Turbo Expo 2013 in San Antonio, Texas

Trends in the Global Energy Supply and Implications for the Turbomachinery Industry

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JOIN MORE THAN 3000 PROFESSIONALS from over 50 countries for ASME Turbo Expo 2013 – a premier 5-day Technical Conference and a 3-day, premium exhibition of turbine products and services supported by leading companies in the industry, such as GE, ANSYS, CD-adapco, and Pratt & Whitney. This year Turbo Expo is being held June 3-7 at the San Antonio Convention Center, in San Antonio, Texas. Register today at www.turboexpo.org. Early registration discount ends May 6. Also, in celebration of our inaugural early Sunday registration hours at Turbo Expo, there will be margaritas, empanadas, and a mariachi band from noon until 3pm.

Why you should go to San Antonio
- Global Networking
- Leading R&D
- Esteemed Industry Experts
- Targeted Leads
- Focused Training
- High ROI
- Cutting-Edge Technology
- Essential Career Development
- Practical Application

Keynote Speakers Announced
Three leading figures in the industry, Alan Epstein of Pratt & Whitney, Stuart Jeffries of ExxonMobil, and Vinod Philip of Siemens Gas Turbines, will speak in the opening keynote session on June 3.

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Welcome to the Global Gas Turbine News (GGTN), the quarterly newsletter of the International Gas Turbine Institute (IGTI). This will be my final contribution to the GGTN from the chair as I pass the gavel on to my successor, Professor Karen Thole, in June.

Professor Thole is the Department Head of Mechanical and Nuclear Engineering at Penn State University. Her research interests lie particularly in the domain of heat transfer. I would like to thank Karen and Ron Bunker, our current past chair, for their collaboration concerning the further development of IGTI. Their efforts have been crucial in furthering the efforts of IGTI along with the vision and goals of the board.

Until recently, IGTI has been mainly associated with Turbo Expo. In North America and Europe, Turbo Expo holds a long tradition of being an outstanding conference for gas turbines. In the past few years, the biggest industry advances have been developing outside these two continents. Therefore, I am especially pleased to learn about the success of the first ASME Gas Turbine India Conference last December and its continued presence in 2013 and beyond. The next conference will be held on the 5th and 6th of December, 2013, in Bangalore. GT India is an important step for IGTI in establishing conferences that are tailored to local needs in diverse countries that are increasing their interests in the turbomachinery industry.

IGTI continues to pursue a leading position in new fields. A big step forward in this effort was made last year on the topic of Organic Rankine Cycles (ORC). The plans for an ORC conference in The Netherlands this fall are well under way and up to 500 participants are expected. The IGTI board is indebted to Professor Piero Colonna from the Delft University of Technology for organizing an ORC conference in 2011. The IGTI ORC Committee is currently in its foundational stages and has ambitious plans that extend well beyond the usual activities of IGTI committees. Along with focusing on the ORC conference, the ORC Committee also provides information and training propositions along with the “Knowledge Center on Organic Rankine Cycle Technology.” I would like to wish Piero all success when implementing these plans.

Despite the current expanse of IGTI’s activities, Turbo Expo remains the focal point. I am particularly happy about the great interest in this year’s conference in San Antonio, which will most likely prove to be the largest and most successful Turbo Expo ever held in North America.

STUDENT NEWS

Participate in the Newly Formed ASME-IGTI Student Committee

ASME IGTI is pleased to report that the Student Advisory Committee is currently finalizing their committee by-laws and plans for Turbo Expo 2013. Georg Baumgartner (Technical University-Munich), Reid Berdanier (Purdue), Emily Boyd (University of Texas-Austin), and Amy Mensch (Penn State) have accepted the task of launching the ASME-IGTI Student Advisory Committee, which will be presented in the inaugural meeting.

If you are a student attending the 2013 Turbo Expo in San Antonio, please stay tuned for the date and location of the first ASME-IGTI Student Committee meeting and please consider becoming a member of this dynamic group!

Don’t Miss the Special Networking Event for Young Engineers at Turbo Expo 2013!

The ASME International Gas Turbine Institute (IGTI) provides invaluable professional development benefits for early career engineers and students! While attending Turbo Expo 2013 in San Antonio, young engineers won’t want to miss this special networking event on Wed., June 5, for rising engineers. This event will give young engineers the opportunity to meet a variety of representatives from the turbomachinery industry as well as members of IGTI’s technical committees. Visit www.turbo.expo.org today for more details and to register. Students qualify for discounted registration.
AS THE TURBINE TURNS...

