‘Comeback’ user group gains enviable support

If there were a “comeback award” for user groups serving the gas-turbine-based power and process communities, as there is in sports, it most certainly would go to the Frame 6 Users Group. This group met annually from 1986 through 2000, but interest waned as the machine matured and users *thought* most issues had been resolved. Budget cuts adversely impacted corporate support and participation by GE Energy, Atlanta, and no meetings were held in 2001, 2002, and 2003.

Last year, California-based Foster Wheeler Martinez sponsored a conference in Las Vegas with the goal of revitalizing the group as a self-funded organization. The Frame 6 Users traditionally had been supported by large industrial companies that owned and operated 6B engines—such as Amoco Chemicals, ExxonMobil, BASF, Celanese, etc.

Participants at the 2004 meeting responded positively and a steering committee was formed. Larry Flashberg, plant engineer, Saguaro Power Co, Henderson, Nev, and Jeff Gillis, senior staff engineer, ExxonMobil Chemical Co, Baytown, Tex, were elected co-chairmen (see sidebar, p 130, for names of all committee members). To ensure success as a self-funded entity, the group brought Wickey Elmo (704-753-5377, wickelmo@goosecreeksys.com) onboard as conference coordinator. Elmo has years of experience managing user groups.

It was a formula for success. The 2005 meeting, held the last few days of August in Houston as Hurricane Katrina was pummeling the Gulf Coast to the east, drew just under 100 user attendees—a number some other groups would envy. More than half of the users came from refineries and chemical plants, some from far-off lands—including Nigeria and Oman.

The mission of the organization is to provide members an open forum for dialog and exchange of information to improve O&M practices related to GE Frame 6B series GTs and to interface with the manufacturer regarding generic issues with the 6B fleet. For information on participation in this user group, access www.frame6usersgroup.com.

Group objectives certainly were met in Houston. In fact, it’s probably fair to say that the meeting exceeded expectations. However, whether the Frame 6 users know how to relax is open to debate after the Houston experience. Serious activity was nonstop from the time Elmo’s registration desk opened at 4 pm Sunday, August 28. Well, that’s not exactly true: There was a relaxing welcome reception sponsored by ACT Advanced Combustion Technology Inc.

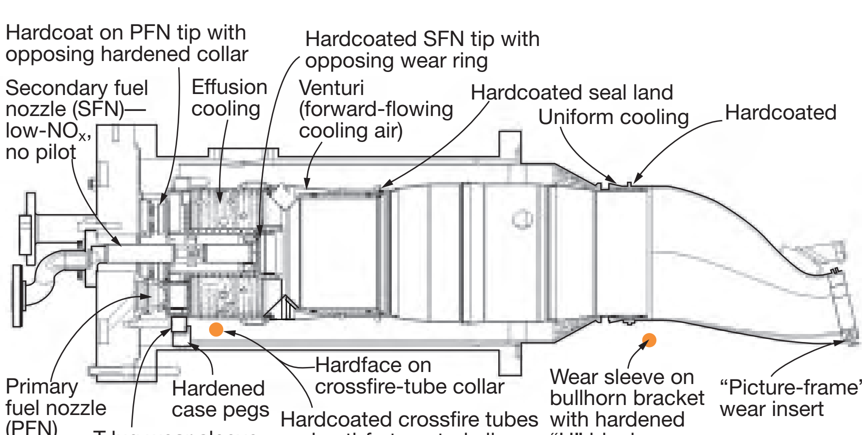
Then the serious program started. Most user groups feature golf on the first day, or have a tour of a local attraction. Not Flashberg/Gillis and company. What do they do for fun on a Sunday evening? Visit a repair facility. At 8 pm a bus ferried three dozen or so attendees from the comfortable South Shore Harbour Resort and Conference Center in League City to ACT’s shops near Hobby airport. As crazy as it sounds, it was the ideal time for a productive visit—no phones ringing, no other interruptions.

President/Operations Manager Joe Cosart and his entire senior staff were available to present ACT’s facilities, explain the processes the company uses for repair and refurbishment of various turbine components, and answer any questions (sidebar, p 125).

It was approaching midnight when the bus returned. But there was no aftershock; the breakfast room was full at 6:30 the next morning. With Elmo directing the kitchen, everyone eats well and few meals are missed. Flashberg and Gillis called the meeting to order an hour later and the users went flat out for the next two and a half days—including eight prepared presentations and 13 roundtable discussions. So much

Plan ahead: 2006 annual conference

The Frame 6 Users Group steering committee announced at the Houston meeting that the organization’s 2006 conference will be held June 12-15 in Phoenix. Contract for the meeting facility had not been signed by press time. Delegates and exhibitors with interest in attending should access www.frame6users group.com for the latest information. Or, contact Wickey Elmo, conference coordinator, at wickelmo@frame6usersgroup.com or 704-753-5377.



Upgrade kits facilitate change-out of standard combustors or factory-installed low-NO$_x$ systems to the LEC III, which comes with a 16,000-hr inspection-interval guarantee

Sulzer Hickham: World class from every angle

There were only about a dozen attendees along for the Sulzer Hickham facilities tour and that was unfortunate—much to see, much to learn. But the visit to this world-class repair facility was scheduled on the last afternoon of the meeting in the aftermath of Hurricane Katrina and many attendees had to rush home.

Hickham is an impressive success story. The company was established in LaPorte, Tex, in 1974. It was purchased by Switzerland's Sulzer in 1985 as a wholly owned subsidiary. Annual revenues were about \$6 million and employees numbered 60 at that time. By the millennium, revenues had grown 10-fold, employees six-fold.

Frame 6 users saw a little bit of just about everything—and that took nearly three hours. Too many questions, perhaps, for a willing host to answer. Blade/airfoil manufacturing and repair, gas- and steam-turbine repair shops, at-speed rotor balancing facility, machining and welding centers, coating shops, metallurgical lab, and NDE centers all were stops on the tour.

