global
Gas Turbine News
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ATLANTA, GEORGIA USA /// ASME INTERNATIONAL GAS TURBINE INSTITUTE

Register Today for ASME Turbo Expo 2011 Keynote Speakers Announced

In this issue

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

Event registration and housing reservations for Turbo Expo 2011 in Vancouver are now available online at www.turboexpo.org!

KEYNOTE SPEAKERS ANNOUNCED

Three leaders from the aeroengine and power generation industry will highlight current development needs and trends by addressing the theme *"Clean & Efficient Turbomachinery Technologies for Future Low Carbon Economies"* at Turbo Expo in Vancouver.

Walter DiBartolomeo, Vice President Engineering, Pratt & Whitney Canada; **Roland Fischer**, CEO Business Unit Products, Fossil Power Generation, Siemens Energy Sector; and **Gary Mercer**, Senior General Manager in Engineering, GE Infrastructure Energy, will all speak at the opening keynote on Monday, June 6.

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.

Walter DiBartolomeo has been with Pratt & Whitney Canada for over 20 years. He began his career at P&WC in 1985 as an aerodynamicist, assuming roles of increasing responsibility in engineering. He has gained broad experience in the areas of aerodynamics, ice protection, project engineering, nacelle design, accessories and mechanical systems integration.

Roland Fischer worked as a development Engineer for MTU aero engines until 1998, when he became General manager of MTU Maintenance Malaysia. In 2003 he became Senior Vice President for MTU, where he headed the Defence Program, as well as various programs in production, engineering, supply management and service. In 2008 Fischer joined Siemens as CEO of Business Unit E F Products, where he is responsible for development, manufacturing and component sales of rotating equipment (gas turbines, steam turbines, generators) for fossil power generation.

Gary Mercer began his engineering career at Dresser Industries Clark Division. In 1985 he started his GE career at Aircraft Engines Business Group in Ohio. In 1993 he became part of Power System's gas turbine new product development engineering team, where he ultimately served as GM for the H gas turbine development. When the organization was brought to the Greenville production facility in 1999, he completed his MBB certification and spent 2 years as the Power Generation Programs Manager. Then Mercer took on the role of GM Engineering for GE Oil & Gas in Florence, Italy. Mercer has now returned to GE Energy in Greenville, SC, and in his current role he provides engineering leadership to support GE Energy's renewable business.

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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, starts with a non-turbine news item. I just built a new home. That does not sound very news worthy, unless you are the leader of a world power or a major business icon, but it does form a parallel with IGTI. ASME has recently laid the foundation for a new "home" by revising its vision and main objectives. ASME's new vision statement is that **"ASME will be the essential resource for mechanical engineers and other technical professionals throughout the world for solutions that benefit humankind"**, and it's three main strategic objectives are Energy, Diversity, and Global Workforce Development. This redirection of ASME is necessary to transform from the [perceived] heavily US-based mechanical engineering organization to an international association of mechanical engineering and related professionals dealing with the major global challenges of the next fifty years. In fact, we should be using the correct name, ASME International.

What may not be clear to most present readers is that the International Gas Turbine Institute (IGTI) and it's sister institute the International Petroleum Technology Institute (IPTI) are the role models for the restructuring and expansion of ASME International to meet it's new global objectives. To follow my initial comment, IGTI and IPTI are the proven blueprints for the base of ASME's new home. IGTI is a very successful global organization of volunteers focused on being **"the world's foremost vehicle for the development and dissemination of gas turbine educational and technological information"** (our vision statement). While IGTI is a single focal area institute model, IPTI's equally successful institute model is that of an umbrella organization including the three ASME divisions of Petroleum, Ocean/Offshore and Arctic Engineering, and Pipeline Systems.

IGTI and IPTI together form the Institute Sector Board (ISB) of ASME. The ISB is recognized as the growth engine for ASME International. The proven success of IGTI and IPTI place these institutes in key roles as mentors for emerging new institutes, or for the merging of existing divisions into institutes. Institutes operate under the direction of their own Boards with support from dedicated ASME staff and a network of highly driven professional volunteers. Institutes of technical communities, such as that for gas turbines, provide the most successful approach to sustainable global growth.

