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Authors:
D.R. Hafer
M.J. Mudd
M.E. Zando

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TEST RESULTS FROM THE 70 MW TIDD PFBC DEMONSTRATION PLANT

D. R. Hafer, M. J. Mudd, M. E. Zando

American Electric Power Service Corporation
Columbus, Ohio

ABSTRACT

The 70 MWe Tidd PFBC Demonstration Plant in Brilliant, Ohio, the first PFBC demonstration Plant in North America, is in its third year of operation and testing. Operation of the Tidd Plant has provided invaluable experience with the systems required to apply PFBC technology to electric power generation. It has also provided operating data to verify the ability of the PFBC process to achieve a high degree of sulfur removal and low NOx emissions when burning high-sulfur bituminous coal.

This paper provides an update on the operating experience of the Tidd PFBC Demonstration Plant, reviews the lessons learned with PFBC technology in the start-up and debugging of the PFBC systems, and provides data from the operation and performance tests conducted at the Tidd Plant.

INTRODUCTION

The Tidd PFBC Demonstration Plant, a 70 MWe electric generating station in Brilliant, Ohio, is the first pressurized fluidized bed combustor to operate in combined-cycle mode in the United States. Owned and operated by Ohio Power Company, a subsidiary of AEP, the plant is located on the banks of the Ohio River, approximately 75 miles downstream of Pittsburgh, Pennsylvania. Funding for the $193 million project is being provided by Ohio Power Company, the U. S. Department of Energy ($60.2 million), and the Ohio Coal Development Office ($10 million).

Engineering and design services for the project were provided by American Electric Power Service Corporation. Technology related equipment was supplied by ASEA Babcock, a partnership between ASEA Brown Boveri Carbon and Babcock & Wilcox. New construction and modification of the old facility were carried on by Ohio Power Company.

American Electric Power began investigating pressurized fluidized bed combustion in 1976, and after a decade of studies and testing of the technology, detailed design work began in May, 1986. Construction began for the demonstration plant in April 1988, and unit start-up was initiated in November 1990. The first combined cycle operation was achieved on November 29, 1990, and the three-year demonstration period began on February 28, 1991. Through the end of 1992, the plant has achieved over 3000 hours of coal-fired operation.