Frame 6 users share a light moment at fixture to hold transition pieces during rework (left). Kyle Todt of Sycamore Cogen is at left. Moving right: Larry Flashberg, Saguaro Power; Olaf Barth, Dominion; Nile Jackson, Saguaro Power; and Homer Boswell, Dominion. At right is a Frame 6 rotor in the final stages of overhaul

material was covered during the meeting that the editors had to split their coverage into two articles. This one focuses only on the prepared presentations. A followup feature (next issue) will provide an overview of the roundtable discussions.

The first full day was capped by a vendor fair (see pages 126-129 for profiles of most participating companies) and reception, the second by the Frame 6 Dinner. Both went until 9 pm. Final event of the 2005 meeting—after lunch on the third day—was a visit to Sulzer Hickham's repair and overhaul facilities in nearby LaPorte (sidebar, above).

Very-low-NO_x combustion

It's tough enough getting commitments from eight speakers, let alone getting eight solid presentations. But the Frame 6 steering committee got the results desired. With many users concerned about meeting emissions regulations that are being ratcheted down in many parts of the country, Clay Moran's presentation showed just how low you can drive NO_x emissions with commercially available equipment.

Moran, director of Power Systems Mfg LLC's combustion product line, reported on experience with the company's low-emission combustor (LEC)—specifically the LEC III. Moran said that PSM, based in Jupiter, Fla, is the only after-market company with a proven DLN (dry low-NO_x) combustion system for GE Energy's Frame 6B installed base. The company offers complete upgrade kits to "easily replace" standard combustors or factory-installed low-NO_x systems to the LEC III, which comes with a 16,000-hr inspection- interval guarantee (figure, p 123).

The 6B field experience to date has been with a gas-only LEC III. However, Moran told attendees that PSM has developed a dual-fuel LEC for the 6B which also is guaranteed to operate at less than 5 ppm NO_x on gas. It has additional liner features and water-cooled liquid-fuel distributor valves to ensure reliable operation on distillate. The combustion system is ready for field implementation, he said.

Results of validation-rig tests, high-time operational hardware condition, and instrumented engine data, reported Moran, combine to prove system reliability and performance are equivalent to the OEM's (original equipment manufacturer) DLN-1 offering, except that PSM's LEC III is capable of much lower emissions.

He presented a chart that summarized operating experience. It listed a half-dozen 7EA, 6B, and 7B-to-E machines in service with LEC III "drop-ins." The five most recent installations (installed 2003-2005) are operating at below 5 ppm NO_x and 2 ppm CO. The sixth, the first commercial LEC III system, installed in 2001on a 7EA, is running at under 6 ppm NO_x and under 2 ppm CO.

Of particular significance to the Frame 6 users was Moran's data that showed emissions deterioration has been minimal, if any. The data stream, from Dow Chemical's Seadrift (Tex) facility, showed the drop-in system achieving 4 ppm NO_x and 9.6 ppm CO when it went into service in March 2004. Unit was producing 38.5 MW at the time of the test; exhaust temperature was 1019F, exhaust spread 49 deg F. In June 2005, emissions of 4.05 ppm NO_x and 4.19 ppm CO were recorded with the unit operating at 32.7 MW. Exhaust temperature was 1051F and the spread 43 deg F. Note that Seadrift is the Frame 6B fleet leader with more than 11,000 hours of service. Currently there are three 6B units operating with the LEC III; another will be starting up shortly.

PSM's vision is to get to a guaranteed 2.5 ppm NO_x to compete with SCR (selective catalytic reduction) head-to-head. Moran acknowledged that technology application will vary in complexity from site to site. He also mentioned that NO_x reduction by use of "blended fuels" is under development.

Moran said that key features of the LEC III include a pilotless secondary fuel nozzle and complete elimination of diffusion combustion. Additionally, the head end is a greatly enhanced premixer because of air-flow distribution changes. Less air is used for wall cooling because of the efficiency of effusion cooling, so more air is available for mixing. This arrangement is key to maintaining a near-uniform temperature profile in the reaction zone of about 2700F thereby eliminating the hot spots (temperatures of 3500F) that drive up NO_x production.


Moran

Improved manufacturing techniques also contribute to a more uniform temperature profile by minimizing the flow variation from liner to liner, he continued. Engine hot streaks are virtually eliminated and exhaust temperature spreads have been reduced from a typical 60 deg F to the 30s or 40s—as the Seadrift data confirm.

The company's combustion liner was redesigned so that the venturi is arranged in a forward-flowing cooling-air configuration. This patented technology, Moran said, "has proven to be a tremendous CO reducer." All of the venturi cooling air discharged is collected in an outside plenum surrounding the liner and reinjected into the liner head end. Venturi air is preheated, becomes part of the premixer, and is completely used in the combustion process.

In the OEM's system, by contrast, the aft-flowing cooling air is discharged as a cold unmixed stream that surrounds the reacting gases. As a result, a significant amount of CO is "locked in" and prevented from forming CO_2.

PSM's liner design also benefits from the latest analysis tools to achieve greater durability, Moran continued. Wear-resistant materials at critical interface locations help minimize loss of fit-up. This also is a key system feature to assure minimum deterioration.

Nozzle restoration

Matthew C Lau of Sulzer Hickham's Component Div, LaPorte, Tex, spoke on a subject of tremendous importance to anyone in the competitive power business: Maximizing the life of critical components. First-stage nozzle restoration was the example presented.

Lau began with the question he often is asked by users: "What is the life of my critical components?" The general perception in the industry, he continued, is that once a Frame 6 first-stage nozzle operates for a certain number of hours it no longer is serviceable. This is true, Lau said, but nozzle life often can be extended with correct restoration.


Lau

One of the most critical factors in determining remaining life is the metallurgical state of the nozzle segment, which is cast from the cobalt material FSX414 and is subject to alloy depletion. Reason alloy depletion is important is that it can affect the weld capabilities of the nozzle. Corrosion and oxida-

Continues on page 130

ACT's expanding service capabilities

President/Operations Manager Joe Cosart greeted the Frame 6 users at the entrance to ACT's facilities in the shadow of Hobby airport. Outside it was pitch black, not much of a moon. Inside ACT's comfortable climate-controlled main shop it was like high noon. Shop? It's more like a clean-room facility used to machine parts for the space program. No, Cosart didn't have his workforce "turn-to" with the expectation of impressing visitors. The shop looks the same in the middle of a work day. It reflects Cosart's meticulous nature and is conducive to quality work in the demanding business of gas-turbine component repair.


