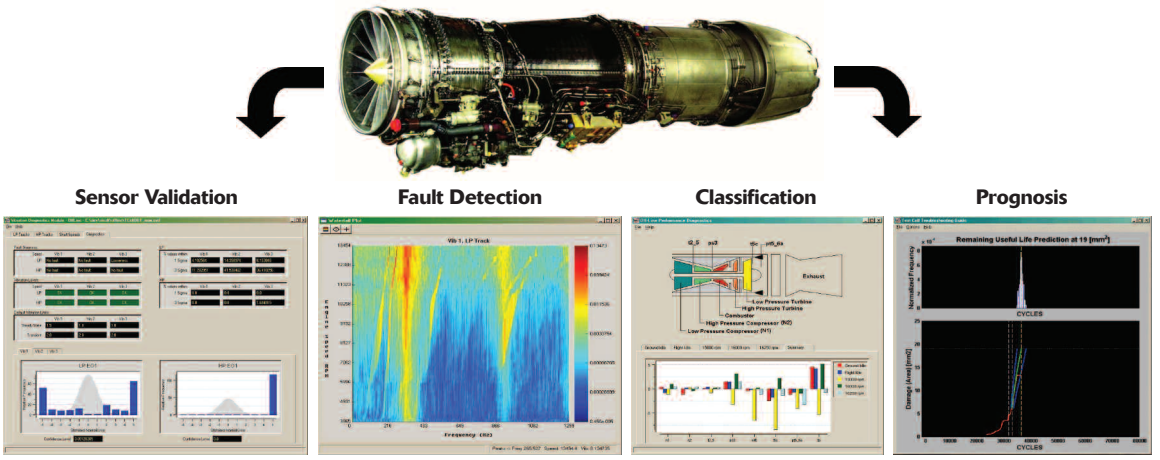
Let's take a quick look at some of the leading technologies that are being used today for assembling a successful gas turbine health management program used for CBM. The first step usually involves implementing a dedicated sensor validation module to ensure that reliable data is being used by the downstream PHM software and any sensor or connector issues are detected up front. Controlling false alarms is paramount, hence implementing fault detection software that can use information from multiple sources to provide a more confident fault assessment is recommended. In a parallel process, the validated sensor data and real-time current/past diagnostic information is utilized by various prognostic modules to predict future time-to-failure, failure rates and/or degraded engine condition (i.e. vibration alarm limits, performance margins, etc.). The prognostic modules typically utilize physics-of failure or stochastic models, taking into account randomness in operation profiles, extreme operating events and component forcing. In addition, the diagnostic results can be combined with past history information to train real-time algorithms (such as a neural networks or real-time probabilistic models) to continuously update the projections on remaining life.

In the special case of a prognosis module, it must have the ability to forecast the future condition or failure risk of a component or system given the past operating environment and how the engine is expected to be operated in the future. These are often implemented using physics-based approaches that typically incorporate mechanical or thermodynamic models as their basis. In addition, probabilistic elements are often used for addressing inherent modeling uncertainties that most directly affect the component life limiting factors such as material properties, dynamic forcing, and operating variability.

The desired output of these modules is typically a distribution of the remaining useful life that is determined by calculating the effects of these life-limiting factors in a stochastic process given past operating conditions. Operating hours can be statistically analyzed, trended and projected into the future to provide the models with forward looking conditions. More advanced models that represent failure mode uncertainties, projected operational parameters, and rare/random events can also be used to help predict failure mode propagation. When possible, these physics-based models should be calibrated using in-service data to clearly reflect the root cause of the in-service failure mode experiences.

Once the predictions of time-to-failure or degraded condition are determined with associated confidence bounds, they can be used in a risk-based analysis to optimally decide the best time for performing specific maintenance actions. This process should examine the expected value between performing maintenance on an engine or component at the next opportunity (therefore reducing risk but at a cost of doing the maintenance) versus delaying the maintenance action (potential continued increased risk but delaying maintenance cost) until a later time. The difference in risk between the two maintenance or operating scenarios and associated consequential and fixed costs can then be used to optimize the maintenance intervals or alter operational plans.