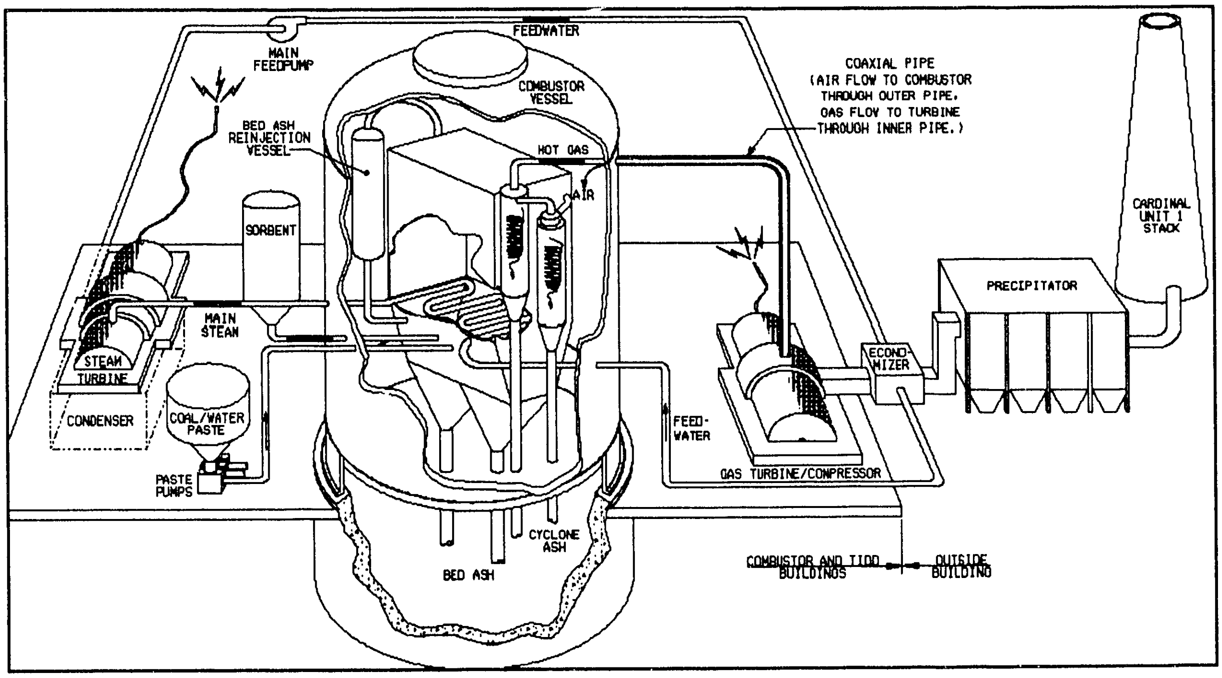

FIGURE 1
TIDD PFBC ISLAND

PLANT DESCRIPTION

The original Tidd Plant, consisting of two 110 MWe conventional coal-fired generating units, was built in the 1940's and decommissioned in 1976. Unit 1 was repowered with a PFBC system by replacing the boiler and reusing most of the balance of plant equipment. Other major plant additions and improvements associated with the demonstration plant include the combustor building, economizer, electrostatic precipitator, and storage areas for coal and sorbent.

PFBC Power Island

The PFBC island, (Figure 1) which has been incorporated into the existing conventional steam cycle, provides a nominal steam flow of 440,000 pounds per hour (55.4 kg/s) at 1,300 psia (89.6 bara) and 925°F (496°C), and has a gross electrical output of about 70 MWe (55 MWe from the steam turbine and 15 MWe from the gas turbine).

Combustion air at about 175 psia (12 bara) is provided by the gas turbine compressor to the combustor pressure vessel through the outer annulus of a coaxial pipe. The combustion air fluidizes and entrains bed materials consisting of coal, coal ash, and sorbent (either dolomite or limestone). The bed temperature is held in the range of 1540 to 1580°F (838 to 806°C), which is between the coal combustion temperature and the ash fusion temperature. Formation of NO_X is minimized due to the relatively low combustion temperature of the PFBC process. SO_2 generated during combustion is removed by reaction with the sorbent material.

Seven strings of two-stage cyclones located within the combustor vessel remove about 99 percent of the entrained ash from the fluidized bed exhaust gases. The clean, hot gases leave the pressure vessel via the inner flow path of the coaxial pipe and are expanded through an ASEA Stal GT-35P gas turbine, then exit through the turbine exhaust gas economizer. An electrostatic precipitator further cleans the gas of particulate prior to exhausting to the atmosphere.

The steam cycle is a Rankine cycle with a once-through boiler. Condensate is heated in three stages of low-pressure heaters and the gas turbine intercooler as it is pumped to the deaerator. A single high-pressure heater and the economizer raise the final feedwater temperature to about 480°F (250°C). The feed-water passes through the boiler bottom zone and into the in-bed evaporator surface. Steam generated there is conveyed to a vertical separator outside the pressure vessel; flow to the separator is two-phase up to about 40 percent

