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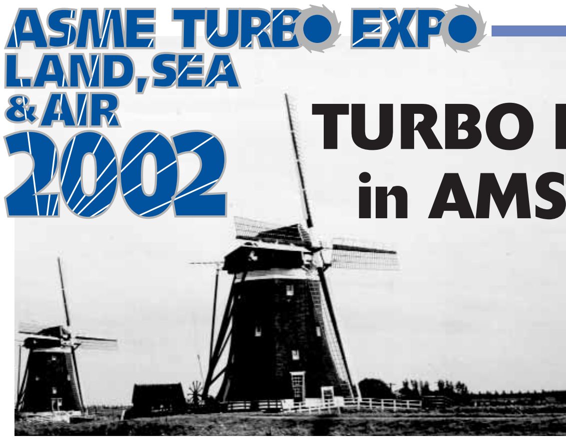

TURBO EXPO '02 in AMSTERDAM 3-6 June

Start Your Planning Now!

IN THIS ISSUE...

FEATURED THIS YEAR

at the 47th ASME TURBO EXPO – Land, Sea & Air:

- Leading edge technology.
- Key industry issues relevant to your profession.
- Exceptional Keynote Speakers.
- Hosted Welcome Reception at the Rijksmuseum.
- CD-ROM with all 500+ published papers included in registration.
- Special pre-conference workshop for users.
- Full Gas Turbine Users Symposium program dedicated to Operations & Maintenance, Repair Technology, and Engineering & Business.
- Large networking session by and for users.
- Highly informative facility tours.

This year TURBO EXPO, the world's premier educational program for engineers, managers and users of gas turbine technology in all its applications, will again feature its world renowned Technical Congress, a practical Gas Turbine Users Symposium, and a great international Exposition of gas turbine engines, peripheral equipment and industry services. Special articles on pages 12-15 will provide additional details. ✲

TOP KEYNOTERS to SPEAK at TE'02

The Monday morning Keynote Session at TURBO EXPO is open to all TE'02 registrants, regardless of their registration category. This gives all industry visitors and participants at TE'02 an opportunity to hear from industry world leaders. The theme of this year's Keynote is "Gas Turbines for a Better Tomorrow." The distinguished Keynote Speakers are:

Peter F. Hartman, Managing Director & Chief Operations Officer of KLM

Ludo M. J. van Halderen, Chief Executive Officer of NUON, the leading Dutch energy and water company

Nick Salmon, Executive Vice President of ALSTOM

Special welcoming comments will be given by an official government representatve from The Netherlands and by ASME President William A. Weiblen. ✲

Dave Wisler
Chair
IGTI Board of Directors

Openness and Balance

IGTI membership is very broad-based, with constituents from universities, industry, research labs, government, small companies and individual contributors. Many issues are important to this constituency including the quality of the technical papers, cost of the TURBO EXPO conference, location of the conference, quality and relevance of the exhibition, educational opportunities, and the quality of opportunities to interact with associates, vendors, customers and suppliers. The complexity is that the committees, and sometimes individuals within committees, have their own interests and concerns relative to these issues which they promote in major or minor ways. The difficulty for your Board is to keep well informed about committees' and members' interests so that appropriate decisions can be made.

To that end, your Board of Directors has undertaken three new initiatives: (1) publicizing open Board meetings, (2) achieving balance in Board membership, and (3) restructuring the Leadership Workshop. These are described below.

1 Open Board Meetings:

It comes as a surprise to most IGTI members that their Board of Directors' meetings are open to the public, except for relatively short executive sessions. I, too, was surprised when I first learned this.

As Board Chair, I have taken steps to broadcast and capitalize on this "openness." For our August meeting, I invited a dozen "thought leaders" not only to attend but also to participate in the meeting. Admittedly, there was some skepticism, accompanied by concerns that this would be disruptive and unproductive. It turned out quite the opposite. In reality it was immensely productive. We addressed many important issues, such as: strategies for TURBO EXPO, pros and cons of potential alliances and joint ventures, opportunities for new initiatives including a second event, and a discussion of awards, honors, scholarships and other programs. The thought leaders summarized the current thinking of their committees; challenged the Board to address Board-Committee communication, conference business strategies and increasing aircraft engine user participation at TURBO EXPO; and offered feedback to the proposed session organization for Amsterdam. Item #3 of this report, "Restructuring the Leadership Workshop," is a direct result of this dialogue. We will be continuing this policy of meeting openness for the foreseeable future.

If you would like to attend a Board Meeting, please feel free to contact the IGTI office for a meeting schedule and tell the office if you plan to attend.

2 Balance in Board Membership:

Your Board has formally adopted measures to ensure a balance in its membership that is consistent with IGTI makeup. There are two main constituencies of IGTI for which parity is important; namely, the base committees and the applications committees. They each have different goals and agendas. The base committees, or advanced technology committees, are responsible for creating forums that bring together the world's best researchers and engineers to exchange ideas and findings on the leading edge of technology. Historically they have been driven by the aero engine industry with committee participation coming from a broadly based constituency of industry, university and government personnel. Examples of base committees include Turbomachinery, Structures and Dynamics, Heat Transfer, and Combustion & Fuels, to name a few.

