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Development of technically and economically viable processes for the conversion and utilization of fossil fuels is a major objective of both the DOE Fossil Energy program and EPRI. Many new and different processes are being investigated in areas of coal gasification, improved power generation and advanced combustion. As these processes evolve to the pilot plant stage and beyond, materials selection and component design become increasingly important for reliable and economical operation. The newsletter is intended to serve as a medium for exchange of information and experiences pertinent to the use of materials and components among the communities interested in the development of fossil energy systems.

Long-Term Test Results for Protective Coatings on the Furnace Walls of a Supercritical Boiler

One feature of a tightly-spaced, high heat-release boiler design developed by Babcock & Wilcox (B&W) during the 1960's which incorporates highly efficient burners in an opposed wall firing configuration is that it produces high levels of nitrous oxides (NO_x), typically in the 0.9-1.3 lbs/10^6 Btu range. These emissions must be reduced by at least 50% if this design is to comply with the 1990 Clean Air Act Amendment. A research project by B&W, with support from EPRI and the Department of Energy, resulted in the development of a new burner system able to achieve the desired NO_x reduction, while minimizing the capital cost of the system, as well as operational impacts such as furnace wall corrosion, large increases in unburned carbon in the fly ash, and CO emissions. This low-NO_x cell burner design is shown in Fig. 1, as configured for installation in Allegheny Energy Supplies' Hatfield's Ferry No. 2 boiler. The principal difference from the standard cell burner system is that the two burners in each cell are replaced by a single burner, closely coupled with an over-fire air (OFA) or NO_x port. In most cases the OFA port is located above the burner, but combustion modeling for Hatfield indicated that it was beneficial to reverse this order for some burners in the bottom row, to reduce the level of CO and H_2S near the side walls.

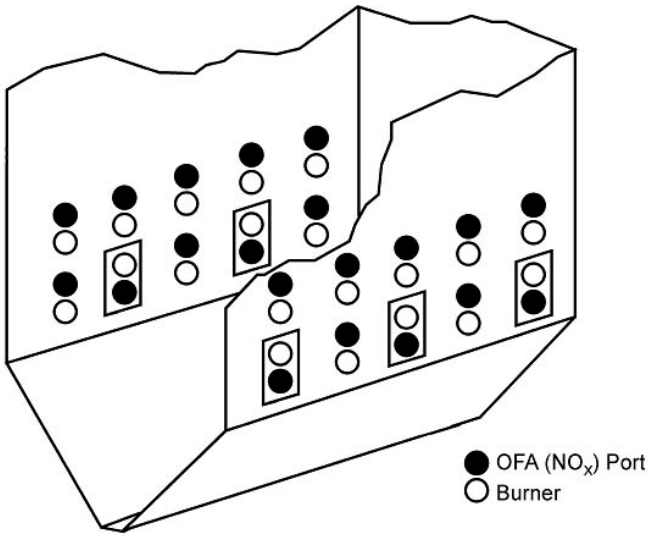

Figure 1. Schematic diagram of the low-NO_x combustion system as installed at Hatfield's Ferry No. 2

This burner system was first demonstrated on a commercial scale in the Stewart Station of Dayton Power and Light. In order to assess any increased corrosion potential of the low-NO_x burner system, a corrosion test panel of furnace wall tubes was installed. This panel contained samples of bare T-2 low-alloy steel (0.5 Cr-0.5 Mo, in wt %) and a Cr-diffused coating. The coating was approximately 0.5 mm (10 mil) thick, with a Cr content near the surface of the coating of 20-30%. The flue gas composition near the panel was found to be quite variable in both

In This Issue

Long-term test results for protective coatings on the furnace walls of a supercritical boiler....p. 1
Improved refractory materials for coal gasifiers....p. 4
Simulation of gasified biomass....p. 6
Materials and components developments in Siemens Weshinghouse's ATS program....p. 9
Recent developments....p. 12
Canadian approach to clean coal technologies....p. 13
Meetings calendar....p. 15
Calls for papers....p. 15
A word from our sponsors....p. 16

time and location, with maximum CO and H_2S contents (after burner optimization) of 8% and 500-600 ppm, respectively.

Corrosion loss measurements were made on the test panel after exposures of 15 and 30 months, and indicated corrosion rates of approximately 16 and 10 mil/yr, respectively (linearly-extrapolated). In contrast, the chromized coatings showed no measurable loss over the duration of this test. The T-2 tubes were found to have formed iron sulfide-rich scales, confirming that sulfidation was the main corrosion mechanism. Nevertheless, the sulfide scale exhibited reasonably good adherence to the tube surface and provided some protection to the bare metal. As a result of these tests it was concluded that the increase in corrosion potential from the use of these burners was relatively small

When cell burners were fitted to the Hatfield Station, a corrosion model based on the H_2S content of the flue gas and the corrosion rates observed at the Stewart Station predicted maximum corrosion rates less than 20 mil/yr (0.5 mm/yr), even though the sulfur content of the coals burned at the Hatfield Station was twice that at the Stewart Station. This led to a decision to apply a relatively inexpensive, in situ thermal spray coating (containing 44% Cr) to protect all areas thought susceptible to corrosion. In addition, to provide performance data on alternative coatings, corrosion test panels were installed in the furnace walls. After operation for 1.5 years, it was found that the corrosion rates were much higher than predicted, and that the thermal spray coatings had not provided adequate protection in the most corrosive areas. These observations led to the installation of another test panel that contained shop-applied weld overlay coatings, in addition to thermal spray and diffusion coatings. The compositions of the