In the end, a successful CBM program that implements prognosis modules on the most critical components or subsystems will have a decisive advantage when planning maintenance actions and thus driving cost and expected downtime to lower levels. ✻



Key Modules of a Gas Turbine CBM System

NASA Turbomachinery Technical Working Group Technology Assessment

By James D. Heidmann, Ph.D. , *Senior Technical Advisor, Subsonic Fixed Wing Project, NASA Glenn Research Center*

A NASA-led Turbomachinery Technical Working Group has been assembled consisting of technical experts from industry, university, and government agencies. The formation of this group was prompted by the desire of NASA's Subsonic Fixed Wing (SFW) Project to establish working groups focused on the key technologies relevant to the SFW Project goals in each technical discipline. It was anticipated that the group would be a forum for exchange of the latest ideas in the Aerothermodynamics Discipline and a method to inform the project of the critical needs in this area. It was decided to focus the group on turbomachinery, although the purview of the Aerothermodynamics Discipline is slightly more comprehensive to include all engine flows.

Initial membership of the group consisted of Jim Heidmann (NASA, chair), Tony Strazisar (NASA), Dick Rivir (AFRL), Aspi Wadia (GE Aircraft), Ron Bunker (GE Global Research Center), Jayant Sabnis (Pratt & Whitney), Sanjay Hingorani (Pratt & Whitney), Om Sharma (UTRC), Steve Wellborn (Rolls-Royce), Malak Malak (Honeywell), Ed Greitzer (MIT), Zolti Spakovszky (MIT), Karen Thole (Penn State), Reza Abhari (ETH-Zurich), and Howard Hodson (Cambridge). The group met for the first time in a face-to-face meeting at the 2007 ASME Turbo Expo Meeting in Montreal, Canada. Subsequently, the group has convened periodically by telecon in addition to subsequent face-to-face meetings at NASA Glenn Research Center and at the 2008 and 2009 ASME Turbo Expo Meetings in Berlin, Germany and Orlando, Florida.

One of the tasks of the group has been to undertake a technology survey of the turbomachinery area. This exercise was meant to address the need for a systematic method to identify high payoff research activities in the turbomachinery area aimed at addressing the SFW noise and fuel efficiency goals for future generation aircraft:

NASA Subsonic Transport System Level Metrics

...technology for dramatically improving noise, emissions, & performance

CORNERS OF THE TRADE SPACE	N+1 (2015)*** Technology Benefits Relative to a Single Aisle Reference Configuration	N+2 (2020)*** Technology Benefits Relative to a Large Twin Aisle Reference Configuration	N+3 (2025)*** Technology Benefits
Noise (cum below Stage 4	- 32 dB	- 42 dB	- 71 dB
LTO NOx Emissions (below CAEP 6)	- 60%	- 75%	better than - 75%
PERFORMANCE: Aircraft Fuel Burn	- 33%**	- 40%**	better than - 70%
Performance: Field Length	-33%	-50%	exploit metroplex* concepts

*** Technology Readiness Level for key technologies = 4-6
** Additional gains may be possible through operational improvements
* Concepts that enable optimal use of runways at multiple airports within the metropolitan areas

Initially, a fairly comprehensive list of research areas was generated by the group. Subsequently, the group was asked to rank each research area on the basis of "interest and impact". The results were compiled, and upon consolidation of related topics, several key technology areas emerged:

- INLET FLOW DISTORTION SENSITIVITY AND STABILITY
- TIP LEAKAGE FLOWS IN HIGH PRESSURE RATIO CORES
- ENDWALL CONTOURING
- TURBINE TIP FLOWS
- COMBUSTOR/COOLED TURBINE INTERACTION
- HIGHLY LOADED LOW PRESSURE TURBINES

The group recognized the need to describe the importance and payoff of each technical area to the NASA SFW mission and undertook creation of a white paper on each topic. A technical expert was assigned lead authorship of each topic, but the entire working group was given the opportunity to revise and augment these drafts.