The applications committees and the GTUS Advisory Group are responsible for creating forums that deal with the very complex and often frustrating issues of keeping the gas turbine machines running to create power in its multiplicity of forms. They are generally driven by operational and field problems, maintenance and repair issues, training of personnel and government regulations. Examples of the applications committees include Aircraft Engine, Electric Power, Industrial & Cogeneration, Marine, and Oil & Gas Applications.

For the health of IGTI, parity on the Board must exist between the base and applications committees so that both can flourish. In addition, the "agenda field" of each Board member must be sensitive to the needs of both types of committees.

3 Restructuring the Leadership Workshop:

Just prior to opening of each TURBO EXPO and Congress, there is a Leadership Workshop held on Sunday afternoon. Traditionally, this workshop is organized and run by the first-year Board member, with the participation of the other Board members. All Committee Chairs and Vice-Chairs are invited to attend. Although provocative topics have been discussed at this workshop, the thought leaders (see Item #1) gave strong input to the Board that the communication that takes place appears to the committees as "tablets coming down from the mountain." The thought leaders suggested that the Board reorganize the workshop so that the Committee Chairs would run the meeting, with input going to the Board regarding Committee concerns.

This will be done in Amsterdam; but it means that the Committee Chairs must be pro-active in organizing and leading the Workshop, under the guidance of the incoming Board member.

The Board looks forward to trying this new approach and expects much valuable input from the Committees. Of course, the Board will still provide important input to the Committees at the Workshop.

We hope that the three initiatives described above will result in much improved communication between the Board of Directors and the members it serves. ✰

Boeing is preparing to test fuel cells and electric motors for auxiliary power instead of gas turbines. ``Fuel cells show the promise of one day providing efficient, essentially pollution-free electrical power,'' said Dave Daggett, a researcher in Boeing's environmental performance strategy group. ``Our ultimate goal is to replace the auxiliary power unit,'' Daggett said. ``But first, we're going to learn more about fuel cells by powering a small airplane and, as the technology matures, use fuel cells to power an aircraft electrical system.''

Rolls-Royce (RR) released details of its new Marine Trent 30 gas turbine. The gas turbine is to be available for service in either mechanical or electrical genset. The total package, including enclosure and auxiliaries, weighs less than 57,320 pounds (26,000 kg), giving it a market-leading power-to-weight ratio in its class. Available for delivery from late 2003, the Trent 30 has 80-percent commonality with the Trent 800 aeroengine.

General Electric's big new GE90-115 turbofan has reached 120,316 pounds of thrust - the highest ever produced by a thrust gas turbine. The record-setting thrust level was established on November 19 during tests of a GE90-115B development engine at GE Aircraft Engines' outdoor test complex near Peebles, Ohio. The engine reached 120,316 pounds of thrust and then ran at a steady state of 117,446 pounds of thrust.

Pratt & Whitney Canada has enjoyed a successful first run of a complete PW625F turbofan demonstrator, which it regards as the first step in marketing jet engines for the general aviation and super light business aircraft markets. The engine's core is to be scalable down into the 1,000 pound thrust range.

Honeywell/General Electric have reduced the weight of their LV100-5 vehicular gas turbine to the point that it is now 45.5 kilograms (100 pounds) under design weight. In addition, the engine is more fuel efficient than it was a year ago. Honeywell/General Electric are continuing to work on further weight reductions and increased fuel efficiency to power the US Army's Crusader next-generation self-propelled artillery system.

On a related note, the **Army** presently plans to retrofit the LV100 to about 200 M1A2 System Enhancement Package tanks and M1A1 Abrams Integrated Management tanks per year at the Lima Tank Plant beginning in 2004. Another 200 tanks per year will be retrofitted in the field. The Army presently plans to upgrade only 2,845 of its 8,000 tanks over an eight year period, replacing the rest with a next-generation tank.

France's **Snecma** and Russian engine maker **NPO Saturn** are teaming to develop a 12,000-15,000-lb.-thrust-class turbofan for the regional and large business jet market. Designated the SM146, the engine is intended for the markets which are expected to be the most active parts of the air transport business over the next 20 years.

UQM Technologies has received a $100,000 first phase contract from the U.S. Department of Energy to develop a power inverter for distributed power under the Small Business Innovation Research Program. Power electronic inverters are used to convert direct current (DC) output of power generation equipment such as reciprocating engine generators, wind turbines, solar panels, microturbines and fuel cells to 110/220 volt alternating current (AC). The development furthers the move toward the distribution of power generation sources throughout a grid and beyond, fundamentally changing the entire market for providing power.

Catalytica Energy Systems Incorporated and **Solar Turbines Incorporated** have announced the start of a new developmental program that could result in combining Catalytica Energy Systems' Xonon™ Cool Combustion technology with a 5-MW Solar Turbines Taurus™ 60 gas turbine, as part of a $3.0 million grant recently awarded to Solar Turbines by the California Energy Commission (CEC). Xonon is a catalyst-based pollution-prevention system for reducing emissions of oxides of hydrogen.