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

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

Gears Galore!

Recently, I wrote an article[1] on Pratt & Whitney’s new geared turbofan (GTF) engine, now scheduled for airline operation as early as 2014-2016.

Currently, P&W’s first generation GTF engines use a gear reduction of 3:1, with a resulting bypass ratio of 12:1. This yields a fuel consumption as much as 16% lower than with current conventional fan engines. Noise reduction is substantial, with the characteristic turbofan whine being replaced by a lower frequency “whoosh”. The thrust range on P&W’s first generation GTF engines is 18,000-30,000 pounds of thrust (lbt), a range that powers twin-engine single-aisle, narrow body 70-200 passenger aircraft – and the most lucrative market for engine companies.

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FIGURE 1
Photo: Honeywell

After reading my GTF article, Fred Borns of Phoenix-based Honeywell, emailed to remind me that his company had been developing and producing geared turbofan engines for several decades. Their TFE731 geared fan engine program actually started in 1968 and grew in 1995 with the addition of the AVCO Lycoming ALF502/507 GTF series. Honeywell has produced well over 15,000 geared fan engines for business, airline and military jets, all in the 3,500-7,000 lbt range. Let us review some gas turbine and Honeywell history to gain more prospective on the status of geared fan engines.

The addition of a fan to a jet engine, first proposed by Frank Whittle, one of the inventors of the jet engine, increases thrust and reduces fuel consumption. In a 1940 patent[2] he envisioned the fan to be a set of impeller blades, turbine mounted and aft on the engine. In the late 1950s, Rolls-Royce with the Conway engine and Pratt & Whitney Aircraft with the JT3D developed their first turbofan engines, by adding a fan at the front end of an existing turbojet engine. At the same time, General Electric, initially following Whittle’s 1940 patent, had an aft fan mounted on the turbine of their CF700. GE switched to front mounted fans on subsequent engines.

Now common in the jet engine industry, Pratt & Whitney and Rolls-Royce were the first to develop a dual spool engine for more efficient operation over a range of flight conditions. Concentric dual rotational shafts provide the means to have a high pressure (HP) spool and a low pressure spool (LP). (Some Rolls-Royce models have a third intermediate pressure spool.)

On a turbofan engine, the LP spool shaft transmits power from the LP turbine to the LP compressor and the front mounted fan, at a compromise rpm, determined by the conflicting needs of the fan and the LP compressor/turbine. The fan operates most efficiently at lower rpms (lower noise levels and lower fan tip speeds at its greater diameter satisfy stress and supersonic flow limitations) while the LP compressor/turbine is more efficient at higher rotational speeds. Thus, by putting a concentric reduction gear box between the fan and the rest of the LP spool, it makes it possible for both components to run more efficiently, closer to their optimal operating speeds.

Work started on the geared fan TFE731 at the Garrett AirResearch Phoenix Division in 1968[3], some 45 years ago. Unlike many commercial engines that emerged from antecedent military designs, the TFE731 was derived from Garrett’s auxiliary power unit (APU) programs. The LP compressor design...
The Big Bang – Bird Strike Certification Testing

Background Information

FAA certification of new commercial transport engines requires demonstration testing of bird ingestion tolerance at takeoff power under FAR §33.76. There are multiple requirements that include:

- One Large Bird (e.g. Canada goose) weighing from 4 to 8 lbs depending on engine size.
  - Engine must not catch fire and be able to be safely shut down after 15 seconds with no throttle movement.
- Multiple Medium Flocking Birds (e.g. gulls) weighing 1.5 to 2.5 lbs.
  - Engine must continue to deliver at least 75% of normal takeoff thrust for 2 minutes with no throttle movement followed by a ~20 minute run-on period at various power levels consistent with aircraft return to airport and landing.
- One Large Flocking Bird (e.g. snow goose) weighing 4 to 5.5 lbs.
  - Engine must continue to deliver at least 50% of normal takeoff thrust for 1 minute followed by a ~20 minute run-on period.

The single large bird test targets the most critical area of the fan blade. The single large flocking bird is targeted at 50% fan blade span. The multiple medium flocking birds are targeted at critical areas of the fan plus at least one bird must enter the engine core. This article focuses on the multiple medium flocking bird test.

