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Participating Organizations

American Gas Association

EPRI

Fuel Cell Power Association

GTA Gas Turbine Association

GCPA Gulf Coast Power Association

SCIES

U.S. CHPA United States Combined Heat & Power Association

USEA United States Energy Association

"Gas Turbines for a National Energy Infrastructure"

Policy and Technology Converge

February 26-27 … in Arlington, VA

Top gas turbine industry executives and top policy makers will come together at the DoubleTree Hotel Crystal City in Arlington, VA next February 26-27 to discuss legislative and policy issues and to examine current and emerging technologies. Participants will discuss demand growth, new markets, energy efficiency, U.S. energy self-sufficiency, energy system security, distributed generation, the impact on the environment and much more. Discussions taking place at the Conference will help to form the basis of a Position Paper to be developed by ASME and distributed to relevant legislative offices and congressional committees.

ASME International IGTI

Co-Sponsored by the ASME International Gas Turbine Institute and the

U.S. Department of Energy
Office of Fossil Energy
Office of Energy Efficiency and Renewable Energy

The projected increase in demand for electricity over the next decade, its satisfaction through gas turbine technologies, and the potential vulnerability of the energy infrastructure to terrorist attack in light of 9/11, have implications for the entire nation. Everything from fuel sources and availability, to siting and grid connectivity of distributed generation facilities, to security of the system from well-head to customer, to potential environmental trade-offs need to be examined carefully for the best match of policy and technology. Let your organization's voice be heard on these issues of industry and national importance. Plan now to participate.*

See additional articles on pages 12-13 of this newsletter for more details and how to register. Refer to the IGTI web site at www.asme.org/igti/ for updates.

More Inside

ASME TURBO EXPO Power for Land, Sea & Air

IJPGC INTERNATIONAL JOINT POWER GENERATION CONFERENCE

See pages 20-22

Georgia World Congress Center • June 16-19, 2003 • Atlanta, Georgia USA
www.asme.org/igti/ and www.asme.org/ijpgc

VIEW FROM THE CHAIR

David Wisler, Chair, IGTI Board of Directors
Thomas Loughlin, ASME Managing Director, Engineering

A New Relationship with ASME

We've buried the hatchet, figuratively speaking of course, and we're not going to leave the handle sticking out. The younger among us may ask, "what hatchet"? The older ones familiar with IGTI's history will understand. IGTI has operated fairly independently from ASME for several decades. The historical success of our TURBO EXPO, reinforced by progressive cultural isolation, led to an autonomous IGTI operation and, in some areas, mutual mistrust. Over the years ASME and IGTI have grown further and further apart. There have been many complex factors that have contributed to this situation—too many to constructively enumerate here.

Dave Wisler
Chair
IGTI Board of Directors

But recently, a number of internal and external factors have arisen which have created an unprecedented opportunity for IGTI and its Board to conduct a critical assessment of their strategy, position and working relationship within ASME. These factors include:

- Recent poor financial performance of Turbo-Expo
- Changes in ASME staff in New York and new ASME approaches
- Change in the IGTI Managing Director in Atlanta
- Changes in the ASME Council on Engineering (COE)
- Recent degradation of portfolio investment returns in both camps
- Process improvements in tools for handling conference papers (Web Tool)
- ASME E-commerce initiative (including new accounting software)
- The need for improved service, flexibility and models for technical publications
- The need for broader educational products and services that generate revenue
- The need to be aware of and participate in ASME government relations activity

> ***"We've buried the hatchet ... and we're not going to leave the handle sticking out."***

In order to take advantage of this unprecedented opportunity to improve relationships with ASME, I invited several key ASME staff members and a number of thought leaders from several IGTI committees to our September IGTI Board meeting. The purpose was to have an open, forthright and action-oriented meeting to address the myriad of issues facing our Institute. Within the scope of the meeting, Tom and I made it clear that ASME was a resource that could help IGTI address its issues and that it was time for the relationship to fundamentally change. To that end, ASME staff made the following presentations.

Council on Engineering (COE) Overview – Frank Adamek (ASME Sr. VP) and Tom Loughlin presented an overview of COE. The COE is comprised of a number of divisions, whose total membership dwarfs that of IGTI. COE lines of business and a financial overview were presented. The changes taking place and the opportunities to work together were highlighted. Several divisions of COE want to become institutes like IGTI and COE wants to use IGTI as a model of an excellent, well-run institute.

Financial Overview – Joe Holm made a presentation that highlighted ASME's financial processes; investment policy & practice; and the e-resource project. Joe made a compelling presentation covering each issue. He clearly outlined the advantages to IGTI of participating in ASME's investment strategy and resources.

Government Relations – Patrick Quinlan and Francis Deitz made a comprehensive presentation covering the services and capabilities of the Washington office; state and local activities; fellows programs; and specific activity related to the power industry and gas turbines. IGTI had no clue about what this group did and how it could benefit IGTI. Opportunities for IGTI involvement were addressed.

Technical Publications – Tom Loughlin presented an overview of ASME Technical Publications that included highlighting past problems, issues and perceptions and the actions underway to resolve things. Highlights included reviewing the new model to support conferences with the web tool and opportunities to support IGTI, especially those plans that will now permit IGTI to benefit financially from its publications.

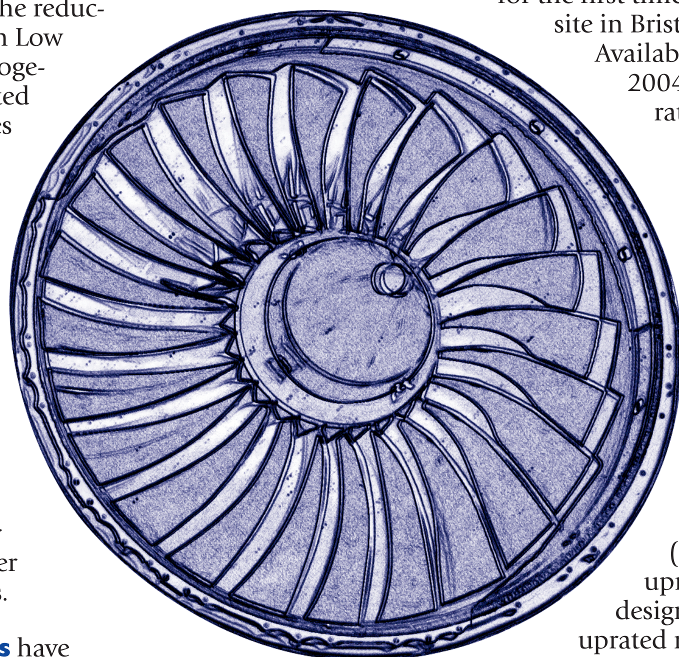
Managing Director (MD) Search – Paul Belford of JDG Associates gave an overview of the executive search process and status for hiring the IGTI MD.

Your Board listened, questioned and acted. Although it will take work and time to bring about change, we have begun. The following are being implemented.

...continued on page 23

The first of its kind fuel cell-gas turbine hybrid unit was successfully performing test runs at the **National Fuel Cell Research Center** at the University of California in Irvine in the Spring of 2002. The $16-million mini-power plant, about the size of a trailer, passed a site-acceptance test and the endurance test phase of the unit is in progress. The hybrid unit will have the capacity of generating 190 kW of electricity. **Siemens-Westinghouse** supplied the solid oxide fuel cell and **Ingersoll-Rand** supplied the microturbines. Plans for the technology are expected to reach commercial markets by fall of 2003.

Cheng Power Systems has been granted a patent for its unique steam injection system for the reduction of NOx and CO. The Cheng Clean Low NOx system (CLN) uses a highly homogeneous mixture of fuel and steam injected through specially designed fuel nozzles resulting in not only NOx and CO levels near 5 ppm, but also increased power output from the gas turbine due to the additional mass flow through the engine.



The **U.S. Federal Aviation Administration** (FAA) has awarded Type Certificates to **GE Aircraft Engines** (GEAE) for CF34-8 Growth jet engines for three aircraft applications. The 12,000-14,500 pound thrust CF34-8 Growth engines are designed to power twin-engine airliners scheduled to enter revenue service over the next two years.

NPO "Saturn" and **Snecma Moteurs** have signed a Memorandum of Understanding (MoU) for qualification of Russian materials and their suppliers for development and production of the 12,000 - 15,000 pound thrust-class SM146 turbofan engine. Russian Qualification will be undertaken through the Central Institute of Aviation Motors (CIAM) and the Institute of Aviation Materials (VIAM).

The GE MS9001FB was introduced by **GE Power Systems** in June. The Frame 9FB configured with GE's new HEAT™ steam turbine in gas-fired, combined-cycle operation is designed to produce 412 megawatts and achieve nominally 58-percent net plant thermal efficiency.

Capstone Turbine Corporation has established a distribution relationship with **Samsung Corporation** of Korea for the sales, installation and service of Capstone's onsite microturbine energy generation systems in South Korea. Samsung plans to market the microturbines in combined cooling/heating/power installations in which the exhaust heat is used for water and building heating as well as absorption chilling. They further intend to sell into power reliability applications as well as landfills and sewage plants where biogas can be used as a source of renewable fuel for continuous power and heat generation.

GE Power Systems (GEPS) announced plans in July to eliminate approximately 2,500 jobs over the next nine months, and expected further reductions in late 2003 in response to the reduction in the demand for power generation equipment. The announced employment reductions will occur primarily in the turbine production facilities of its Energy Products business.

The new **Rolls-Royce** MT30 gas turbine ran for the first time at the Rolls-Royce (RR) site in Bristol, UK this past summer. Available for delivery from early 2004, the MT30 has a power rating of 36 MW. Rolls considers the engine to be cost-effective and efficient compared to all existing marine gas turbines above 25MW. The engine can also be used in either mechanical or electrical genset applications for both commercial and naval marine markets.

GE Power Systems (GEPS) has introduced an uprated version of the Frame designated PG6111FA. The uprated machine offers an output increase of 9.2 percent and a heat rate improvement of 2.7 percent. The uprated 6FA will offer an output of 75.9 MW and 35-percent efficiency in simple-cycle applications. In combined-cycle service, the machine will have an output of 117.7 megawatts with 54.7-percent efficiency, a one-point improvement. The advances add up to a 2.8-percent improvement in the cost of electricity for these machines. The first PG6111FA is scheduled to be shipped in the second quarter of 2003. ✻

Gas Turbine News in Brief ... is compiled for **Global Gas Turbine News** *by Carl E. Opdyke, Power Systems Aerospace Analyst, FORECAST INTERNATIONAL, 22 Commerce Road, Newtown, Connecticut 06470.*

Condition Monitoring and Its Effect on the Life of New Advanced Gas Turbines

by Dr. Meherwan P. Boyce, P.E. and John A. Latcovich, Jr.

Introduction

Gas turbines have advanced greatly in the past 10 years in the power levels generated and efficiencies reached (up to 45%). Gas turbine availability has decreased by about 10% as the efficiency has increased by about 10%. New blade materials and coatings have enabled the turbine to reach new highs in gas turbine firing temperatures. However, the average first stage turbine blade life has been reduced from 45,000 hours to 20,000 hours, and the second stage blade life has been reduced from 60,000 hours to 25,000 hours. There are now few base loaded plants. Nearly all plants, even plants of the size of 2800 MW, are cycled in a day from 40-100% load. In many cases the plants or parts of the plants are shutdown during the weekends.

A revolution in plant health assessment management is necessary. The combination of condition monitoring techniques with modern data handling systems and risk-informed operating and maintenance strategies should enable cost savings to be achieved that cannot be matched by conventional engineering approaches. Improvement in the reliability, availability, and maintainability (RAM) of advanced gas turbines requires a new look at the ways plants are operated.

Today's new power plants are combined cycle, which in most cases, consists of the combination of the Brayton and Rankine cycles. This combination is one of the most efficient cycles in operation for practical power generation systems. The Brayton cycle is the gas turbine cycle and the Rankine cycle is the steam turbine cycle. In most combined cycle applications, the gas turbine is the topping cycle and the steam turbine is the bottoming cycle. Thermal efficiencies of the combined cycles can reach as high as 60 percent. In the typical combination, the gas turbine produces about 60% of the power and the steam turbine about 40%. Individual unit thermal efficiencies of the gas turbine and the steam turbine are between 30% and 40%. The steam turbine utilizes the energy in the exhaust gas of the gas turbine as its input energy. The energy transferred to the heat recovery steam generator (HRSG) by the gas turbine is usually equivalent to about the rated output of the gas turbine at design conditions. At off design conditions the inlet guide vanes (IGV) are used to regulate the air so as to maintain a high temperature to the HRSG.

> **“Improvement in the reliability, availability, and maintainability (RAM) of advanced gas turbines requires a new look at the ways plants are operated.”**

In the traditional combined cycle plant, air enters the gas turbine where it is initially compressed and then enters the combustor where it undergoes a very high rapid increase in temperature at constant pressure. The high temperature and high pressure air then enters the expander section where it is expanded to nearly atmospheric conditions. This expansion creates a large amount of energy, which is used to drive the compressor used in compressing the air, plus the generator where power is produced. The compressor in the gas turbine uses about 50%-60% of the power generated by the expander.

The air upon leaving the gas turbine is essentially at atmospheric pressure conditions and at temperatures between 950°F-1200°F (510°C-650°C). This air enters the HRSG where the energy is transferred to the water to produce steam. There are many different HRSG units. Most HRSG units are divided into the same amount of sections as the steam turbine. In most cases each section of the HRSG has a pre-heater, an economizer and feed-water, and then a superheater. The steam entering the steam turbine is superheated.

The insurance industry concerns itself with the risks of equipment failure. For advanced gas turbines, the frequencies of failures and the severity of failures are major concerns. In engineering terms, however, risk is better defined as:

Risk = Probability of Failure x Consequences of Failure

where:

The consequences of failure include the repair/replacement costs and the lost revenue from the downtime to correct the failure.

Actions taken, which reduce the probability and/or consequences of failure, tend to reduce risk and generally enhance insurability. Because of the high risks associated with insuring advanced gas turbines, demonstrated successful operation is important to the underwriting process. If insurance underwriters consider the equipment risks to be adverse, the availability of insurance coverage may be limited or the policy terms and conditions may be adverse (i.e., high deductibles). In the next section, we have an insurer's view of new advanced turbines and their technologies; we also evaluate some of the latest trends in condition monitoring technologies. Condition monitoring system design requirements for insurability will also be discussed.