For example, as noted in the last issue of GGTN, the organic growth initiative known as IGTI-Plus applies IGTI's technical communities expertise to related turbomachinery areas like wind turbines, steam turbines, fans and blowers, and solar Rankine / Brayton cycles. IGTI-Plus can be thought of as the major upgrades to our home. Beyond this analogy, IGTI needs to now establish new homes in global locations other than the US and Europe, such as India, MidEast, East Asia, and South America. IGTI and IPTI intend to lead the way for ASME by example, and to help ASME International transform to a mainly institutes-based organization. This will not happen overnight, nor will it take place without significant efforts from our volunteers. Inertia can be a powerful force against change. The IGTI Board will work with ASME staff and the Board of Governors to affect positive changes and growth. Your suggestions, insights, and efforts are most welcome with regard to both a more diverse global presence for IGTI and the proposed reformation of ASME.

On a closing note, I just returned from the ASME International Mechanical Engineering Conference and Exhibit (IMECE) held in Vancouver, Canada, the site of our upcoming 2011 Turbo Expo. The conference facility is new, spacious, and within walking distance of many fine downtown hotels and restaurants. Vancouver is a beautiful city in a great location. I hope to see many of you there. ✻

In November, Southwest Research Institute (SwRI) held its annual one-day expert lecture series and forum to discuss future key technologies for the reduction of carbon and other greenhouse gas (GHG) emissions. This year the lecture series had over 100 scientists and engineers in attendance on the 1200 acre SwRI campus in San Antonio, Texas. The 2010 lectures featured 10 distinguished speakers and industry experts covering a variety of topics such as **Energy Efficiency Carbon Capture**, **Conversion and Storage (CCCS)** and **Renewable Energy**. L to R: Charles Roberts Ph.D., Danny Deffenbaugh, Klaus Brun Ph.D., Michael Ming, Jeff Moore Ph.D., Francis Huang Ph.D. and Cris Eugster. ✻

CALENDAR OF EVENTS

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, METS will be closely modeled after the Turbomachinery Symposium that has been held in Texas since 1971.
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/gte/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://igti.asme.org

MAY 2011
Gas Turbine Courses at Cranfield University,
Bedfordshire, UK
http://www.cranfield.ac.uk/soe/shortcourses/gte/
May 9-13: Mechanical Integrity of Gas Turbines
May 16-20: Gas Turbine Performance
May 16-20: Gas Turbine Transient Performance:
May 16-27: Gas Turbine Component Technology

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.

JUNE/JULY 2011
Gas Turbine Courses at Cranfield University,
Bedfordshire, UK
http://www.cranfield.ac.uk/soe/shortcourses/gte/
June 20-24: Combined Cycle Gas Turbines Course
June 27 – July 1: Gas Turbine Combustion

AUGUST 1-3, 2011
AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit
San Diego Convention Center | San Diego, CA
The objective for JPC 2011 is to identify and highlight how innovative aerospace propulsion technologies powering both new and evolving systems are being designed, tested, and flown.
Visit www.aiaa.org for more details

SEPTEMBER 12-15, 2011
40th Turbomachinery Symposium
George R. Brown Convention Center | Houston, TX
The Symposium, which features technical sessions and an exposition, focuses on users concerned with maintenance, performance, troubleshooting, operation, and purchase of rotating equipment

NOVEMBER 13-18, 2011
International Gas Turbine Congress 2011
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 to share in the latest information on developments in the field of gas turbines, turbochargers, steam turbines, and their applications.
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.

ASME Turbo Expo 2011 Keynote Speakers . . . CONTINUED FROM PAGE 45

DON'T MISS THESE TURBO EXPO EVENTS:

Technical Conference

Turbo Expo has a well-earned reputation for bringing together the best and brightest experts from around the world to share the latest in gas turbine technology, research and development, and application. Now, the IGTI community is enhancing its leadership role in turbomachinery as it broadens the program scope to include related topics from wind and steam turbine technology as well as fans and blowers and the Solar Brayton and Rankine Cycle. The 2011 Technical Conference proceedings, alone, are worth the price of admission, as the DVD will contain over 1,000 peer-reviewed publications!