United Technologies has reorganized its industrial gas turbine businesses under a single organization, **Pratt & Whitney Power Systems (PWPS)**. With this new structure, PWPS can deliver and support the industrial gas turbines built at Pratt & Whitney Canada (250 kW to 4 MW) as well as the FT8 product line (25 - 60 MW) provided by the former Turbo Power and Marine organization.

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*

GAS TURBINE and COMBINED CYCLE DATA COLLECTION and USE

by Bob Richwine, Power Generation Management Consultant
Bjorn Kaupang, Consultant
Sal DellaVilla, Strategic Power Systems, Inc.

INTRODUCTION ...

One of the key conclusions of the recent 18th World Energy Congress held in October, 2001 in Buenos Aires, Argentina was:

"If the substantial gap between worldwide average performance and the top performing plants could be eliminated through the application of best practices, this would result in an estimated savings of up to U.S. $80 billion per annum in building and operating capacity and a reduction in CO_2 emissions of one Gt (billion tonnes) per annum as well as a reduction in other pollutants."

To help in reducing this gap the World Energy Council's (WEC's) Performance of Generating Plant (PGP) Committee has been collecting, summarizing and communicating Performance Data of worldwide fossil steam and nuclear power plants for the past three decades. In addition, the PGP Committee has been conducting workshops and conferences that focus on identifying and sharing industry best practices, especially in the use of historical data to improve future plant performance.

In the late 1980's the Committee recognized that simple cycle Gas Turbines (GT) and gas turbine powered Combined Cycle (CC) power plants were likely to become the technology of choice for new power generation. Therefore, it was decided to begin collecting Performance Data on GT's and CC's in addition to that for fossil steam and nuclear plants. The PGP is currently setting up processes to collect Performance Data on hydroelectric plants plus newer technology "renewables" including wind, photovoltaic, biomass, and geothermal.

GT & CC PERFORMANCE RESULTS TO DATE

Beginning with GT and CC plants from six Pacific Rim countries: Indonesia, Japan, Malaysia, Taiwan, Thailand and Korea, the PGP Committee collected Availability Data and published the results for the years 1991-1993 at the WEC's 16th Congress in Tokyo, Japan in 1995. During the next six years countries and plants were added so that the 2001 report included 691 unit-years of GT data and 1216 unit-years of CC data from 17 countries.

In addition to the original six, the other countries contributing to the database now include Argentina, Egypt, Finland, Hong Kong, Kenya, Mexico, New Zealand, Pakistan, Slovenia, Syria, USA and Venezuela. (Note that only units whose utilization factor was greater than 40% when the unit was available were recommended to be included in the database).

The following Tables give some of the results from the 2001 publication. The complete report can be ordered from the WEC web site at www.worldenergy.org. It will also be available for downloading from the WEC site in March 2002.

The data collection effort for base load gas turbine and combined cycle plants is still under development. For countries with time-based availability data collection systems, unavailability data due to partial outages was requested in addition to the data items shown. The size classes are based on ISO ambient conditions (sea level, 60% relative humidity and a temperature of 15 degrees C). Planned Unavailability (PUF) consists of planned partial and full outages scheduled well in advance. Unscheduled Unavailability (UUF) consists of all unplanned partial and full outages requiring shutdown and repair.

Table 1

Availability Statistics for Gas Turbine Plant
Cumulative for All Years Collected 1991-1999

Size Class MW	Unit Years	Average MW/unit	Availability Percent	Unavailability (%) PUF[1]	UUF[2]	Total
30-75	475	45	80.65	11.54	7.81	19.35
76-150	216	107	86.13	7.08	6.79	13.87
All Sizes	691	64	83.50	9.22	7.28	16.50

1. Planned Unavailability
2. Unscheduled Unavailability

A more detailed analysis (not shown) of the data in Table 1 indicates the rolling three year availability factors for the 30-75 MW group of gas turbines show a definite decline in the three year time periods since the 1991-1993 period, while the 75-150 MW class shows an improving performance over time.

Table 2

Availability Statistics for Combined Cycle Plant
Cumulative for All Years Collected 1991-1999

Size Class MW	Unit Years	Average MW/unit	Availability Percent	Unavailability (%)		
				PUF[1]	UUF[2]	Total
101-200	682	138	84.48	13.55	1.97	15.52
201-300	346	241	84.86	10.99	4.16	15.14
300 & Up	278	404	85.37	8.73	5.90	14.63
All Sizes	1306	222	84.93	10.94	4.13	15.07

1. Planned Unavailability
2. Unscheduled Unavailability

A look at the rolling three year availability factors for the combined cycle group (not shown) indicates an improvement and then a falling off of performance in all power classes. As more plants and more countries are added to the database, the causes of this apparent deterioration may be more fully explored.