Risk View of New Advanced Gas Turbines and Their Technologies

The benefits of advanced gas turbines and their technologies are easily quantified. The gas turbines produce more power, use less fuel, provide higher combined cycle efficiencies, and reduce emission levels significantly. The advanced gas turbines have developed very high efficiencies of between 40-45% due to high pressure ratio (30:1 for frame and aero engines) and high firing temperatures (2400°F, 1315°C). The advantages of advanced gas turbines have been eclipsed by the following major problems experienced in the operation of these turbines:

- Lower Availability (up to 10% lower)
- Lower Life of Nozzles and Blades (averaging 15,000 hrs.)
- Higher Degradation Rate (5% - 7% in first 10,000 hours of operation)
- Instability of Low NOx Combustors

Meetings with users have indicated that the users are satisfied with the efficiency of these turbines but would like to see an improvement in the overall operation and maintenance of the turbines. A survey of users indicated that the following were their major concerns regarding the operation of gas turbines:

- Low Availability and Reliability
- Repair of Single Crystal Blades
- Stability of Low NOx Combustors
- Surge in Compressors
- Bearings and Seal Problems

The insurance industry parallels this concern. Because, when you step back and examine where new turbines are today versus where they were previously, there is a significant down side. The following are the major concerns:

- New advanced turbines are run at higher firing temperatures, are physically larger in size, have larger throughput (airflows and fuel flows), and have higher loadings (pressure and expansion ratios, fewer airfoils, larger diameters) than previous gas turbine designs.
- New advanced turbines are run at higher pressure ratios (as high as 30:1). This creates a very narrow operating margin. Thus any deposits on the blade could lead to degraded performance and surge.
- The technologies (design, materials, and coatings) required to achieve the benefits are more complex to concurrently meet gas turbine performance, emissions, and life requirements.
- The design margins with these technologies tend to be reduced or unvalidated. While analytical models may be extrapolated to evaluate the new designs, full-scale verification of the new designs is an absolute necessity. Similarly, the materials being used are either relatively new or are being pushed to new limits.
- There is no reliability record for the new designs. While component rig testing (scale or sector) may help validate some component's performance, the first time the unit reaches design conditions is in the owner's plant. Essentially, the units are considered prototype or unproven designs for the first three years of operation or until all the major design problems are identified and corrected.
- The cost of hardware and subsequent cost of ownership have increased due to the complex designs, increased size, and higher throughput in the advanced machines.
- Gas turbine operation has similarly become more complex and computer driven requiring new/different skill sets for staffing in plants.

When several of the major characteristics of advanced gas turbines are examined from a risk viewpoint (i.e., probability and consequences of failure), there are no characteristics which reduce the probability of failure and/or decrease the consequence of failure. The trends for compressors are toward fewer, thinner, larger 3D/CDA shaped airfoils with smaller clearances and higher pressure ratios (Rc). There are also trends toward water injection at the inlet or between compressor sections which will likely affect airfoil erosion life. The smaller clearances and high pressure ratios tend to increase the probability of encountering rubs. Design margins are set by Finite Element Modeling (FEM) at the element level which results in lower safety margins than previous designs. The costs of these larger, thinner, less-rub tolerant, and more twisted-shape airfoils are usually higher.

The trends for turbines are similar with fewer, larger, 3D airfoils with smaller clearances and higher expansion ratios (Re) being used. For the early stages of the turbine, complex multi-path serpentine cooling designs are utilized. Higher strength directionally solidified (DS) or single crystal (SC) materials coupled with oxidation resistant coatings and/or thermal barrier coatings (TBCs) are required to meet turbine life requirements. Design margins are set by FEM at the element level, but the long-term creep strength characteristics of the turbine materials are not well-defined. In addition, the turbine materials utilized typically have reduced temperature margin to melting as compared to previous designs. As with compressors, the smaller clearances and higher expansion ratios associated with the new design turbines tend to increase the probability of encountering rubs. The costs of these larger, complex-cooled, more twisted-shape airfoils with more sophisticated materials and coatings are substantially higher per airfoil stage.

The trends for combustors are driven by the desire for reduced emissions. The typical stable, simple, diffusion flame combustor has been replaced with barely stable, staged-combustion systems with multiple injection locations which vary with gas turbine load. This combustion system has to be monitored and tuned precisely for stability from starting to full load while maintaining low emissions and avoiding flashback and high pressure pulsations which could damage combustor and turbine components. The management of air in the combustion process and for cooling of the combustor is particularly critical so that dry low NOx (DLN) combustors have complex combustor mechanical, cooling, and TBC systems to provide adequate life for both can and annular combustion systems. The fuel nozzles are more complicated and larger in number due to the multiple injection locations. When dual fuel is involved or water injection is used to further reduce emissions, the purge systems for the multiple injection points are complex and can be a significant source of problems with fuel nozzle plugging and localized hot section damage. As with new design compressors and turbines, the costs of these complex combustion systems are high.

The risks and costs of these new design technologies present real problems for insurers, OEMs, and owners. Insurance is mandatory for new projects as well as for subsequent ownership and commercial operation. However, with no track record of the designs to quantify risk for insurance, investors, cost of ownership, etc., handling of the risk is difficult during the first three years of operation, i.e., until the design is proven. Insurers' appetites for new designs are limited. These reflect one-of-a-kind, prototype designs with few spares that can only be validated at the owner's site. Insurers typically cover sudden and accidental damage and do not want to insure design deficiencies. When these designs are insured, the insurers try to spread the risk to other insurers and re-insurers to minimize the amount of potential loss.

Historically, the insurers reaction to accepting risk is dependent upon industry experience. For the later "F", "G", and "H" technology designs, the early reliability experience has been poor. There have been problems with all designs: failure and/or major rubs of compressor blades and vanes; oxidation damage and failure of turbine airfoils and coating systems; and flashback, pulsation, distortion and/or failure of DLN combustors, control systems, and transition sections.

Recent reports published based on information from "Moderne Gas Turbinen-Technologie, Risiken und Schaden," Dr. J. Stoiber, Allianz Zentrum fur Technik Gmbh, VGB PowerTech 2/2002, divides the problems for gas turbines into sizes smaller than and larger than 220 MW. Figure 1 and Figure 2 show the major problem areas experienced in gas turbines less than 220 MW and larger than 220 MW, respectively. In the smaller turbines, the problems are concentrated in the hot section, as has been traditionally experienced. The interesting point as seen in Figure 2 is that the compressor problems are greatly increased as the turbine ratings increase. In fact, the compressor problems are slightly larger than the turbine problems. This is related to the high flow and high pressure in the larger turbines.

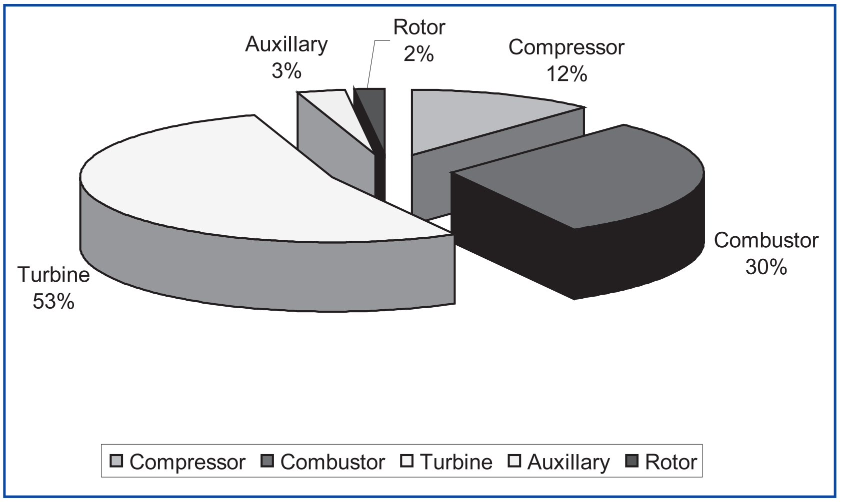


Figure 1 – Major Failures in Gas Turbines Less Than 220 MW

The failures of the gas turbine in the compressor section are in the Inlet Guide Vanes, at the transition between the low pressure and high pressure compressors and the later stages. The larger units have high pressure ratios, have both low pressure and high pressure compressors, and have high exit temperatures, all leading to problems in the compressor section.

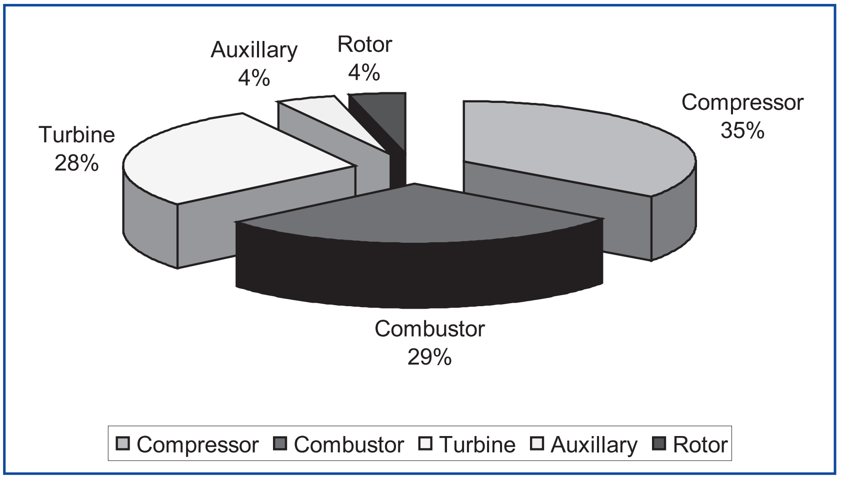


Figure 2 – Major Failures in Gas Turbines Larger Than 220 MW

Goals of Condition Monitoring for Advanced Gas Turbines

Increases in the reliability, availability, and maintainability of advanced gas turbines resulting in a 15% reduction in operation and maintenance costs is a major goal set by the Department of Energy. To achieve this goal, the following are the major points which need to be addressed:

1. On-Line Condition Monitoring
2. Limit Degradation to 2% per year
3. Reliability Based on a Minimum of 400 Starts per Year
4. Flexibility of Multiple Fuel Applications, especially with Dry Low NOx Combustors
5. Operate at High Efficiency Conditions During Off-Design Operation
6. Improve Hot Section Component Life (25,000 hrs.)
7. Increase Time between Hot Gas Path Inspections (8,000-12,000 hrs.)

Condition Monitoring Technologies

The current state of condition monitoring technologies for advanced gas turbines, from the operation and maintenance as well as the insurance perspectives, has not been particularly effective. The following are some of the reasons:

- Vibration monitoring – These systems were initially used proactively to determine changes in vibration and health of the turbine rotor system. This still is done in the chemical, oil, and gas industries. In the power generation industry, it has been relegated to essentially control room wallpaper or monitor displays where it may get attention only when alarm levels are reached. There is no on-line spectrum analysis at most of these plants.
- Pulsation monitoring – These systems came into being when high levels of combustor pulsations were encountered with the predecessors of today's dry low NOx (DLN) systems. Now pulsation monitoring is an absolute necessity for tuning and operating DLN systems.
- Performance monitoring – These systems were used by some to determine the amount and source of deterioration in their machines as well to determine water washing frequencies. Now, the only concern seems to be lost power (MW's) and emissions levels (regulatory requirement).
- Trend monitoring – In conjunction with performance monitoring, these systems and their associated software were designed for proactive monitoring of changes in critical machine parameters (temperatures, pressures, flows, vibration, etc.) and to alarm when a specified change in value occurred. Now, the systems and software are installed, but they are not used until after-the-fact troubleshooting of a problem.

In general, the improvements have tended to be reactionary to problems and not proactive to detect a change in equipment health or to prevent/minimize a failure.

The implementation of a condition monitoring system in a major utility plant requires a great deal of forethought. A major utility plant will have a number of varied, large rotating equipment. This will consist usually of various types of prime movers such as large gas turbines, steam turbines, pumps, electric generators and motors. The following are some of the major steps, which need to be taken to ensure a successful system installation:

1. The first step is to decide on what equipment should be monitored on-line and what systems should be monitored off-line. This requires an assessment of the equipment in terms of both first cost and operating costs, redundancy, reliability, efficiency, and criticality.

2. Obtain all pertinent data of the equipment to be monitored. This would include details of the mechanical design and the performance design. Some of this information may be difficult to obtain from the manufacturer and will have to be calculated from data obtained in the field or during commissioning tests in a new installation. Obtaining baseline data is critical in the installation of any condition monitoring system. In most systems it is the rate of change of parameters that are being trended not the absolute values of these points. It is also important to decide what type of alarms will be attached to the various points. Rate of change alarms must be for bearing metal temperatures especially for thrust bearings where temperature changes are critical. Prognostic alarms should be applied to critical points. Alarms randomly applied tend to slow down the system and do not provide added protection.

3. The following are some of the basic data that would be necessary in setting up a system:
   a. Type of gases and fluids used in the various processes. The Equation of State and other thermodynamic relationships, which govern these gases and fluids.
   b. Type of fuel used in the prime movers. If the fuel analysis is available, include the fuel composition and the heating values of the fuel.
   c. Materials used in various hot sections such as combustor liners, turbine nozzles, and blades. This includes stress and strain properties as well as Larson-Miller parameters.
   d. Performance maps of various critical parameters such as power and heat consumption as a function of ambient conditions, pressure drop in filters, and the effect of backpressure, as well as compressor surge, efficiency, and head maps.

4. Determine the instrumentation which exists and the actual location. Location of the instrumentation from the inlet or exit of the machinery is important so that proper and effective compensation may be provided for the various measured parameters. In some cases additional instrumentation will be

needed. Experience indicates that older plants require ten to twenty percent more instrumentation depending upon the age of the plant.

5. Once the data points have been decided, the limits and alarms must be set. This is a long and challenging task as the limits on many points are not given in the operation manuals. In some cases the criticality of the equipment may necessitate that the alarm threshold on certain points be lowered to give early warning of any deterioration of the system. It should be noted that since this is a condition monitoring system, early alarm warnings are in most cases desirable.

6. Types of reports and summary charts should be planned to optimize the data and to present it in the most useful manner to plant operations and maintenance personnel.

7. The types of Distributed Control Systems (DCS) and the control systems available in the plant. The protocol of these systems and their relationships to the condition monitoring system. The slave or master relationship is important in setting up the protocols.

8. Diagnostics must be set up for the system to identify any unusual characteristics of the machinery, especially in older plants, which have a history of operation inspections and overhauls.

9. Costs of operations such as fuel costs, labor costs, down time costs, overhaul hours, and interest rates are necessary in computing parameters such as time of major inspections, off–line cleaning, and overhauls.