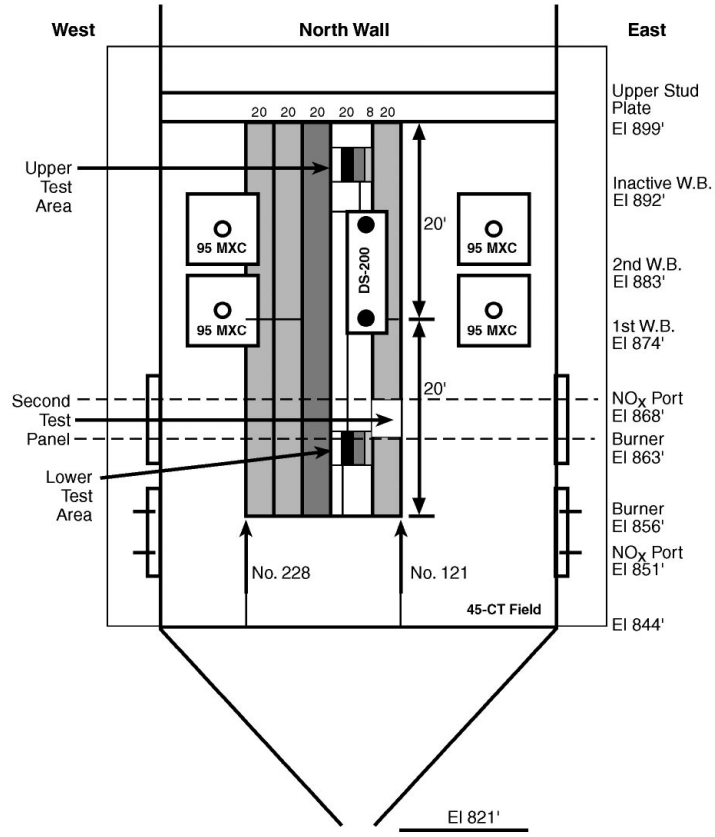

Figure 2. Schematic Diagram showing location of the test panels on the north wall of at Hatfield's Ferry No. 2

thermal spray coatings installed in the panels, designated 'upper' and 'lower' test panel in Fig. 2, are shown in Table 1. All of the panels were installed on the north sidewall of the boiler, since in this boiler design the sidewalls experience the most corrosion. The total exposure time experienced by these coatings was 39,816 hours, with most materials being removed after 12,633, 10,072, and17,155 hours.

Table 1. Composition of Coatings

Designation	Coating type	Composition, weight percent[e]						Thickness[f], mm (mil)
		Fe	Ni	Cr	Si	Mn	Other	
Coatings applied to first test panels								
A	wire arc[a]	0.4	bal	43.5			0.6Ti	0.5 (20)
B	wire arc[b]		bal	45	1.0	0.1	2.0 Al	0.5 (20)
C	HVOF		bal	42	2.0			0.5 (20)
D	wire arc[c]	bal		26	4			0.5 (20)
E		bal	6.5	21	1.8	1.0		0.5 (20)
Coatings applied to second test panel[d]								
Cr	diffusion	bal		20				0.2 (8)
Cr/Si	diffusion	bal		10	14			0.28 (11)
410	weld overlay	bal		12				2.8 (109)
625	weld overlay	1	57	21			14Mo, 7Nb	2.5 (99)
309	weld overlay	bal	12	23.5	2.5	2.5		3.3 (131)
312	weld overlay	bal	7	31	1.6			3.4 (135)

a: pre-alloyed feed wire
b: un-alloyed feed wire
c: shop applied
d: some thermal spray coatings also applied
e: composition of diffusion coatings as installed; weld overlays are nominal composition of filler metal (dilution during installation ≈ 15%)
f: nominal thicknesses of thermally-sprayed coatings; thicknesses of diffusion coatings quite uniform; thickness of overlay coatings variable due to bead overlap (min. wall thickness up to 0.75mm/30 mil less than average thickness)

Low Alloy Steels

During the first exposure period a significant difference was found between the corrosion rates of T-2 in the upper and lower test panels (rates of 0.75 vs 1.5 mm/yr; 30 vs 60 mil/yr). Flue gas measurements indicated similar amounts of H_2S (300-500 ppm) in both areas, but the deposits in the lower test areas consisted mainly of FeS, whereas those in the upper test area contained mainly Fe_3O_4. A detailed analysis of the scales and scale/metal interfaces showed that sulfidation was the only corrosion mechanism present. No chlorides or other corrosion products were detected. It was concluded that iron sulfide in the deposits was responsible for the high wastage observed in the lower panel. This additional wastage probably occurred during low-load operation (mainly at night), when the local oxygen content of the flue gas increased to 1-2%.

The corrosion mechanisms observed in the second test panel (containing weld overlays) were more complex. The presence of partially-oxidized, but still FeS-rich deposits suggested that the deposit again increased the sulfidation rate. However, the presence of chlorides in the deposit, and the high variability of the corrosion losses of both the first- and second-pass tubes, indicated that chloride corrosion may have played a significant role. This was confirmed by the presence of iron chloride at the scale-metal interface in a few locations, as illustrated in Fig. 3. Laboratory experiments had indicated that attack by gaseous HCl or Cl_2 could not explain the extreme variation in corrosion rates observed. It was suggested that the highly-variable wastage observed might be explained by irregular deposition of chlorides along the length of the tubes, with areas with high chloride content expected to show high corrosion rates, even though the average chloride content of the deposit was quite low. The proposed chloride corrosion mechanism appears likely to be similar to the attack by alkali chloride deposits sometimes seen in municipal solid waste-fired boilers under reducing conditions. Under oxidizing conditions, there is usually enough sulfur in the coal to prevent alkali chloride deposition (since sulfates are more stable than chlorides at deposition temperatures) but under reducing conditions a large part of the sulfur in the coal remains as FeS, or is converted to H_2S and other reduced sulfur species, so that alkali chloride deposition may be possible.