The Big Bang

I will begin this article by relating my practice as an engineer at Pratt & Whitney for “witnessing” the medium (flocking) bird ingestion certification test for a new engine. Rather than joining the crowd of test and project engineers and FAA officials in the control room, I would always stand in the parking area just outside of the inlet to the test stand. At this location, one could hear the engine roar into life and accelerate to full takeoff power, and then after a few minutes, the “big bang” characteristic of the engine surge associated with birds being ingested into the engine core. This event is clearly illustrated in the first figure and the bang is the shock wave associated with engine flow reversal as evidenced by flame out the inlet. The “big bang” would be followed immediately by one of two possibilities. The one everyone hoped for was a change in the engine’s noise characteristic and amplitude signifying the damage to fan blades and importantly a rapid surge recovery. The other possibility was the quieter sound of a rapid engine deceleration and shut down, indicative of a test failure. As mentioned earlier, failure here means the engine is unable to deliver at least 75% of normal thrust for the 2 minutes without throttle movement followed by the ~20 minute run-on period after the ingestion event. Meeting these requirements demonstrates the ability of the engine to complete the takeoff without pilot action after which the pilot can make a go around to land the aircraft.

Now what caught my interest early on was the fact that in most cases when an engine “failed” the test, it could be restarted and run successfully for longer than the post-ingestion requirement with more than the necessary thrust. Subsequent engine teardown and inspection typically showed no significant core damage and tolerable fan blade damage. To unravel this mystery, let’s review the sequence of events leading up to the test and the milliseconds immediately after the “big bang”.

Engine Test Set Up

For this test, the engine is configured only with production level instrumentation necessary for the engine control – rotor speeds, fuel flow, burner pressure, exhaust gas temperature, etc. The special test equipment consists of the cannons that fire the euthanized birds and the high speed cameras and special lighting. As can be seen in the following figure, the fan blades are painted white and numbered to allow the confirmation that the “flock” of birds are spread across the fan and meet the pre-agreed targets in terms of blade span. These targets are selected to assure that all critical areas of the fan blade are hit by at least one bird and that one or more birds enter the engine core.

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Don’t Miss These Turbo Expo Events:

Career Development Workshops

Taking place just before the conference begins, our Turbo Expo workshops provide focused, fundamental training. Choose from seven courses to be held Saturday and Sunday, June 1-2, 2013.

Annual Women's Dinner

Women working in the turbomachinery industry who register for Turbo Expo are eligible to attend our women’s networking reception and dinner. The dinner will be held during Turbo Expo on Tuesday evening, June 4, 2013. This year the dinner will feature speakers Jeanne Rosario, Vice President of Aviation Engineering, GE Aviation, and Taryn Riley from Siemens.

ROSARIO has 15 years experience in engine design and 10 years in systems leadership, contributing to both commercial, military and marine and industrial product lines. She currently directs the research, design, certification and in-service support of all engine programs for commercial, military and industrial customers.

RILEY is currently an Engineering Manager for Siemens Energy in the Gas Turbine Technology Department. She has worked for Siemens since June 2000, beginning in the engineering development program where she rotated through various functions of gas turbine engineering. Five of those years were spent as a service engineer traveling the world gaining hands-on experience.

Special Networking Event for Young Engineers

While attending Turbo Expo 2013, young engineers won’t want to miss a special networking event on Wed., June 5, for rising engineers. This special networking event will give young engineers the opportunity to meet a variety of representatives from the turbomachinery industry as well as members of IGTI’s technical committees. Come and meet potential mentors and seek advice from industry experts during Turbo Expo in San Antonio! Visit www.turboexpo.org today for more details and to register. Students qualify for discounted registration. Be sure to attend the mixer for a chance to win an iPad mini!

Organic Rankine Cycle Committee

ASME International Gas Turbine Institute is pleased to announce the Organic Rankine Cycle (ORC) committee. We look forward to working with this new, dynamic committee in the future.
The Big Bang...continued from page 52

After the Big Bang

An engine surge typically requires only about 150 milliseconds for the flow to reverse, the burner to depressurize and then re-establish flow and burner pressure. However, during a bird strike the bird becomes “fluidized” and takes a similar time to traverse the engine compression system length and arrive at the combustor. Here the fluid becomes gasified, necessarily expands due to greatly reduced density and back pressures the compressor. This may delay the surge recovery and can even precipitate a second surge event. Now during the short time span of the surge, the engine rotor speeds fall sharply due to loss of pressure required to drive the turbines. The main core compressor rotates independently of the fan and booster compressor and decelerates more quickly due to its lower moment of inertia. In addition to the high moment of inertia of the fan, any damage to the fan reduces its ability to pump air. This reduced air pumping load further reduces the rate of deceleration of the fan/booster. I was able to use the high speed camera records and numbered fan blades to verify that more fan damage resulted in reduced fan deceleration during a bird strike induced surge.