A Total Condition Monitoring System must be designed to provide the operators and rotating equipment engineers with clear insight into machinery performance problems:

- Enhance predictive maintenance capability by diagnostic tools.
- Plant operation with minimum degradation based on optimal washing of the train.
- Integrated condition monitoring utilizing field proven hardware and software.
- Provide voltage free contacts at the monitors for machine safeguarding.
- Data link to and from the plant DCS system so as to upgrade performance curves in the DCS system which controls plant processes.

A condition monitoring system designed to meet these needs must be composed of hardware and software designed by engineers with experience in machinery and energy system design, operation and maintenance. Each system needs to be carefully tailored to individual plant and machinery requirements. The systems must obtain real time data from the plant DCS and, if required, from the gas and steam turbine control systems. Dynamic vibration data is taken in from the existing vibration analysis system into a data acquisition system. The system can be comprised of several high performance networked computers depending on plant size and layout. The data must be presented using a graphic user interface (GUI) and include the following:

1. *Aerothermal Analysis:* This pertains to a detailed thermodynamic analysis of the full power plant and individual components. Models are created of individual components including the gas turbine, steam turbine heat exchangers, and distillation towers. Both the algorithmic and statistical approaches are used. Data are presented in a variety of performance maps, bar charts, summary charts, and baseline plots.

2. *Combustion Analysis:* This includes the use of pyrometers to detect metal temperatures of both stationary and rotating components such as turbine blades and the use of dynamic pressure transducers to detect flame instabilities in the combustor, especially in the new dry low NOx applications.

3. *Vibration Analysis:* This includes an online analysis of the vibration signals, FFT spectral analysis, transient analysis, and diagnostics. A wide variety of displays are available including orbits, cascades, Bode and Nyquist plots, and transient plots.

4. *Mechanical Analysis:* This includes detailed analysis of the bearing temperatures, lube, and seal oil systems and other mechanical subsystems.

5. *Diagnosis:* This includes several levels of machinery diagnostic assistance available via expert systems. These systems must integrate both mechanical and aerothermal diagnostics.

6. *Trending and Prognosis:* This includes sophisticated trending and prognostic software. These programs must clearly provide users with an understanding of the underlying causes of operating problems.

5. *"What-If" Analysis:* This program should allow the user to do various studies of plant operating scenarios to ascertain the expected performance level of the plant due to environmental and other operational conditions.

New Technologies

New technologies have emerged and others are being designed by companies that provide real improvements. A number of these products need to be tested and a number of them are under testing. The following are some of the new products being developed:

- Wave energy monitoring – Principally the system characterizes the structureborne noise signature of components to detect changes in component health and wear with time.
- Balanced charge cleaning of oil/fuel – This system principally charges contaminants in lube or fuel oil, cause the charged particles to combine, and then removes them from the fluids. The process actually removes contaminants from the wetted surfaces of tanks, sumps and piping with time.

- Real time IR/XRF condition monitoring of oil – These systems utilize infrared (IR) or X-Ray fluorescence (XRF) for monitoring of flowing oil systems to determine the type of contaminants and/or elements (wear particles) in the oil.
- Age/creep fatigue monitoring of airfoils – Their advanced inspection technologies have a demonstrated credibility in several industries in detecting fatigue damage as well as detecting turbine coating/substrate problems.
- Blade metal temperature sensors – A number of these sensors are being designed … from pyrometers to special instruments such as special high temperature sensors. The fundamental operating principle of the total temperature sensors is based on convective heat transfer and is measured at two known surface temperatures from which the total or recovery temperature can be deduced.
- On-line monitoring of ferrous and non-ferrous particles in the lubrication system – These systems in the past have been limited to detecting only ferrous materials. On the large gas turbines the babbitt lining in bearings may be a non-ferrous material and thus if on-line systems are going to be able to predict failure, they must be able to sense non-ferrous material in pipe lines which are six inches or larger.
- On-line monitoring of exhaust gases for metal particles – The U.S. Air Force has some programs to measure coatings, which usually start peeling prior to blade material failure thus giving early warning.
- Long-term dynamic pressure transducers for surge and combustion monitoring – Dynamic pressure probes are used in conjunction with on-line spectrum analysis. These signals are used to detect surge based on the increase in spectrum levels at blade passing frequencies. The major development needed is the ability of these transducers to withstand very high temperatures. A project to achieve this is underway under a U.S. Air Force contract.
- Flashback in dry low NOx combustors – Dry low NOx combustors have problems with flashback occurring in the pre-mix chambers. Instrumentation is being developed under a U.S. Department of Energy project to detect the flashback as soon as it occurs and prevent failures of the pre-mix chambers.

The bottom line is that technology levels incorporated into advanced turbines have not carried over to condition monitoring capabilities and in-service condition assessments. This is being changed by interest from the U.S. Department of Energy.

Insurers' Design Requirements for Advanced Condition Monitoring Systems

For condition monitoring to be of mutual benefit to all OEMs and owners, resulting in a more positive view by insurers, the systems have to be more direct in preventing/minimizing failures. From this perspective, the design requirements for advanced condition monitoring systems should include the following:

- The system has to be integrally designed and validated with the advanced gas turbine from the very beginning.
- Measurements taken and inspection capabilities provided for the system need to be proactive and fundamental in detecting health changes in critical components and/or sections.
- The system design and instrumentation needs to be both simple and reliable. Recognizing that the advanced gas turbine environment can be unfriendly to instrumentation, the use of retractable probes and instrument isolation techniques will most likely be required.
- The primary function of the system should be to advise the owner/operator of health changes in the turbine and to initiate mitigating or corrective actions to prevent damage.
- Sharing of fleet data by users is very important to the overall success of the systems.

In addition to the basic design requirements for an advanced condition monitoring system, there needs to be a fresh look (i.e., out of the box thinking) at how systems should be designed and what they should be capable of doing. Some suggestions include:

1. Use embedded sensors/probes to enhance problem detection.
2. Spectral analysis vibration monitoring of the gas turbine, critical blade rows, and combustion system.
3. Time at temperature or creep rupture life monitoring.
4. Critical airfoil temperature monitoring for loss of cooling flow or thermal barrier coatings (TBC).
5. Blade tip clearance monitoring in critical compressor and turbine stages to prevent/minimize rubbing.
6. Performance based predictive monitoring, trending and predicting (i.e., detect problem areas in compressor, turbine, combustor).
7. Remote video/IR borescoping and sound analysis spectral monitoring.

Including an advanced condition monitoring system as part of a new advanced turbine program will add costs to both the development and acquisition of the new system. Given the costs of failures and problems to industry insurers, OEMs and owners, the additional costs should be small preventive investments as compared to the cost of unmitigated damage and unscheduled repairs to advanced turbines.

Conclusions/Summary

To achieve the goals of maximizing plant efficiency and reducing operation and maintenance cost by 15%, the development of maintenance programs based on on-line performance-based condition monitoring is needed.

Development of new instrumentation with new techniques of data validation is very important in the development of reliable condition monitoring systems for combined cycle power plants.

To achieve increases in availability and reliability, component lifing studies are necessary with major inspection intervals based on total performance condition monitoring. Prognostic systems have also proven to be very effective in improving availability, and increasing the time between overhauls.

In summary, more sophisticated condition monitoring systems are a necessity for advanced gas turbine systems. The systems need to provide a broad range of proactive inspection capabilities and condition based measurements for the owner/operator. The systems also need to detect problems and deterioration and provide protection to prevent or mitigate damage to very high cost equipment. When advanced turbines have a risk-reducing condition monitoring system, they will be looked upon more positively by insurers. ✲

This article is excerpted from a paper prepared for and presented at the Gas Turbine Users Association Conference in Houston, Texas on April 21-25, 2002. Dr. Boyce is Managing Partner of The Boyce Consultancy in Houston, TX. John A. Latcovich, Jr. is Fleet Manager, Rotating Equipment for The Hartford Steam Boiler Inspection and Insurance Company in Hartford, CT. You may contact them at www.boyceconsultancy.com and John_Latcovich@hsb.com.

ASME TURBO EXPO 2002
Amsterdam Highlights

The historic, cultural, and dynamic city of Amsterdam hosted ASME TURBO EXPO 2002 last June 3-5. Over 4,000 people drawn from industry, academia and government attended this principal annual event of the international gas turbine community.

Executive Conference Chair, Ron van den Handel, Department Manager, Rotating Equipment, Shell Global Solutions International B.V., joined with the Local Liaison Committee under the leadership of Andre Mom, Director of the Dutch Gas Turbine Association (VGT) to warmly welcome attendees and made every effort to enhance their TURBO EXPO experience in The Netherlands.

The week began with an elegant Welcome Reception in the famous Rijksmuseum, sponsored by the City of Amsterdam and Shell Global Solutions International B.V.

Pre-Conference Workshop

The first all-day workshop hosted by the Gas Turbine Users Symposium Advisory Group on Sunday, June 2, was an immediate success. Operations and maintenance personnel from all over the world filled the seats allotted for "Basic Gas Turbine Metallurgy & Repair Technology."

Keynote Session

The Netherlands Marine Band opened the keynote with an invigorating concert followed by welcoming comments from Mrs. Annemarie Jorritsma, Minister of Economic Affairs, The Netherlands. The keynote speakers provided high-level insights on the impact of gas turbine engines worldwide. Addressing the keynote theme of Gas Turbines for a Better Tomorrow were Alexis Fries, Power Sector President, ALSTOM Power; Ludo van Halderen, Chief Executive Officer, NUON; and Peter Hartman, Managing Director & Chief Operations Officer, KLM Royal Dutch Airlines.

Technical Congress

IGTI's 17 technical committees organized 142 technical panel and paper sessions that presented cutting-edge developments, innovative practices, and technology trends. Vital industry topics dealt with included advanced technologies, fuel cells, education challenges, emissions concerns and options, axial flow turbine aerodynamics, alternative fuels, combustor technology, improved operating efficiencies, and many more. Four-day registration included a CD-ROM of the 620 technical papers published for TURBO EXPO.

Users Symposium

A highlight of the Gas Turbine Users Symposium (GTUS) was a large networking session that provided a forum for open discussion and practical problem solving of issues not covered in the other sessions. From career-building tutorials to bottom-line panels and discussions on major topics such as long-term service agreements, hot section repairs and life extension, the 28 GTUS sessions targeted the interests of those actively involved with the installation, operation, repair and maintenance of gas turbines. The sessions were organized along three tracks: Operations & Maintenance, Repair Technology, and Engineering & Business.

Exposition

The 150+ companies exhibiting at TURBO EXPO 2002 benefited from busy attendee traffic. Many reported obtaining high quality leads. Exhibit visitors enjoyed daily prize drawings of portable, hand-held televisions and selected the Dutch Pavilion and the von Karman Institute as People's Choice award winners for Best Display.

Other Special Events

The Blue Friends Jazz Band, courtesy of the Dutch Gas Turbine Association (VGT), delightfully entertained guests at the annual IGTI Awards Dinner on June 3. Congratulations to all the well-deserving award recipients.

The enduring success of ASME TURBO EXPO is due solely to the dedication and efforts of gas turbine professionals worldwide who persistently volunteer their time for the advancement of their industry. TURBO EXPO 2002 was no exception, and those responsible should be particularly gratified in light of the challenges set off by the events of September 11, 2001. Although there is not space for every name, our sincere thanks go to:

- The conference attendees, our exhibitors, and our sponsors;
- All the authors, panelists and other session presenters and speakers;
- Our stalwart and hardworking Technical Committee point contacts, vanguard chairs, session organizers, and reviewers;
- Our prominent keynoters and Executive Conference Chair Ron van den Handel
- All Local Liaison Committee members (Andre Mom, Chair);
- All members of the IGTI Board of Directors;
- Leadership team members: Chair of Conferences, Ron Natole; Technical Program Chair, Geoff Sheard; GTUS Chair, Oscar Backus; Review Chair, Erio Benvenuti; and Chair of the Distributed Power Generation Task Force, Norman Holcombe

… all of you worked extremely hard to produce a TE '02 marked by excellence and innovation! Thank you all.

We hope that each and every one of you who attended TE '02 found it to be valuable for knowledge exchange, problem solving and network building. Those who missed it lost out on a valuable experience. Don't lose out next year! Plan now to attend ASME TURBO EXPO 2003 in Atlanta, Georgia, USA, June 16-19, at the Georgia World Congress Center. ✲

"Gas Turbines for a National Energy Infrastructure"

February 26-27, 2003

CONFERENCE REGISTRATION:

Full Registrations includes:

- **Admission to all sessions**
- **AM refreshments**
- **2 Keynote luncheons**
- **Other refreshment breaks**
- **Networking Reception**
- **Presenter notes**

Register on the IGTI web site:
www.asme.org/igti/
OR
on-site at the DoubleTree Hotel
Crystal City, Arlington, VA:
On-site hours: Feb. 26: 8-9 am
Feb. 27: 8-8:30 am

Conference Registration Fees:

On or before February 12: $525*
After February 12: $625*

*Discount for members and employees of Sponsors and Participating Organizations: – $50

Hotel Reservations:
DoubleTree Hotel Crystal City
300 Army Navy Drive
Arlington, VA 22202

Hotel Reservation Phone:
1-(800) 222-8733 or (703) 416-4100

Ask for rates for the
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Special Conference Rates:
$159 single; $179 double.

Last day for conference rates:
January 24, 2003

Book early, only a limited number of rooms are available at the conference rate.

Sponsorships Available:
A select number of corporate sponsorships are available for keynote luncheons, the networking reception and other activities at this Conference. Act today.

Contact: Kevin Gaffney, IGTI
(404) 847-0072, ext. 235
gaffneyk@asme.org

ASME International

Office of Fossil Energy
Office of Energy Efficiency and Renewable Energy

Outstanding Program Awaits Participants in the "Gas Turbines for a National Energy Infrastructure" Conference next February …

Albright and Glotfelty Invited as Luncheon Keynoters

The two-day Conference in Arlington, Virginia (suburban Washington, D.C.) next February 26-27 will feature top industry and policy speakers from throughout the United States … bringing together policy and technology for a more certain future.

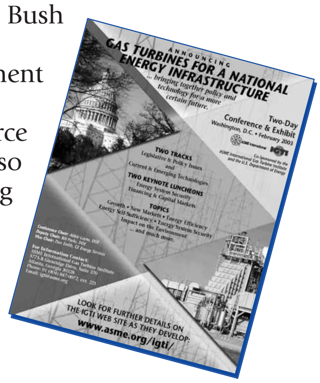
The highlight of the Conference will be **two Keynote Luncheons**. On Wednesday, February 26, **Penrose (Parney) Albright**, Asst. Director for Homeland and National Security at the White House Office of Science and Technology Policy, will speak to "Securing Our Nation's Energy Infrastructure." On Thursday, **James Glotfelty**, Senior Policy Advisor, DOE, Office of the Secretary of Energy, has been invited to present "DOE's Perspectives on Future U.S. Energy Legislation and Policies." These will be presentations you don't want to miss!