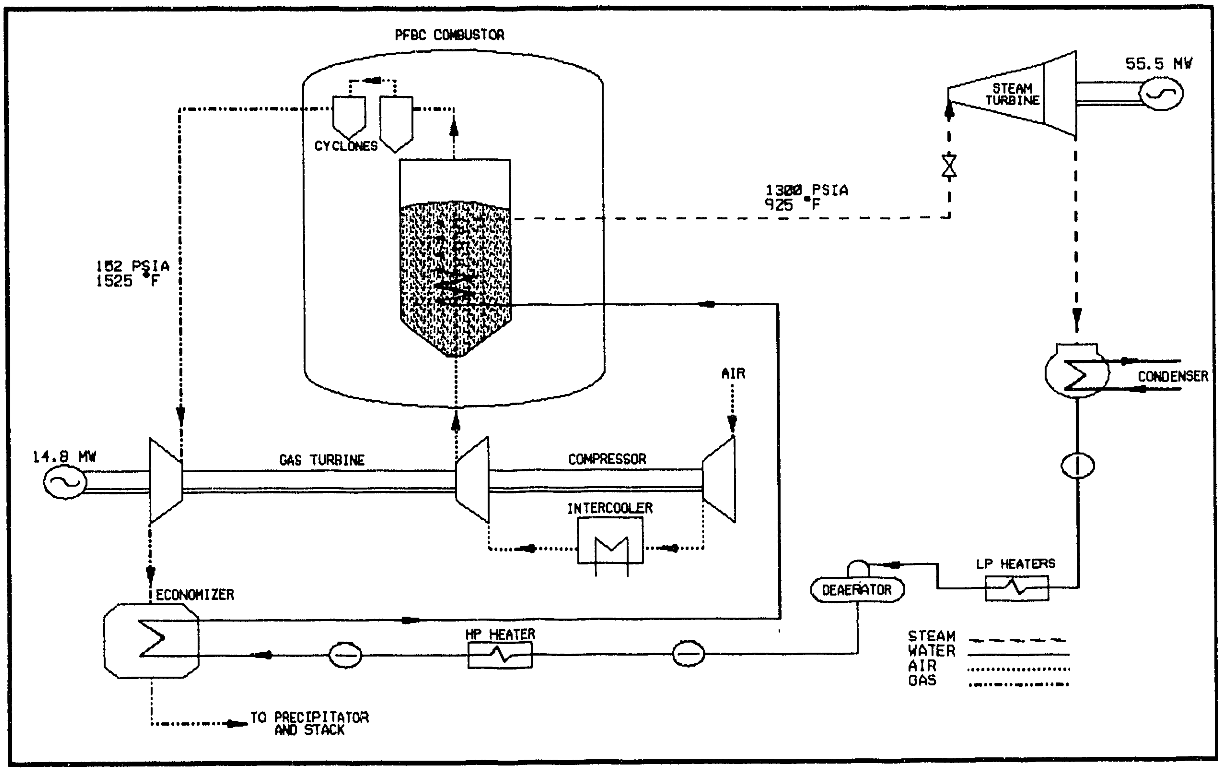

FIGURE 2
TIDD CYCLE SCHEMATIC

load and slightly superheated at full load. Saturated or slightly superheated steam from the vertical separator is routed back to the in-bed tube bundle where it passes through primary and secondary superheater sections. Final steam temperature is controlled by spray attemperation between the primary and secondary superheaters. Figure 2 depicts the Tidd combined cycle.

Material Preparation and Handling Systems

Coal is injected into the combustor as a coal-water paste (CWP) nominally containing 25 percent water by weight. Paste preparation begins by reducing the 3/4" (1.9 cm)x0 feedstock to -1/4" (.63 mm) in a Krupp Polyseus double roll crusher. The crushed coal is conveyed to a vibratory screen (which controls the coal top size), and then into the coal-water paste mixer where water is added. The mixer discharges the coal-water paste to two interconnected surge tanks which feed six hydraulically driven piston pumps, each of which supplies an individual fuel nozzle. The fuel nozzles are located under the bed.

The sorbent, dolomite or limestone, is crushed from 3/4" (1.9 cm)x0 to 1/8" (.32 cm)x0 by a hammer mill crusher. A vibratory recycle screen controls the top size of the prepared sorbent. Crushed sorbent is injected into the fluidized bed via two pneumatic feed lines supplied from dual lock hopper strings.

Bed ash, which comprises about 50 percent of the total ash produced, is removed from below the bed via a lock hopper system. Elutriated ash collected by the cyclones is removed via a pressurized pneumatic transport system which depressurizes and cools the ash without using valves or lock hoppers.