Exposition

Now in its 56th year, ASME Turbo Expo is recognized as the *must attend* event for turbomachinery professionals. Turbo Expo offers unrivalled networking opportunities with a dedicated and diverse trade show floor. The 3-day exhibition attracts the industry's leading professionals and key decision makers, whose innovation and expertise are helping to shape the future of the turbomahinery industry. Join ANSYS, CD-adapco, GE, Pratt & Whitney, Sulzer Metco, and many more on the floor! Daily lunches plus afternoon networking receptions in the exposition are included in the registration package for delegates and exhibitors.

Career Development Courses

Taking place just before the conference begins, our Turbo Expo short courses provide focused, fundamental training. Choose from several courses to be held Saturday and Sunday, June 4-5, 2011. Register for the conference and then take advantage of the opportunity to attend short courses while you are in Vancouver! Course topics include gas turbine operation and maintenance, metallurgy and repair, turbine coatings, aero-thermo-mechanical design, aerothermodynamics and performance calculations, and optimization methods & tools for multi-disciplinary design in turbomachinery. See page 50 for more details and visit www.turboexpo.org to register.

Annual Women's Dinner

Women working in the turbomachinery industry who register for Turbo Expo are eligible to attend our women's networking reception and dinner. The dinner will be held during Turbo Expo on Tuesday evening, June 7, 2011. Registered female delegates will receive an RSVP email from IGTI later this spring. Be sure to respond promptly! This year the dinner is generously sponsored by both Pratt & Whitney and Siemens.

Special Networking Event for Young Engineers

The ASME International Gas Turbine Institute (IGTI) provides invaluable professional development benefits for early career engineers and students! Featuring the top experts and leading companies in the field of turbomachinery, there is no better place for young engineers to be than Turbo Expo! While attending Turbo Expo 2011, young engineers won't want to miss a ***special networking event on Wed., June 8, for rising engineers***. This special networking event will give young engineers the opportunity to meet a variety of representatives from the turbomachinery industry as well as members of IGTI's technical committees. Come and meet potential mentors and seek advice from industry experts during Turbo Expo in Vancouver! **Visit www.turbo.expo.org today for more details and to register.** Students qualify for discounted registration. ✲

Five Steps to Evaluate a Gas Turbine Inlet Air Filtration System

By Melissa Wilcox, Research Engineer, Machinery Structural Dynamics Group,
Mechanical Engineering Division of Southwest Research Institute, www.machinery.swri.org

A typical gas turbine (GT) ingests millions of pounds of air every day. Therefore, even a small concentration of debris in the air can correlate to a large amount of debris in the GT. For example, 10 ppm of debris in 400,000 lb/hr of air is equal to 4 lb/hr of debris. A GT inlet filtration system is used to protect the turbine from harmful debris which can lead to reduced efficiency and power, component performance degradation, and blade failures. In this article, five steps are suggested for evaluating a current GT inlet filtration system and determining the need for any improvements.

STEP 1: THE OPERATING ENVIRONMENT

The first step to evaluate an inlet filtration system is to study the operating environment. It is important to understand what must be removed from the air by the filtration system before evaluating the existing system. The environment, type of debris, and amount of debris dictates how the filtration system should be configured and maintained. Operating environments can be classified into nine main categories. These categories and a list of common debris are summarized in Figure 1. A GT may operate in one or more of these environments throughout the year.

In addition, there can be local, seasonal, and/or temporary debris in the air. Plant emissions are one example of a localized source. The layout of the plant site with respect to the turbine inlet will influence how much soot from exhaust, cooling tower aerosols, or other emissions enter the inlet filtration system. Other examples of localized sources are mining operations or agricultural sites. Seasonal changes and weather patterns (wind, humidity, precipitation, and temperature) will also affect what must be filtered. Lastly, temporary sources such as construction sites will affect air quality.

When defining the operating environment, the first step is to complete a visual survey of the operating site and surrounding area. Next, an air quality survey can be completed near the turbine to obtain information on debris size and concentration. It is also valuable to complete compositional analyses on used filters and samples of deposits from the first stages of the compressor. This will give insight into what is and is not being removed from the air with the current system.