The dynamics of the fan/booster decelerating more slowly than the core compressor created a situation in which the flow capacity of the core compressor drops below the level necessary for stable operation of the booster compressor. In recognition of these dynamics, engines are designed with a surge recovery bleed between the booster and core compressor to compensate for this flow mismatch. The surge recovery bleed timing is rapid enough to stabilize the engine within one or two surges. All of this takes place so rapidly that human senses only detect what seems like a single “big bang”.

Now all should be well once the surge bleed opens and restores stable operation and subsequently closes as dictated by the engine control surge recovery logic. Why then does the engine fail to operate in some bird strike tests? The key differential is the amount of damage to the fan blades and resultant loss of flow pumping load. With similar power from the turbine driving the fan/booster, this leads to higher than normal fan/booster rotor speed relative to the core compressor. If this mismatch of rotor speeds is great enough, the booster cannot operate stably and repetitive surging becomes inevitable when the normal closure of the surge recovery bleed takes place.

The key to resolving this dilemma is to have the engine control recognize that additional surges after normal closure of the surge recovery bleed is indicative of damage to the fan and loss of flow pumping. Once the control recognizes this sequence, it can limit the surge recovery bleed to only a partial closure. Doing so allows the engine to remain stable and deliver the necessary thrust to enable the pilot to safely land the aircraft. I can happily report that once this feature became a standard control element in Pratt & Whitney engines, the uncertainty of the “big bang” aftermath became a part of past history. Were someone to stand near the test stand inlet today, he or she would hear the intended sequence of “big bang” followed by extended engine operation until its intentional controlled shutdown at the conclusion of the test.

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was based on their APU for the Boeing 747 and two spool shaft dynamics from their APU for the Douglas DC-10. Given the high rotational speed of APU LP spool (about 20,000 rpm), to avoid fan tip excessive speeds, Garrett engineers developed a concentric epicyclic gear box to drive the fan. This was based on the company’s experience with turboprop gear trains. (A hand cranked pencil sharpener uses epicyclic gearing.)

The TFE731 gear box resulted in a gear reduction of 1.8:1, to power the fan for a 2.5 bypass ratio, which was very high for the 1960s. A modern TFE731 fan gear box, shown in Fig. 1, is about 8.5 inches in diameter and transmits on the order of 3,000 hp to the 29 inch diameter fan. By way of comparison, a Pratt & Whitney GTF hub-mounted epicyclic gear box is shown in Fig. 2. It is about 18 inches in diameter and transmits as much as 30,000 hp.

The TFE731 was certified in 1972 and has since become one on the most successful small gas turbine aircraft engines, with over 11,000 produced. It is one of the most widely used engines in its class, powering such aircraft as Jetstars, Learjets, Dassault Falcons, Cessna Citations, Gulfstreams and many military trainers. Honeywell also has another geared turbofan engine, the ALF502. It was developed by AVCO Lycoming in Stratford, Connecticut (followed by the ALF507), and has a 6,000-7,000 lb thrust range. It entered commercial service in 1980 and, along with other aircraft, powers the British Aerospace BAE 146-100 four engine regional transport aircraft.

Honeywell’s successful 45-year record of producing geared fan small gas turbines gives promise of a bright future for geared fans on large commercial jet engines, providing lower fuel consumption and less noise.

References
A SUPPLEMENT TO MECHANICAL ENGINEERING MAGAZINE

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SEPTEMBER 30 - OCTOBER 3, 2013
ASME Turbine Blade Tip Symposium & Course Week
Hamburg, Germany

This technical symposium and course week will address the current state of the art in the design, analysis, and improvement of turbine blade tips. A two-day course of lectures will precede the technical symposium to provide background, state-of-the-art design, and operability issues surrounding the topic. A two-day symposium will build upon the lecture series with current proposed or enacted solutions, studies to gain insight into the physics, and an industry panel session for open discussion. The course and symposium are aimed at turbomachinery designers, as well as experimental and CFD aero-thermal scientists.