HGCU Test Facility

In 1992 a demonstration-scale hot gas clean-up (HGCU) system, separately funded by the U.S. DOE as an R&D project was installed at the Tidd Plant. One-seventh of the PFBC main gas flow is diverted to a new ceramic barrier filter and back-up cyclone, and is then directed back to the secondary cyclone outlet header inside the combustor pressure vessel. Reference (2) provides details concerning the Tidd HGCU system.

OPERATIONAL OVERVIEW

From November 1990 through the end of 1991, Tidd operated on coal for a total of 818 hours, with the longest continuous run being 110 hours. A number of operating difficulties were experienced during the early runs of the unit, and frequent minor modifications were made to improve unit operability. Several significant deficiencies affecting unit performance and reliability were also identified during the first year of operation, and in mid-September 1991, the unit was taken out of service for a planned twelve-week outage to make major modifications. Some of the major modifications made during that twelve-week outage include:

- Added steam generation surface to the in-bed boiler tube bundle to increase the steaming capacity of the unit.
- Replaced the expansion joints in the sparge (fluidizing air) ducts due to thermal cracking.
- Installed steam nozzles in the freeboard.
- Revised the cyclone ash removal system.
- Replaced the CWP pump mixer internals and rebuilt the CWP pumps.
- Revised the sorbent lockhopper valves.
- Installed sootblowers and anti-vibration bars in the economizer.

Details of these changes are discussed later in the paper.

The unit was returned to service in December 1991. After some initial problems which required another short outage to correct, the unit began to operate more consistently. However, run durations were still limited by operating problems. From mid-December 1991 through early March 1992, the unit operated on coal for a total of 530 hours, with the longest run being 154 hours.

In mid-March 1992, fatigue cracks were discovered in the blade roots of the low pressure gas turbine. The cracks were due to resonant vibration at certain operating speeds of the variable-speed shaft. This problem was generic to the design of the GT-35P gas turbine, and was not directly related to PFBC technology. The turbine blades were replaced during an ensuing nine-week outage. The HGCU test system, configured in the bypass mode, was also tied in at this time. In addition, an extensive coal preparation system test program was undertaken during this outage in an attempt to improve coal paste quality and crusher reliability.

The unit was returned to service on May 10, 1992, but experienced a failure of an expansion joint in the newly installed HGCU piping. In order to allow the operation of Tidd while the HGCU System was being modified, the one cyclone string used by HGCU was isolated, to allow operation of the unit with six cyclone strings.

The unit was returned to service in early June 1992, and operated continuously for 31 days at a capacity factor of nearly 70 percent. During this run, unit acceptance tests were conducted. In July 1992, the unit was removed from service in a controlled manner to perform equipment inspections.

Table 1 provides a summary of the operating statistics of the Tidd Plant through the end of 1992.

TABLE 1
TIDD OPERATING STATISTICS
THROUGH DECEMBER, 1992

INITIAL COMBINED-CYCLE OPERATION	Nov. 29, 1990
TOTAL OPERATION ON COAL	3220 Hours
LONGEST CONTINUOUS RUN	740 Hours
HIGHEST BED LEVEL ACHIEVED	142 In. (3.6 m)
HIGHEST GROSS GENERATION	70 MWe
TOTAL GENERATION	125,974 MWh

SYSTEM OPERATING EXPERIENCE

Post-Bed Combustion

Tidd experienced incomplete combustion in the bed during the early operation of the unit, leading to post-bed combustion. Two different types of post-bed combustion were experienced during the first year of Tidd operation.

The first type of post-bed combustion occurred primarily at low loads and was centered in the dip legs (lower portion) of the cyclones. Such fires were attributed to excessive carryover of carbon at low bed heights and were particularly prevalent when sorbent was not being injected. Ash sinter formation with resultant pluggage of cyclone dip legs and ash removal lines was a typical consequence of post-bed carbon fires.