VALUE OF DATA COLLECTION: RISK VERSES REWARD

Power plant owners increasingly ask "Why should I collect and share my plant's Performance Data when that could potentially hurt my competitive position?" These owners can see very clearly the costs they are incurring to collect accurate data and perhaps believe that sharing that data carries risk (they may not be sure, but why take that chance?). The PGP Committee is aggressively trying to answer their concerns by publishing compelling examples of instances where the value has been clearly demonstrated to be much higher than the cost plus risk. Examples will include case studies from a broad range of industry applications including:

- Equipment Design (incorporating operating data into next generation design).
- Configuration Optimization (trade-off between initial cost and performance value).
- Generation Planning (optimizing reserve margins, etc.).
- Project Development and Financing (helping to prove that the plant will make money).
- Operations (where to focus training, etc. to improve the plant's profits).
- Fuel Quality (is there justification for burning a higher cost, higher quality fuel).
- Maintenance (should I invest in an advanced condition monitoring system).
- Trading and Marketing (what confidence do I have that my plant will be available).
- Risk Management (what hedging options will be cost-effective).
- Life Management (how much am I reducing the economic life of my plant by cycling).
- High Impact-Low Probability (HILP) Event Reduction (reducing catastrophic events).
- Benchmarking and Goal Optimization (how to set optimum economic performance goals).

As a specific example in the area of Generation Planning, a large utility in the U.S. sets their reserve margin based on the point where the marginal cost of additional customer service reliability would equal the marginal value to the customer resulting from a reduction of his Expected Unserved Energy (EUE). Since 90+ percent of the EUE happens during the peak season, the reliability of their generating units during this season was a major contributing factor in determining the optimal reserve margin and the utility's generation plan. In the past the Generating Planning organization had been using an annual average for their unit's reliability. However, studies proved conclusively that the reliability was substantially higher during this peak season, especially for their GT's and other cycling/peaking units. By comparison, base loaded nuclear units' reliabilities were virtually unchanged between the peak and non-peak seasons.

After the Generation Planning Department modified their programs to incorporate seasonal plant reliabilities, the result was a reduction of one full percentage point in the optimal reserve margin. For this large utility, the resulting savings was in the 10's of millions of dollars, while maintaining the optimal economic customer service reliability. In this case no one actually did anything differently or spent any more money (except to do the initial study). But by analyzing the reliability data, they were able to save substantial amounts of money by incorporating into their planning models the higher reliability they were actually achieving during the peak season.

It came as no surprise to the production personnel that the plants were achieving the higher reliabilities, because there were incentives in their goals system to do so. However, no one realized the impact it would have on generation planning and overall savings.

This example is just one that you will soon be able to find on the WEC's website *www.worldenergy.com* at the PGP homepage as part of the PGP Committee's "Study of the Month." The "Study of the Month" will present actual case studies that demonstrate how the value of data collection, analysis and sharing is much greater than the cost.

...continued on page 6

FUTURE APPROACH FOR GT AND CC DATA COLLECTION

The WEC will continue to collect, compile and publish Performance Data for GT's and CC's as well as for fossil steam, nuclear, hydroelectric and renewables. The value is great and will become even greater following the significant structural and technological changes that are taking place in the power generation industry worldwide. Deregulation, global market strategies, and increasing competitive forces are creating significant structural change. Challenging goals for greater output and record efficiency (approaching 60%) with optimized environmental friendliness (NO_x levels at less than 10 ppm on natural gas, and CO_2 sequestration) have motivated technological change and product advancement.

The dynamics of change, however, have created an atmosphere of uncertainty in the market. The uncertainty of meeting demand is exacerbated by the need to have a sustained operating and maintenance process that allows life cycle cost expectations to be met. And while this uncertainty exists, consumer expectations and national interests remain constant ... each demanding a stable, reliable, clean, and affordable supply of electricity. The challenge is to improve the performance of existing generating plants and to build enough new reliable generation and transmission capacity, moving both electricity and the gas supply, to meet growth in demand. Worldwide, 668 Gigawatts of new power generation capacity is planned through the year 2005 with the majority coming from gas turbines in either simple or combined cycle configurations.

Although the level of detail in the current WEC GT and CC data collection process is adequate for general trends to be followed, the PGP Committee believes that it must be enhanced in order for existing and future plants to take full advantage of historical Performance Data. Therefore, the PGP has begun a new initiative to develop an improved data collection program for GT's and CC's, one that will build on the present program but will address future needs. IGTI's Sal DellaVilla is serving as chair of the PGP subcommittee charged with planning for this data collection. The Global Gas Turbine News will keep you informed of further developments. ✫

If you have questions of the authors, or wish to provide feedback, you may contact them by email at:
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and Sal DellaVilla … sal.dellavilla@spsinc.com.

South American Seminar Series a Success at WEC

IGTI's Seminar Series at the October 21-25, 2001 World Energy Congress drew participation from New Delhi to Houston to Yokohama. Topics included "Gas Turbine Project Development Economics," "Overview of Gas Turbine Maintenance and Repair Technology," "Performance of Mature 'F' and Advanced Technologies 2000 Gas Turbines," and "Benefits of Gas Turbine Power Plants."

Speakers included Victor Der, U.S. Dept. of Energy; Ron Natole, Natole Turbine Enterprises; and Septimus van der Linden, ALSTOM Power, Inc. Frederik Bok, Axel von Rappard and Salvatore DellaVilla contributed presentation materials. Sessions averaged 25 persons each. ✫

Sponsors for the series were:
Duke Energy, Bechtel Corp., and ALSTOM Power.

Sep van der Linden (top rt.), IGTI Chair of South American Conferences, welcomes guest speaker Victor Der to the IGTI Seminar Series held in conjunction with the World Energy Congress in Buenos Aires, Argentina. Mr. Der spoke to representatives from around the globe on the latest developments in effective use of gas turbine power plants.