Common Debris in Different Environments

Coastal	Arctic	Desert
Salt Land debris Water (rain, sea mist) Sand	Ice Insects Snow Summer dust	Sand Pollen, sticky substances from local vegetation Fog
Marine	**Tropical**	**Rural**
Salt (dry and wet) Water (rain, sea mist, waves, wake) Sand Ice	Water (rain, humidity) Insects Pollen Salt (if near ocean)	Water (rain, snow, fog) Agricultural dust Pollen, ground dust, seeds Leaves Ice
Offshore	**Industrial**	**Urban**
Salt Water (rain, sea mist) Sand Cooling tower aerosols Hydrocarbons, soot, exhaust	Water (rain, snow, fog) Ice Cooling tower aerosols Ground dust Hydrocarbons, soot, exhaust	Water (rain, snow, fog) Pollen, ground dust, seeds Leaves Ice Soot, pollution, exhaust fumes

Figure 1. Debris in Several Different Environments

STEP 2: THE EXISTING SYSTEM

Once the operating environment is defined, the existing filtration system can be evaluated. The configuration of the filtration system should already be documented or it can be determined from visual inspection. The majority of filtration systems in operation have multiple stages and each stage should be defined. An example of documentation of a filter configuration is shown in Figure 2.

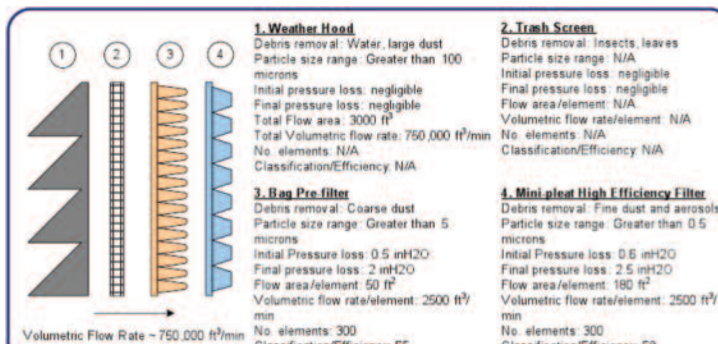


Figure 2. Example of Filtration System Configuration

The operator can evaluate the system by comparing the debris in the air and the type of filtration system the GT has. A brief description of different filter components and their purposes is provided in Figure 3. During the evaluation, it is important to consider filtration efficiency, volumetric flow rate, and pressure loss. In addition, a visual inspection of the filtration system should be performed before filters are replaced. Some specific items that should be noted are:

- Filters are wet or dry (wet filters are an indication that water is entering the system),
- Rust in filter housing (this indicates that water is entering system and housing is degrading),
- Loading of filters across entire filter bank (look for even loading and if filters need replacement),
- Leaks in the filtration system (leaks defeat the purpose of the filtration system and should be sealed),
- Installation of filter elements (ensure filters are being installed correctly),
- Damaged filter elements (determine root cause of damage: FOD, material defect, filter overloaded, or wet filter), and
- Deposits on housing downstream of the last filter stage or deposits on first stages of compressor (indication of what is not being removed by filtration system).

A review of these items will provide the operator with a comprehensive assessment of the current state of the inlet filtration system.

STEP 3: MAINTENANCE PRACTICES

Maintenance is an important part of any system. It ensures that the system will stay in an operable condition and perform as required. There are several tasks which, if performed consistently and correctly, can ensure that the filtration system operates properly.

The largest maintenance item of a filtration system is the replacement of the filters. Filters are designed for a certain lifespan which is quantified by

Common Filtration System Components

Weather Hood: Minimizes the amount of rain, snow, and large dust that enters the filtration system. Comprised of a sheet metal hood which requires the air to flow upwards.

Weather Louvre: Performs the same functions as a weather hood. Comprise of a series of turning vanes.

Trash/Insect Screen: Prevent large trash objects (plastic, leaves, etc.) and insects from entering the filtration system. Consists of a mesh screen.

Anti-Icing System: Prevent ice from forming in filtration system or inlet of gas turbine. Provides hot air from compressor bleed or heating elements.

Coalescer: Removes large water particles and conglomerates small water particles. Consist of fiber mesh pad.

Inertial Separator: Removes large water and dust particles. Has geometry which utilizes gravity and inertial forces to remove debris.

Pre-fitler: Removes medium to large dust particles. Consists of fiber media.

