Combined Cycle Users' Group begins a new tradition in Baltimore

COMBINED CYCLE USERS' GROUP

The inaugural meeting of the Combined Cycle Users' Group (CCUG) was held in late March as part of the Electric Power 2004 Conference and Exhibition in the Baltimore Convention Center, a stone's throw from Inner Harbor and the *USS Constellation.* Judging from the attendance and a first-class technical program, this event is on a fast track to becoming the premier industry event for folks who operate and maintain combined-cycle power plants. A quick survey of raised hands the first day showed that the majority of the attendees were owners or operators. Questions from the floor confirmed that the CCUG is a valuable forum for the exchange of ideas and operating practices beneficial to the entire industry—and espcially to the attendees.

Skillfully moderated by CCUG Chairman Andy Donaldson, project manager of Parsons Energy & Chemicals Group Inc., the three-day meeting featured a well-balanced program of technical sessions, application guidelines, and industry experience. Always a highlight of any users' group conference, questions from the floor kept the pace lively and the focus on finding answers to real-world problems facing plant operators (Figure 1). Other members of the CCUG board include Jeff Schroeter of Genovation Group Inc., Earl Saville of Bay Solutions, Murl Wallace of Progress Energy Inc., and Steve Clark of Calpine Corp.

During each of the meeting's three sessions, invited presenters addressed one or several industry-submitted focus issues with a brief speech and/or slide presentation. Each presentation was then followed by a Q&A session that gave everyone in the audience a chance to share how their plant approached and solved similar problems. In many cases, several effective solutions were detailed, along with a few that didn't work out as planned. But for most attendees, the opportunity to learn how to solve even one problem back home—not to mention the peer-to-peer interaction—made attending the CCUG meeting not just worthwhile, but invaluable.

Start-up planning counts

Joe Schroeder, VP of engineering at Nooter/Eriksen, kicked off the first-day session by discussing the interactions among major combined-cycle plant systems during cycling operation (Figure 2). His main topics were ramp rates and how to determine optimum start-up and shutdown times. Schroeder explained that the start-up of a heat-recovery steam generator (HRSG) must be carefully controlled to prevent steaming at low combustion turbine (CT) loads. Of particular concern is how to ramp up the CT from 20% to 50% load as its exhaust temperature peaks while the HRSG is just warming up. The superheater (SH) and reheater (RH) must be properly drained and care taken not to overuse desuperheating sprays to control steam outlet temperature. The last thing the HRSG and steam turbine need is "dumping of a lot of cold water into the HRSG," Schroeder said.

At the same time, the steam turbine must warm up and begin a load ramp while controlling SH temperature with attemperation flow. According to Schroeder, operating a combined-cycle plant is a "juggling act" that requires a "coordinated effort" to maximize the life expectancy of plant systems.

Schroeder presented a rule of thumb for determining a combined-cycle plant's start-up rate: the drum saturation temperature ramp rate, in degrees F per minute, should be equal to 160 divided by the thickness of the steel in the downcomer nozzle or thickest cross-section. For example, if the steel is 4 inches thick, then the start-up rate of the steam drum saturation temperature should be less than 10F/min.

Best cycling practices

During the same session, Jeff Philips of Fern Engineering presented an overview of results of a client study on best practices for cycling HRSGs. The results indicated that the best-performing plants:

- Conducted a design review whose results could be used to specify cycling design conditions and assess remaining fatigue life and ramping limits.

1. He's got the floor. Questions from the floor often spotlight practical problems and solutions that canned presentations fail to address. That was the case at the inaugural meeting of the CCUG, which was attended by about 100 operators, engineers, and technicians of combined-cycle plants. *Source: Platts*

- Implemented effective water layup procedures that could be either wet (using nitrogen or steam cap) or dry (draining hot and nitrogen cap).

Among the other results of the benchmarking study pertinent to short-term cycling operation were the following tips:

- Plants should gradually reduce SH temperature at shutdown and moderate the CT purge and its effect on steam temperature.
- Add SH/RH motor-operated drain valves and automate the drain sequence. In response to this advice, several attendees commented that many drain lines are undersized and should be increased in size and number. The consensus was that ¾-inch diameter drains are inadequate for cycling units. Nooter/Eriksen recommends that SH and RH drains be at least 2 inches in diameter.
- Keep the HP drum level as high as possible during shutdown.
- Add a stack damper to minimize loss of heat up the stack.
- For longer-term shutdowns, add filming amine to the boiler's feedwater to protect its tubes.