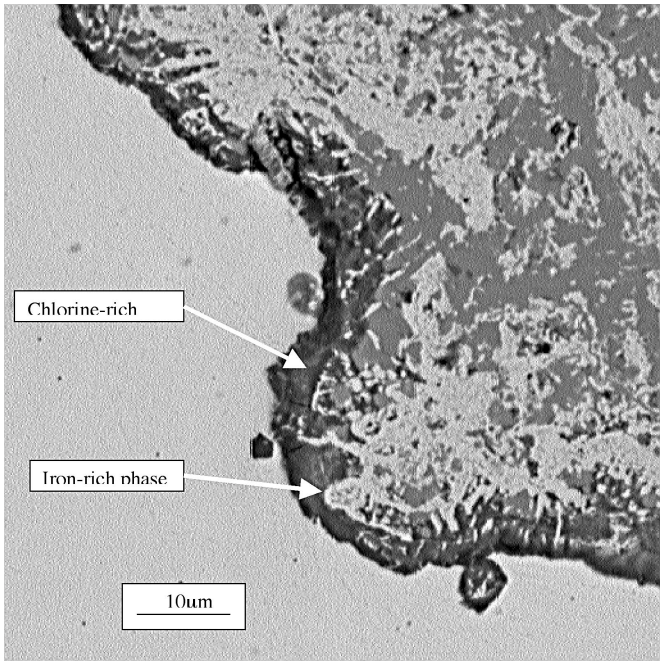

Figure 3. **SEM image of scale/metal interface of T-2 steel after 17,000+ hours of exposure**

Thermal Spray Coatings

The performance of the thermal spray coatings that were mostly applied by a wire-arc spray gun was mixed. The rate of wastage of the coatings was relatively low, and some spallation was noted on almost all coatings. The projected service lives were in the range of 3-5 years, or less in the most corrosion areas as indicated by a few forced outages within the two-year maintenance intervals. Adjacent to the area where maximum corrosion occurred, the performance of the thermally-sprayed coatings was generally good, whereas bare-tube corrosion rates in this location are generally less than 0.75 mm/yr (30 mil/yr).

Diffusion Coatings

The diffusion coatings used in the second test did not perform well. This may have been due in part to poor quality: thickness was marginal (0.25 mm/10 mil) and the Cr contents were lower than desired. However, experience with chromized coatings in gasification environments has indicated that they do not perform well when chloride deposits are present. Chloride corrosion may have accelerated the corrosion of the coatings in these tests.

Weld Overlays

Weld overlays with 12% Cr suffered from general corrosion similar to that seen on the bare tube metal, but at about half the rate. Weld overlays with more than 20% Cr generally exhibited very low corrosion rates. Alloy 625 (20-21% Cr) was the only weld overlay that exhibited measurable corrosion rates, in the range 0.125-0.25 mm/yr (5-10 mil/yr). This rate would provide a projected service of 8-16 years. The losses measured for type 309 stainless steel (23.5% Cr) and type 312 (31% Cr) were within the error of the measuring technique, so that their projected life was well in excess of 15 years. It was noted that alloy 625 is, in fact, preferred when chloride is a major corrodent in, for instance, municipal waste incinerators. The fact that the corrosion rate of this alloy was slightly higher than that of type 309 may indicate that sulfidation in the Hatfield boiler was still the dominant corrosion mechanism.

Abstracted from: W. T. Bakker, *EPRI*, J. L. Blough, *Foster Wheeler Development Corporation*, S. C. Kung, *McDermott*, T. L. Banfield, and P. Cunningham, *Allegheny Energy Supply*, "Long-Term Testing of Protective Coatings and Weld Overlays in a Supercritical Boiler Retrofitted with Low-NO_x Burners," Paper 02384, presented at NACE Corrosion/2002, Denver, Colorado, April 2002. Published by permission of NACE International.

Improved Refractory Materials for Coal Gasifiers

Despite the ability of coal gasification processes to convert coal to syngas at high efficiencies while providing for low environmental emissions, widespread adoption of coal gasification-based power generation systems will depend on whether the reliability, availability, and maintainability issues experienced by current units can be resolved. A key issue is the development of materials having longer service lives in gasifier systems that would allow extended periods of continuous gasifier operation. The main materials issues addressed in this work are refractories used for lining and insulating the slagging gasifier vessel, and thermocouple assemblies used to monitor gasifier operating temperatures.

The current generation of refractory linings used in slagging gasifiers typically are replaced every 10-18 months, involving materials and installation costs that can range up to two million dollars. These costs are compounded by the lost-opportunity costs during the 3-4 weeks that the gasifier must be off-line for refractory exchange. Further, the current generation of thermocouple devices used in gasifiers rarely survive the gasifier startup process, thus leaving the operator with no real means of temperature measurement during gasifier operation.

Current Status of Gasifier Refractories

Post mortem analysis of refractory bricks removed from commercial gasifiers, together with laboratory studies of refractory behavior in simulated gasifier environments, have indicated that a primary cause for the rapid degradation of the refractory lining in slagging gasifiers is slag penetration and attack of the refractory material. Figure 4 is an attempt to schematically illustrate these mechanisms. Essentially, stresses generated as the brick expands during heat up of the gasifier may lead to some initial cracking, and subsequent pinch spalling at the brick corners. As the feedstock is introduced into the gasifier and slag begins to flow down the refractory wall, the refractory is immediately penetrated by the slag and corrosion begins. Since the thermal gradient within the hot-faced brick is relatively flat (approximately 4°C/cm or 18°F/in), and the viscosity of the slag is typically low at gasifier operating temperatures, the slag is able to move deep into the refractory (to depths greater than 4 cm/ 1.6 in) via the interconnected porosity or along matrix grain boundaries. Slag penetration is facilitated by the presence of cracks vertical to the hot face.