The turbomachinery research summarized here primarily benefits the Subsonic Fixed Wing project goals by allowing the project to meet its N+1 and N+2 reduced fuel burn goals. The project charts emphasize the need for propulsion improvements in order to reach the overall aircraft fuel burn goals. In the N+1 configuration, propulsion technology improvements contribute the majority of the expected fuel burn reduction, and they are expected to be required in even greater measure to accomplish the more aggressive N+2 fuel burn goals. In addition, constraints imposed on the propulsion system by noise and emissions technologies require technology improvements even to maintain fuel burn for a given configuration.

The following is a summary of the 6 key technology areas identified by the group:

Inlet Flow Distortion Sensitivity and Stability

Current aircraft engine design trends tend towards higher bypass ratio, low-pressure ratio fan designs for improved fuel burn. Lower fan pressure ratios lead to increased propulsive efficiency, and besides enabling thermodynamic cycle changes for improved fuel efficiency, significant noise reduction can be achieved. Unfortunately as the fan pressure ratio and fan speed are reduced, the fan design becomes more sensitive to inlet flow distortion and installation stagnation pressure losses. Casing treatments have been extensively used in aero-engine compressors to enhance operability. However, a rigorous assessment of this technology in advanced low-pressure ratio fan designs has not yet been carried out

...continued on page 6

and the effectiveness and efficiency penalties are unknown. The proposed effort focuses on the rigorous investigation of the underlying mechanism and the necessary technologies to reduce inlet distortion sensitivity and stability issues in low-pressure ratio aero-engine fan systems.

Tip Leakage Flows in High Pressure Cores

It is well known, through a large amount of experimental, analytical, and numerical investigations, that the flow in the tip and near casing region of axial compressors and fans has a strong influence on both the aerodynamic efficiency and the operating range. The demand for smaller size cores has increased with new engine architectures. With the anticipated smaller cores and the resulting larger blade tip clearance of 2 to 4% of blade height, the resulting compressor efficiency loss due to the tip gap would be of the order of 2 to 5%, corresponding to ~3% SFC impact, relative to current designs. A 50% reduction in tip clearance loss in the next 3 years would result in a 1-2% improvement in SFC and fuel burn.

Endwall Contouring

The three-dimensional contouring of turbine airfoils has become commonplace since about 1990. Much of this art has now become reality in recent turbine products, driven primarily by gains in aerodynamic efficiency. As an example of the potential for aerodynamic gain, a nearly +0.6% increase in HPT aero efficiency has been demonstrated through non-axisymmetric contouring of the vane and blade endwalls. Projection of such gains through the fan, compressor, and turbine stages, leads to potential aero efficiency increases of several points. Combined with consequent advantages in cooling flow reductions due to better aero, the overall entitlement for engine cycle efficiency could be as much as +2%.

Turbine Tip Flows

For current large commercial engines, tip clearance gaps contribute to about 25% to the loss in unshrouded turbine efficiency. It should be pointed out that the high pressure turbines in current operational engines are designed to operate at very tight clearances. Next generation of engines, with smaller cores, need to operate at higher normalized clearance levels. New technologies will therefore need to be developed to maintain performance and durability of the turbines at higher normalized clearance levels. Every 1% in blade gap height results in 1.5% to 2% of the aerodynamic efficiency reduction. With the anticipated smaller cores and the resulting larger blade tip gaps of 2 to 3% of blade height, the resulting turbine efficiency loss due to the tip gap would be of the order of 3 to 6%, corresponding to 2-4% SFC impact.

Combustor/Cooled Turbine Interaction

Increased turbine inlet temperatures have been enabled by advances in both materials and turbine cooling technologies. Cooling technologies have historically been responsible for about two-thirds of the improvement. It is difficult to predict and thereby improve current designs with existing computational fluid dynamics (CFD) tools because of the combination of complex geometries, near-wall modeling required, and potential unsteady flow effects on the heat transfer and resultant material temperature prediction. The problem is complicated by the fact that the turbine durability is governed by the turbine material temperature field rather than the gas temperature, so the thermal conduction problem must also be considered. It is imperative for improved future cooled turbine designs and engine performance that improved methods and models be developed that not only accurately describe the complex heat transfer physics, but also have reasonable turn-around time to impact the design cycle. The expected outcome of such a research effort would be a better understanding of the complex flow and mixing processes in a combustor/turbine flowfield, which would lead to validation of both CFD tools and design tools used for cooled turbine design.