Best shutdown practices

During the same opening session, Bill Reed of FPL Group Inc. discussed the utility's successful use of inlet and stack dampers on "V" series CT plants. FPL's approach, he said, is to close the stack when the CT is at 300 rpm, close the inlet damper two hours later, and keep it closed until the unit is restarted. A Calpine Corp. representative in the audience noted that virtually all of the company's units are equipped with stack dampers and that standard practice is to bottle up the boilers when cycling. Bottling up the boiler can give the plant another 24 hours of downtime and make warm starts possible. He also suggested insulating the stack casing to the top. During the Q&A, other attendees recommended steam sparging to keep temperature and pressure up.

The lively discussion of plant shutdown procedures elicited several valuable comments from the floor. Attendees' concerns centered on the significant residual heat in headers during shutdown and the potential for quenching the lower headers. The consensus was that steam temperatures should be ramped down slowly. Keeping SH/RH temperatures at about 800F before taking the turbine off-line means the HRSG has to endure only a 200F temperature shock (at a saturation temperature of about 600F). If the steam temperature is allowed to be as high at 1,050F, the likely results are a turbine trip and considerably shortened fatigue life of key components.

Another bit of practical advice that emerged from this part of the session was the following. When using stack and inlet dampers, install controls interlocks to ensure that the dampers are open during start-up. Don't rely on delta P switches because they don't respond fast enough.

2. Joe Schroeder. The VP of engineering at Nooter/Eriksen, shared his thoughts on the interactions among the combustion turbine, HRSG, and steam turbine during plant start-up and shutdown. *Source: Platts*

Rules of the road

FPL's Reed observed that there are as many ways to start up a plant as there are control room operators. One of his company's keys to successful operation is using procedures and check sheets to standardize operations. To ensure that a plant is operated within its design limits, FPL recommends that users challenge original equipment manufacturers' (OEMs') requirements based on their operating experience. As an example, Reed discussed how FPL now delays starting the boiler feed pump at its plants until after the gas turbine is synchronized, to reduce auxiliary power use. Based on experience, FPL operators have established that the start-up water level should be about 1 foot below the operating level in the HP drum to account for swell.

Reed also shared several other operating recommendations:

- Establish one operations procedure and stick to it, for consistency's sake.
- Understand OEM requirements, learn which parameters maximize equipment life, and make sure there are plenty of ways to measure them.
- Get buy-in from plant operators.

Get involved!

The Combined Cycle Users' Group (CCUG) has been formed in cooperation with the ASME Power Division Combined Cycles Committee, the Electric Power Conference, and other industry groups. The CCUG's mission is to address issues of importance to users, particularly the interactions among the major systems of combined-cycle power plants: the steam turbine, combustion turbine, and heat recovery steam generator.

Copies of all presentations given within the CCUG track of Electric Power 2004 are posted on the group's Web site for members to download.

For more information, visit www.combinedcycleusers.org.

Life-cycle design

The final set of presentations at the opening session was led off by Vogt Power International Inc.'s Akber Pasha, who discussed how low-cycle fatigue and creep-design criteria are used in HRSG design. Essentially, HRSG manufacturers typically use a 50/50 split between fatigue and creep in their designs. But Pasha said that, in some cases, a detailed finite element analysis (FEA) is used when ASME code guidelines are inadequate. With FEA, the approach may get more detailed. Such analyses use a life-cycle profile of 20% cold, 30% warm, and 50% hot starts to more accurately reflect a customer's specific application.

Pasha was followed by Nooter/Eriksen's Lew Douglas, who began by noting that because fatigue is caused by pressure and thermal cycling, thorough definition of cycles is a prerequisite for any analysis. Once cycles are properly defined, an OEM can then model and analyze transients, understand how every part in the HRSG responds to them, and incorporate expectations of the most severe service expected into the final design.

Douglas also discussed the various codes that OEMs use to determine the fatigue life of components. In addition to ASME Section VIII, Division 2, there are the European codes TRD301 and EN12952-3, which provide much more detail and include pressure vs. temperature ramp rates and steam drum thermal gradient guidelines. The EN guidelines also provide usage control information that comes in handy if the plant's distributed control system is used to make component life assessments.