Interaction of the slag with the refractory causes changes in mineralogy and/or physical characteristics that lead to the formation of cracks parallel to the hot face near the interface of the slag-penetrated zone with the virgin refractory. Sudden or large changes in gasifier operating temperature cause interconnecting of this crack system, which ultimately leads to large-scale material removal.

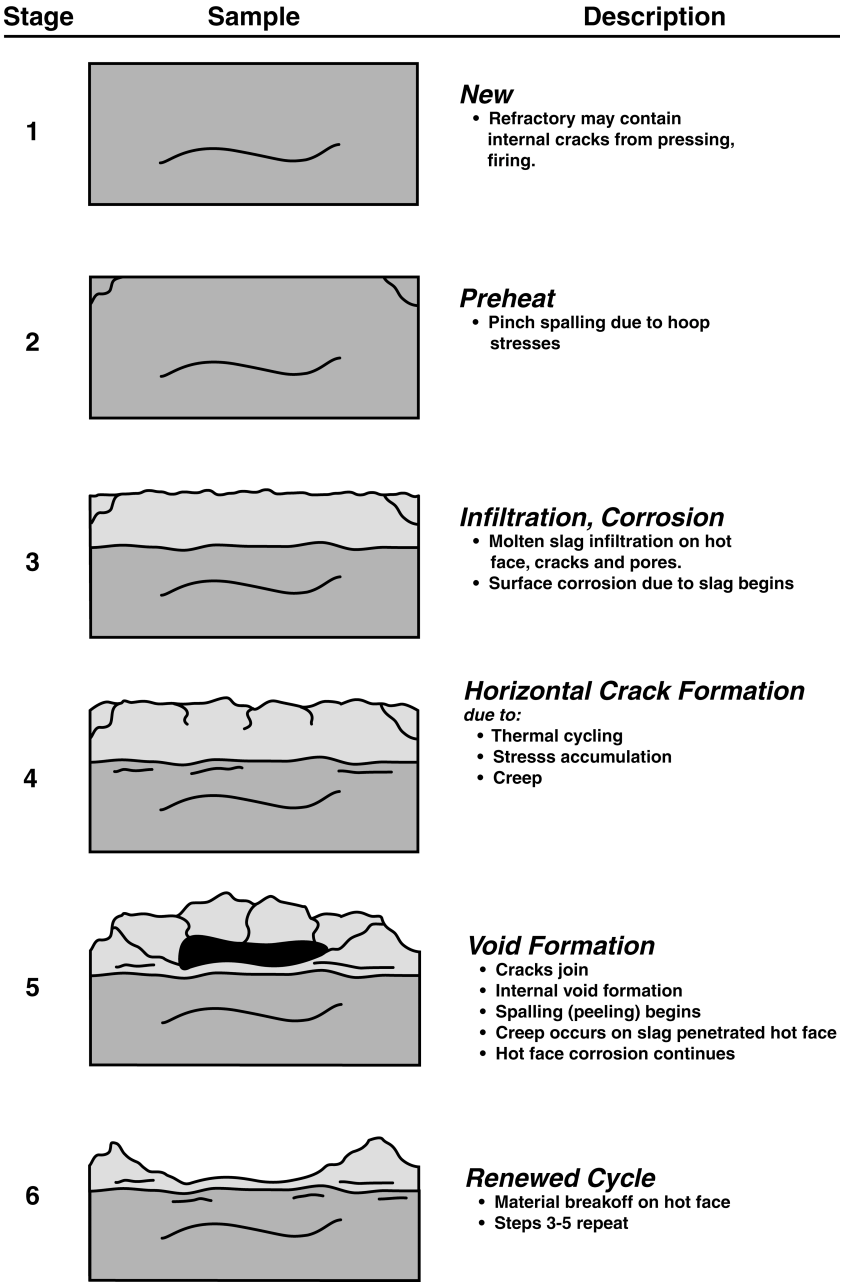

Figure 4. Suggested sequence of events in penetration and attack of a refractory by coal slag

After this occurs, the cycle begins again with renewed slag penetration and attack of the fresh refractory surface.

This overall failure mechanism is known as *structural spalling*, in which the actual volume of material removed is defined by the depth of slag penetration. Potential ways of reducing the ease of slag penetration into the refractory include:

- Changing the wetting characteristics of the slag by changing the slag composition or the wettability of the refractory;
- Reducing the level of interconnected porosity in the refractory by changing the pore size distribution; and
- Introducing an in situ change in the refractory microstructure upon reaction with the slag that effectively seals off the surface. Obviously any such changes must not degrade the other desirable properties of the refractory.

Refractory Development Approach

The approaches selected were to reduce the extent of slag penetration and attack or to modify the refractory such that changes in its microstructure resulting from interaction with the slag will effectively seal off the surface. Modified refractory compositions were exposed in a laboratory cup exposure test, in which a cup was drilled into each refractory brick, and then filled with a coal ash slag and exposed in a furnace at 1600°C (2912°F) for 24h under argon. The composition of the ash slag was (in weight percent): 51 SiO_2, 21 Al_2O_3, 20 Fe_2O_3, 6 CaO, and 2 MgO. The depth of penetration of the slag into the refractory was measured and compared to that for an unmodified, high-chromia (>80 wt % Cr_2O_3) refractory that was exposed in the same test and used as a standard for comparison. Microstructural and microchemical analyses were performed by scanning electron microscopy. The most effective addition was found to be a phosphate-based material (less than 5 wt %) such as $AlPO_4$, or $CrPO_4$. While the unmodified refractory control samples experienced essentially complete penetration by the slag to the bottom of the cup (>20 mm/0.8 in) in this test, slag penetration in the phosphate-modified refractory was limited to <1 mm (<0.04 in).