The second type of post-bed combustion affected the entire gas stream through given cyclone strings. This type of combustion was attributed to incomplete combustion of volatiles in the bed due to localized oxygen depletion near the fuel nozzle outlets. Excessively high freeboard and cyclone temperatures that approached material limits, and thus necessitated a load reduction or unit trip, were typical consequences of post-bed volatile fires. Initial efforts to mitigate volatile fires were directed at achieving better distribution of the fuel in the bed (by biasing fuel flow to individual nozzles, by adding baffles above the fuel nozzles, and by providing more air to the fluidizing nozzles near the fuel injection nozzles), which resulted in some improvements. It was also determined that the intensity of the fires could be reduced by firing drier coal paste. This was apparently due to the ability of the fuel nozzles to produce larger and more uniform-sized "paste lumps" with dry paste, thereby reducing volatile releases in the immediate vicinity of the fuel nozzles.

During the Fall 1991 outage, additional modifications were made to the coal injection system to improve the distribution of the fuel within the bed. In addition, a freeboard gas mixing system was installed to mix the freeboard gas using steam jets, and cause any volatiles which escape the bed to burn in the freeboard region. This allowed the concentrated heat release to be spread over the entire gas flow rather than allowing it to concentrate in one or two cyclone strings. In addition to these hardware changes, operating practices were developed to allow production of a drier coal paste that could still be readily pumped.

The above efforts produced a noticeable improvement in volatile fires during test runs in the period from December 1991 to March 1992. However, on-going efforts to dry out the paste frequently resulted in coal injection line pluggage. The cyclone dip leg fires that had previously occurred only at low loads were now occurring at much higher loads. It was discovered that these fires could also be controlled through use of the freeboard steam mixing system, which tends to more evenly distribute the unburned carbon to the cyclone strings.

Presently, with improved coal paste quality (as discussed later) and continuous use of freeboard mixing, the unit operates with no evidence of significant post-bed volatile or carbon fires.

Boiler

The amount of in-bed boiler tube surface provided initially was inadequate and resulted in achieving only 73 percent of design heat transfer at the original full bed height of 126 inches. During the Fall 1991 outage, approximately 25 percent more in-bed surface was added above the existing tube bundle to increase the heat absorption. The new full bed height at Tidd is now 142 inches (3.6 m).

After over 3,000 hours of operation on coal at Tidd, in-bed tube erosion has not been an issue. Only minor tube erosion, due to local flow disturbances, has occurred in localized areas near the bottom of the tube bundle.

TEG Economizer

The finned-tube turbine exhaust gas economizer has exhibited significantly heavier fouling than anticipated, resulting in excessively high gas side velocity. Vibration induced by the high velocity is believed to be the cause of four tube failures that occurred during mid-1991. In order to resolve this issue, eight soot blowers and additional anti-vibration tube supports have been installed.

Sorbent Injection System

At initial start-up, the sorbent injection system experienced numerous operating difficulties related to valve and rotary feeder malfunction and wear. Severe erosion of the sorbent transport piping was also a problem. Through various material changes and equipment replacement, the system is now reliable.

An additional concern relates to the formation of sorbent-based deposits in the tube bundle above the two sorbent injection nozzles and the adjacent coal nozzles. The deposits, which are agglomerates of bed material and very fine sorbent particles (with no evidence of fusion), appeared for the first time in January 1992. The cause of the deposits was not readily apparent. However, changing the point of sorbent admission into the bed (by shortening the injection nozzles) and slightly increasing the sorbent injection velocity has eliminated these formations during subsequent runs. Additional investigations and experiments will be performed in the future in order to obtain a better understanding of this phenomenon.

Coal Preparation/Coal Injection System

The coal preparation system was designed to crush 3/4" (1.9 cm) x 0 coal to a size distribution suitable for both good paste pumpability and good combustion within the fluidized bed. The critical parameter for good pumpability is that at least 20 percent of the crushed coal must be -325 mesh. This allows the moisture content of the paste to be maintained in a range of 24 to 25 percent by weight. As the fraction of -325 mesh declines below 20 percent, the moisture content of the paste must be increased to preclude pluggage of the system.