Cosart

ACT is a 10-yr-old company with more than 35,000-ft^2 of shop space dedicated to the repair and rejuvenation of nozzles/vanes, blades/buckets, transitions, liners/baskets, etc—and growing. Most recent addition is a state-of-the-art fuel-nozzle flow test and repair facility capable of servicing components from GE's Frame 5s through 7FA+e machines as well as those from many engines built by Westinghouse. This facility is in a new 15,000-ft^2 building that also accommodates a bid walk and job preview area complete with customer office and meeting center. For details, visit www.gasturbinerepair.com.


ACT's Joe Cosart, at far left, explains vane repair procedure to Union Carbide's Larry Hamilton, Petroleum Development Oman's Talal al-Mahruqi, UK-based NPower Cogen's Ian Gaunt and Steve Hicks, and Saguaro Power's Larry Flashberg (l to r). In photo at right, Chevron's Mike Wenschlag, Mike Popp, and Ruben Lopez (l to r) inspect repaired blade

Frame 6 Users Group steering committee

Co-chair: Larry Flashberg, plant engineer, Saguaro Power Co, larry.flashberg@saguaropower.com.
Co-chair: Jeff Gillis, ExxonMobil Chemical, william.j.gillis@exxonmobil.com.
Scott Berry, plant manager, Anderson and Richmond powerplants, Indiana Municipal Power Agency, sberry@impa.com.
Homer Boswell, supervisor of maintenance, Rosemary Power Station, Dominion Virginia Power, homer@panda-rosemary.com.
Brian Walker, manager of maintenance, Foster Wheeler Martinez Inc, brian_walker@fwc.com.
Zahi Youwakim, Huntsman Corp, zahi_youwakim@huntsman.com.


Flashberg


Gillis


Berry


Boswell


Walker


Youwakim

Continued from page 125
tion erosion cause thinning of base material, but surface coatings can be applied to help extend the life of that material.

Another consideration in component life assessment is the dimensional disposition of the nozzle assembly. Installation and operational problems occur when it becomes distorted/deformed, adversely impacting unit performance. Dimensional distortion can start a cascading effect that ultimately shortens the life of the nozzle assembly.

Incoming inspection is where many potential problems are identified. Here's what is done in the Sulzer Hickham shops after parts are unpacked:

- Perform "typical" incoming inspections—liquid penetrant, ultrasonic testing (UT), metallurgical, weld capability, and dimensional.
- Review each segment while in an assembled state to identify potential problem areas within the assembly.
- Measure inner and outer sidewall joint gaps; inconsistencies can be a sign of underlying problems.
- Run assembly through an inner-support-ring simulator to quantify the amount of individual segment distortion.
- Set up each segment on a flat table and measure twist and distortion.

Lau presented individual slides to show the location of UT testing, how retaining-ring repairs are made, how flatness is corrected, steps in the complete weld repair process, etc. His handout is a valuable "how to" for writing specifications, evaluating alternative repair facilities, and for following future work.

Conclusions of the presentation were these:

- Full dimensional restoration can help extend the lives of the nozzle assembly and all affiliated components—including transition pieces, inner support ring, shrouds, etc.
- Full heat-treatment rejuvenation (solution anneal, stress relief, etc) can restore most materials and their mechanical properties.
- A fully restored nozzle generally has a reduced scope of repairs on subsequent cycles, thereby reducing costs.

Selecting a repair facility

Hans van Esch of Houston-based Turbine End-user Services Inc (TEServices), who has more than two decades of experience in the repair of GT components—including several years at Sulzer Hickham—followed Lau on the program (hvanesch@teservices.us). While he overlapped some of Lau's presentation on incoming inspection, van Esch started "at the beginning," suggesting how users might assess the condition of their GT parts onsite and use this information to prepare meaningful component repair specs and then select the appropriate repair vendor for their particular situation.

Justice could not be done to van Esch's thorough handbook-type presentation in a few hundred words here. A better approach is to read the first of a series of articles on the subject of his presentation, "Six steps to successful repair of GT components," which appeared in the 2Q/2005 edition of the COMBINED CYCLE Journal (CCJ, www.psimedia.info/ccjarchives.htm). It covers onsite parts assessment and specification preparation. The third step, selection of an appropriate repair vendor, is detailed in the 2006 OUTAGE HANDBOOK supplement to this issue beginning on p OH-7.


van Esch


Pond

The remaining steps in the repair process—vendor verification of incoming inspection, repairs, coatings, and final inspections—will be addressed in detail in the 4Q/2005 and 1Q/2006 issues of the CCJ.

Outage planning

Charlie Pond of Pond and Lucier LLC (www.pondlucier.com), Clifton Park, NY, conducted a meaningful tutorial on outage planning, including the identification of outage issues, that was tailored to the Frame 6 fleet. His presentation, a handy guide for any 6B owner/operator, will be part of the conference proceedings to be compiled on a CD and offered for sale by the user group (write Elmo at wickelmo@frame6usersgroup.com for details).

Here is Pond's 15-step procedure for planning and organizing a successful outage:

- Identify the job scope and date—for example, combustor inspection (CI), hot-gas-path (HGP) inspection, major inspection, generator inspection, system maintenance, etc.
- Make a spare-parts list. Don't forget fuel nozzles, crossfire

tubes and retaining clips, combustor liners, gaskets, new fasteners, etc.

■ Order parts early. Make sure you fully understand the supplier's system for doing this to avoid heartache later. Order parts early to get the best price. Don't forget the expendables such as rags, duct tape, plywood, etc.

DeBaecke

■ Decide how to perform the outage—for example, long-term service agreement, turnkey, hire technical advisor and labor separately, train staff and do internally.

■ Plan, plan, plan. Select a commercially available critical-path software package to do overall planning and then fine tune by brainstorming internally to identify ways to shorten the total length of the job.

■ Identify ways to shorten critical tasks.

■ Analyze the OEM's TILs (technical information letters) and decide which to do, skip, or postpone.