While the slag penetrated along matrix grain boundaries in the modified refractory as well as by interconnected porosity, there was very little slag interaction when fine-grained matrix and aggregate phases were used. It is thought that the improved resistance to attack results from an increase in the melting point of the slag following interaction with the phosphate constituent. This limits penetration to a narrow surface region and therefore reduces the potential for loss of large volumes of material from structural spallation. Additionally, the relatively small amount of phosphate addition required is not expected to lead to large-scale changes in the mechanical and thermal properties of the refractory.

Thermocouple Issues

The common experience of rapid failure of thermocouples in the gasifier environment is also a result of slag penetration and attack of the thermocouple assembly. The thermocouples used typically consist of an outer sheath (or sheaths) that are often made of Al_2O_3 or SiC, a filler material (which is usually Al_2O_3), and the individual thermocouple wires which are encased in an Al_2O_3 protective tube. However, since most molten gasifier slags are unsaturated with respect to Al_2O_3 at the operating temperature, the high-Al_2O_3 protection tubes and filler materials are particularly susceptible to attack. The SiC components are subject to rapid degradation from a combination of the high-temperature reducing conditions and the presence of iron in the molten slag. The approaches being used to increase the life of thermocouple assemblies include:

- Application of coating compositions formulated for resistance to the molten slag. These include Cr_2O_3 and W, and
- Development of an economical method of manufacturing thermocouple filler materials having a composition similar to the improved refractory material described previously.

These new or modified materials will be subjected to slag exposure testing and analysis to indicate directions for optimization.

Abstracted from: C. Dõgan, K-S. Kwong, J. Bennet, R. Chinn, and C. Dahlin, *U.S. Department of Energy, Albany Research Center*, "Improved Refractories for IGCC Power Systems," *Industrial Heating*, pp. 157-161, September 2002. Published by permission of Business News Publishing Company.

Simulation of Gasified Biomass

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Materials and Components Developments in Siemens Westinghouse's ATS Program

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Recent Developments

New low-NO_x Coal Combustor

Technologies developed by Alstom, Windsor, Connecticut, and Praxair, Danbury, Connecticut, can in many cases achieve the aggressive NO_x reduction required to meet the same stringent emission limits for which selective catalytic reduction (SCR) currently is needed. The Praxair burner was co-funded by the Energy Department in cooperation with the University of Utah, the University of Arizona, Reaction International Engineering Inc., and Alstom Power Inc. The Praxair technology enhances the combustion process with oxygen, which improves NO_x reduction compared to burners using only air. The Alstom project was also co-funded by the Department of Energy, and included participation from Progress Materials, Inc. and Kennecott Energy Co. The Alstom combustion system uses advances in control systems, combustion process modifications, and special carbon burnout technology to lower the formation of NO_x. A major advantage of these systems is that they are less complex and can be installed at a lower cost than SCR equipment. The next step will be to demonstrate both combustion systems in full-scale, multiple-burner configurations at sizes typical of larger commercial power plants.

—For more information, contact: David Anna, DOE National Energy Technology Laboratory, 412-386-4646, e-mail: anna@netl.doe.gov, or Bruce Lani, DOE National Energy Technology Laboratory, (412)-386-5819, e-mail: lani@netl.doe.gov

A New Order for the GE H-System CCGT

The General Electric Company is to supply three Frame 9H combined-cycle gas turbine systems for Tokyo Electric Power Company's (TEPCO) Futtsu Thermal Power Station Group No. 4 Project. Each system will include an MS9001H Gas Turbine, a steam turbine, and a generator. GE will be the prime contractor for the Futtsu No. 4 Project, with the three 9H gas turbines being built at the GE Greenville, South Carolina, plant. The gas turbine compressors, steam turbines, and generators will be built by Toshiba Corporation at its Keihin facility. The heat recovery steam generators, de-nitrification systems, and ancillary plant will be supplied by Toshiba Corporation and Hitachi Limited. The Futtsu Power Plant is scheduled to generate 1,520 MWe and the first unit is expected to be in commercial operation in mid 2008. All three units will be in service by mid 2010. TEPCO also operates 14 combined-cycle units based on the GE Frame 9E gas turbines, and three plants that feature GE Frame 9F-powered combined-cycle units.

The first application of the GE H-System engines is in Baglan Bay, Wales (See Materials and Components No. 157, pp. 13, April 2002). The Sithe Energies Heritage Station in up-state New York, which planned to be the first in the US to employ GE Frame 7H (60 Hz) gas turbines and to start operation in 2004, has been cancelled. This project apparently was a casualty of the Enron collapse.

—Abstracted from GE Power Systems News Releases.

Fuel Cell Developments

A hybrid power generation system combining a Siemens Westinghouse solid oxide fuel cell with an Ingersoll Rand (formerly Northern Research and Engineering Corp.) microturbine installed at the National Fuel Cell Research Center on the campus of the University of California-Irvine, has passed a 1,000-hour proof-of-concept test during which it was gradually brought to its full performance level. The next step is to operate the system for an extended period of time to ensure system stability. In this unit, the two technologies are combined to produce approximately 190 kW of electric power using natural gas as fuel. Early test data show electrical efficiencies of approximately 53%. Improvements in the technology could ultimately raise efficiencies to 60% for smaller systems, and 70% or higher for larger systems. Funding partners in the $16 million project include the U.S. Department of Energy, Edison International, the Electric Power Research Institute, the South Coast Air Quality Management District, and the California Energy Commission.