High Efficiency Filter: Removes small to medium dust particles and aerosols. Consists of fiber media.

Self-Cleaning Filter System: Removes small to medium dust particles and has self-cleaning capabilities. Consists of fiber media.

Figure 3. Description of Common Filtration System Components

the pressure loss across the filter. This should be monitored in the filtration system. Each filter is prescribed an initial and final pressure loss and a maximum lifespan by the manufacturer. The filters should be replaced when they either reach the final pressure loss or maximum calendar lifespan. Filters operating past this will have reduced filtration efficiency and high pressure losses. Leaving fully loaded filters operating will lead to reduced performance and increased degradation of the GT, and the possibility of complete filter failure/collapse. This will result in bypass of the system and thus GT contamination.

In addition to filter replacements, maintenance needs to be performed on any auxiliary systems. This can include drainage systems, self-cleaning systems, and/or anti-icing systems. Also, inspection should be performed periodically including: filter condition, filter to frame seal leaks, seals on filter housing joints, inspection ports and doors (closed and sealed properly), drainage points, water drains for plugging, flexible connections in draining system.

If maintenance practices are found to be inadequate, a primary focus should be placed on correcting filter replacement intervals and inspecting the filtration system for any leaks. After these items are improved, an inspection plan should be implemented. This will help to ensure the filtration system performs properly in the future.

STEP 4: UPGRADES TO THE SYSTEM

During the evaluation, the operator may find deficiencies in the current filtration system. If this is the case, then upgrades should be considered. The system can be upgraded on several levels. A filtration system, housing and all, could be completely replaced, or just the filter elements could be upgraded. When considering an upgrade, several items should be evaluated.

- What are the requirements for inlet air filtration?
- What are the weaknesses of the existing system?
- What debris is not being removed by the system that should be removed?
- Could the filtration system perform as needed by changing out the filters more often or is a different modification required?
- Does the system have sufficient weather protection (snow, ice, rain)?
- What is the expected performance of the GT while using the existing system? Is this performance acceptable for the future operation?

The operator must determine the benefits of upgrading the filtration system. These can be realized in several areas: increased filtration efficiency, reduced degradation, improved gas turbine performance, or decrease in pressure loss across filters. When evaluating upgrades to the filtration system, several different upgrade configurations should be evaluated for their cost and benefit.

STEP 5: OVERALL COST OF SYSTEM

One of the most straightforward methods for comparing the cost and benefit of different filtration system options is by completing a Life Cycle Cost (LCC) analysis. This analysis quantifies the cost and performance of a system in monetary terms to obtain a lifetime cost of the system. The lifetime costs between two different system options can be directly compared.

An LCC analysis for a filtration system has seven main components: initial costs, maintenance costs, availability and reliability considerations, GT degradation losses, compressor washing effects, pressure loss effects, and potential failures or events costs. The initial cost is the main cost that is typically considered when looking at upgrading a system. This cost is important for an LCC analysis, but not necessarily the most important or dominant cost. Costs associated with maintenance (i.e. replacement parts, labor, and downtime) and those associated with GT performance (i.e. efficiency) are also important components of an LCC. The effects of the inlet filtration system performance (pressure loss and GT performance degradation) are quantified by placing monetary values on lost power, increases in heat rate, and reduced efficiency.

Once all of the costs of a filtration system are quantified, a lifetime cost of the system in terms of present value is found. Since inlet filtration systems do not produce a profit, the system with the least negative value will have the best lifetime cost. The advantage of an LCC analysis is that it provides a method to perform an objective analysis of different filtration system upgrades.

By completing the five steps described above, the operator can evaluate the current filtration system. This includes determining what debris must be removed from the air, verifying the configuration of the current system, identifying weaknesses in the filtration system, evaluating the current maintenance practices, considering possible upgrades, and analyzing the cost and benefit of changes to the system. The results of these tasks will provide direction for improvements in the operation and performance of the inlet filtration system and GT. ✻

ASME IGTI Professional & Member Development

By Shirley Barton, IGTI Professional & Member Development Manager

Professional Development:

- 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"***.

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.