■ Review possible upgrades/uprates and decide which to do, which to postpone or skip. Don't forget to evaluate the impact of any GT improvement on other plant equipment—such as the heat-recovery steam generator (if installed), generator, etc.

■ Review/consider common Frame 6 issues—such as failures of buckets and transition pieces at about 40,000 hours.

■ Borescope in advance of planning to ensure more accurate budgeting and scheduling.

■ Analyze operating data thoroughly. This is a good benchmark to quantify real improvements made as a result of the outage. Very important to verify if contract terms were met, if upgrades met guarantees, etc.

■ Perform tasks in advance of the outage to the extent possible—for example, get parts, expendables, and cribbing onsite and arranged before the outage begins.

■ Identify special tooling needed. Precision measuring instruments, turbine support jacks and stands, nozzle pulleys, and the load gear centering ring are some of these.

■ Pay special attention to variable inlet guide vanes (IGVs). They have become a big maintenance item. High-flow IGVs should be considered as an upgrade; significant increase in output is likely.

■ Write the RFQ (request for quote), making sure to spell out what is included and what is not included.

Gear drive O&M

When was the last time you were at a power/process-industry meeting and listened to a presentation on gear-drive preventive maintenance and repairs? The Frame 6 users were treated to a solid engineering presentation on the subject by one of the leading professionals in the field, Jules DeBaecke Jr, VP engineering at Philadelphia Gear Corp (www.philagear.com), Norristown, Pa.

Gear drives are easy to take for granted. But this would be foolish, because if they fail you don't produce electricity. For gears, a little bit of attention goes a long way. DeBaecke's simple six-step preventive maintenance program:

■ Look at trend data, not single data points.

■ Be consistent during data acquisition.

■ Automate record keeping to enable rapid evaluation of data.

■ Run baseline data sets at startup and after repair.

■ Identify and maintain access to critical spares.

■ Buy only top-quality replacement parts.

Price

Diagnosis of equipment health demands periodic visual inspection as well as analysis of vibration signature, lube oil, and noise and temperature levels. What to look for in your inspection forms the basis for "And finally, don't forget the gears," included in the 2006 OUTAGE HANDBOOK supplement to this issue, p OH-77.

The article also presents a lube-oil system checklist to help you maintain this critical fluid in the top condition required for long gear life.

Accurate evaluation of vibration is important for an accurate assessment of gear condition. DeBaecke cautioned that data are easily misinterpreted. Reasons for this include improper instrumentation, bad choice of data points, variations in operating conditions, and system complexity and/or multiple vibration problems. He added that the choice of data points is critical. Also, that complex systems with multiple data points are difficult to analyze.

DeBaecke suggested that users resist the temptation to be a JV vibration expert. If you identify a problem, he said, call in a professional to interpret the data.

Reverse engineering

The availability of non-OEM parts is likely to help many owner/operators of GT-based generating facilities weather the competitive storm. But all third-party parts are not created equal; caveat emptor. Before you leap at what appears to be a good deal, it is a good idea to review carefully the engineering and manufacturing processes used to create the parts.

Michel Price, the project manager for nozzles at TurboCare Gas Turbine Services LLC (www.turbocareGTS.com), Dallas, Tex, helped Frame 6 users better understand the practice of reverse engineering.

Her presentation examined the process of reverse engineering turbine nozzles and buckets—including analyses performed to verify improvements and manufacturing checks made to ensure quality. Five key steps in the process, which takes up to two years to complete, are:

■ Review public data.

■ Acquire samples.

■ Characterize samples (dimensional, visual, functional, material, documentation).

■ Create part definition.

■ Manufacture parts.

The details of TurboCare's procedures and tools (engineering and manufacturing) for producing quality third-party components was of high interest.

Many non-OEM parts are simply replicated, Price noted. This is the fastest path to market and if done properly should enable the machine to achieve as-new performance. The most-capable of the non-OEM parts manufacturers often re-engineer or redesign the original component. A goal of re-engineering is to reduce a part's cost by making it easier to produce and/or repair. Redesigns, which are patentable, are done to improve durability/life, performance, cost, and/or repairability.

Price said that the goals of reverse engineering are a design that's fully interchangeable with the OEM's part, and equal to or better than it. Quality also must be equal or better than what the OEM offers. Finally, price and order-leadtime must be much less than that for the OEM's parts. CCJ

FRAME 6 USERS GROUP

Open dialog among users key to meeting's success

"Comeback user group gains enviable support," published in the 3Q/2005 issue of the COMBINED CYCLE Journal (available online at www.psimedia.info/ccjarchives.htm), focused on the prepared presentations at the 2005 meeting of the Frame 6 Users Group, held in late August near Houston. The article also presented an overview of the meaningful shop tours conducted by two of the conference's local hosts, ACT Advanced Combustion Technology Inc and Sulzer Hickham.

The primary goal of the organization is to provide members a forum for open dialog and exchange of information conducive to improving O&M practices related to the Frame 6 series of gas turbines (GTs). Also, to interface with the manufacturer—GE Energy, Atlanta—regarding generic issues associated with the 6B fleet.

These objectives are accomplished at the annual meeting through user-only roundtable discussions. Remainder of the year, communication is group-wide via a special interactive website at http://GE6B.users-groups.com and bilaterally by phone and personal e-mail. Meeting attendance is your access to the value-added Frame 6 network.

Pencil in on your calendar now that the 2006 conference will be held at the Wyndham Buttes Resort, Tempe, AZ, June 12-15. Information for attendees, exhibitors, and sponsors will be posted at www.frame6usersgroup.com as it becomes available. Contact Wickey Elmo of Goose Creek Systems Inc, conference coordinator at 704-753-5377 or wickelmo@frame6usersgroup.com with specific questions.

Larry Flashberg (larry.flashberg@saguaropower.com), plant engineer, Saguaro Power Co, Henderson, Nev, and Jeff Gillis (william.j.gillis@exxonmobil.com), senior staff engineer, ExxonMobil Chemical Co, Baytown, Tex, the group's co-chairmen, led the roundtable discussions. These sessions moved so quickly, note-taking was difficult at best. The only way to assure that you don't miss something important is to attend. Other members of the steering committee—Scott Berry, Homer Boswell, Brian Walker, and Zahi Youwakim—participated actively in the roundtables and facilitated the discussion.