WEDNESDAY, FEB. 26

The first day of the Conference opens with a **Plenary Session** that sets the tone for the panels to follow by looking at what's going on nationally and internationally regarding gas turbines and the energy infrastructure. **Daniel Yergin**, President of Cambridge Energy Research Associates, Pulitzer Prize winning author, member of the Board of the U.S. Energy Association, and member of the U.S. Secretary of Energy's Advisory Board, has been invited to discuss alternative fuels and alternative energy sources, putting into perspective coal, oil, gas, hydro, nuclear, solar and renewable fuels. He will also address gas turbines vs. other energy conversion methods.

Next, **John G. Rice**, President & CEO of GE Power Systems and Chairman of the U.S. Energy Association, will present the equipment producer's perspective along with insight into how equipment and project financing has changed since the terrorist attacks on the World Trade Center and the Pentagon on 9/11.

Finally, **F. Henry (Hank) Habicht II**, Principal and co-founder of Capital E, and former CEO of the Global Environment and Technology Foundation (GETF), will discuss what is happening in the U.S. and the world from an environmental perspective. Mr. Habicht served as a presidential appointee in both the Reagan and Bush administrations. He led the Environment and Natural Resources Division at the U.S. Department of Justice from 1983-1987, and managed all national litigation related to energy and resource development and environmental policy. He also served as Deputy Administrator (Chief Operating Officer) of the Environmental Protection Agency in the Bush Administration from 1989-1993 with Administrator William Reilly. Mr. Habicht also advised both the Energy and the Environment transition teams for the current Bush Administration.



Following the Wednesday Keynote Luncheon, participants will have a choice of two sessions featuring further panel presentations and discussions ... one on policy and one on technology.

Session 2: Legislation & Policy Panel. This session will provide an overview of the legislation and policies affecting the siting, operation, and application of gas turbines in the U.S energy portfolio. Experts will share their perspectives on current White House, Congressional and state policies and actions. The Energy Bill, the President's State-of–the-Union Address, and the Federal Budget relating to energy priorities will also be discussed. Representatives from the American Gas Association and from Federal agencies such as the Environmental Protection Agency (EPA) and the Federal Energy Regulatory Commission (FERC) will discuss policies and rulings ranging from air emissions to the role of gas turbines in electricity markets.

Session 3: Large Power Generation - Trends & Technology Panel. This panel will look at future market trends as the "boom" in the construction of large gas turbine driven power plants subsides. It will also discuss the increased gas supplies needed to meet the demand for clean power and the options for coal derived clean fuels. Trends in advanced technology machines will be examined, and a large generator will look at its experience with recently installed equipment vs. early projections. In addition, as advances in gas turbine component technology flowing from the U.S. DOE and industry Advanced Turbine System (ATS) program are entering commercial service, early field experiences will be presented.

Wednesday's schedule will be topped off with a **Networking Reception** from 5:00 – 6:30pm wherein all participants will have an opportunity to relax, make new acquaintances, talk informally and discuss further the ideas presented during the day.

THURSDAY, FEB. 27

Thursday features two concurrent panel sessions in the morning and two in the afternoon following the Keynote Luncheon. The morning sessions are 4 and 5, the afternoon sessions are 6 and 7.

Session 4: Trends in Generation Fuels and Infrastructure. This panel session will address the market and technology issues associated with the future use of stationary gas turbines and affected by fuel options. The enabling and breakthrough technologies necessary to reduce capital and operational costs and meet emission requirements in order to increase market share for coal, natural gas, petroleum, hydrogen and renewable fuels will be discussed. Gas turbine system improvements needed to meet efficiency, emissions and reliability goals and to reduce installed cost will be addressed. Supporting infrastructure issues and technologies that affect fuel supply and distribution for different fuels will also be discussed.

Session 5: Emerging Technologies - Distributed and Dispersed Power. Distributed and dispersed power applications are growing both within the U.S. and worldwide. Gas turbines ranging from 30kw microturbines to multi-megawatt gas turbines and combined cycle plants are increasingly selected for power generation in commercial and industrial applications and for high efficiency combined heat and power (CHP). This panel will examine the market forces and the customer requirements that are driving this new gas turbine opportunity and the products available to meet this growing need. Successful experience in distributed and dispersed gas turbine operation in both power generation and CHP installations will be discussed along with an examination of the environmental implications and considerations faced by these emerging applications.

Session 6: Electrical Infrastructure – Generation, Transmission and Distribution: A Changing Paradigm. Generation, transmission and distribution are necessary components of a robust and functional electrical infrastructure; but recently market conditions, infrastructure vitality, environmental regulations and government driven deregulation have changed the old paradigm. And to these paradigm changes has been added the increased risk of possible terrorist attacks. The new potential for power outages creates significant mission oriented and financial risk for the most vulnerable users of electric power. This panel session will examine how utilities, municipalities, commercial and industrial users are responding to the new opportunities and threats associated with the generation and use of electric power.

Session 7: Advanced Gas Turbine Concepts. This panel will present for discussion an overview of advanced gas turbine concepts that have the potential to dramatically improve the performance and facilitate the use of gas turbines and microturbines in new markets. The status of technologies such as advanced low emission combustion schemes, steam cooling, and advanced ceramics and their impact on gas turbine performance will be explored. The potential for new high efficiency systems under development pairing microturbines or small gas turbines with thermally activated technologies for building heating and cooling and hybrid cycles with fuel cells will also be examined. ✲

Outstanding speakers with world class knowledge in their given areas have agreed to serve on each of these panels. The discussions should be exceptional. Refer to the IGTI web site at www.asme.org/igti/ for the speaker/panelist list and for more details as they are finalized.

"Gas Turbines for a National Energy Infrastructure"

February 26-27, 2003

LEADERSHIP TEAM

Ron Natole	***Abbie Layne***	***Bill Parks***	***Dan Smith***
Natole Turbine Enterprises	Office of Fossil Energy, DOE	Office of Distributed Energy & Electricity Reliability, DOE	GE Energy Services
IGTI Chair of Conferences	*Conference Program Chair*	*Conference Program Deputy Chair*	*Conference Program Vice-Chair*

Global Energy Resources–Recent Trends

by Rakesh K. Bhargava, Ph.D., ASME Fellow
Chair, IGTI Oil & Gas Applications Committee; Universal Ensco, Inc., Houston, Texas USA

Crude oil and natural gas are two of the major and depletable energy resources of the world. In the study presented here, trends of these energy resources combined with total primary energy consumption (PEC), national gross domestic product (GDP), population growth and associated carbon dioxide (CO_2) emissions of the world during the last decade are discussed. Note that PEC is defined as the total gross energy supply before conversion of the primary energy into final energy form has taken place.

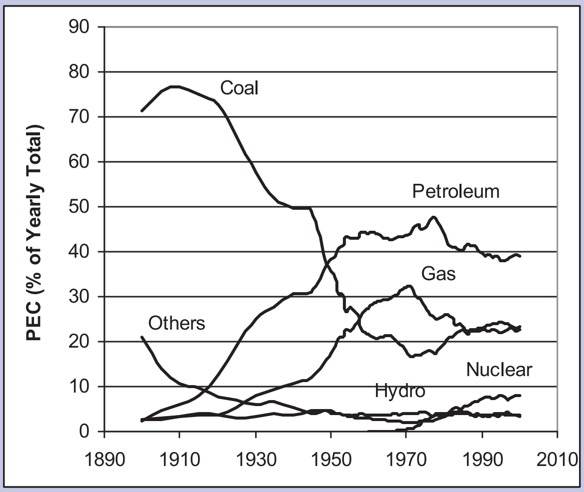


Fig. 1 Energy consumption of United States by fuel source in the last century

History has shown a definite correlation among a country's energy consumption, standard of living and degree of industrialization. Furthermore, the fuel sources utilized for energy consumption by mankind have evolved over a period of time driven by factors such as economics, technical advancements, politics and the degree of awareness of their environmental impact. As an example, consider the variation of PEC by fuel sources in the United States in the last 150 years[1]: in the mid-nineteenth century, 90% of fuel energy came from the combustion of wood; in the early part of the twentieth century, as can be seen in Fig. 1, coal became the major source of energy consumed (77%); by 1960, approximately 72% came from petroleum and natural gas combined and the dominance of coal diminished to 22%; by the end of the 20th century, energy consumption using petroleum and natural gas combined was down to 62%, and coal was up slightly to 23%. Hydro, nuclear and "others" accounted for the rest. Note that the fuel category "others" includes energy sources such as geothermal, solar, wind, wood, etc.

NOMENCLATURE	
GDP_PC	per capita gross domestic product
Oil_P	crude oil production
NG_P	natural gas production
PEC	primary energy consumption
PEC_PC	per capita primary energy consumption

ACRONYMS	
BBBL	billion barrels
BBtu	billion British thermal units
FSU	Former Soviet Union
GDP	gross domestic product
MMBtu	million British thermal units
TCF	trillion cubic feet

Knowledge of the historical use of energy resources in combination with population growth (among other factors) is helpful in understanding our future energy needs. The other factors include reserves of fuel sources and GDP (indicative of economic growth). It is estimated[2] that approximately 80% of all CO_2 emissions result from the combustion of fossil fuels with a subsequent impact on global climate change. More than 85% (yearly average) of the energy consumed in the world during the last decade was produced from fossil fuels. Therefore, CO_2 emissions produced by these fuels will also be briefly examined.

The values of crude oil and natural gas reserves have been obtained from data published in various issues of the Oil & Gas Journal[3]. Data on production and consumption of crude oil and natural gas, primary energy consumption, population, gross domestic product, and CO_2 emissions have been obtained from the database managed and published by the Energy Information Administration (EIA), a division of the United States Department of Energy[4]. It must be noted that more emphasis is given to the changes rather than the absolute values of various parameters examined.

WORLD OIL AND GAS RESERVES

World crude oil reserves, in the last three decades, have grown slowly with sudden increases in the late eighties, mainly in Central & South America and the Middle East. At the end of 2001, world natural gas and crude oil reserves were 5,451 trillion cubic feet (TCF) and 1,032 billion barrels (BBBL) respectively. Compared to 1970, by 2001 world natural gas and crude oil reserves increased 244% and 69% respectively (Fig. 2).

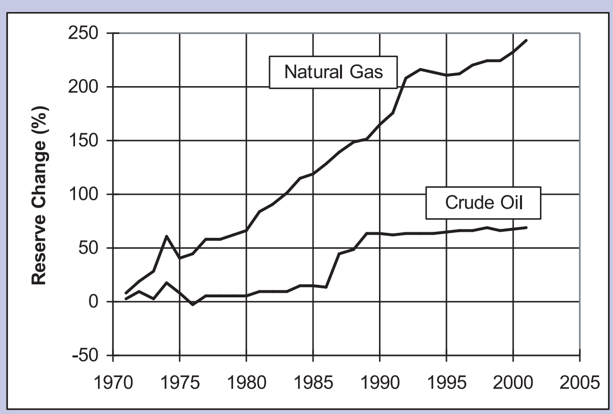


Fig. 2 Change in world total natural gas and crude oil reserves (Reference year 1970)

A further examination of natural gas reserves by region reveals that the largest increase, compared to 1970, has taken place in the Asia & Pacific region whereas the smallest change, in fact a net decrease in reserves, took place in North America. One of the reasons for the observed large increases in some regions could be due to the fact that not much effort was made in exploring natural gas reserves during the 1970s. An analysis of these changes by decade indicates that the poor showing for North America is alarming because the worst decline occurred most recently. This trend of decay is of concern because during this time North America was one of the largest consumers of natural gas in the world, annually averaging 30% of the world total. Also, looking at crude oil reserves since 1970, the worst decline also took place in North America, particularly during the later part of the last decade. This trend (like that of natural gas reserves) is of concern too because during the 1990s North America was also the world's largest consumer of crude oil (similarly averaging 30% of the world total annually).

The most recent available data on worldwide reserves (end of 2001) show that 67% of the crude oil reserves exist in the Middle East, whereas the largest natural gas reserves (39%) are in West & East Europe combined, particularly in the Former Soviet Union (FSU). The Middle East, however, is a close second in natural gas reserves.

A discussion of the reserves of crude oil and natural gas would be incomplete without considering the reserve-to-production (R/P) ratio of these fuels. The R/P ratio, obtained by dividing the known reserves by the annual production for a country, yields the number of years a particular fuel reserve would last, assuming no new reserves are found. The R/P ratio of crude oil, based on data for the year 2000, for the major crude oil producing countries of the world, clearly identifies countries with fast depleting reserves (Fig. 3). At the 2000 production rate, reserves for the top three crude oil producing countries (Saudi Arabia, Russia and the United States) are expected to be depleted in approximately 89, 21, and 10 years respectively. The percent values of world crude oil production for selected countries are also included in Fig. 3.

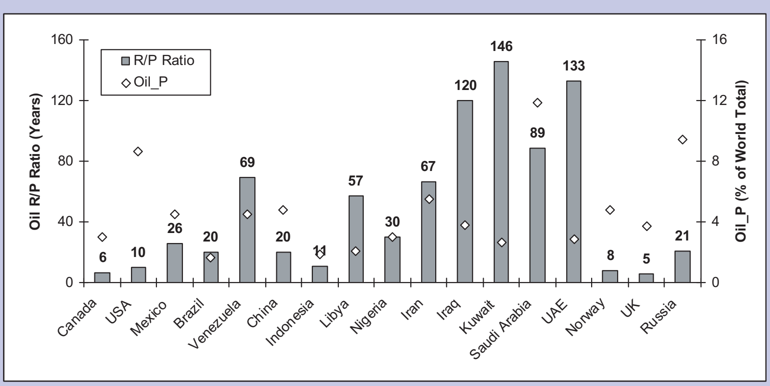


Fig. 3 Reserve-to-production ratio of crude oil for selected countries for the year 2000

Saudi Arabia is the largest producer with approximately 12% of the world total. Russia and the United States are next with about 9.5% and 9% respectively.