OCTOBER 7-8, 2013
ASME ORC 2013
De Doelen, Rotterdam, The Netherlands

The International Seminar on ORC Power Systems provides an exciting opportunity to learn and discuss about the latest advances in ORC research & development, application/demonstration and a variety of issues related to ORC energy systems. The seminar features presentations by scientific groups, leading ORC companies and expert users at the forefront of ORC research and development. Themes include system optimization, applications, simulation and design tools, operational experience, prototypes, components, and working fluids.

DECEMBER 4-6, 2013
ASME 2013 Gas Turbine India Conference
Bangalore, India

Presented by the ASME International Gas Turbine Institute and National Aerospace Limited (India).

PROFESSIONAL DEVELOPMENT

IGTI Awards & Scholarships

2013 IGTI Student Scholarship

The deadline to submit an application is May 15, 2013

IGTI will provide up to 20 $2000 (US) scholarships per year to qualifying students registered at an accredited university (U.S. or international). For application and requirements, please visit the following web page: http://igti.asme.org/Honors/.

2013 Dilip Ballal Early Career Award

Nominations for the 2014 award are due to igtiawards@asme.org by July 1, 2013.

Early Career Awards are intended to honor individuals who have outstanding accomplishments during the beginning of their careers. Visit http://igti.asme.org/ for more detailed information. The first recipient of the Dilip Ballal Early Career Award will be presented with the award at Turbo Expo 2013.

If you have a topic you think will be of value to the turbine industry and would like to present it in a webinar format or a “face-to-face” format, please contact the IGTI professional development department at: bartons@asme.org

IGTI Gas Turbine Training Week

Georgia Tech Global Learning Center

Earn Professional Development Hours (PDH’s) and receive certificates of completion!

The International Gas Turbine Institute will hold a specialized training week this spring at the prestigious Georgia Institute of Technology. From April 29 – May 3, 2013, attendees will have the opportunity to advance their knowledge and gain professional development hours on the focused topics of Gas Turbine Design, Operation and Maintenance; Gas Turbine Combustion: Emissions and Operability; and Centrifugal Compressor Design, Operation and Maintenance. The topics will be divided into three courses and will be instructed by Thomas Van Hardeveld and Georgia Tech’s own Tim Lieuwen.

April 29 – 30, 2013: Gas Turbine Design, Operation and Maintenance

This course contains a thorough description of the technology of gas turbines and their design, operation and maintenance. A wide range of gas turbine types in use today is covered from various types of industrial units to aeroderivative versions. New technologies such as low NOx, performance monitoring and condition monitoring techniques are explained.

May 1, 2013: Gas Turbine Combustion: Emissions and Operability

This one day course introduces students to gas turbine combustion emissions, operability issues and combustion dynamics.

May 2 – 3, 2013: Centrifugal Compressor Design, Operation and Maintenance

Participants of this course will receive a thorough description of the technology of centrifugal compressors and their design, operation and maintenance. Participants will also receive a fundamental understanding of all of the basic components of centrifugal compressors and the important role of critical auxiliary systems such as sealing, control and monitoring, antisurge, and lubrication.
The present multidisciplinary ASME 2013 Turbine Blade Tip Technical Symposium and Course Week addresses the current state of the art in the design, analysis, and improvement of turbine blade tips. Despite decades of applied research, the issue of blade tip burnout has remained as one of the most intractable in gas turbines. Yet the degradation of blade tips continues to represent a large fraction of the turbine losses, both in terms of the operational aero-thermal efficiency and the engine life cycle maintainability. A two-day course of lectures will precede the technical symposium to provide background, state-of-the-art design, and operability issues surrounding the topic. A two-day symposium will build upon the lecture series with current proposed or enacted solutions, studies to gain insight into the physics, and an industry panel session for open discussion. Interested attendees can register for the course only, symposium only, or for both parts of the event at http://asmeconferences.org/TBTS2013/.

Topics of Course Lectures and Symposium:

Track 1 – Turbine blade tip steady and unsteady aerodynamics
Track 2 – Turbine blade tip heat transfer, internal, external, and film cooling
Track 3 – Unshrouded and shrouded blade tip design
Track 4 – Clearance effects and clearance control
Track 5 – Blade tip or shroud surface treatments and abradable coatings

Track 6 – Operational steady and transient effects
Track 7 – Service and repair requirements and issues
Track 8 – Turbine stage losses and downstream effects
Track 9 – New or modified designs and innovations
Track 10 – Propulsion and power generation gas turbines
Track 11 – Axial and radial turbines
Track 12 – Experimental and numerical

Who Should Attend:
The course and symposium is aimed at Turbomachinery designers, as well as experimental and CFD aero-thermal scientists. *