—For more information, contact: Robert C. Porter, DOE Office of Fossil Energy, 202.586.6503; for Southern California Edison contact: Paul Klein, 626.302.8066.

Siemens Power Generation is to supply a 250 kW solid oxide fuel cell (SOFC) to the Herren Hausen Power Plant in Hannover, Germany, under contract to Stadtwerke Hannover and E. On Energy A.G. The SOFC operates at almost 1000°C, and can use natural gas directly as a result of an internal conversion process. To date, Siemens Power Generation has nine demonstration plants in operation or on order. The SOFC is intended to provide 225 kW of electricity to the Stadtwerke Hannover grid, as well as some 160 kW of heat for Hannover's district heating network. The plant is to be ready in 2003. This unit is described as being close to Siemens first standardized SOFC power plant design, which will be marketed as the CHB250, with a cogeneration capacity of 250 kW. Work on constructing the production facility in Pittsburgh started in 2001, and series production is expected by 2003. Plans are to expand the capacity of the production facility in three phases, to exceed 100 MW per year by 2006.

Eventually, the range of products will be extended to include fuel cell systems as well as down-stream microturbines, for fuel cells with capacities of more than 500 kW.

Sulzer Hexis has delivered four of its HXS 1000 Premier fuel cell units to each of four marketing partners: ENBW Energie Baden-Wurttenbeg (Karlsruhe, Germany); BWE Oldenburg, Germany; EWR Elektrizitatswerke Worms, Germany; and to a consortium of Energie AG Oberosterreich and Oberosterreichische Ferngas AG, Austria. Plans are to install approximately 400 fuel cell combined heat and power (CHP) units by 2003, mainly in Germany, Austria, and Switzerland. These units are aimed primarily at the domestic CHP market. Sulzer Hexis received European Union quality compliance certification for this unit in 2001, which allows it to be marketed throughout the EU without the need for individual approval procedures.

DuPont, Canada, has initiated a four-year program in collaboration with Technology Partnerships, Canada, a government agency for strategic research investment, with the intention of developing key fuel cell components in addition to its current interest in membranes. The two main objectives are to develop conductive flow field plates (inter-connectors) and to design unitized cells which are intended to be the building blocks for stacks in proton exchange membrane (PEM)-based fuel cells. The first phase of the program will develop direct methanol-fueled PEMs, while PEMs fueled by reformate hydrogen or direct hydrogen will be addressed subsequently. The first commercial prototypes of the conductive flow field plates are expected to be delivered late in 2002. A pilot development facility is being created within DuPont's Research and Business Development Center in Kingston, Ontario, where evaluation and durability testing will be conducted.
—Abstracted from: *Modern Power Systems*, p. 45, March 2002.

A PEM Fuel Cell made by H Power Corporation of Clifton, New Jersey, and owned and operated by the Fall River Rural Electric Cooperative was installed in May 2002 at the western entrance to Yellowstone Park, where it will supply electricity to three entry station kiosks and an office building. In addition, it will provide heat to the office building. The fuel cell contains a steam reformer which allows it to produce hydrogen from the propane fuel used in this application. This residential cogeneration unit (RCU) 4500 Version-2 produces 4.5 kW of electricity, as well as supplying heat in the form of hot water. The fuel cell will undergo a one year trial in this difficult location, which involves not only a long, cold winter, but also a thin atmosphere (at 7,000 ft). The high altitude originally led to problems in adjusting the regulator on the fuel cell to obtain the correct mixture of hydrogen and oxygen.
—Reported on H Power Web Site, www.hpower.com.

Canadian Approach to Clean Coal Technologies

Finding cleaner ways of burning coal is a major priority considering the ongoing debate about Canadian strategies for meeting greenhouse gas reduction targets under the Kyoto Protocol. Coal was the source of nearly 82 percent of Canada's electricity-related emissions in 1999, even though coal-fired generation accounts for only about 18 percent of the country's power production. Since new technologies could lead to solutions that are both cleaner and more efficient, Natural Resources Canada (NRCan) provides the Canadian Government contribution to the Canadian Clean Power Coalition (CCPC) through two initiatives: the Industry Energy Research and Development Program, which is focused on energy efficiency, and Technology Early Action Measures, which is concerned with climate change.

The CCPC is in the early stages of a feasibility study that will guide the selection of technologies for two commercial-scale demonstration plants (roughly 300 MWe each), one retrofitted (by 2007) and one a 'green-field' site (by 2012). Three representative coals are being considered: Alberta sub-bituminous, Saskatchewan lignite, and the typical bituminous coal used in Nova Scotia and Ontario.

Technology Choices
The primary focus of the CCPC is on three technologies:

- Gasification
- Amine scrubbing
- CO_2/O_2 (oxy-fuel) combustion

Gasification is considered to be the best option for a green-field plant, while the other two are better suited for retrofit to an existing plant. There are several proprietary technologies for gasification and amine scrubbing, while the oxy-fuel approach is presently the least developed, in commercial terms.

Oxy-fuel combustion is based on the principle that if coal burns in an environment where nitrogen is absent or

minimized, the resulting CO_2 will be much less diluted and, therefore, easier to capture and sequester. While the underlying science has been developed by Natural Resources Canada, so far there has been no practical testing outside the laboratory. The oxy-fuel concept emerged at a theoretical level in the 1980s and has been the subject of important experiments in Canada, the US, and Japan. Canada became a leader in this effort when NRCan's CANMET Energy Technology Centre launched the Vertical Combustor Research Facility in 1994. The Argonne National Laboratory in the US undertook similar experiments, as did Ishikawajima-Harima Heavy Industries, with funding from Japan's Central Research Institute of Electric Power Industry (CRIEPI).