Highly Loaded Low Pressure Turbines

The efficiency of the LP turbine strongly influences the specific fuel consumption of an engine, where a 1 percent increase in LP polytropic efficiency improves the fuel consumption by 0.5 to 1 percent. With efficiency levels already much greater than 90 percent, there will be little scope for improving this aspect of performance without a step change in technology. The LPT of the NASA's Subsonic Fixed Wing Project is likely to have Reynolds numbers in the range 70,000 to 200,000 at cruise conditions. Understanding and, crucially, being able to predict the unsteady separated/transitional suction-side boundary layer is essential in developing airfoils with increased lift that retain the already high levels of efficiency. Unfortunately, increasing the lift beyond today's levels represents an even greater challenge, especially as a reducing core size means that the Reynolds numbers are also reducing. The three-dimensional design of LPT airfoils also holds tremendous promise for achieving improved performance. While this has some elements in common with the endwall contouring topic, the LPT presents unique challenges, both in the blade and in the endwall. ✲

IGTI and ASME Scholarships for Gas Turbines

The International Gas Turbine Institute (IGTI) provides scholarships for undergraduate and graduate students studying gas turbines. IGTI also is offering travel awards for young engineers to attend Turbo-Expo. These are available for both U.S. and international students.

There are currently three different types of awards being funded by IGTI:

1. ***ASME-IGTI Scholarship.*** This $4,000 scholarship is available to any ASME student member from any country and can be for study at either the undergraduate or graduate level. Students can apply online in Feb. 2010 at www.asme.org under "ASME Scholarships".

2. ***IGTI Scholarship Program.*** There will be multiple $2,000 awards, for students at the undergraduate or graduate level. Each University with a gas turbine research or teaching component may nominate one student for the award. Nominations for the 2010 cycle are due by December 31, 2010. Nomination letters from a faculty member, such as the ASME Student Section Advisor or Department Chairman, should be sent to:

IGTI - Attention: Scholarship Committee:
6525 The Corners Parkway, Suite 115 • Norcross, GA 30092 USA
igti@asme.org

3. ***Young Engineers Travel Award.*** These are awards for either students or young engineers employed in industry or government to attend the International Gas Turbine Conference and Turbo-Expo to present a paper on which they are an author. To apply the engineer should write an application letter requesting travel funds and send to igti@asme.org. Typical awards are for $2,000.

IGTI will be seeking additional funding for these awards from corporate sponsors. This is a great way to make young engineering students aware of the wide range of exciting career opportunities in the gas turbine industry. If your company is interested in contributing to this worthy cause please contact IGTI at igti@asme.org to make a tax deductible contribution. Become a sponsor today. ✲

ASME Turbo Expo 2010 . . . CONTINUED FROM PAGE 1

The emergence of 'Total Care' contracts with operators in the late 90s (often referred to as Power by the Hour in the Civil world), which offer *availability*, have driven a significant investment in EHM diagnostic and prognostic capabilities in order to enhance fleet management. Another key focus change has been on repair technology, in particular for high value assets such as blisks and turbine blades and vanes.

During the 90s the first University Technology Centres (UTCs) were launched. The UTCs give close contact with the best academic institutions and grant RR access to a wealth of talent and creativity and protect capability in the future. Research at UTCs covers the majority of the power systems capability spectrum up to TRL4 – a recent focus of UTCs has been into low cost manufacturing.

There has been a significant focus over the last few years on research into Integrated Power Systems (IPS). Recognising the challenges of increasing electrical demands (with the ever increasing complexity of ISAR platform sub systems), platform thermal management (due to the more electrical aircraft, ISAR sub systems mentioned above and reducing opportunities for heat dumping into a/c structures to increased use of composites), RR will provide IPS solutions for future platforms which manage the above in addition to power/thrust, at platform level, as a step change to simply providing a gas turbine.