During the first 14 months of operation, the coal crusher was not capable of producing the proper size of coal required for good pumpability. With the -325 mesh fraction varying from 12 to 15 percent, the moisture content of the paste had to be increased to the range of 25 to 28 percent by weight, which adversely affected combustion performance. Numerous changes were made to the crusher during this period to improve the production of -325 mesh fines, but without success. Modifications included installation of larger drives, installation of grooves on the roller surface, and application of several different control modes.

Just prior to the gas turbine outage in March 1992, a recycle loop was added to the system to permit up to 100 percent of the feed coal to be fed through the crusher a second time. This has been effective in producing a higher amount of -325 mesh fines. The 31-day continuous run in June-July 1992 verified this mode of operation when the -325 mesh fraction ranged from 18 to 22 percent and the coal paste was consistently maintained at 24 to 25 percent moisture by weight.

Another problem experienced with the coal system was rapid corrosion of carbon steel surfaces in contact with paste. The nominally 3.5 percent sulfur Pittsburgh No. 8 coal being tested at Tidd, when mixed with water, produces a paste with a pH as low as 3. This resulted in significant corrosion damage to the coal paste mixer and coal paste pumps from November 1990 to September 1991. During the Fall 1991 outage, all carbon steel surfaces in the mixer and paste pumps were replaced with austenitic stainless steel. To date, these modifications have been successful.

The coal preparation system has also demonstrated a sensitivity to the type and moisture content of the coal being fed. The crusher has experienced pluggage and slipping of coal between the rollers when there has been a significant change in the surface moisture of the coal.

Gas Cleaning Cyclones/Ash Removal Systems

The gas cleaning equipment for Tidd consists of seven parallel strings of cyclones. Six of the strings have two stages of cyclones referred to as the primary and the secondary. The seventh string has a primary cyclone, followed by the Hot Gas Clean Up Advanced Particle Filter. Ash collected in each cyclone is pneumatically transported from the combustor vessel using the combustor pressure as the driving force.

During early plant operation, from December 1990 to March 1991, pluggage of the secondary cyclone ash removal system resulted in unacceptable unit availability. Numerous modifications were made to reduce pressure drop in this system and thus increase transport capacity. Originally, the seven primary and seven secondary ash lines combined into one line which was routed to the cyclone ash silo. By March 1991, the primary and secondary cyclone ash removal systems were decoupled and the secondary ash line was routed to the precipitator inlet. In addition, several modifications were made to the ash lines inside of the combustor vessel to further improve transport capacity.

Starting in March 1991, secondary ash transport capacity during unit operation was sufficient to permit reliable operation of the secondary ash system. At shutdowns, however, ash buildup in the cyclone dip legs would not permit restart of the unit until the ash was removed from the dip leg. In order to minimize the impact of this build-up on unit operation, the dip legs of all secondary cyclones were shortened approximately 20 feet during the Fall 1991 outage.

After the Fall 1991 outage, pluggage of the secondary ash system again adversely impacted unit availability. In mid-January 1992, pluggage was found to be caused by excessive pressure drop in the secondary ash line outside of the combustor vessel. The pressure drop was reduced by redesign and replacement of the ash line, and the system began to function properly. The secondary ash removal system is now considered marginally acceptable. Pluggages still occasionally occur at start-up, but experience has shown that they tend to clear themselves when combustor vessel pressure increases after firing coal. During the 31-day run, one secondary cyclone remained plugged, however, subsequent inspection revealed the pluggage was due to a restriction of the ash pick-up nozzle by a foreign object.