3. Diverse presenters. To ensure lively discussions and represent the perspectives of both vendors and users, the CCUG meeting's organizers maximized the diversity of presenters. At the dais during this session were (from left to right): Joe Schroeder of Nooter/Eriksen, Bill Reed of FPL, Steve Clark of Calpine, Akber Pasha of Vogt, and Jeff Philips of Fern Engineering. Andy Donaldson, Parsons E&C and CCUG chairman is behind the podium. *Source: Platts*

Size your staff

Judging from the other sessions, the staff of the typical combined-cycle plant has become as diverse as the plants represented at the meeting. For example, Reed noted that the staff of FPL Energy's Doswell plant has gone through several evolutions over the 12 years it has been in service.

In 1997, after the loss of several key people, Doswell took a multifunctional team approach by going to four or five teams with a minimum of four people per shift. In addition to having an area of expertise, each team member was cross-trained in operations, electrical, mechanical, instrumentation and control (I&C), and analytical skills. To promote continuity from shift to shift—especially in maintenance—communication is encouraged by a production coach. Currently, Doswell has a staff of 30.

Continuing the discussion, Mark DeWold of Progress Energy's Rowan County plant in North Carolina explained that his plant is dispatched, on average, about 100 days each year and occasionally is started up twice in the same day. Rowan County, which has five GE 7FA combustion turbines (two operating in combined-cycle mode) has a staff of 25, 16 of whom are CT technicians working in a 4 x 4 shift configuration.

During the same session, Mike Daigle, operations manager of Calpine Corp.'s Columbia Energy Center in South Carolina, explained that his plant has four control room (A) operators, six outside (B) operators and three I&C and three mechanical technicians. One A and two B operators are on shift at any time. Questions from the floor suggested that most plants do not differentiate between A and B operators.

If the comments made during the Q&A portion of this session are representative of industry practice, a trend in combined-cycle plant staffing is to hire journeyman operators qualified in one skill and then teach them other skills—using a combination of courses and on-the-job training. For summer cycling plants, the shoulder months seem to be the preferred times to do that training. Reed explained that at FPL, 70% to 80% of new operators come from the military, so they adapt quickly to shift work.

One operator of a unionized plant noted that it was extremely hard to get operators to branch out into other skill areas. However, the vast majority of the plants represented by attendees seemed to be non-union shops, so that was not considered a big problem.

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Hold your water

At one of the second-day sessions, Dennie Hunt of Vogt noted that one of the biggest challenges facing combined-cycle plant operators is proper care and maintenance of their feedwater treatment system. Flow-accelerated corrosion (FAC) is pH-driven, but it's tough to maintain a pH between 9.6 and 10 in a three-pressure steam generator, he said. Each plant requires a well-trained plant chemist to watch the water chemistry like a hawk.

Nooter/Eriksen's Schroeder added that while steam purity specs (sodium, cation conductivity, chlorides, and silica) are set by the steam turbine, the HRSG is typically concerned with pH and oxygen levels (using scavengers). Other issues discussed were the reliable measurement of pH and cation conductivity, and using an independent agent rather than your chemical supplier to audit your plant chemistry. On this topic, Kajal Mukherjee of Parsons E&C recommended that the oxygen levels in the deaerator should be around 7 to 10 ppb without oxygen scavengers. But he advised against going below 2 ppb, because doing so might expose the HRSG to more FAC.

Optimize pump size

Mukherjee went on to note that a typical 2 x 1 combined-cycle plant uses 20 to 25 gpm of water makeup. Based on his experience, different owners size their pumps as a function of their appetite for risk. For example, some may size the condensate pumps as 3 x 50%, or perhaps 2 x 100% for economic reasons. In either case, Mukherjee emphasized, the pumps should be value-engineered for the specific installation. The head requirements of the condensate pumps may be dictated either by the HRSG or by the steam dump requirements for the percent bypass required by the plant specification.

In the end, Mukherjee recommended optimizing the pumps to the HRSG's rather than the dump valves' requirements. Occasionally, these demands can be contradictory: At low load, the pumps' head and flow are down, but the attemperator sprays need high flow, especially during start-up. This natural tension must be resolved as a part of the value-engineering process during plant design, Mukherjee explained. Some plants have reported using boiler water from the hot end of the economizer as an alternative source of spray water, he said.

For another example of that tension, consider the diversity of configurations of boiler feed pumps at combined-cycle plants. At one plant, 2 x 100% pumps are used per HRSG. But at another, one of the pumps includes a hydraulic coupling. Though the operating costs of the second plant are higher, the hydraulic coupling saves power when the plant operates at part load for extended periods of time. Yet another strategy is to operate with a single boiler feed pump and keep a spare in the warehouse. ■