For detailed information on upcoming training events and webinars for the gas turbine industry, please visit the IGTI web site at http://igti.asme.org/

Member Development:

Please contact Shirley Barton regarding information on:

- Navigating the IGTI "Who's Who" directory
- Committee member updates
- Volunteer opportunities
- IGTI Awards and Scholarships

Awards and Student Scholarships Available from IGTI:

New in 2011!

IGTI will award **10 scholarships of $2,000 each**, to students who submit all the required documentation and meet the qualifications. **Applications will be accepted from February 15, 2011 through April 15, 2011.** Applications will be reviewed in June/July and the award winners will be notified in September and receive their scholarship in October. For application and requirements, please visit the following web page: http://igti.asme.org/Honors/

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.

The International Gas Turbine Institute (IGTI) Scholarship Award

The ASME International Gas Turbine Institute awards **one $4,000 scholarship** every year based on superior academic performance and demonstrated interest in the gas turbine, propulsion, or turbomachinery industries to an undergraduate or graduate student. 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 ✲

IGTI AWARDS...

The ASME Gas Turbine Award

Award is given in recognition of an outstanding contribution to the literature of combustion gas turbines or gas turbines thermally combined with nuclear or steam power plants.

R. Tom Sawyer Award

Award is bestowed on an individual who has made contributions to advance the purpose of the Gas Turbine Industry and to the International Gas Turbine Institute over a substantial period of time.

The IGTI Industrial Gas Turbine Technology Award

For sustained personal creative scientific or technological contributions unique to electric power or mechanical drive industrial gas turbine technology. Eligible areas of accomplishment are gas turbine design, application, operations/maintenance, and research/development/deployment, performed in an industrial, academic or research laboratory environment.

The IGTI Aircraft Engine Technology Award

For sustained personal creative contributions to aircraft engine technology in the areas of aircraft engine design and/or research and development performed in an industrial, academic or research laboratory environment.

The IGTI John P. Davis Award

Awarded annually by IGTI in recognition of the technical paper that most significantly: describes new or continuing gas turbine applications; identifies planning, installation, operating and/or maintenance problems and their solutions; and exemplifies candid exposure of real-world problems and solutions and is judged, therefore, to be of exceptional value to others supplying or using gas turbines and their support systems. The Award was established in 1985 and includes a US$1,000 honorarium (divided equally among recipients if awarded to a multiple-author paper).

The IGTI Scholar Award

Established in 1989, IGTI gives this Award biannually to a person with a significant depth of knowledge in some aspect of gas turbine technology, who writes and presents a learned and comprehensive paper to industry peers. The recipient may be from industry, government, education, or private professional practice and need not be an ASME member.

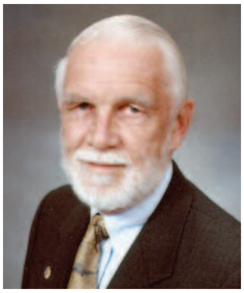
IGTI Technical Committee Best Paper Awards

Each year the Technical Committees have the opportunity to select a paper published at ASME TURBO EXPO to receive their committee's Best Paper Award. This is a chance to recognize outstanding technical papers, to acknowledge the author's contributions to the gas turbine industry, and to support and maintain the high quality of papers presented by each committee. Award recipients are honored during individual committee meetings at ASME TURBO EXPO.

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

Gas Turbine Progress through Trouble

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



Recovered R-R Trent 900 intermediate pressure turbine disc segment from Qantas A380 Flight QF32. Photo provided by Australian Air Transport Safety Bureau, courtesy of Aviation Week & Space Technology.

An uncontained engine failure is a jet engine company's worst nightmare. It usually involves the failure and disintegration of a rotating disc associated with the fan, compressor or turbine of the gas turbine. Rotating at many thousands of rpm, a disc holds and constrains metal or composite engine blades, each of which can be subjected to centrifugal forces equivalent to 20,000 gs, or more. Thus armed with enormous rotational kinetic energy, the disintegrated parts of a failed disk and its blading will become dangerous flying projectiles.

Such was the case of the inflight failure of the Rolls-Royce Trent 900 engine on Qantas Flight QF32 on the morning of November 4, 2010, with 466 passengers and crew onboard. The super jumbo four engine Airbus A380 had just taken off from Changi International Airport, Singapore, bound for Sydney.