For the United States, one of the largest consumers and producers of natural gas in the world, the natural gas supply at present is expected to last for approximately nine years at the 2000 rate of production (Fig. 4). In contrast, Russia, the largest natural gas producer in the world, has a remaining supply of about 82 years. Iran and Qatar, with their low production rates, have reserves that should last more than 300 years. Of course, as other countries' reserves are depleted, production should increase and the R/P ratios decrease for today's low producers.

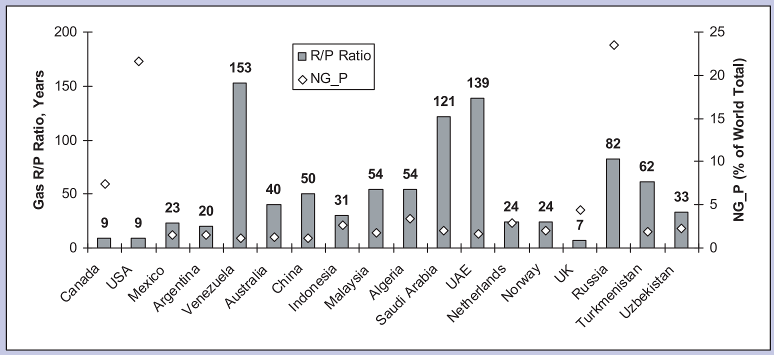


Fig. 4 Reserve-to-production ratio of natural gas for selected countries for the year 2000

With fast depleting reserves of crude oil and natural gas in the United States, there do exist strategic reserves for both fuels. As of April 2002, the total amount of crude oil in the Strategic Petroleum Reserve (SPR) was approximately 564 million barrels (equivalent to approximately 8.3 times the total daily production of the world for the year 2000, or approximately 29 days of supply at the United States' daily consumption rate for 2000). Natural gas stored in underground storage reservoirs was 6.9 TCF (equivalent to approximately 8% of the total yearly consumption of the world for the year 2000, or approximately 112 days of supply at the United States' daily consumption rate for 2000).

In addition to discussing oil and gas reserves and production, it is important to take a careful look at changes in world population during the last decade. Compared to 1990, the largest population growth occurred in Africa with an average annual growth rate of 3%. The population growth rate has been lowest (0.25%) in the region of West & East Europe, due mainly to a decrease in the population of East Europe and the FSU during the decade. In contrast, the Asia & Pacific region, where approximately 56% of the world population lives, has seen the fourth largest population growth rate (1.6%) in the last decade. It may be noted that the average global population growth rate during this period was also 1.6%. The effects of population change will be taken into account in discussing trends of PEC, GDP and CO_2 emissions.

PRIMARY ENERGY CONSUMPTION AND GROSS DOMESTIC PRODUCT

Compared to 1990, the most rapid growth in primary energy consumption was in the Asia & Pacific, Middle East and Central & South America regions (Fig. 5). Primary energy consumption decreased in West & East Europe in the last decade due mainly to decreases in East Europe and the FSU.

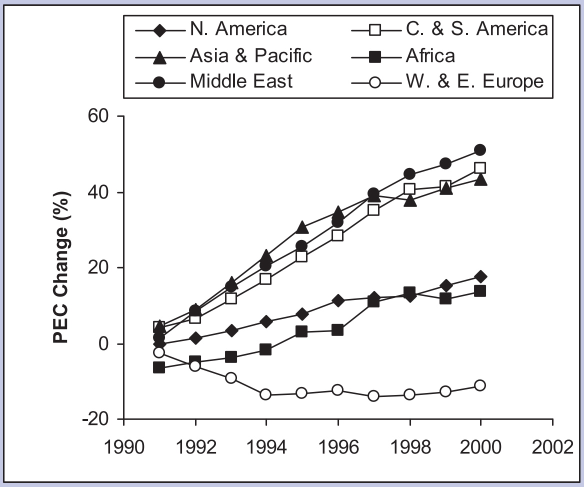


Fig. 5 World primary energy consumption trend by region (Reference year 1990)

Crude oil has been the major fuel source in the last decade (39%), with coal and natural gas coming in second and third place respectively. Together these three fuel sources account for just under 85% of total worldwide primary energy consumption.

A comparison of primary energy consumption by fuel type shows some interesting results (Fig. 6):

- The rate of change in primary energy consumption attributable to fuel sources such as renewable energy (fuel category entitled "others"), nuclear and hydro are higher than the three major fuels used in a given year. ("Others" not shown in Fig. 6.)
- The rate of change in primary energy consumption associated with natural gas has been higher than for the other two fossil fuels, crude oil and coal.
- The change in primary energy consumption attributed to coal, the second largest fuel source in the world, is lowest but also shows an increasing trend.

The possible reasons for the observed trends are multifold, but include 1) the overall increase in world energy demand, 2) greater environmental consciousness on the part of many countries, and 3) the recent preference for gas fired gas turbines as the technology of choice for clean, efficient and easy to install power production in base load, peaking and combined cycle applications in many parts of the world.

To get a more realistic picture of energy consumed worldwide, it is appropriate to analyze primary energy consumption data on a per capita basis (PEC_PC). For analyzing this data, it was necessary to divide countries into two groups: Group A - countries with PEC_PC values greater than 100 million Btu per year (MMBtu/year); and Group B - countries with PEC_PC values less than 100 MMBtu/year. This approach became necessary because of significant differences in values of PEC_PC for different countries. The analyzed data reveal that for both groups, the growth rate in PEC_PC during the last decade was highest for countries in the Asia & Pacific and the Central & South America regions.

Trends in GDP_PC during the last decade, expressed in 1995 US dollars, show higher economic growth rates for countries mostly in the Asia & Pacific regions in both groups. Japan, however, with the highest GDP_PC in the last decade, showed little economic growth. On the other hand China, with a GDP_PC 1/50th that of Japan, showed the highest economic growth rate in the last decade. It must also be noted that the two most populated countries of the world, China and India, have the lowest values of PEC_PC and GDP_PC. Despite this, in looking at the data for both groups, it is evident that there exists a significant difference in values of PEC_PC and GDP_PC for selected countries. It should therefore be noted that a high value of GDP does not necessarily indicate higher energy consumption for a country.

PRODUCTION AND CONSUMPTION OF OIL AND GAS

In the last decade, the greatest proportion of crude oil production was in the Middle East region (annual average of 30% of the world total). In 2001 the United States, Saudi Arabia and Russia were the top three oil producing countries in the world, producing 9.02, 8.73 and 7.29 million

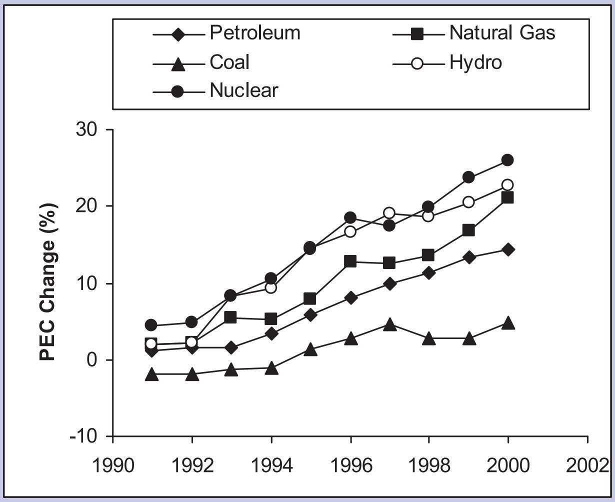


Fig. 6 World primary energy consumption change trend by fuel type (Reference year 1990)

barrels per day respectively[5]. Looking at the growth in oil production over the last decade, the highest growth was observed in Central & South America, whereas oil production was lower in North America and the West & East Europe regions, particularly in the United States and Russia.

Also in the last decade, approximately 60-65% of the world crude oil produced was consumed in North America and West & East Europe combined. The greatest change in crude oil consumption during the last decade took place in the Asia & Pacific region, whereas the least growth (in fact a decrease) in consumption took place in West & East Europe and the FSU in particular.

Looking at natural gas production over the last decade, the regions producing the most (40-50% of the world total) were West & East Europe, particularly in the FSU, and North America. However, the greatest growth in production occurred in the Asia & Pacific and Middle East regions. It is ironic that although the West & East Europe region had the largest natural gas production in the last decade, it is the only region where the change in natural gas production showed a decrease.

On the consumption side, approximately 75-80% of the world's consumption of natural gas took place in the same two regions where the most crude oil was consumed … North America and West & East Europe. Even though West & East Europe consumed the most natural gas during the last decade, the largest growth in natural gas consumption took place in the Asia & Pacific and the Middle East regions … identical to the regions of greatest growth in natural gas production.

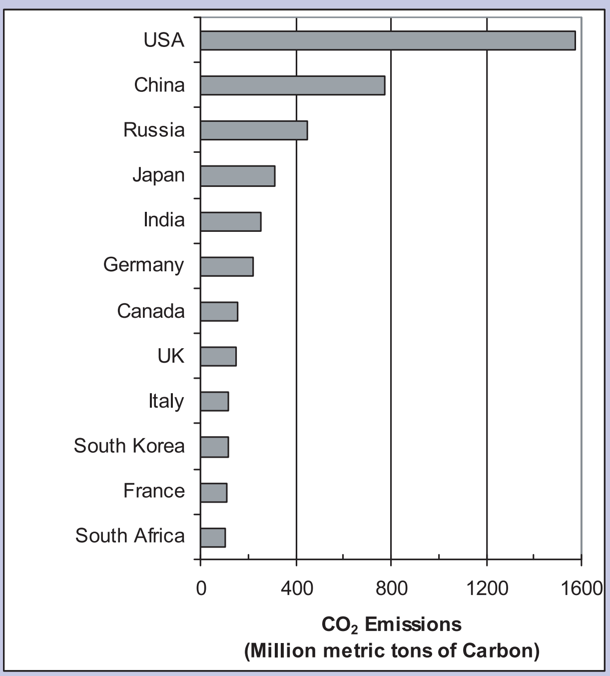


Fig. 7 Major CO_2 emissions producing countries of the world for the year 2000

CARBON DIOXIDE EMISSIONS

In terms of absolute levels of CO_2 emissions, in 2000 the United States produced 24% of the world total and more than any other country (Fig. 7). However, seven out of the top 12 CO_2 emissions producing countries are the developed nations.

In spite of the fact that the absolute level of emissions produced by a country is important, to compare emission levels for different countries, the absolute value of CO_2 emissions alone is not an appropriate criterion. The GDP produced through the use of the energy and the resultant emissions should be taken into account. So also should the population of the country concerned. This may be done by using either per capita CO_2 emissions or by normalizing CO_2 emissions by the energy consumed. The EIA, in their latest report has analyzed CO_2 emissions data by normalizing it with GDP[2]. A better method, however, is to compare CO_2 emissions divided by the country's primary energy consumption (PEC) and plot that against the per capita GDP. The resulting chart (Fig. 8) shows not only the relative cleanliness of the energy sources utilized in each country, but also the resulting economic growth weighted by population. CO_2 emissions per unit PEC can be termed "emission intensity." It must be mentioned that the use of emission intensity for comparing emission level can over/under estimate CO_2 emissions depending on contributions of other than fossil fuels in the total value of PEC. As can be seen for selected countries in Fig. 8, Brazil has the cleanest power production, but with relatively little per capita GDP. This is probably due to the large proportion of hydroelectric generation in the country. China, on the other hand, has 33% more emission intensity compared to the United States, even though its absolute level of CO_2 emissions is

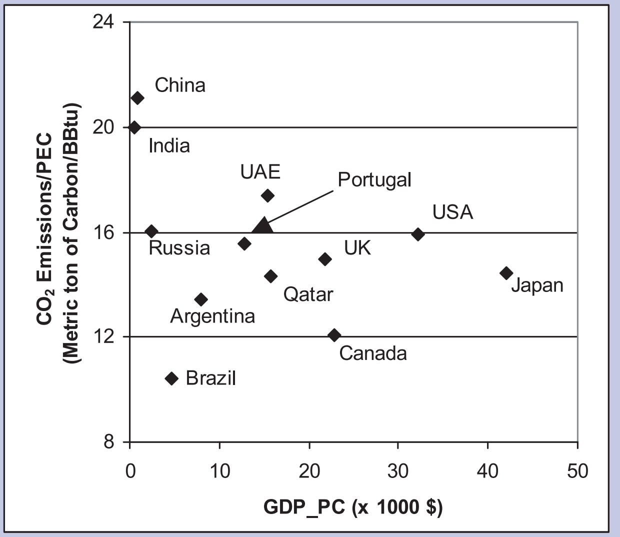


Fig. 8 Relationship among CO_2 emissions, primary energy consumption and per capita GDP for some countries for the year 2000

50% that of the USA as is evident from Figures 7 and 8. This may be due in no small part to its relatively high reliance on burning high sulfur coal for power generation.

CONCLUDING REMARKS

Care must be taken in drawing conclusions regarding future opportunities and resource direction based on historical data alone. Underlying assumptions may change and/or available data may be incomplete or non-representative of the true nature of things. For example, the discussed data indicate that the USA has only 9-10 years of oil and natural gas reserves remaining at current production rates. That is truly frightening and should have significant implications for the entire U.S. energy industry. However, because of tax implications it is fairly normal for companies in the U.S. (and possibly other countries) to not claim reserves until they are close to being needed. Likewise, more exploration takes place as the reserves dwindle and the increasing price of energy makes it more worthwhile.

What can be gleaned from the data analyzed is that in coming years the oil and gas industry and related businesses can be expected to grow at a comparatively higher rate in those regions that have experienced the greatest growth in natural gas and oil production and consumption, taking into account the base from which the growth occurred. This indicates that opportunities in the oil and gas industries may exist in the Asia & Pacific and the Central & South America regions. There is no doubt that developing countries in these regions have more growth potential in energy market than the developed countries in the other parts of the world. It may be worth mentioning that according to the recent report by EIA – International Energy Outlook 2002, energy demands in developing Asia and Central & South America are projected to more than double by 2020.

Looking at the data, it is also likely that an increased emphasis will be placed on CO_2 emission reductions in the U.S. similar to the emphasis recently placed on NOx reductions. However, from a global perspective, looking at Fig. 8, it may be more productive to look at prospects for CO_2 reduction in the relatively more polluting countries and, within the U.S., in the older, more polluting technologies. ✲

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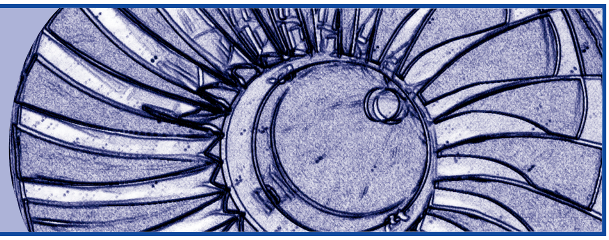
JOURNAL OF TURBOMACHINERY



Important News ... from Ted Okiishi, Editor

Lynn Rosenfeld (RosenfeldL@asme.org) is the current ASME Technical Publishing staff member who is responsible for getting each issue of the *Journal of Turbomachinery* ready for production. So, she is a key contact person for that step in publishing. I urge all journal paper authors who are not already doing so to work closely with Lynn on production matters (galley proofing, color printing, clarity of figures, etc.). Once papers get this far, my main function is to specify their serial order in the specific journal issue they are in.