The key focus of the IPS is the Integration – this also includes the design of the intake and exhaust systems, which have a significant affect on the power source. The IPS approach in conjunction with the holistic or systems engineering approach will ensure the end platform is optimised in terms of size, weight and cost and ultimately, capability, in conjunction with the 'system integrator'. The ability of an IPS to perform an intelligent power management function will enable a greater degree of autonomy – which could be realised through increased endurance and reductions in operator workload. IPS is equally applicable to manned and unmanned platforms.

Q How are current energy technology issues relating to the turbomachinery industry being addressed?

A There are a number of R&T programmes on going within RR addressing current technology issues such as:

- Affordable Capable Engine Technology (ACET) – Covering Blisk Repair, Robust leading edges, Blade Tip Timing and TiMMC development for Blings
- SEED/Mantis – Developing and demonstrating key IPS building blocks and also unit cost reduction
- Exploitation of UAV operation in controlled aerospace via the ASTRAEA
- Taranis - Developing and demonstrating the LO integration building blocks on an IPS.
- ENTAPS – Developing Fan Systems for operation behind convoluted intakes, combustion & turbine technologies to support higher core thermodynamic cycles to offer step changes in SFC.

Q What are some future energy technology challenges?

A
- Unit Cost Reduction
- Integration of Power Systems and the through life support
- Reducing the gap in SFC between Civil and Defence
- Positioning to capitalise on the introduction of alternative and new fuels (e.g. liquid hydrogen storage)
- Compliance with Civil emissions requirements (Noise, smoke, NOx)
- Reducing the operational dependency on fossil fuels as expressed by the forthcoming MoD Capability Vision
- Meeting future UAV endurance targets which will typically be in terms of days and one day, weeks!

Q With a record number of abstracts submitted, conference participation is projected to be at the highest level ever. From an OEM perspective, what is the value of ASME Turbo Expo for turbomachinery professionals?

A I am delighted to see the level of interest in the ASME conference. A successful conference will help to enforce the strategic importance of R&D investment into greener, more affordable technologies to a wider audience. The conference is an excellent opportunity to promote and network with the world leaders in this field. It could also potentially act as a catalyst for building future business relationships.

Beginning in 2010, ASME Turbo Expo is broadening its scope to include complementary topics relating to steam turbine and wind turbine technology. IGTI asked Conference Chair Klaus Brun, Manager - Machinery Section, at Southwest Research Institute to comment on this development.

Q How did this direction in broadening the scope occur?

A Today's energy market is in flux, with dramatic changes such as new environmental regulations on green house gasses, natural resources becoming more valuable, and a globalization of energy supply and demand. The members and the board of IGTI recognized that research in new important energy areas, beyond our traditional focus on gas turbines, will provide the information and technology to our members that they need to respond to these market changes. Turbo Expo will provide an excellent "home" for technical papers in wind and steam turbine technology and other broader energy related areas. IGTI members will significantly benefit from this expanded scope of Turbo Expo. In the future, IGTI intends to further broaden Turbo Expo's content to include other energy and machinery related topics that will be of current interest and significance to the membership.

Q In broadening the scope to include additional turbine technologies, how do you expect the 2010 ASME Turbo Expo to be different from our past conferences?

A Turbo Expo will have the same excellent papers on gas turbine as in the past, but 2010 will also include valuable additional content that still relates closely to IGTI's traditional strengths: turbomachinery, jet propulsion, and energy technology

Q How will broadening the conference scope in 2010 and beyond influence participation?

A We hope that this diversification will appeal to engineers, scientists and other professionals working on wind and steam turbines, thus, increasing Turbo Expo's attendance, further the exchange of information between different disciplines, and result in improved energy technology for our future.

Q Will this growth affect the status of ASME Turbo Expo as the premier international gas turbine conference?

A Turbo Expo will continue to be the worlds foremost conference for both jet and ground based gas turbines and will continue to attract the highest quality gas turbine technical papers and presentations. IGTI's core mission is and will stay focused on the gas turbines but other related energy technologies will allow Turbo Expo to attract additional audience from areas that are beyond our current strengths. ✻

GTUS09 Delivers Solid Content

The 2009 ASME Gas Turbine Users Symposium (GTUS) was co-located with Texas A&M's Turbomachinery Symposium in Houston for the second year in a row on September 14-17.