There were a dozen roundtable discussions over the two-day conference that addressed the following subject areas:

1. Unit operating history.
2. Compressors.
3. Maintenance execution, including LTSAs.
4. Combustion section.
5. Environmental issues, DLN.
6. Accessory and load-gear issues.
7. Generator and excitation
8. Mark IV to Mark VI control system upgrade.
9. Component repairs, parts evaluation.
10. Turbine section.
11. Power enhancement.
12. Inlet system, including cooling.

The nearly 100 attendees were polled several times throughout the meeting to get a general sense of the experience base present and help participants gain valuable perspective on the comments offered. A quick look here at some of the demographic information collected is helpful for justifying to management your participation in the 2006 conference. Be confident that there will be several others at the upcoming meeting from facilities that have the same equipment and duty cycle that your plant has. This makes the conference an ideal place to network. Some others certainly have experienced the same "issues" as you, and have had the experts tell them, as they have told you, "Never saw this problem before."

Demographics of interest include:

- All roundtable attendees were experienced Frame 6 owner/operators.
- About 90% of the audience represented combined cycle and/or cogen facilities; remainder, peaking plants.
- Roughly half of the users had DLN-equipped machines, about half had steam injection; a few units used water injection.
- Approximately half the audience was equipped for firing only natural gas.
- Regarding hours of operation, the fleet leader (at the meeting) had accumulated more than 170,000, four engines represented were over 150,000, 25% of the attendees were operating units that had logged more than 100,000 service hours.
- More than half of the participants represented petrochemical plants; there were a few more from refineries. The remainder were employed by generating companies or their contract operators.

A review of the suggested discussion topics submitted by the Frame 6 member community in advance of the meeting offers an idea as to the broad scope of the user information exchange. Topics included air filters, upgrades, sticking rotors, rotor/bearing vibration, cooling of inlet air, exhaust thermocouples, effects of cycling, high wheel-space temperatures, online water wash, flame detector problems, first-stage bucket refurbishment, abradeable coatings, GT alignment, seal leaks, valve freeze-up in winter, etc.

Unit operating history

Flashberg and Gillis got the meeting rolling in high gear with a roundtable discussion on Frame 6 operating history. Most meetings ramp up gradually, especially on a Monday morning—but not with this group. One of the first problems presented was ovaling of the turbine casing on a unit that had accumulated more than 100,000 hours of operation. A couple of attendees nodded, indicating they had similar experience.

One user said he was losing upwards of 3% efficiency because of blowby and looked to the OEM for a fix. The response was "no grinding, rely on the abradeable coating." Someone else said that when the upper half of the casing is removed at his plant, it springs out and is tough to get back on. Another user offered the observation that each machine is a little different and you have to figure out how best to take yours apart and put it back together. Grinding of shroud blocks was one suggestion for minimizing blowby. Two cautions: Measure blocks as you pull them out and then recoat. Be careful not to over grind or you risk pinching the casing.

Bellmouths were the next topic. Participant from a plant located near the ocean said that after about 15 years of operation, the bellmouth inlet was pretty rough. Refurbishing to as-new condition and adding fogging capability during a major and picked up about 1 MW. A question regarding the portion of the power increase attributable to surface restoration alone could not be answered. Challenge of this repair, which added a couple of days to the outage schedule, was in removing the lower half of the bellmouth.

Interestingly, another attendee had recently completed the same project. He suggested that others considering a similar repair take plenty of measurements before removing the lower half of the bellmouth. Also, that jacking the front end of the compressor will facilitate reinstallation. This plant contracted with a company in Los Angeles that used a two-part epoxy restoration system.

IGV issues concerned tubing and bushings for the most part. Vibration was thought the cause of tubing breaking right at the actuator at one plant. Stress testing confirmed the observation and suggested tubing with a thicker wall and restraints to prevent movement. New tubing with 125-mil wall has performed well and all original tubing is scheduled for replacement.

A couple of plants reported that bushings had slipped some. At one facility, the maintenance team used stakes to restrain the bushings until they could be replaced at the next major. The other facility changed out bushings without having to take a shutdown: Technicians made new bushings, split them in half to install, and then inserted stakes. Several users reported bushings closing up, primarily from dirt. To open up clearances, bushings had to be pulled and cleaned.

General consensus was that nondestructive examination (NDE) of inlet guide vanes should be conducted during each major. Some users said they do dye penetrant checks annually, others during each combustor inspection, still others during hot-gas-path (HGP) inspections. No one reported finding IGV failures during these inspections.

However, IGV failures have been experienced. A few attendees attributed the problem to the change in vane material from C403 to C450. Initial failure mechanism was corrosion pitting, which was said to have caused cracking.

Leak-by was reported as a chronic malady of old actuators, those in service for 15 years or longer. Some users simply replace them at majors because the actuators located underneath the machine are virtually inaccessible under normal circumstances. The OEM was said to be working on a solution—specifically, relocating all cylinders in the side of the machine for more convenient access.

Compressor discussion

Experience with compressor blades was the first topic addressed in this part of the program. Five attendees with more than 135,000 hours on their machines said they were still running with the original compressor blades; about a quarter of the group said they haven’t replaced a single blade.

Ocean site and fogging were two reasons cited for blade replacement.

One unit located near the coast was down for its 120,000-hr inspection when engineers became uncomfortable with the surface condition of the first-stage rotating blades. They found a set within a week and replaced them. Another user said fogging at a rate of about 20 gpm was the cause of first-stage blade deterioration at his plant and that the complete set of R1 C450 blades had been replaced twice. Now the plant is investigating a change-out of its fogging system.

Washing online and off. About half of the attendees wash online, most daily. A couple participants said they were online washing once per shift (twice daily). Demineralized water was almost the unanimous choice as the washing medium. One uses a detergent every other day; two weekly. One of the weekly users said they gained about 500 kW after a detergent wash because of the poor quality of ambient air. A participant volunteered that they ran with soap every other day followed by a demin-water chaser. But they heard some stories about detergents fouling flame sensors and decided to go water-only; no regrets, works fine.