ISO's ... continued from page 7

The results for 1999 and 2000 are summarized in Table 1[2]. These show that for 2000 the availability for aeroderivitive gas turbine power plants was 88%, simple cycle gas turbines 83%, combined cycle 78%, compared to a system average of 81%. The comparatively low availability value of 63% for 2000 for new combined cycle plants was based on seven new gas turbine-steam turbine units which entered service in 1999 - 2000.

Table 1

Weighted Equivalent Availability Factors (%) by Unit Type, all New England Units

	1999	2000
SYSTEM AVERAGE	**80%**	**81%**
Fossil Steam	79	78
Nuclear Total	82	89
Millstone Point	80	92
Nuclear w/o Millstone	84	87
Jet (aero derivative) Engine	70	88
Combustion Turbine	90	83
Combined Cycle Total	77	78
Pre-1999 combined cycle	91	89
New (installed 1999-2000) combined cycle	32	63
Hydro	81	81
Pumped Storage	90	86
Diesel	76	88
Other	79	91

The low availability of these new gas turbine units is a subject of concern. One could speculate that such unpredictable performance, if not improved, could lead to consideration of gas turbine certification, similar to that used now for aviation gas turbines. The ISO charter of "keeping the lights on" is a matter of public safety, given the extreme importance of electricity to modern everyday life.

Thus the administrative role of ISO's is an important one. As one wholesale electricity supplier put it, ISO's are "in the catbird's seat." Based on bids submitted and electrical power demand, the ISO administered wholesale market determines which generators will run. ISO's have the means to collect data on unit availability and, in order to protect the reliability of the electric power supply, can influence what gas turbine powered units will run. This in turn can influence what gas turbine units might be purchased in the future.

Recently FERC made a proposal to "bundle" ISO's into larger Regional Transmission Organizations (RTO's). As you read this, that suggested reorganization is already underway. In any event, in the U.S.'s deregulated electricity market, one can say that ISO's really have the power over the power. ✣

1. "Overview of ISO New England and NEPOOL", www.iso-ne.com
2. "Understanding New England Generating Unit Availability," June 14,2001, www.iso-ne.com

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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.

JOURNAL OF TURBOMACHINERY

Ted Okiishi

Important News ... from Ted Okiishi, Editor

Valerie Winters, "Production Editor" of the Journal of Turbomachinery since it began in 1986, left ASME last fall. I would like to publicly acknowledge the very high value of her production work and thank her for her years of dedicated and effective service to the journal and its stakeholders. She was absolutely vital to the process of getting the journal into the hands of readers and we will miss her expertise.

For the second consecutive year, papers presented at TURBO EXPO began appearing in print in the October journal issue of the same year and should all be published by the July issue of the following year. These papers are mainly from three technical committees of IGTI, Turbomachinery (18 of 91papers presented recommended for publication in the journal), Heat Transfer (34 of 91) and Structures and Dynamics (33 of 62 presented recommended for publication in either the Journal of Turbomachinery or the Journal of Engineering for Gas Turbines and Power).

These data prompt some discussion. We are currently allocated 850 pages per year by ASME. On average, our papers are about 9 pages long (note that mandatory excess page charges of $200 per excess page over 9 (was 6 until last year) are required of authors) so about 94 papers can be published per year. Most of these are from TURBO EXPO, only 4 papers per year on average are accepted for publication from submissions directly to the journal. Considering that the Structures and Dynamics papers mentioned above are divided between two journals, do the arithmetic and you will see that the backlog problem is no longer an issue. However, fewer papers than we have pages for are being published.

Before we give up our journal pages all too willingly, I ask you to consider the following and let me know what you think by some kind of response (tedo@iastate.edu).

I think most of us are okay with fewer archived papers per year as long as all of the papers presented at TURBO EXPO that are of "permanent interest" are indeed being published. Occasionally, after a paper judged to be of current interest only is presented, more than a few qualified individuals then consider it to be of "permanent interest." In these few instances, a re-review driven by the session chair or the editors of the journal is justified.

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TURBO EXPO is still a great venue for presenting new and important technical knowledge about turbomachines to a critical audience of enough size, variety and expertise to make it all worthwhile. The discussions at TURBO EXPO about these papers usually add considerably to the value of these presentations. I would like to encourage more of us to submit written discussions for response by authors and for publication in the journal. This extension of the discussion aspect of our papers by the journal could be a good feature of the journal if we exercise it more often than we currently do.

> ***"I would like to encourage more of us to submit written discussions for response by authors and for publication in the journal."***

All of the presented papers at TURBO EXPO are reviewed, something that is becoming more and more rare for technical conferences. The IGTI review process in place is one of the most rigorous available, especially when organized correctly. While it is already good, I think we can afford to continue to work on improving the quality of the IGTI paper review process. Any suggestions?

Currently the papers sponsored by the Structures and Dynamics Committee of IGTI are published in either the Journal of Engineering for Gas Turbines and Power or the Journal of Turbomachinery. Should more of them be published in the Journal of Turbomachinery? What do you think?

I look forward to hearing from you. This is your journal, own it.