Now that the technical feasibility of this technology has been demonstrated, the next step is to show commercial viability. To this end, the CCPC has commissioned engineering studies to estimate the baseline costs for existing technologies, including the pollution abatement retrofits that will be necessary regardless of any strategy chosen for CO_2 sequestering. Once these base costs are established, it will be possible to estimate the marginal cost of removing CO_2. An important consideration is that a new technology does not have to be 100 percent effective to be economically viable—it needs only to be at least as good as the next best alternative for substantial expansion of generation capacity: natural gas. Meeting that standard would require removal of roughly half the CO_2 contained in the emissions of coal-fired power plants, although a zero-emission solution remains the ultimate goal.

Funding Problems

Public funding of clean coal technology development is subject to the same debate as in the US, but two main arguments are thought to have merit:

• while natural gas is becoming increasingly important, global energy demand is increasing much too quickly for gas (or other alternative energy sources) to provide all of the solution; and
• Canada has eight billion tonnes of proven coal reserves that represent a natural resource advantage.

Regardless of the source of funding, it is unlikely that clean coal technologies can be developed fast enough to meet the present targets, and this has fueled further debate. Predictions from modeling indicate that the least-cost response to reaching the Kyoto target, based on Canadian action alone, would require the electricity sector to contribute between 40 and 60 percent of the total, and that reductions of this magnitude within the required time frame would necessitate the retirement of coal-fired plants, with reductions of up to 75 percent in coal-fired generation. A major concern would be substantial stranded investment costs that would be passed on to consumers as existing plants were scrapped part way through their useful life.

However, because of the uneven distribution of energy resources across Canada, any strategy that places a disproportionate burden on coal in meeting the Kyoto targets has the potential to disrupt Canada's regional balance. Ontario, Quebec, British Columbia, Manitoba and Newfoundland have substantial hydroelectric assets and are less reliant on fossil fuels than the other provinces. Alberta, Saskatchewan, and Nova Scotia generate as much as 80 percent of their power from coal, and have only limited hydro resources. While these provinces also have substantial reserves of natural gas, they are challenged to manage their non-renewable resources in a balanced way to achieve long-run sustainability. Ontario is a major coal user, generating 24 percent of its electricity from five large coal-fired plants, but has no significant coal mining industry and their coal is imported, largely from the US. These considerations make the development of clean coal technology a Canadian national priority.

Commercial Viability

The CCPC faces significant technological obstacles in demonstrating the commercial feasibility of clean coal technologies. As was the case in the Clean Coal Technology program in the US, this will require spurring manufacturers and the engineering community to bring about a major change in the performance of technology. Commercial viability is especially important in light of the sweeping restructuring taking place in the electricity industry. Alberta and Ontario, which house about half of Canada's population, have unbundled and deregulated their generation, transmission, and distribution systems, and several other provinces have introduced varying degrees of competition into their wholesale electricity markets. Large, vertically integrated monopolies no longer dominate the industry. As a result, the market will ultimately allocate the costs of clean coal technology. While government has a role to play in developing the basic technology, in the longer term the application of that technology will have to be borne by the investors in the plants, and passed on to consumers.

Abstracted from: Ken Waldie, "The Search for Clean Coal Technologies," Combustion-News, http://www.combustion-net.com/library/combustion-news/0205/0205-clean-coal-technologies.htm

Meetings Calendar

November 28-30, 2002: The National Convention on Corrosion/Corcon 2002/The NACE East Asia Pacific Regional Conference, Goa, India. See Materials & Components, No. 157 for details.

December 2-6, 2002: The Fall Meeting of the Materials Research Society will be held in Boston. See Materials & Components, No. 158 for details.

December 2-6, 2002: A symposium on High-Temperature Thermal Spray Coatings-Thermal Barrier Coatings, will be held as part of the Materials Research Society's Fall Meeting, in Boston. See Materials & Components, No. 158 for details.

March 2-6, 2003: A symposium on "Materials Processing Under the Influence of Electrical and Magnetic Fields," held in conjunction with the 132nd Annual Meeting & Exhibition of TMS, San Diego, California, USA. See Materials & Components, No. 157 (Calls for Papers) for details.

March 2-6, 2003: A symposium on Computational Phase Transformations will be held at the 132nd TMS Annual Meeting & Exhibition, San Diego Convention Center, San Diego, California. See Materials & Components, No. 158 for details.

March 10-13, 2003: The 28th International Technical Conference on Coal Utilization & Fuel Systems, theme: Coal: Energy Security for the Future, will be held on at the Sheraton Sand Key Hotel, Clearwater, Florida. The goal is to present an extensive overview of emerging, evolving, and innovative technologies, fuels and/or equipment in the power generation industry, through the presentation of accomplishments, opportunities and challenges in the areas of: environmental & health aspects; advanced power systems & green coal technologies; utility perspectives on coal-based fuels; opportunity fuels; domestic & worldwide coal resources quality issues; transportation issues; international programs – technical developments/policy issues. For further information, contact: Barbara A. Sakkestad (CTA), 'phone: 301/294-6080; fax: 301/294-7480; e-mail: BarbaraSak@aol.com; or Web site: www.coaltechnologies.com.

March 16-20, 2003: CORROSION NACExpo 2003 will be held in San Diego, California. See Materials & Components, No. 158 for details.