This year's GTUS once again provided timely topics and offered solid technical solutions. Gas turbine users could attend sessions in four tracks: Design, Operation & Maintenance, Advances, and Environmental Issues. Symposium highlights included a full-day, three-part tutorial on Introduction to Gas Turbines, which provided a comprehensive overview in the function, performance characteristics, and in particular, the typical operational issues for industrial gas turbines. In addition, specially-selected, application-oriented technical papers from ASME Turbo Expo 2009 were presented. Other topics this year included fuels, advanced inspection technologies, combustion and emissions, and repairs.

A highlight of the week was the annual networking dinner, generously sponsored by GE Oil and Gas. In conjunction with GTUS, IGTI also presented two full-day, well-attended workshops, Combustion Dynamics in Gas Turbine Power Plants and Basic Gas Turbine Metallurgy and Repair Technology.

The GTUS planning committee, chaired by David Mucz, Manager, Business Operations with Alliance Pipeline, Ltd., in Calgary, Alberta, Canada, is evaluating ways to increase user participation in the coming years. IGTI will also be highlighting User sessions at ASME TurboExpo 2010 in Glasgow, Scotland on June 14-18, 2010.

Please plan to join us for the 2010 ASME Gas Turbine Users Symposium, which will be co-located for the third year with Texas A&M's Turbomachinery Symposium in Houston on October 5-7, 2010. ✲

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

New IGTI Policy on No-Show Authors

The IGTI Board of Directors has instituted a new policy intended to reduce the number of no-show authors at future Turbo Expos. This is in response to input from the IGTI Membership concerning a significant increase in the number of authors that failed to show up to present their papers or even notify the session organizers.

There were more than 100 no show authors in Orlando. Along with detracting from the general environment at the conference, this increases costs because all of us have to pay for unused rooms. These costs are ultimately passed to attendees through increased registration fees. IGTI works hard to keep the costs as low as possible and reducing the number of no-show authors will save money.

Starting with the next Turbo Expo, no-show authors will not be permitted to submit technical papers for future IGTI conferences until they have paid the three-day registration for the conference they missed. This applies to all authors on the paper. If no author is able to attend, which is sometimes unavoidable, a replacement speaker should present the paper, after they are fully briefed on the content. While this is less than a good option, we understand that problems arise and it is not always possible for one of the authors to attend.

The Conference Chair is able to grant a waiver from this policy. However, a documented effort to attend or find a replacement speaker is generally needed. ✲

In Memoriam: William T. Sawyer

"…his keen judgment and foresight in recognizing the great potential of the gas turbine as a prime mover in marine service and for contributions that ultimately resulted in numerous applications in this field."

IGTI is sad to learn of the passing of a member of the gas turbine community, William T. Sawyer. Sawyer was a retired Captain in the U.S. Navy.

CAPTAIN SAWYER received his BS from the Naval Academy, his MS from MIT, and his doctorate from the Swiss Federal Institute of Technology in Zurich. After 28 years in the Navy, he retired to accept the position of Head of the Engineering Department at Catholic University in Washington, D.C., and later became Dean of Instruction at Chesapeake Community College in Maryland.

Sawyer was an ASME member and a member of the Marine Gas Turbine Technical Committee. In 1956 he was awarded a citation from the ASME Gas Turbine Power Division. The citation recognized "…his keen judgment and foresight in recognizing the great potential of the gas turbine as a prime mover in marine service and for contributions that ultimately resulted in numerous applications in this field."

Sawyer also published various papers relating to marine gas turbines, including "Prospects of Gas Turbines in Naval Applications" in *Mechanical Engineering*, April 1950; "The Marine Gas Turbine in 1951" in the *Trans. Society of Naval Architects & Marine Engineers*, November 1951; and "Design Aspects of Marine Gas Turbine Ducting" in the *Journal for Power*, March 1966. His marine gas turbine ducting research was also presented at the 11th Annual Gas Turbine Conference and Products Show in Zurich, Switzerland. ✲