Other Happenings at TE'02

Special events and activities at TURBO EXPO include:

- Pre-Conference Workshop
- Exposition
- Welcome Reception
- Facility Tours

Pre-Conference Workshop

"Basic Gas Turbine Metallurgy & Repair Technology" is the topic of an all-day User Workshop on Sunday, June 2 sponsored by IGTI's GTUS Advisory Group. A separate registration is required. To register, check the Pre-Conference Workshop box on the TURBO EXPO '02 Registration Form and include the registration fee in your total payment. See page 15 for more information, and refer to the IGTI Web Site (www.asme.org/igti/) for additional details.

Exposition

Make plans to meet with the best minds in the business at the ASME TURBO EXPO Exposition, where you will receive first-hand information … face to face … and hot off the press!

Visit the exhibit hall to see where the "rubber meets the road" with the latest technological advances to propel your gas turbine business into a "better tomorrow." You owe it to yourself and your company to acquire the right knowledge to make the right decisions! The exhibit hall is a great place to network with your peers and discover innovative solutions to your business problems.

Continuing the 3-day format, you'll have plenty of time to meet and network with a variety of the leading gas turbine industry professionals from around the world! Admission to this world-class Exposition of gas turbine products is free to all registered participants and guests at TE'02 Monday thru Wednesday … 3-5 June … in the Hollandhal at the RAI Exposition Centre. Open hours are Monday from noon to 6:00 pm; Tuesday from 11:00 am to 6:00 pm; and Wednesday from 11:00 am to 4:30 pm. Come to TURBO EXPO … and bring a colleague. ✲

Viewing the Exposition

Exhibitor Showcase ! Check out the most current list of exhibitors online at www.asme.org/igti for a continuous list of companies that will be represented. You'll now be able to look at each company's description and category, and link directly to the exhibitor's site to learn more.

Welcome Reception

A Welcome Reception will be held Sunday evening, 2 June, at the world famous Rijksmuseum. The Reception is sponsored by the City of Amsterdam and by Shell Global Solutions International B.V. The Rijksmuseum houses a wonderful collection of international art including "The Night Watch" by Rembrandt. A city official will be present to welcome TE'02 participants. Tickets are required, and will be distributed free-of-charge on-site by IGTI. Safety regulations limit attendance to 750 persons. Ticketing details will be available on the IGTI Web Site.

(courtesy Netherlands Board of Tourism)

"The Night Watch"

Facility Tours

Four facility tours will be available to participants at TURBO EXPO this year. At press time the following descriptions have been received:

- **Amer Power Station** - Facility tour of a plant where a 30 MWe Alsthom/ABB gas turbine has been retrofitted with SwirlFlash overspray injection of hot water. This technology is reported to augment power by 10% and reduce NOx by 40%.
- **Trigeneration Plant RoCa-3** - A visit to what may very well be one of the most environmentally friendly power stations in the world. This 200 MWe plant not only generates electricity, but also supplies heat and CO_2 for greenhouse horticulture.

Further details on these and other facility tours will be made available on the IGTI Web Site as they are received. Tour participation is solely up to the sponsoring facility and is normally very limited. Sign-up takes place in the Exposition during show open hours. ✲

Keep Up-To-Date Automatically

To keep up-to-date on these and other happenings at TURBO EXPO as they are posted, go to the IGTI Web Site and sign up for our "E-Bulletin" … an automatic e-mail update to TURBO EXPO and other IGTI activities.

TO REGISTER for TE'02

go to the IGTI WEB PAGE at … www.asme.org/igti/
or CALL IGTI for a FORM … (404) 847-0072
For Hotel Information, go to the web site also …
REMEMBER, Housing Deadline is March 15 !

Basic Gas Turbine Metallurgy AND Repair Technology Workshop

Hosted by the IGTI Gas Turbine Users Symposium (GTUS)

Learn from the Experts!

Operations and Maintenance Personnel Learn …

- *About gas turbine metallurgy and repair technology!*
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(4) It has been insufficiently recognized that the Whittle project essentially depended on the marriage of a jet engine with a new subgenus of airframe, and that the boldness and completeness of the total concept (as appreciated by Bramson) went beyond the mere proposal of using a gas turbine to produce a propulsive jet ...

SALIENT CONTENTS OF THE BRAMSON REPORT ...

While space does not allow reproduction of the full Report here, the overall structure is provided below with salient points and excerpts.

TERMS OF REFERENCE

"The purpose of this Report is to record the result of an independent step by step check of the theories, calculations and design proposals originated by Flt. Lt. Whittle, and having for their object the achievement of practical stratospheric transport. No investigation of the patent situation has been attempted."

MATERIALS SUBMITTED BY FLT. LT. WHITTLE

"The inventions and discoveries of Flt. Lt. Whittle have not yet reached the experimental stage, and so the material available for investigation is, necessarily, confined to a reasoned statement of the principles involved, coupled with justifying aerodynamic and thermodynamic calculations and design proposals."

DESCRIPTION

The Problem

This section describes the importance of high-speed flight, the inability of the propeller to function at high altitudes even with supercharging, and the impracticality of previous proposals.