April 7-9, 2003: The Fifth International Conference of the Engineering Integrity Society, "Fatigue & Durability Assessment of Materials, Components and Structures," Queens' College, Cambridge, England. See Materials & Components, No. 157 for details.

December 1-4, 2003: The World Conference on Corrosion and Corrosion Maintenance Expo and Celebration of the Ninth Corrosion Awareness Day, Mumbai, India. See Materials & Components, No. 157 (Calls for Papers) for details.

January 30-31, 2003: A European federation of Corrosion Workshop on Metal Dusting, Carburization and Nitridation (EFC-Event No. 258), DECHEMA, Frankfurt am Main, Germany. See Materials & Components, No. 158 for details.

Calls for Papers

April 7-9, 2003: The Fifth International Conference of the Engineering Integrity Society, "Fatigue & Durability Assessment of Materials, Components and Structures," will be held at Queens' College Cambridge, England. See Materials & Components, No. 157 (Calls for Papers) for details.

June 8-13, 2003: The Third Mediterranean Combustion Symposium (MCS-03), will be held in Marrakech, Morocco. See Materials & Components, No. 157 (Calls for Papers) for details.

September 1-5, 2003: Euromat 2003, The European Congress on Advanced Materials and Processes, will be held in Lausanne, Switzerland. See Materials & Components, No. 157 (Calls for Papers) for details.

September 15-19, 2003: The Twentieth Annual International Pittsburgh Coal Conference will be held in downtown Pittsburgh at The Westin Convention Center. Your contribution is solicited for the Combustion Technologies topic area. The session will focus on forward-looking approaches related to novel combustion systems, as well as sharing knowledge and insights on retrofitting and re-powering existing coal-fired fleets to assure clean, affordable, and reliable electricity supply. The Combustion technologies focus areas are: recent results in combustion of solid fuels including co-firing; advanced combustion concepts, e.g., IFC, FBC, PFB, CFBC, supercritical cycles, hybrid systems, Rankine cycle improvements; oxygen-enriched and other combustion modifications; pollutant formation; compliance technologies; other topics, e.g., environmental issues, permitting and regulations, issues on plant construction schedules, capital costs, plant siting, insurance, etc. One-page abstracts should be submitted by e-mail on or before January 1, 2003 via the web site at: http://www.engr.pitt.edu/pcc (Submission of Abstracts). The Session Coordinator is Arun C. Bose, Senior Project Manager, DOE/NETL; 'phone: 412-386-4467; e-mail: arun.bose@netl.doe.gov.

A Word From Our Sponsors...

EPRI is planning an international conference on *Materials and Corrosion Experience For Fossil Power Plants* for November 19-21, 2003 at the Wild Dunes Resort, Isle of Palms, South Carolina. This international conference is being organized to highlight fossil power plant experience in the areas of materials and corrosion. The major theme of the conference is to review, document, and transfer technology surrounding recent experience and developments in understanding the mechanisms, root causes of failures, assessment methodologies, remedial actions, and application of permanent solutions. The overall aim is to provide fossil plant engineers and operators, who are faced with continuingly aging power plant equipment and tighter maintenance budgets, access to improved understanding of the materials and corrosion experiences will assist them to avoid repeat equipment failures, and to effectively decide on replacement materials when required. Presentations will be made by U.S. and foreign utilities, equipment manufacturers, and consulting/research organizations. The preliminary technical scope of the conference sessions is as follows:

Metallurgical Characterization Methodologies: oxides, fracture strain of oxides, and oxide dating techniques; alloy embrittlement mechanisms and toughness correlation techniques; failure, failure analysis and mechanism identification; metallurgical and root cause analysis; field metallographic techniques; NDE methods for creep damage assessment or fatigue life prediction; sub-size specimen testing techniques; and residual stress characterization methodologies.

High-Temperature Materials: damage and failures in P91 or other 9Cr steels for piping and headers; characterization of damage in seam welded piping and girth welds; thermal fatigue damage in header ligaments; international utility experience with T91 tubing; life extension methodologies for high-energy components; cold-forming issues for austenitic and ferritic steels; and developments in ultra-supercritical materials.

Low-Temperature Corrosion: flow-accelerated corrosion in feedwater piping; condensers and auxiliary heat exchangers and corrective actions; corrosion in air preheater and ductwork; scrubbers, flue ducts and stacks; stress corrosion cracking experience in rotors/discs SPE, coatings; water cooled electric generators; cooling towers and raw water systems; feedwater treatment systems; selected catalytic reduction corrosion issues; materials, welding, and corrosion requirements for HRSGs; low-temperature corrosion monitoring techniques

High-Temperature Corrosion: assessment of oxides and their exfoliation in boiler materials; wastage and wastage rates in waterwalls; performance of corrosion-resistant waterwall weld overlay materials; boiler tube failures, prediction, and prevention; and fireside corrosion instrumentation.

The conference will consist of both invited and contributed technical papers. Abstracts must be submitted by March 31, 2003, to Melissa Wade, Conference Coordinator, EPRI, 1300 W.T. Harris Blvd., Charlotte, NC 28262; 'phone: 704.457.6176; fax: 704.547.6109; or e-mail: melwade@epri.com.

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Materials & Components Newsletter is available free of charge to qualified individuals worldwide who are involved in present or potential materials/components activities related to the development of fossil energy systems. Requests to be placed on the distribution list should be addressed to: Ian G. Wright, Oak Ridge National Laboratory, Bldg. 4500-S, P.O. Box 2008, Oak Ridge, TN 37831-6156, telephone (865)574-4451, fax: (865)241-0215, e-mail: wrightig@ornl.gov.

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