Picking just “any old” detergent is not a formula for success. Product selection is dictated by the quality of ambient air and its constituents, and operating regimen. A suggestion was to test different formulations when the machine was down for its next inspection. Here’s how: Work up a series of spray bottles for the alternative products and spray each on a few blades. Selecting the appropriate detergent should be simple.

Majority of users wash every time the unit is shut down. Of course, the typical duty cycle for a Frame 6 user is considerably different than that for his counterpart at a plant with large frame machines competing in the merchant market. For a couple of attendees, this means offline washing semiannually; another every six weeks; two more, monthly.

The question was raised: “What motivates offline washing? Several said when output drops about half a megawatt. Another: They shut off steam augmentation and make a decision based on compressor discharge pressure. A couple more said they calculate compressor efficiency and decide; 87% was cited as the point of intolerance. Yet another said they track the temperature vs load curve in the DCS and initiate a wash when it falls off by 5%.

Many Frame 6s operate in difficult industrial environments and some compressor-blade deposits don’t respond well to conventional washing solutions. One user in the oil patch cited a baked-on carbonaceous residue that detergents couldn’t handle, so they tried CO_2 blasting, which had worked well before on highly fouled blades—but ones with deposits that weren’t baked on. That didn’t work either. Answer to the $64 question: oven cleaner.

Inlet air filters. The Frame 6 Users Group vendor fair has to be a filter peddler’s dream. So many of these units operated in polluted environments filter change-out is second nature to plant staffs. Replacing prefilters three or four times a year is standard in some areas.

One user located alongside a coke pile near a refinery on the Mississippi River said prefilters are changed when the differential pressure hits 3 in. H_2O, which occurs after about six to nine months of operation. Final filters last about three years. A participant from the Port Arthur area said that prefilters are changed monthly; semiannually, unit is shut down to offline wash and change primary filters.

A suggestion from the floor was that when you replace filters, be sure to examine contaminant capture by all panels. This will tell you if flow is relatively uniform across the entrance to the air inlet house. If not, you may be replacing filters more often than necessary. Modification of the structure to ensure better distribution of inlet air should be considered. Person offering this operating tip cited a poorly designed filter house that caused air flow through outside filters double that of those in the middle of the array.

At a riverfront location, plant installed an evaporative cooler with glass deck media certified for five years of service. This allowed staff to remove prefilters and extend the life of final filters to five years. Another user said his plant only got two years from glass deck media.

Bleed valve maintenance seems to be one of those unfortunate realities of operation. About two-thirds of the group said they did maintenance on these valves each outage. Sticking solenoids was annoyance shared by several users; one solution was to double-up on the solenoids. Another user was resigned to just replacing all bleed valves when the unit was down for overhaul. Used valve set was sent out for refurbishment, returned, and reinstalled during the next outage.

A cure offered for valve hang-ups attributed to rust was to install moisture bleed-off connections. Heat tracing was suggested for valves with a history of wintertime hang-up.

Maintenance execution, LTSAs

Only about 15% of the users in attendance operated their plants under long-term service agreements (LTSAs), which is in sharp contrast to the much higher percentages you hear at user-group meetings focusing on large frame machines. More than half of the participants said they do not use the OEM for any maintenance.

Comments from those with full-blown OEM LTSAs:

- Experience level of service reps decreasing. The participant from one plant in its tenth year of a standard 10-yr LTSA said they were on their eighth service rep.
- First six years or so of the LTSA, most everything was fine. Since then more financial burden has been placed on the customer; today, most jobs have adders for “extra work.”
- Another user had a six-year LTSA and won’t renew. He cited lack of teamwork among OEM personnel as the source of much dissatisfaction.

An alternative to the LTSA that seemed to be working for a few users was the CSA—customer service agreement. It guarantees prices of key parts and services over a long period—12 years in one case. During the contract term, they are locked in to buying from GE. Attendees thought this might be a good option for plants that don’t need planning assistance.

Some others use the OEM for maintenance almost exclusively, but bids are required for each job. Several more users just request RFQs for parts and services from multiple organizations, including the OEM. One of these offered that the OEM usually does not get their mechanical work, but wins most of the awards for controls work. Others did not share this philosophy, especially with regard to Mark IV controls found on many Frame 6s. The dissenters claimed that many service personnel have experience only with late-model control systems.

If there’s a conclusion you can draw from all this discussion it’s probably that performance evaluations of service work generally have a strong emotional component related to the perceptions and expectations of plant O&M personnel.

Maintenance intervals were a vibrant topic of discussion. Considering the age of machines in the fleet, use of both steam injection and DLN combustors for NOx control, the considerable O&M experience of many attendees, and minimal reliance on LTSAs, you'd expect intervals to vary. And they did.

First, let's look at what the attendees representing continuous-duty machines had to say. A combustor inspection (CI) on a standard package typically is performed every 8000 hours, or annually. However, nine participants raised their hands when attendees were polled regarding extender packages. Their hope is to stretch out the CI to 24,000 hours. Experience thus far:

* Two users with extender kits have passed 16,000 hours and headed for 24,000. One of them does a 12,000-hr mini, which means they pull a couple of cans and if the cans look good operation continues.
* Another user said he had three steam-augmentation units fitted with extender packages—one at 16,000 hours. Not sure how many hours they can operate before a CI is necessary. Will decide what works best by taking units out at different intervals and comparing results. If you want the answer, be sure to attend the 2006 meeting in June.
* Six participants with standard DLN packages are bypassing the standard CI and doing a combined hot-gas-path (HGP)/CI inspection at 24,000 hours; major at 48,000.
* Yet another user did a CI at 16,000 hours and HGP at 32,000 hours on one machine; now at 30,000 on a sister unit and going for 40,000 before the HGP.
* One attendee with steam injection is doing 16,000 hours intervals for his HGPs.
* Most majors are scheduled at 48,000 hours, but a few users are going for 64,000.

In the course of this discussion, attendees were polled regarding turbine inlet temperature. About half the group said they were operating at 2020F or above; five were at or above 2065F. A particularly interesting question came up at this point. One user said a unit at his plant was operating at 1980F and asked how long he could extend maintenance intervals based on 2020F operation. He was aware of the rule of thumb that states for every hour you run at 2120 (100 deg F above 2020F) HGP parts are assessed six hours of operation. Consensus was that the additional component lifetime was relatively few operating hours.