"(Previously proposed jet propulsion concepts) have failed to provide a solution in the main, either because they involved carrying in the aircraft not only the fuel but also the oxygen required for combustion, or because though theoretically capable of functioning in the stratosphere, the means proposed were incapable of raising the aircraft to the stratosphere."

Solution Proposed by Flt. Lt. Whittle

This covers a description of a clean aerodynamic form aircraft with a circular air inlet facing the air stream conducting air to the turbojet and an efflux jet via a propulsion nozzle that provides thrust. The design concept is for a 500 mph aircraft operating at an altitude of 69,000 ft.

Aerodynamic Principles: This section shows that aircraft drag for practical purposes, is inversely proportional to the square root of the air density and that a thrust that would produce say 125 mph at sea level would result in an airspeed of 500 mph at 69,000ft.

Thermodynamic Principles: The basic thermodynamic cycle is presented here, including compression, combustion, expansion through the turbine blades and propulsion nozzle, and return to normal atmospheric pressure. Whittle includes pressure-volume diagrams and entropy diagrams for two sets of conditions: a) 500 mph at 69,000 feet altitude, and b) no airspeed at sea level. Calculations indicate that if the assumed efficiencies of 80% for the compressor and 75% for the turbine are achieved with a pressure ratio of about 4:1, the plane should not only fly, but also demonstrate very rapid acceleration and climb.

Efficiencies: Calculations indicate a thermal efficiency of 48% giving an overall efficiency of 17.13%. Bramson defined thermal efficiency as the kinetic energy given to the working fluid divided by the heat energy input, and overall efficiency as being the thrust horsepower divided by the input of energy in unit time (corresponding to the thermal efficiency of an aeroengine multiplied by the propeller efficiency).

Engineering—The Power Unit: "The Whittle Reaction Engine consists of a single-stage (double-entry) turbo-compressor directly coupled to and driven by a gas turbine of the pure impulse type. Taking the case of a unit capable of a throughput of 2.25 lb of air per second at 69,000 feet, the impeller would be 19 inches and its speed would be 17,850 rpm giving a linear tip speed of 1,470 feet/second." The overall compressor diameter would be 43 inches.

"For efficiency, the linear speed of the single row turbine blades should be one-half that of the gases issuing from the turbine nozzle, which is 2,500 ft/s. The turbine blade speed should therefore be 1,250 ft/s and the effective diameter of the turbine should be 16.15 inches.

"The turbine exhaust gases pass straight to the propulsion nozzle where … the speed of the gases is accelerated to 2,320 ft/s. The volume per lb of gas has at this point expanded to 591 cu ft/lb giving a total of 1,330 cu ft/s in the particular case considered. This gives a propulsion nozzle outlet diameter of 10.25 inches."

Engineering—The Aeroplane: The aircraft as envisioned by Whittle is described here. It would consist of a fuselage of correct streamline form with a sealed compartment for the pilot, passengers and controls. An annular opening of at least 100 sq. in. cross-section would face the air stream. Cabin pressurization would be achieved by using compressor bleed. The wing would be of the cantilever monoplane type with a 52 sq. ft. area and loading of 19.3 lb/sq ft. The plane would weigh about 2,000 lbs.

CRITICAL DISCUSSION

In this section, Bramson checks Whittle's calculations and comments extensively on the following areas: Aerodynamics, Thermodynamics (including compressor efficiency, turbine efficiency, temperature rise due to compressor, turbine blade temperature, and thrust), and Engineering (including the engine, combustion chamber and burners, turbine, weight, and the stratospheric aeroplane design). He then comments on the degree of permissible error in fundamental assumptions regarding compressor and turbine efficiencies.

"The design problems and difficulties to be overcome, in their probable order of importance, (Bramson) summarized as follows:

1. To make provisions for the combined heat and centrifugal stresses at the turbine blade roots.
2. The design and manufacture of a compressor rotor capable of withstanding the centrifugal and bending loads on the vanes.
3. To guard against turbine blade and compressor blade vibration.
4. Design of main shaft to avoid torsional vibration periods, and to resist gyroscopic couples."

Bramson did not regard any of these problems as insurmountable. However, he did not predict the difficulties Whittle would experience with the combustion process.

SUMMARY

Bramson summarized his calculations as corroborating those of Whittle, even considering compressor and turbine efficiency uncertainties.

CONCLUSIONS

Bramson came to the following conclusions:

1. Flt. Lt. Whittle's theoretical calculations and deductions therefrom are substantially correct.
2. His fundamental discovery is that the gas turbine although very inefficient as a prime mover when power is required in the form of shaft horsepower, can be adequately efficient as an auxiliary to the production of a power jet.
3. Should the discovery be successfully put into practice, the points of superiority over existing aeroplanes would be:
   - Economical speeds of 500 mph and over.
   - Probable ranges of 5,000 miles and over.
   - The use of non-volatile fuel.
   - Freedom from noises and vibration.
4. The proposed development, though necessarily speculative as regards time and money required, is so important that it should, if possible, be undertaken.

RECOMMENDATIONS

"The 'Brief Outline of Development Procedure' appended to this Report … has, by request, been prepared by the inventor.

"I recommend the adoption of the procedure therein proposed with the proviso that all designs should be submitted to an independent authority on turbine and compressor design before actual construction is undertaken.