The October issue of the journal was made up entirely of TURBO EXPO 2002 papers and I anticipate all of the 2002 congress papers recommended for journal publication being in print by the July issue next year. Thanks to those authors who worked fast to get their TURBO EXPO 2002 papers ready for October publication. I wish I could say that the transition from congress paper to journal publication is currently as smooth as it should be. It is not yet; however, we are working on getting it that way. Any suggestions you may have are welcome.

At TURBO EXPO 2002 I met with members of the Structures and Dynamics Committee and we agreed that journal papers sponsored by them that involved main flow path components would be published in the *Journal of Turbomachinery*. This is a change from past policy and I am glad that Lee Langston, editor, and Marc Mignolet, associate editor, of the *Journal of Engineering for Gas Turbines and Power,* approved this transition. Some benefits of this change include less publication backlog time for the papers involved and the combining of main flow path aero-driver and structural response papers in the same journal.

I received an expected larger than usual number of appeals from authors of TURBO EXPO 2002 papers that were not recommended for journal publication and I am still working through them. It may be of interest for you to know what I do in response to an appeal. First, I look at the papers and the review files involved. Then, I go to the review organizers and visit with them about the appeals. I would like to rely on review organizers to reconsider appealed papers along with the original reviewers and this is what usually happens. Sometimes, however, I have to rely on others, for example associate editors, to properly address the appeal. In the end I make a decision based on input from several individuals.

Expect to hear more news soon about improving the IGTI paper review system. For example, I think it would be helpful to better define "current interest" and "permanent interest," the descriptors we now use to sort pamphlet papers from journal papers. Also, we may benefit from a more formal way of factoring audience response to a paper, favorable or not, in the final judgment of a paper. Further, we may want to involve technical committee leadership and journal editors more in the judging process. I hope you will take the time to "weigh in" with your opinions and suggestions when given the opportunity. While the current system is good, I think it can become better.

As always, I welcome comments from those who read this column. I can be reached at tedo@iastate.edu. ✻

IGTI Board Elects Dick Hill of U.S. Air Force, Turbine Engine Division, WPAFB to Serve as Board Advisor

Richard J. Hill, chief of the Turbine Engine Division of the Air Force Research Laboratory's Propulsion Directorate at Wright Patterson Air Force Base, has been invited to serve as Advisor to the IGTI Board of Directors.

Mr. Hill holds the U.S. Air Force Meritorious Civil Service Medal and has 10 U.S. Air Force awards for engineering excellence including the 2001 U.S. Air Force Research Laboratory Senior Leadership Award. In addition, Mr. Hill is the U.S. Air Force nominee for the Franklin Institute's 2002 "Bower Award for Business Leadership."

He is the author or co-author of twenty-eight publications dealing with the subjects of turbine engine technology research, development and testing. Publications include: *Journal of Aircraft, Aeronautics & Astronautics,* NASA Technical Reports, USAF Technical Reports, NATO AGARD Proceedings, AIAA/SAE/ ASME Proceedings, ISABE Proceedings.

Mr. Hill began his engineering career with the U.S. Air Force in 1971 and has obtained extensive experience in the research, development and testing of advanced turbine engine technology concepts.

Prior to his current assignment, Mr. Hill held many key positions:

- Technical Manager in charge of advanced structural analysis and turbine engine component design methods for 10 years
- Manager of the Integrated High Performance Turbine Engine Technology (IHPTET) Program for 3 years
- Manager of the U.S. Air Force's advanced aircraft and missile experimental demonstrator engine test programs for 10 years
- Chief of Technology for turbine engine research for 7 years
- U.S. Coordinator for Propulsion and Energetics Panel (PEP) to NATO's Advisor Group for Aerospace Research and Development (AGARD) for 6 Years.

Mr. Hill is a member of Tau Beta Pi (U.S. National Honorary Society in Engineering) and Sigma Gamma Tau (U.S. National Honorary Society in Aerospace Engineering). Mr. Hill has a Bachelor of Science degree in Aeronautical Engineering from Wichita State University and a Master of Science degree in Aeronautical and Astronautical Engineering from the Ohio State University. He joins Abbie Layne of the U.S. Dept. of Energy as Advisor to the IGTI Board of Directors. ✻

GE VP Mark Little Heads Leadership Team For ASME TURBO EXPO 2003

Keynote to feature GE, Delta, and Southern Company Executives

by Erio Benvenuti, Conference Chair

"The ASME TURBO EXPO is one of the world's leading international gas turbine conferences," according to Dr. Mark M. Little, Vice President, GE Power Systems' Energy Products (Schenectady, N.Y.). "It is a unique forum bringing together experts from across the broad spectrum of gas turbine technology for aircraft propulsion, power generation and mechanical drive applications to promote technology exchange."

The ASME International Gas Turbine Institute is pleased to announce that Dr. Little will serve as Executive Conference Chair of ASME TURBO EXPO 2003: Power for Land, Sea & Air. The event hosts the world's largest exclusive gathering of developers, manufacturers and users of gas turbine products and services. TURBO EXPO 2003 (TE'03) will be held, June 16-19, at the Georgia World Congress Center in Atlanta, Georgia, USA.

Little, who joined GE's turbine business in 1978, is Vice President for General Electric Energy Products, the world's leading supplier of power generation equipment, which includes gas and steam turbines for industrial power generation, oil and gas applications and commercial marine power, turnkey power plants and energy management services. Key business locations are located in Schenectady, NY, Atlanta, GA, Greenville, SC in USA and Belfort, France and Florence, Italy in Europe.

As Executive Conference Chair of TE'03, Dr. Little provides direction for the activities supporting the conference keynote theme, *Global Power and Propulsion Solutions*. He will also lend strategic support and offer recommendations for the TURBO EXPO Technical Congress, Gas Turbine Users Symposium and Exposition.

The impressive lineup of keynote speakers for TURBO EXPO includes Little; Udo Rieder, Vice President – Engineering and Planning, Delta Air Lines; and Paul Bowers, President of Southern Company Generation and Energy Marketing.

ASME TURBO EXPO 2003, the premier event in gas turbine technology for aircraft propulsion and land-based applications for power generation, oil and gas, marine and vehicular applications, is a comprehensive venue for gas turbine professionals. The **Technical Congress** *(see below)* encompasses hundreds of papers and sessions offering leading edge technologies. The **Gas Turbine Users Symposium** *(Gas Turbine Operations & Technology Conference, see page 21)* features practical solutions to industry-related issues through panels, tutorials and discussion groups, and a major Exposition will showcase manufacturers, equipment suppliers and service companies representing many of the world's leaders in the gas turbine industry.

In 2003, TURBO EXPO will co-locate with another well-respected power industry meeting, the ASME International Joint Power Generation Conference, the power industry's most technically acclaimed event (see adjacent article). Both events will be held jointly at the Georgia World Congress Center in Atlanta.*

See all the exciting plans for TURBO EXPO, follow the development of the conferences, and view abstracts online at http://www.asme.org/igti/.

**Atlanta is an exciting, entertaining, and enjoyable host city for TURBO EXPO. See article, page 22.* ✲

Technical Congress 2003

by Kenneth Hall, Technical Program Chair

The Technical Congress at ASME TURBO EXPO is the premier annual technical event for gas turbine engine technology. TURBO EXPO is the largest conference of its kind, and the quality of papers, panel sessions, and tutorials are second to none. The 2003 event is shaping up to be the best ever, with more than 600 technical papers likely.

Technical Congress topics cover the breadth of gas turbine technology including detailed technical design and analysis of machine components, the environmental impact of gas turbines, regulatory issues, innovative materials, and advanced cycle concepts. The variety of machines studied range from the largest gas turbine power generators to marine and aircraft engines to the smallest microturbines.

Of **special interest** this year is the Scholar Lecture to be presented by Alan H. Epstein of the Massachusetts Institute of Technology. He will describe the design and application of shirt-button sized gas turbines. These amazing machines, which may one day replace chemical batteries as a compact portable power source, are manufactured using photolithography techniques more commonly used in the semiconductor industry.

Finally, we are pleased to offer a **new service** this year in advance of the conference. You may preview all accepted technical paper abstracts online and follow the content development of the nearly forty program tracks at http://www.asmeconferences.org/igti03/. ✲

ASME TURBO EXPO
Power for Land, Sea & Air

IJPGC
INTERNATIONAL JOINT POWER GENERATION CONFERENCE

IJPGC Joins TURBO EXPO in Atlanta

World's Premier Gas Turbine and Power Industry Conferences

The International Joint Power Generation Conference (IJPGC), the power industry's most technically acclaimed event, is joining with TURBO EXPO for the second time, following the success of the two events meeting concurrently in New Orleans in 2001. The concurrent events will have a unified registration, allowing conference registrants access to the keynote session, admission to the 3-day exposition (June 16-18) and four days of conference sessions.

A joint exposition will showcase more than 200 manufacturing companies, equipment suppliers and service firms representing power plants, land-based industrial engines, aviation and marine companies, pipeline applications and others.

Technical session topics within IJPGC will focus on areas of new research in various disciplines of power generation and industry trends, including:

- Components, Plant Systems and Design Engineering
- Operations, Maintenance, Reliability, Availability and Maintainability
- Combined Cycles, Combustion Turbines, Steam Turbines and Generators
- Fuels, Combustion and Emission Issues
- Advanced Energy Systems

IJPGC is sponsored by ASME's Power Division. Together, IJPGC and ASME TURBO EXPO will draw nearly 5,000 participants from 60 countries, including industry leaders, engineers, researchers, manufacturers and users of gas turbine engines and power industry products and supplies. ✲

John Bendo (standing), representing IJPGC, looks on with IGTI staff Judy Osborn (seated) and Lenore Taffel as IGTI Board Chair Dave Wisler signs the IJPGC and TURBO EXPO agreement.

Specialized Workshops to Precede TE'03

On Sunday, June 15, five workshops will be available as an adjunct to TE'03. A separate registration is required for these one-day workshops and CEUs will be available. Planned topics are:

- Design and Development of Aircraft Engines
- Industrial Gas Turbine Operation and Performance
- Steam Turbine Fundamentals
- Basic Gas Turbine Metallurgy and Repair Technology
- Combustion Dynamics

Stay tuned to the TE'03 web site for more details and how to register ...

www.asme.org/igti/

Gas Turbine Users Symposium 2003

Gas Turbine Operations & Technology Conference

by Terry Morgan, Users Symposium Chair

What is the primary concern of gas turbine users/operators in today's environmentally demanding, cost-constrained world? Applying cost effective technology to the operation, maintenance and upgrade of their gas turbine fleets, according to discussions and input at the Users Networking Session in Amsterdam in June 2002. In response, the Gas Turbine Users Symposium (GTUS) in 2003 in Atlanta will focus more intensely on *gas turbine operations and technology,* while continuing to improve networking opportunities and interaction among all parts of the *gas turbine community* to support successful gas turbine operations.

Assembling a complete *gas turbine community* — including knowledge providers (consultants, EPCs, academics, etc.), operators, original equipment manufacturers, and third party service providers — is a key component of IGTI's focus on *gas turbine operations and technology,* because these four segments of the gas turbine community influence all aspects of the life cycle cost to operate a gas turbine fleet.

The GTUS Advisory Group represents the community that operates and applies gas turbines for commercial purposes. Programs are designed to address user issues and facilitate information exchange. The primary focus of the GTUS is on gas turbine use in industrial cogeneration, power generation (prime and peaking), and oil and gas applications both on- and offshore. ✲

New for TE'03
Earn $$ for Bringing Your Colleagues

Registrant Referral Reward Program

Receive a $50 American Express gift certificate for every first-time registrant or registrant returning to TURBO EXPO or IJPGC after an absence of at least 4 years who lists you as the colleague who referred them to the event!

HOW IT WORKS:

To earn the Registration Referral Reward:

- You must register for TURBO EXPO or IJPGC at the full, 4-day rate and attend the event.
- You must be listed on the referred person's registration form as the "referring registrant."

The person whom you refer:

- Cannot be a publishing author in any sessions at TURBO EXPO or IJPGC.
- Must register at the full, 4-day rate and attend the event.
- Must register and pay by the Advance Registration deadline of May 16.
- Must not have attended TURBO EXPO or IJPGC as a paid registrant since 1998.
- Must list you as the "referring registrant" on their registration form.

Please note:

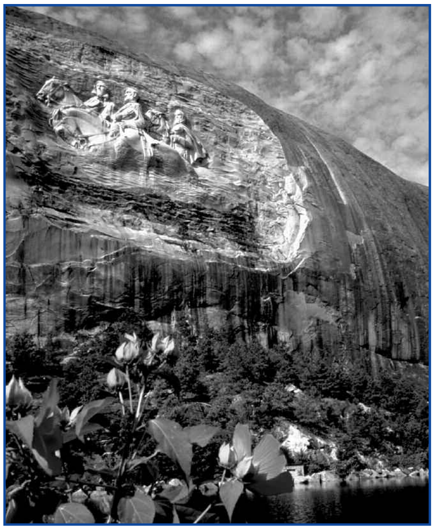
1. ASME and IGTI registration records will be considered the only official source of records of previous registrants.
2. Only one $50 American Express gift certificate will be issued for each referred registrant. Only one person may be listed as a "referring registrant" on a registration form.
3. You may qualify for multiple gift certificates – refer as many people as you wish!

For more information, email
igtiregistration@asme.org
or telephone
+1-404-847-0072, ext. 229.

Atlanta: Exciting … Entertaining … Enjoyable

Experience the entertainment and cultural center of the South during ASME TURBO EXPO 2003! Atlanta has more restaurants, professional sports teams, entertainment venues and cultural attractions than any other city in the Southeast. Many of these attractions are within easy reach of downtown and almost all are accessible via MARTA, Atlanta's rapid rail and bus system.

The excitement never ends in Atlanta. Whether enjoying sports, nightlife, nature, or the arts, you can't help getting caught up in the rush.