For peaking units, the inspection experience naturally was quite different. Here are a few of the comments offered:

- Four dual-fuel units in peaking service since 1992 have each accumulated an average of 410 starts and 2100 operating hours. Machines are borescoped annually and have never been opened.
- Another unit (different owner) went commercial in 1992 equipped with water injection. Did DLN retrofit a year later. Owner joined a power pool in 1997 and unit went into a cycling mode. LTSA bought in 1997. Did a major in 1999, an HGP inspection in 2002.
- Dual-fuel unit in cycling service went commercial in 1990; has accumulated 500 starts. HGP done in 2000 and coating were repaired, CI in 2004. May do major next year.
- Two units went commercial in 2003. To date, fewer than 60 total starts and 300 hours on each. No outages done, none planned.

Outage duration. The discussion migrated from intervals to outage duration. Here are the results from quick poll of the audience:

- Standard major. Five attendees said it took six weeks; one, five weeks; three, four weeks; one, three weeks. One participant did a major in 12 days: He had a spare rotor.
- HGP. Three did it in five days, four in six, three in seven; 20 from one to two weeks.
- CI. Consensus is three days on water-cooled units because it is not necessary to remove the upper casing.

Combustion section

A couple of users experienced cracking in hoses used to inject 850-psig steam just ahead of the fuel nozzle for NOx control. Colleagues thought that perhaps crank-wash liquid could be backing up into the fuel system and suggested blanking off the fuel lines. Another possibility was that the hoses are rubbing or turns are too tight.

Fuel nozzles were mentioned a couple of times. Wear is one problem experienced. Filters, heaters, and coalescers were suggested as possible cures. When wear can't be avoided, one user suggested having an extra set of nozzles to enable a quick change-out during an outage; worn nozzles are then sent out for repair and returned to the plant storeroom for reuse.

Two instances of lock-ring breakage on fuel nozzles for steam-injected units were reported. A suggestion was to redouble efforts to ensure proper installation, then torquing. Two users noted that the OEM had left out lock rings during the last overhaul and welded nozzles in place. Another said welding is necessary if hydrogen is the fuel of choice.

Flow variation from as-new condition permitted by the OEM after nozzle overhaul was reported by at least one attendee to be 5%. Six users say they specify lower—2% is most common—to achieve tight exhaust spreads. Five attendees with DLN units burning natural gas said exhaust spreads were from 40 to 50 deg F. Units not equipped with DLN and burning gas typically were in the range of 50 to 60 deg F (four engines); two were less than 40, two over 60.

The reliability of exhaust thermocouples was part of this discussion. One attendee suggested using a hot box (heat bath) to verify the accuracy of new thermocouples prior to installation. Visual inspection of new thermocouples also is beneficial. A user said he found the junction on one thermocouple was half an inch off target in the sheath and that adversely impacted measurement. It may also be worthwhile to verify annually the accuracy of thermocouple readings.

The pros and cons of changing all thermocouples periodically—for example, during an HGP or major—were noted. Group thinking was that retaining good thermocouples and replacing only those that fail might be a better strategy. Rate of thermocouple failure on first start militates against periodic complete change-outs.

Flame detectors were rated temperamental by the users. One suggested turning off cooling water flow on startup to stabilize readings.

Instrumentation and controls

There probably were no participants in the Frame 6 Users conference still using a 10-yr-old personal computer with 10-yr-old software. And if they were, where would they go for service when needed? A boutique? The original manufacturer and software provider probably would no longer provide support.

So you have to wonder why many in attendance appeared miffed at the difficulty in getting OEM support for the Mark IV control systems still in service on two-thirds of the machines represented at the meeting (all but one of the remainder have Mark V controls on their machines). Especially in an industry where a rule of thumb says you replace control systems every decade to take competitive advantage of enhancements.

Answer probably lies in the demographics of the group. As noted earlier in this report, the majority of Frame 6 engines serve industrial America where the mindset is to fix not scrap. And perfect logic says that if you're not upgrading the process served by the GT why spend money to upgrade the engine's control system? Where's the payback?

Consider the foregoing scenario as a clash of cultures. But what's a plant manager to do, especially in these days of "no budget"? First suggestions focused on identifying and maintaining good relationships with one or more boutique shops that can respond to an urgent need for help when Mark IV problems arise. Names of possible service providers were exchanged, each with a performance report. This is the invaluable information you get from attending user-group meetings.

The polar opposite of replacing defective circuit cards is to retrofit the Mark IV with a Mark VI. The motivation for doing this is to assure the high reliability and availability consistent with modern, proven controls. It also is conducive to undisturbed sleep.

Co-chair Gillis gave a short report on his company's reasons for replacing Mark IVs on three 1988-vintage 6B engines with Mark VIs and progress thus far. The reasons were obvious:

- OEM support for the Mark IV expected to cease within a few years. Even today, adequate technical support may not be readily available when you need it.
- Although the controls have been reliable, ageing effects—breakdowns and maintenance issues—are anticipated.
- Expense associated with training new in-house personnel to maintain multiple control systems. Note that the Baytown complex where Gillis works also has a Frame 7FA with Mark IV controls. Having engines on the same controls platform helps reduce the expense of maintaining spare parts.

The retrofit essentially is a turnkey project supplied by the OEM, including commissioning and startup assistance. The new controls will have the same card revisions as the 7FA Mark VI and spare control systems. While the functionality and the operation of the 6Bs will not change, site operating procedures must be revised to suit the Mark VI. ExxonMobil expects each of the retrofits to take 40 days to complete. Installation will be done during planned outages.

Important for others considering a similar retrofit: The Mark VI panel does not fit in the same footprint of the existing Mark IV panel; some onsite modifications are necessary. Conversion to the Mark VI also allows switching to an all-electronic overspeed trip from the overspeed bolt, which has issues when fouled with oil.

Gillis promised a follow-up report at the 2006 meeting in mid June. This is reason enough to attend the conference in Tempe: Odds are your plant will be doing the same retrofit within the next few years and you'll want to make informed decisions.