About 6 minutes after takeoff at 7,500 feet altitude over the Indonesian island of Batam, the Trent 900 intermediate pressure turbine disc on engine No. 2 failed, sending engine parts shrapnel through the engine nacelle and the left wing. Passengers saw several perforations take place on the upper surface of the wing above engine No. 2, resulting in one hole as large as 65 by 80 cm[1]. Now powered by three of the four engines, the A380 circled to dump fuel (which was also leaking out of two wing tanks, above the failed engine). The Qantas plane then returned to Changi Airport, to land without thrust reversers, using emergency pressurized nitrogen to lower landing gear since the hydraulic system had been compromised by the uncontained engine failure. Controls to engine No. 1 had been damaged, so that the pilots were unable to shut it down after landing. Airport firefighters flooded No. 1 engine with foam to shut it down, further increasing the overall damage cost[2].

Fortunately, all Flight QF32 passengers and crew were safe and uninjured, after this uncontained engine failure. As I write this, Rolls-Royce and European regulators have tentatively identified the intermediate pressure turbine disc failure to be caused by an interior oil fire, highlighting an oil leak from oil service tubes for shaft bearing lubrication. Speculation by others include the possibility of a bearing failure, causing the intermediate shaft to break, resulting in sudden overspeed of the turbine disc. More will be known after the Australian Transport Safety Bureau issues a preliminary report.

If engine history holds true, this very serious uncontained engine failure can result in valuable engineering progress, as the reasons for the failure become known. In the introduction of *Engineering Progress Through Trouble*[3], Sir Henry Guy is quoted, who avowed in 1942 that:

"One begins to recognize that falling into trouble, encountering some unexpected difficulty however harassing at the time, is in fact an opportunity for making a fresh advance and most advances in engineering have in fact been made by turning failure into success."

One historic example of progress through trouble occurred over twenty years ago with the inflight failure of a General Electric CF-6 fan disc and is graphically described in a 1990 U.S. National Transportation Safety Board document[4]:

> ***"On July 19, 1989, at 1516, a DC-10-10, N1819U, operated by United Airlines (UAL) as flight 232, experienced a catastrophic failure of the No. 2 tail-mounted engine during cruise flight. The separation, fragmentation and forceful discharge of stage 1 fan rotor assembly parts from the No. 2 engine led to the loss of the three hydraulic systems that powered the airplane's flight controls. The flightcrew experienced severe difficulties controlling the airplane, which subsequently crashed during an attempted landing at Sioux Gateway Airport, Iowa. There were 285 passengers and 11 crewmembers onboard. One flight attendant and 110 passengers were fatally injured.***
>
> ***The National Transportation Safety Board determines that the probable cause of this accident was the inadequate consideration given to human factors limitations in the inspection and quality control procedures used by United Airlines' engine overhaul facility which resulted in the failure to detect a fatigue crack originating from a previously undetected metallurgical defect located in a critical area of the stage 1 fan disk that was manufactured by General Electric Aircraft engines. The subsequent catastrophic disintegration of the disk resulted in the liberation of debris in a pattern of distribution and with energy levels that exceeded the level of protection provided by design features of the hydraulic systems that operate the DC-10's flight controls."***

As a result of the tragic 1989 Sioux City accident, the gas turbine industry, airlines and regulatory agencies have worked diligently over the intervening years to improve disc inspection, crack detection, manufacturing techniques and fracture mechanics models. An example of the Sioux City work still ongoing is given in a recent ASME paper by Millwater, Enright and Fitch[5].

The troubles we have outlined here, have or will lead to gas turbine progress, which might be best summed by a quote used by Whyte[3]:

"Progress is the art of getting out of trouble you wouldn't have been in if it was not for progress."

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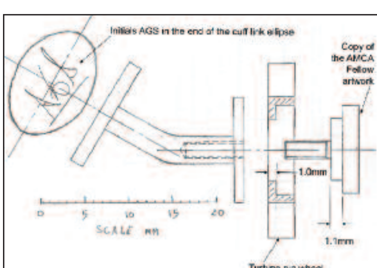
IGTI Volunteer Shows Innovation Beyond His Work

Most former IGTI Technical Committee Chairs are familiar with the turbine wheel jewelry that has served as tokens of appreciation for their service. The turbine wheels were originally designed to fit around the ASME member pin, which could easily be fastened on a lapel and worn with pride. However, over the years, ASME has changed the shape of the membership pins and the current ones no longer fit the existing wheels – leaving some members unable to wear their turbine wheels if their old member pins got misplaced.