Stone Mountain
Georgia Department of Industry, Trade & Tourism

Sports – Recreation – Theme Parks

Atlanta is home to five professional sports teams and fans cheer them on in state-of-the-art facilities. Those who enjoy getting active can engage in hiking, fishing, rafting, rock climbing, camping, tennis or golf at Atlanta's parks and recreation centers. Thrill seekers of all ages can experience the excitement of Atlanta's amusement and theme parks, including Six Flags Over Georgia, White Water, American Adventures, Georgia's Stone Mountain Park and Speedzone. Animal lovers won't want to miss the giant pandas at Zoo Atlanta.

Historical Attractions

Atlanta's historical attractions, such as the Atlanta History Center, Atlanta Cyclorama, the Dr. Martin Luther King, Jr. National Historic Site, Georgia's Stone Mountain Park and the Margaret Mitchell House & Museum, promise a day filled with education and entertainment.

Dining – Nightlife – Culture

World-class restaurants, festive nightlife and an abundance of cultural attractions and events help make Atlanta the center for entertainment in the South. Those in search of nightlife can find entertainment all night long at the dance clubs, sports bars and late night coffee shops of Buckhead. Theaters, museums, galleries and concert halls all over town offer diverse art, drama, dance and music. A wide variety of exciting performances are always on stage in theaters such as the Alliance Theatre, the Fox Theatre, the Rialto Center for the Performing Arts, and numerous smaller venues.

Ya'll Come

Southern hospitality is abundant throughout the city, and the mild climate lends itself to exploration. From the heart of downtown, visitors can reach Atlanta's many attractions, entertainment venues, restaurants and neighborhoods within a short ride by cab, bus or rail. Atlanta's rapid rail and bus system, MARTA (Metropolitan Atlanta Rapid Transit Authority), covers the metropolitan area with 38 rail stations and 154 bus routes—it costs only $1.75 to ride. ✻

VIEW FROM THE CHAIR ... *continued from page 2*

Publication of papers – I negotiated a substantial reduction in ASME costs for handling papers and producing CD's for TURBO EXPO '03. Models will be negotiated with ASME that allow IGTI to share in the net revenue for its publications.

Educational Products – IGTI voted to concentrate efforts on producing high quality educational material, including on-line web based training, with a financial goal of increasing revenue by a factor of ten. The Board, the Education Committee and Atlanta staff will work with ASME's Continuing Education Institute to develop high quality content in a revenue sharing model.

Government Relations – IGTI will assign a Board member to be a permanent liaison to participate in the ASME government relations' activity and flow this information down to the membership.

Accounting Services – IGTI will incorporate ASME's new accounting system into its operation as soon as possible. Benefits from the transition include improved services, elimination of a second audit for IGTI, and commensurate IGTI staff adjustments, thus reducing IGTI's expenses.

Custodial Fund Balance – The Board will likely move IGTI's custodial fund balance to the ASME general fund for investing purposes. IGTI will have full access to their funds at any time as per the ASME governing policy. IGTI will be the sole authority concerning withdraw and use of its funds. IGTI will participate in meetings of the ASME Committee on Finance and Investment (COFI).

ASME News Article – An article will be prepared for ASME news that describes the positive attributes of IGTI as a benchmark institute model.

Inter-divisional Activity – The Institute will support an ongoing and open dialogue to consider joint activity with ASME including exhibits and conferences. The MOU between IJPGC and IGTI for TURBO EXPO '03 is a model for future relations.

IGTI BoD Meetings – I have extended an invitation to the ASME Council on Engineering to send visitors to all future IGTI BoD meetings.

IGTI – ASME Board of Governors Memorandum of Understanding – The executive committee of IGTI and Tom Loughlin have drafted an updated MOU that describes the working relationship between us.

In addition to the above issues, your Board is taking aggressive action to remedy the situation of financial loss suffered in recent TURBO EXPO's. We have a world-class technical conference and we will keep it that way. However, it is obvious that we cannot operate at a loss and stay in business. To address this, the Board appointed Ron Natole to head a conference strategy team. Their goal was to find a viable restructuring strategy for the technical conference, the exhibit and the GTUS that allows IGTI to remain solvent. The team did an excellent job. The proposed dual-conference strategy was endorsed by the Committee Thought Leaders and the Board. You will be hearing more about this as it is implemented. And you will definitely see the change.

The changes described in this article are far-reaching. Not everyone will agree that they should be made. But the world has changed significantly in the past decade and IGTI must adapt. Past baggage must be unloaded. We must reach out to forge a new relationship with ASME and we must adapt the new conference strategy. Our future depends on it.

As my term for Board Chair ends, I want to thank all of the Board members, the Atlanta staff, Committee leaders and ASME for their support and hard work to improve IGTI. I look forward in June to continuing to serve you in the position of ASME Vice President, IGTI. ✲

New Members of IGTI Board of Directors

Oscar Backus has worked for Austin Energy his entire 32-year career, engaged in power production activities encompassing engineering design, plant construction, steam and gas turbine generator installations, project management, and now environmental services. In 1986 he championed the acquisition of 200 MW of used gas turbines for Austin Energy that were refurbished, purchased and installed for $155/kW. With these units Austin Energy was introduced to the world of gas turbines. They now have a total of 400 MW with another 250 MW under construction permitted at 3 PPM NOx emissions. Austin Energy was recognized in the May-June issue of *Gas Turbine World* as the lowest cost electric utility installation in the United States for the year. The recipient of Total Quality Management and Manager's Leadership Awards, Oscar currently manages 30 employees that provide all environmental and plant technical services for facilities owned by the utility.

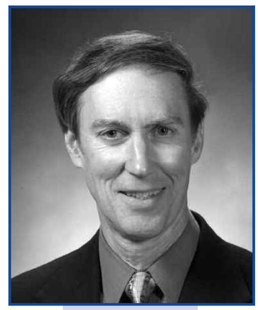
An ASME member who has previously served as Chair of IGTI's Electric Power Committee and as Gas Turbine Users Symposium Chair for TURBO EXPO 2002, Oscar somehow finds time to be an avid jogger and sports car enthusiast/restorer, and to pursue his interests in technical reading, gardening, and landscaping. ✲

MEMBER-AT-LARGE

OSCAR BACKUS (Carmen)
Manager, Environmental & Technical Services
Austin Energy
Austin, Texas USA
Term: 2002-2004

In 26 years in aeroengine fan & compressor research at NASA-Glenn, Tony Strazisar has focused on such topics as optical, non-intrusive flow field measurements, turbomachinery CFD validation, and compressor stall control. His current research interest is in compressor flow control for improved aero performance. Tony's present position as Senior Technologist for Turbomachinery entails technical oversight of all compressor experimental research activity at the NASA Glenn Research Center.

Outside of work, Tony pursues his interests in gardening, woodworking, and foster care. ✲



INCOMING MEMBER

ANTHONY STRAZISAR -"Tony" (Kate)
Senior Technologist
NASA Glenn Research Center
Cleveland, Ohio USA
Attended: Case Western Reserve University
Term: 2002-2004

GLOBAL Gas Turbine News
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INTERNATIONAL GAS TURBINE INSTITUTE

2002 - 2003 BOARD OF DIRECTORS

MISSION STATEMENT

The International Gas Turbine Institute of The American Society of Mechanical Engineers is dedicated to supporting the international exchange and development of information to improve the design, application, manufacture, operation and maintenance, and environmental impact of all types of gas turbines and related equipment.

Get Yours While They Last ... Fewer than 150 Left!

The History of Aircraft Gas Turbine Engine Development in the United States ...

A Tradition of Excellence

by James St. Peter

This absorbing, anecdotal history of gas turbine engine development spans over 50 years of scientific discovery, corporate intrigue, and insight into the minds of the historic personalities who shaped one of the great inventions of the 20th Century.

About the Book.

From the technological beginnings in England and Germany, through the proliferation of research and development in the Unites States, through the Great Engine Wars and the development of Mach 3 and stealth aircraft, to the modern IHPTET programs, this history draws upon the remembrances of those involved and a multitude of research sources that are quickly disappearing.

Included in the 600-page, hard-cover history are 19 chapters and 69 engine addenda, plus hundreds of photographs and illustrations, engine specifications and performance ratings, complete chapter endnotes, and a comprehensive index... ideal for reading, reference or continuing research.

About the Author.

James St. Peter is a Technical Historian contracted by the Air Force to research and write this historical look into the development of aircraft gas turbine engines in the United States. He was ideally suited for this landmark project because of his in-depth knowledge of jet engines and previous research experience.

St. Peter was selected by the Air Force Wright Laboratory, Aero Propulsion & Power Directorate, at Wright-Patterson Air Force Base in Dayton, Ohio. The effort was co-sponsored and financially supported by the Army, Navy, Air Force, NASA, and the ASME International Gas Turbine Institute.

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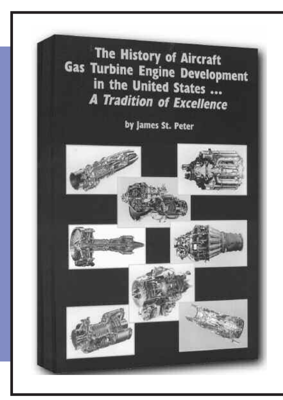
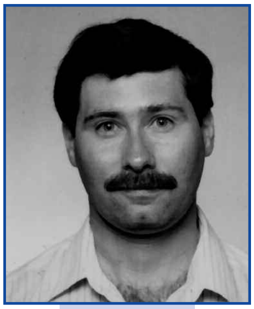


Introducing

SELECTED NEW IGTI COMMITTEE CHAIRS

FOR THE 2002-2004 TERM



John was principal research engineer and technology leader at Honeywell (previously Garrett and AlliedSignal) Ceramic Components from 1987 to 2000. His team successfully developed and introduced advanced structural ceramics into production for aircraft (e.g. APUs) and industrial gas turbine applications. He left Honeywell in 2000 to start his own structural materials consulting business – Tetralux Engineering. Since 2000, John has also been a research fellow in UCLA's biology department, where his interests include developing the fabrication of structural ceramics using bio-mimetics (imitating nature's nanoscale building block processes) to further improve material properties and achieve desired complex microstructures.

John has a lifelong interest in wildlife conservation, and his position in UCLA's biology department has allowed him to pursue the study of conservation genetics (DNA testing and analysis), and also to assist in field studies of coyotes, bobcats, mountain lions, and gray wolves. ✲

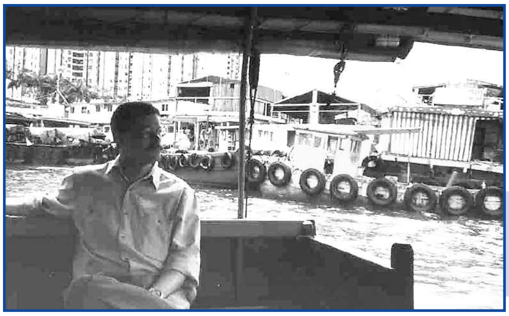
COMMITTEE: Ceramics

John P. Pollinger - "John"
Owner/Principal Engineer
Tetralux Engineering Services
Los Angeles, California USA
Attended: Alfred University
Penn State University
Term: 2002-2004

Assisting National Park Service with annual bobcat kitten survey in Santa Monica Mountains.

Ron has worked in nuclear engineering, aircraft engine gas turbine design, and heat transfer R&D. His gas turbine technology career began with his Ph.D., followed by a Humboldt Research Fellowship in Germany. He has been responsible for a wide range of gas turbine heat transfer research and innovation covering internal cooling devices, external gas path effects, film cooling, and combustor systems cooling, only a portion of which is documented in some 45 papers and publications. In the course of this research, he has been awarded 16 U.S. patents, with 20 more pending. Ron has been an active member of the Heat Transfer Committee since 1993. In 2002, he was elected a Fellow of ASME. He is also a current associate technical editor for ASME's *Journal of Turbomachinery*.

Ron is a regular cyclist on local roads (much to the dismay of local drivers), clocking about 2000 miles per year. He paints Matisse and Picasso on the walls of his house, and now needs a bigger place for this. Other passions include classical music, museums, and literature. ✲



Touring Hong Kong Harbor.

COMMITTEE: Heat Transfer

Ronald S. Bunker - "Ron"
Senior Staff Research Engineer
General Electric Global Research Center
Niskayuna, New York USA
Attended: Arizona State University
Term: 2002 - 2004

New IGTI Committee Chairs ...

Currently the Senior Consulting Scientist at United Technologies Research Center (UTRC), Bal has been employed in the field of mechanical engineering for 28 years. He joined UTRC in 1984 after receiving his Sc.D. degree in Mechanical Engineering from MIT. He developed the Surface Integral and Finite Element (SAFE) code for fracture mechanics for effective modeling of crack growth and life prediction of metallic structural components. In the course of Bal's distinguished career with UTRC, he has received a UTRC outstanding achievement award, a UTRC special award, and the United Technologies Corporation (UTC) President's award. He has authored/co-authored 23 papers, and has edited a book on "Boundary Elements Methods in Engineering." He has also been awarded three patents during his tenure at UTRC.

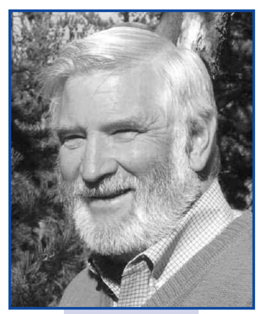
Bal has been a member of ASME since 1977 and an ASME Fellow since February 2002. He has been active with IGTI as author, reviewer, session organizer, Vanguard Chair, Point Contact, and committee Vice Chair. He is also an Adjunct Associate Professor of Mechanical Engineering at Rensselaer Hartford and has taught graduate level courses in fracture mechanics, plasticity, mechanics of materials and mechanical vibrations.

Bal lives in Glastonbury, Connecticut and has two sons, Anand and Vinay. Anand graduated from Boston College with a Bachelor's degree in Business and works at Fidelity Investments in Boston. Vinay is a Junior pursuing a Business degree at Penn State University. Both have played tennis extensively, representing their schools and colleges. Bal also enjoys playing tennis; his other hobbies include playing the tabla (an Indian percussion instrument), and ballroom dancing. ✻

COMMITTEE: Structures & Dynamics

Balkrishna S. Annigeri - "Bal"
Senior Consulting Scientist
United Technologies Corporation
Research Center
East Hartford, Connecticut USA
Attended: Govt. College of Engineering, Aurangabad, India & Illinois Institute of Technology
Term: 2002-2004

Watching son Vinay play tennis at the USTA tournament in Kalamazoo, Michigan.