Of lube oil and NOx

Two generic discussions you can expect at every GT user-group meeting concern issues with lube and hydraulic oil and control of NOx emissions within permit limits. At the Frame 6 conference, one user was obviously frustrated with his machine's inability to provide stable output at part load; operation at full load was problem-free. He said the OEM "couldn't figure it out for sure" and thought the condition was related to servo varnishing. So the plant plans to replace servos during the next outage.

Another attendee reported load swings of from 3 to 4 MW at base load and believed that might also have been related to servo varnishing. Servos were pulled and sent to the manufacturer for analysis. Varnish was not a problem, but some "trash" was found inside the valves possibly indicating that some hydraulic oil was bypassing the filter. The message: Don't jump to conclusions, conduct an engineering investigation. Pull servos and send them out for analysis, lube oil too.

What followed was a long exchange of information among attendees related to their experiences with varnishing, types of oil that appear most prone to varnishing, tests to run, impact of temperature, schedule for changing filters, etc. About a dozen users thought the best strategy was to flush the lube/hydraulic system during a major and recharge with new oil.

Background on the subject can be found in "Maintaining servos to ensure top GT performance" and "The lowdown on the sticky subject of lubricant varnish," both published in the 2006 Outage Handbook supplement to the 3Q/2005 issue of the COMBINED CYCLE Journal; available online at www.psimedia.info/ccjarchives.htm.

The interactive discussion on NOx focused on emissions limits, especially at startup, and operating strategies to avoid compliance problems. Selling of NOx credits versus "bubbling" the plant or multiple company facilities to gain operating flexibility also was the source of much give-and-take.

Component repair experience

Experience with repair vendors was another valuable session for attendees. Which companies don't meet their delivery dates? Which always seem to find "extra work" after your parts arrive in their shop? Which companies are better at A, B, C than the others? Most people selling a product or service admit that referrals close deals. The Frame 6 meeting was proof of that.

Here are some snippets of the interchange: "Company A does a great job on combustors and HGP parts; owner is an honest guy." "Very pleased with the work of Company B." "Whom do I use for rotors? Call Joe at Company C, here's his number." "We now use Company D to overhaul fuel nozzles, tired of dealing with the inflexibility of the OEM."

Philosophies of parts repair and replacement varied widely among attendees, as might be expected because the Frame 6 serves in industries with different duty cycles and different approaches to maintenance. Several users said they run 24,000 hours, repair in-kind, run another 24,000 and scrap. Another attendee suggested the more analytical approach used by his company: Run 24,000, destructively test a bucket, use information provided by the lab to customize refurbishment, run another 24,000 and repeat the analysis/refurbishment cycle, etc. Expectation based on results of the first cycle is that parts should last 96,000 hours.

One user talked of stripping and coating internal cooling passages. Several in attendance believed that this could not be done. However, discussion at the Alstom Roundtable during the CTOTF's (Combustion Turbine Operations Task Force) Fall Turbine Forum (see article elsewhere in this issue) was much more positive regarding that capability.

Experience with third-stage buckets was excellent. Nearly a dozen participants said they had accumulated or expected to accumulate 100,000 operating hours or more on the original parts. The OEM was said to believe that a properly operated and maintained machine burning natural gas could get 120,000 hours from third-stage buckets.

There also were positive feelings about the life expectancy of second-stage buckets, especially the latest designs with six and seven cooling holes. Two users expected 72,000 hours of service.

Exhaust plenums got their share of air time, also. Several users reported cracking, some repaired while others replaced the plenums. One has replaced plenums twice. Hot gearboxes also a problem. So-called Peterson modification was suggested as fix. Essentially a system consisting of a forced- and induced-draft fan delivers cool air to the gearbox and removes the warm air.

A plant safety discussion focused on fire detection and suppression. An observation by one user was that the thermal setting for the detector was 350F, which was higher than the temperature rating for the wire feeding the signal. Worry, of course, is that a fire could destroy the wire before an alarm is indicated. This type of incident was said to have been reported previously. Note that wire replacement is not a casual item; it costs about $2/ft to replace.

Another attendee reported ground faults in the fire detection system that had tripped the GT, a resultthat was frowned upon by the manager of the ethylene plant served. Problem was worn insulation on ageing wiring, the wear-and-tear caused by expansion/contraction during heat-up/cool-down. Wiring was replaced with a product rated for service at up to 250C.

One user said the OEM-supplied fire detection/suppression system was viewed as unreliable which made plant personnel very uncomfortable. It was scheduled for replacement. Personnel at the same plant also believed that the enclosures would not hold the concentration of suppression medium (Halon or CO_2) required because of leakage around doors, etc. They were in search of a procedure to test the entire system.

That brought up the question of how often attendees performed a concentration test. Initially, only one hand went up and that person volunteered the test was run by the insurer eight years after COD (commercial operating date). Then another user said that after several years of operation, it took three days of work to realign doors; replace seals, gaskets, and door latches; add a rack of bottles; and change dispersion nozzles to finally pass a concentration test—after three tries.

With a feeling of concern engulfing the meeting room, this question was asked: “What tests should you run and how often to ensure safety?” Someone responded by saying that NFPA (National Fire Protection Assn) specified a test every six months—but no one in the room knew what the test was. Bottle weight? Concentration test?

And in case there was someone in the room still feeling comfortable, the following experience was presented: System sounded a false alarm and either Halon or CO2 (couldn’t remember which) was released into the enclosure. After plant personnel were satisfied that no fire condition existed, the unit was restarted. Next day a lube-oil fire destroyed the engine; no one had refilled or replaced the bottles.

How long has it been since you heard an authoritative presentation on fire detection and suppression as been made at any power-industry meeting?

Wrap-up. As the meeting was winding down, the floor was opened to questions on any subject having to do with the Frame 6. Power augmentation got some play during the free-flowing discussion. Questions, comments, suggestions were offered on subjects as varied as the selection of media for evaporative coolers, thoughts on a homemade fogging system, thermal ice storage, steam injection, etc.

There is no better way for plant personnel to get a “professional tuneup” than to attend a user-group meeting. Only an ostrich would think otherwise. CCJ

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