M. L. BRAMSON
8th October, 1935"

Bramson's Findings Bear Fruit …

On May 18, 1935 Whittle filed for Patent No. 459980 for an experimental turbojet, which would be called the W.U. Whittle proceeded to design a double entry compressor with a 19″ diameter made of high strength aluminum alloy and having 30 vanes. The compressor was to be driven by a 16.4″ turbine operating at 17,750 rpm. The mass flow rate was to be 26 lb/sec and the pressure ratio 4.4:1. Whittle recognized that the area of greatest technical risk was in the combustor where an exceedingly large heat release had to be achieved in a very small volume. Whittle's aim was to burn 3.3 gal/min in a volume of 6 cu. ft. After talking to several burner manufacturers, Whittle was able to get the assistance of Laidlaw Drew and Co. to work on a small research contract.

In June 1936, Power Jets awarded British Thomson-Houston Co (BTH) of Rugby a contract for the detailed design and construction of the W.U. Due to severe financial constraints, Whittle could not afford component testing and therefore had to boldly take the risk and attempt to run a complete engine.

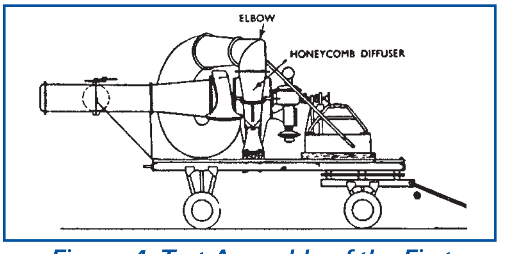

Figure 4: Test Assembly of the First Model of the Experimental Engine.

His initial experiments on combustion were run with very crude combustion test rigs and equipment. Combustion was a major design challenge and the one that Bramson had underestimated. On April 12, 1937, the first runs of the W.U. engine were made (Figure 4). These were eventful because in several instances, the turbine accelerated with a rising shriek to 8,000 rpm even with the fuel valve closed. This uncontrolled and noisy acceleration caused considerable concern as it was usually accompanied by patches of red heat being visible on the combustor, large flames emanating from the jet pipe, and all the operators making a rapid exit from the test cell!

Continued on page 20 …

Finally ...

Finally, it was determined that fuel pump tests conducted prior to engine light-off resulted in an accumulation of fuel in the bottom of the combustion chamber which ignited causing the uncontrolled acceleration. After the W.U., Whittle worked on several engines with the W.1 engine (Figures 5, 6) being used for the first British jet flight.

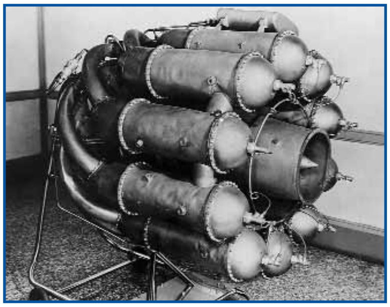

Figure 5: Whittle W.1 Engine

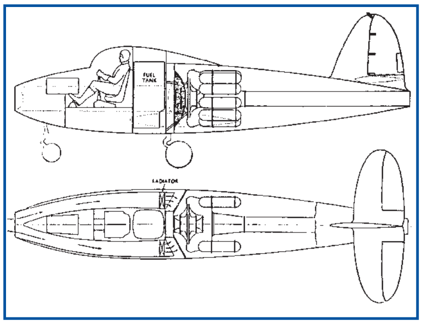

Figure 6: Fuselage of the Experimental E.28/39

On May 15, 1941, the jet age was ushered into the UK with the flight of the Gloster E.28/39, piloted by Flt. Lt. P. E. G. Sayer (Figure 7). Power Jets continued developing engines culminating in the advanced W.2/700 rated at 2,500 lbs thrust. Whittle's theories were proven, and M. L. Bramson's Report was instrumental in that process.

Power Jets Ltd. was nationalized in 1944 and then merged with the aircraft gas turbine section of the Royal Aircraft Establishment to form the National Gas Turbine Establishment. The NTGE was limited to research and to assisting the established aircraft engine industry, which by then, as is typical in most technological revolutions, began to dominate the revolution that it had hitherto resisted.

CLOSURE

As is typical with most technology revolutions, Sir Frank Whittle had to battle not only difficult technical problems but also traditionalists and skeptics who were convinced of the superiority of reciprocating engines. The Bramson Report of October 1935 was a key ingredient in obtaining funding for Power Jets Limited which, in turn, enabled the turbojet revolution. It is interesting to note that all the major western aeroengine manufacturers started their jet engine work based on Whittle's designs. The Rolls-Royce Welland, Derwent, Nene and Tay were based on Whittle designs. Pratt and Whitney entered the gas turbine field after the war using the Rolls-Royce Nene as a basis for its J-42 and J-48 engines. Similarly, General Electric started its jet engine work based on Whittle designs and developed the I-A, J-31 and J-33.

Sir Frank Whittle will always be a beacon of encouragement to engineers not only for his engineering brilliance but also for the tenacious and epic battle he fought against officialdom and entrenched technical opinion to make the jet engine possible. ✯

Figure 7: First Flight of the Gloster E.28/39 on May 15, 1941

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