Geoff Sheard, a former technical committee chair and current chair of IGTI's Controls, Diagnostics & Instrumentation Committee, devised a creative way to once again wear his turbine wheels: he turned them into cuff links!

"When I set myself this goal I had absolutely no idea how difficult it would be to achieve; however, an obsessive and compulsive personality disorder is good for one thing - you don't quit just because the going gets tough," said Sheard.

After four years searching for a jeweler willing to take on the commission, he found one with an innovative approach to jewelry design. Six months later Sheard produced the design in Figure A.



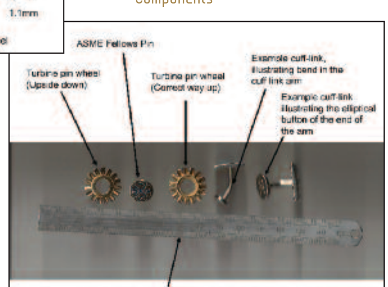


Figure A Cuff Link Design Components

"A critical design feature was that the turbine pin wheel should spin on the cuff link. This made the design rather more challenging; however, my design was essentially adopted with one proviso - the materials had to be the same material for all components, as otherwise the bearing surface between the turbine pin wheel and the cuff link body would be prone to corrosion. The jeweler preferred the mechanical properties of 18 carat gold alloyed with rhodium for ultimate mechanical strength. This combination of a gold/rhodium alloy has only one practical problem - it is the most expensive of gold alloys," said Sheard.

Producing the turbine pin wheel in gold / rhodium necessitated the creation of a turbine pin wheel mould. In the end a multi-point inlet mould was developed, as in Figure B.

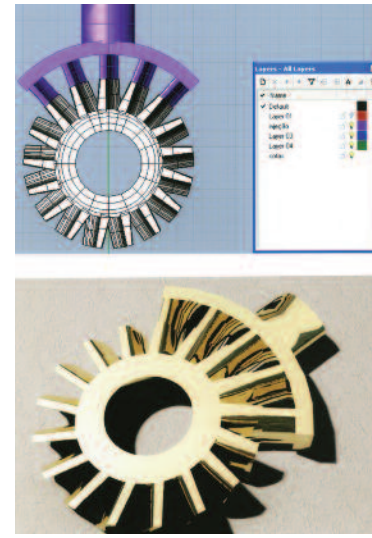


Figure B Multi-point Inlet Mould

Two turbine pin wheels were produced in the preferred alloy, and then the other cuff link components manufactured in the same alloy. Sheard found the finished cuff links (in Figure C) to be quite difficult to photograph, as the high polish reflected the light and made focusing difficult.

"I use the cuff links regularly now, but did have to go out and buy a new set of shirts that could actually accommodate cuff links, much to the irritation of my long-suffering wife. Bit of an oversight really, spending five years developing a set of cuff links and only then realizing that I did not have any shirts that could use cuff links! Nevertheless, it was an easily-rectified problem when put into the context of those problems already overcome," said Sheard.

Upon completion of the project Sheard investigated whether the cuff links would be affordable to purchase on a commercial basis, since he thought there might be some interest among other IGTI volunteers.

"Rather regrettably, the very high cost of gold and rhodium today means that this design would retail at $1,500, so it is not really an option. I then inquired about producing the design in silver; however, the labor involved is still significant, particularly regarding the turbine pin wheel, meaning that the design in silver is still about $375. As such, pure economic considerations mean that my pair of cuff links is likely to remain unique," said Sheard.

Despite producing his now-wearable jewelry, Sheard is still laboring over his cuff link project. He is now in the process of having an oak cuff link box constructed – from materials of the British Naval flagship, HMS Victory, which has been undergoing restoration. ✲

Figure C Finished Cuff Links

Geoff Sheard is Vice President - Fan Technology and Director-Tunnel & Metro for Fläkt Woods, www.fläktwoods.com