Dan has over 30 years of technical management experience leading the development of advanced energy and power generation technologies at GE's Global Research Center in Niskayuna, NY. He currently heads a laboratory developing advanced microturbine systems, fuel cell technology and systems for distributed and dispersed power production, and sensor/systems for improved maintenance and performance of power generation and propulsion equipment. Previous project leadership assignments have included the development of advanced, highly cooled gas turbines; the evaluation of components and systems for integrated coal gasification combined cycle power generation; and the development of comprehensive remote monitoring and diagnostics systems for power generation, propulsion, and medical diagnostic equipment.

Dan is an avid outdoorsman, devoting much of his spare time to landscaping and improving his 20-acre rural farmstead with trails for hiking and skiing using his recently acquired, commercial-sized tree chipper. He and his wife enjoy traveling, with recent vacations to France, Belgium, Colorado, and Wyoming, as well as throughout the U.S. Northeast. ✻

Distributed Generation Task Force

Daniel P Smith - "Dan" (Jule Marie)
Manager, Energy Systems Laboratory
GE Global Research
Niskayuna, New York USA
Attended: Cornell University
Term: 2002 - 2004

New IGTI Committee Chairs ...

Pat is the owner of Rollins Technical Recruiting, a professional placement firm specializing in career planning and placement for turbomachinery professionals. He is a Certified Personnel Consultant, and holds a bachelor of science in mechanical engineering from the University of Maine. Prior to the start of this business he worked primarily in the aviation gas turbine industry. Pat is a graduate of the General Electric Aircraft Engine Engineering Development Program (EDP) and in this capacity has worked in most facets of jet engine design and development. He has worked with most of the world's major airframers including Boeing, Canadair and the Lockheed "Skunk Works."

In addition to his engineering experience, Pat has managed key sales accounts for Bosch Automation Products. He is a member of ASME and the American Institute of Aeronautics and Astronautics. As Chair of IGTI's Education Committee, Pat is assisting in the development and marketing of educational products offered by IGTI.

Pat and his wife Margaret are the parents of two, Catherine (born December 2000) and Matthias (born August 2002). Pat comes from a family of mechanical engineers, most of whom also work in turbomachinery. He describes himself as a frustrated farmer and lumberjack who on any given weekend can be found on his tractor or wielding his chainsaw. Pat's other interests include hunting, traveling, and hiking with his two Cardigan Welsh Corgis. ✻

COMMITTEE: Education

Patrick M. Rollins - "Pat" (Margaret)
Owner
Rollins Technical Recruiting
Canandaigua, New York USA
Attended: University of Maine
University of Cincinnati
Miami University, Ohio
Term: 2002-2004

Pat and Margaret with Catherine and newborn Matthias.

Warren's principal responsibility since joining Sermatech Power Solutions four years ago has been the development of novel repair techniques and processes for advanced IGT, aero-derivative and aircraft engine components. His primary area of expertise is in the welding, brazing and heat treatment of nickel and cobalt based superalloys and titanium based alloys. Prior to joining Sermatech, Warren worked for ten years at CSIR, the largest R&D center in the southern hemisphere, developing high strength weld filler metal formulations, techniques/processes for joining of nickel and cobalt base superalloys, and processes for the repair of blades and vanes. He also gained experience with CVD and aluminide coating systems. At the CSIR, Warren was elected one of the top five among 3,500 researchers. He has authored or co-authored 32 published technical papers.

Warren enjoys traveling and seeing the world. In his younger days he played soccer and cricket at club and city levels. These days, he plays snooker and darts for relaxation. If you play snooker against him, be aware that he is colorblind and sometimes accidentally shoots the brown ball in, instead of the red one. Warren and Portia, his wife of 11 years, look forward to the birth of their first child in April. ✻

Warren playing snooker.

COMMITTEE: Manufacturing Materials & Metallurgy

Warren Miglietti (Portia)
Senior Technology Repair Engineer
Sermatech Power Solutions
Manchester, Connecticut USA
Term: 2002 - 2004

New IGTI Committee Chairs …

Al began his career with United Technologies in 1977 at the Hamilton Sundstrand Division where he has served in a variety of capacities ranging from system designer to technical specialist in areas of engine performance diagnostics, engine modeling, statistical analysis and artificial intelligence in engine control applications. Al joined Pratt & Whitney in August 2000 and currently holds the position of Fellow in Engine Diagnostics.

He is presently technical lead for analytical development in Pratt & Whitney's Advanced Diagnostics and Engine Management (ADEM) program as well as technical task manager for several NASA technology programs relating to engine diagnostics, prognostics and propulsion health management.

In his spare time, Al enjoys traveling and exploring new places. He has a fondness for ballroom dancing and can often be found waltzing around New England antique shops with his wife Ellen. ✻

COMMITTEE: Controls, Diagnostics & Instrumentation

Allan J. Volponi - "Al" (Ellen)
Fellow
Pratt & Whitney
East Hartford, Connecticut USA
Attended: Pratt Institute
Adelphi University
Term: 2002-2004

Al and wife Ellen at Neuschwanstein Castle

Terry worked for 30 years in upstream oil production and gas processing for ARCO (now BP). The last 23 years were spent in Alaska working with 650,000 hp of mechanical drive gas turbines in a fleet of over 2,000,000 gas turbine horsepower. The Alaska career highlights included a major turbine upgrade program and serving as corporate O&M lead on two major service agreements.

Since leaving ARCO, Terry has established a consultancy in oil and gas facility engineering and process safety with emphasis on plant modification and gas turbine operations and maintenance in Laramie, Wyoming. He has been active in major gas turbine user organizations for many years.

Terry's free time is centered on his family who all live in the Rocky Mountain area. Outdoor activities including hiking, canoeing, watching the deer and antelope play (literally), and keeping up with 3.7 grandchildren are all part of living in Wyoming. Drinking good coffee and following the Wyoming Cowboys are big parts of small town life at 7,200 ft. in Laramie.

GTUS Advisory Group

Terry Morgan (Marilyn)
Managing Director and Principal Consultant
Terry Morgan & Associates, LLC
Laramie, Wyoming USA
Attended: University of Wyoming
Term: 2002 - 2004

COMMITTEE NAME CHANGE …

Vehicular & Small Turbomachines Committee Becomes Microturbines & Small Turbomachinery Committee

The Vehicular and Small Turbomachines technical committee of IGTI has changed its name to Microturbines and Small Turbomachinery. Rolf Gabrielsson with Volvo Aero Corporation in Trollhättan, Sweden, is the Chair of the committee.

"The name of the committee was changed to reflect changes in the market for small turbines, " according to Debbie Haught, Vice Chair of the committee and Program Manager for the U.S. Department of Energy. "Small turbines, now called microturbines, are being primarily developed for distributed generation applications. Most U.S. and international programs on vehicular programs have been discontinued with only some military applications remaining," Ms. Haught said.

The Committee's mission statement has been revised to read, "The Committee follows gas turbine, including microturbine and small turbomachine, developments in these categories: stationary and mobile power, transportation (including automobiles, trucks, buses, trains, boats, surface effect machines, tanks and other special military vehicles, off-highway vehicles), auxiliary power units, turbochargers, turbo-compounding, and other small special equipment."

IGTI's 17 Technical Committees, with a combined membership of 1100 leading engineers worldwide, focus on the latest developments in equipment, improvements in techniques, and introduction of new practices throughout the gas turbine industry. ✻

"BASIC GAS TURBINE ENGINE TECHNOLOGY"

Second Edition

> **This course gives a good general understanding of gas turbines in an easy-to-read format.**
>
> *Mark Wolfanger, Engineering Technician, Dresser-Rand/Alfred State College*

This Home Study Course is a 162 page non-mathematical approach to understanding the fundamental nature of gas turbine engines and the processes which affect their performance. The Course is ideally suited to technicians and management personnel. It will also prove to be of value to those engineers starting their careers in the fields of gas turbine engine and auxiliary equipment operation, maintenance or service, specification, sales and manufacture.

Introduced in 1985, more than 4,000 orders for "Basic Gas Turbine Engine Technology" have been received from industry personnel throughout the world. Here is a sample of comments from some of those completing the course:

"Excellent introductory course that maintains your interest throughout."
William G. Machingo, Staff Engineer. Wright Patterson AFB.

"Initially we put one trainee on the Course and found it to be a good indoctrination to the world of gas turbines... we have now put several key personnel, including our Managing Director, through the Course."
Timothy A. Trott, Operations Manager, Maghraby Limited.

Course Content

The Course is organized into ten chapters. Following each chapter when you are ready, you will take a test on that material. Take your time in answering the questions and feel free to double check by referring to the text material. When you are satisfied, send the completed tests to the International Gas Turbine Institute in Atlanta for scoring. Your corrected answer sheets will be returned for your information and review. When you have finished the the entire Course, you will receive a Certificate of Completion.

The cost of $145.00 U.S. includes the text, grading and return of exam questions, and issuance of your Certificate of Completion. A special discount price of $95.00 U.S. is available to qualifying students. ✲

"THE DESIGN OF GAS TURBINE ENGINES– Thermodynamics & Aerodynamics"

Second Edition

This Home Study Course introduces you to the fundamental principles for thermodynamic analysis and design of gas turbine components and systems, with insight into design practice. Selected gas turbine hardware is illustrated and described in the accompanying videotape. A companion personal computer program facilitates investigation of the effects of chosen design parameters on performance. This Course is intended for graduate engineers with a knowledge of thermodynamics and an interest in design analysis and performance prediction of gas turbines and components.

Course Content

This 445 page Course consists of 13 chapters and 8 appendices conveniently arranged in one 3-ring binder.

At the end of each chapter is a test that will help you measure your understanding of the content and your ability to work related problems. Test sheets contain multiple choices for ease of scoring by IGTI; however, when your scored answer sheet is returned, it will be accompanied by a detailed solution to each problem and an explanation of answers to other questions.

THE VIDEOTAPE: The two-hour videotape in for VHS cassette players and is available in either NTSC (U.S.) or PAL (European) format. When ordering, be certain to specify which format you require.

THE COMPUTER PROGRAMS: With this Course you receive software programs with which you can calculate the performance of both simple and fairly complex cycles. Programs may be run on most IBM or IBM compatible equipment. They are designed for immediate use and do not require a compiler or a math coprocessor.

The cost of $345.00 U.S. for the Course includes the text, videotape, computer diskette(s), scoring and return of exam questions and answer sheets, and issuance of a Certificate of Completion. A special discount price of $225.00 U.S. is available to qualifying students. ✲

> **A great course for turbine operators!**
>
> *Arthur Hamilton, Watch Supervisor,Pawtucket Power*

"GAS TURBINE APPLICATIONS & ECONOMICS"

If you are involved in the application of gas turbines in such diverse fields as power generation, auxiliary power systems, and cogeneration, or would like to understand more about the design and performance of gas turbine power systems, this course is for you.

Course Content

Performance is the key to application decisions involving gas turbines, and this course begins with a review of the thermodynamic principles for the prediction of performance of several gas turbine types. The involved processes are described, from simple gas turbine cycles, to complex regenerative and cogeneration cycles. Many example calculations are included, and preferred cycles for several different applications are described.

Performance includes economic optimization as well as efficiency, power output, and emissions control; and the course includes an economic optimization method based on an objective equation. Combustion emission laws and methods of compliance are discussed. A computer program, GTSHAFT, on disk is included with the course for the parametric analysis and optimization of gas turbine systems design. The GTSHAFT program includes both the executable files and the source code for convenient student use.

The 228 page Course is divided into nine chapters, and includes discussions of designs and performance calculations, many worked examples, and actual case studies of successful applications. Self-testing exercises, which will be corrected by IGTI, are included.

The cost of $215.00 U.S. includes the text, computer diskette, scoring and return of exam questions, and issuance of a Certificate of Completion. A special discount price of $140.00 U.S. is available to qualifying students. ✲

> **Excellent review of cycle thermodynamics and performance analysis for engineers involved in unit selection for electric power applications.**
>
> *Albert Taylor, Senior Engineer, R.W. Beck, Inc.*

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In Memory of Dr. Mikio "Mike" Suo (1935 - 2002)

Dr. Mikio "Mike" Suo

Dr. Mikio "Mike" Suo, whose contributions to jet engine design earned him national recognition, died May 5, 2002, of cancer. He was 67.

Dr. Suo was Manager of Heat Transfer and Fluid Systems Design at GE Aircraft Engines before retiring in 1996. He coordinated the efforts of more than 100 engineers in Cincinnati, OH and Lynn, MA.

As much as he was noted for his technical and managerial accomplishments, Mike's family, friends and colleagues remember his thoughtful, compassionate nature, his wide-ranging interests and his natural curiosity about the world.

The son of Japanese immigrants, Mike was born 26 Feb. 1935 on a farm near Fresno, CA. He spent much of his youth working in dusty vineyards, but he also showed an early fascination for moving parts. As a child he applied an oil squirt can to his tricycle and crafted gliders from balsa wood. A high school Latin teacher encouraged him to apply to the University of California at Berkeley. He graduated Phi Beta Kappa and summa cum laude in 1956.

After serving in Europe as an officer in the U.S. Army, he pursued his master of science and doctorate in mechanical engineering at the Massachusetts Institute of Technology, where he also met his wife, Harriet Nicholson Suo.

Initially undecided between a career in academia or industry, Dr. Suo taught at MIT for 3 years before being hired by Pratt & Whitney Aircraft in East Hartford, CT in 1966. He worked there and at United Technologies Research Center before moving to GE Aircraft Engines in 1981. Along the way, he built an international reputation in the field of turbine aerodynamics and heat transfer.

One of Mike's chief accomplishments was to direct the creation of complex computer models that predict the temperature of engine parts in transient operation. He insisted on basing calculations on fundamental physics, rather than rules of thumb. It took the guesswork out of engine design, reducing the time it takes to bring prototypes from drawing board to factory floor. It also made it easier to diagnose problems on engines in service and improved engine safety.

The American Society of Mechanical Engineers named him a Fellow of the Society in 2001, citing his lifetime of contributions to the profession. *

BREAKING NEWS ...

IGTI Board Selects Don Greene as New Managing Director

The IGTI Board of Directors is pleased to announce that after an extensive search, and working in conjunction with ASME Headquarters, it has selected Don Greene as the new Managing Director of IGTI. Don joins ASME/IGTI from Polaris International, an association of CPA firms with a national membership. Prior to Polaris, Don worked at the Institute of Industrial Engineers (IIE). Don is a graduate of the Georgia Institute of Technology with a BS in Industrial Engineering, earned with high honors. He also has an MBA, a PE license and is a Certified Association Executive (CAE). Don starts at IGTI on November 27. Welcome!

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