Operation of the primary cyclone ash removal system has generally been acceptable, except for a two-month period in mid-1991, when pluggage of the primary ash removal system began to impact unit operation. At first, each pluggage could be traced to a process upset, usually in the sorbent injection system. It was believed that the process upset resulted in a temporary increase in ash loading to the cyclones which overwhelmed the transport capacity. However, the system was totally dismantled and inspected as part of the Fall 1991 outage, and the real cause was discovered. It was found that air in-leakage into the primary ash line flanged connections inside the combustor vessel significantly reduced the transport capacity of the system.

An extensive program was instituted during the Fall 1991 outage to eliminate the air in-leakage in both the primary and secondary ash removal systems. Bolted connections were replaced with welded connections where possible, shop fabrication flaws in cast components were repaired, and extensive quality control measures were applied to tightening procedures for the bolted connections that could not be replaced. The modifications were successful in reducing the extent of cyclone pluggage, however, the system was again rebuilt to eliminate leaking connections in January, 1993, after primary cyclone pluggage began to become more frequent. In addition, the unit has experienced several trips during starts when aged spent bed material, or bed material which was excessively handled, was used to build the initial bed. Such bed material tends to break up and overwhelm the primary cyclone ash removal system during start-up. Therefore, sand is the preferred material for establishing a start-up bed after a long unit outage.

Gas Turbine

The gas turbine has experienced a measurable amount of erosion after 2100 hours of coal-fired operation. Periodic inspections have shown that normal unit operation produces very little erosion, however, the erosion rate increases significantly when cyclone ash removal lines are plugged. The most serious erosion has occurred when a primary cyclone ash removal line plugs. In such an event, the corresponding secondary ash removal line is overwhelmed and quickly plugs.

Primary cyclones normally collect 98 percent of the ash in the gas stream and the secondary cyclones remove approximately 33 percent of the remainder. When an entire string plugs, the gas turbine dust loading increases ten fold. A more important factor, however, is the size of the particles reaching the gas turbine. Each cyclone stage collects progressively smaller particles, with the normal secondary cyclone exhaust dust containing virtually no particles larger than five microns. When an entire string is plugged, the gas turbine is exposed to particles as large as 250 microns. The erosion rate is much more sensitive to particle size than to dust loading. Generally, when only a secondary cyclone ash removal line plugs, the increase in erosion rate is minimal. However, during the 31-day run, the unit was operated with one secondary cyclone plugged and erosion was higher than anticipated. The system configuration with six cyclone strings is thought to be a possible contributor to this increased erosion.

An ongoing problem with the gas turbine has been bypassing of air from the high pressure compressor directly into the turbine. The present estimate of this leakage is approximately three times the design value for seal and cooling air flow. Given the limits on compressor volumetric flow, this leakage results in limiting the unit firing rate, with the limit being more severe with increasing ambient temperature. Modifications to a suspected area of leakage during the Fall 1991 outage did not resolve the problem, and investigations are continuing to identify the cause of the leakage.

As noted earlier, fatigue cracks attributed to resonant vibration were found in the root area of a number of low pressure turbine blades in March 1992. New blades designed to prevent this condition were installed before the unit was returned to service in May 1992.

UNIT PERFORMANCE

Unit performance tests for contract acceptance were conducted in June 1992. The tests were run at full bed height with the maximum firing rate and highest bed temperature attainable at that time. Firing rate was limited by the available air from the gas turbine. The steam flow was impacted by deficiencies in both in-bed tube bundle and economizer absorption capabilities. In addition to the effects of reduced firing rate and low steam flow, gross unit output was affected by degraded steam cycle and gas cycle efficiency. Table 2 provides key operating results during the performance tests.

TABLE 2

TIDD PFBC PERFORMANCE TEST RESULTS

	Test June 1992	Test Feb 1992	Design
Unit Firing Rate			
(MWT)	190.3	205.1	204.4
Gross Unit Output			
(MWe)	60.2	70.0	72.5
Gas Turbine Output			
(MWe)	13.2	15.8	15.4
Mean Bed Temperature			
(F)	1550	1579	1580
(C)	843	860	860
Main Steam Flow			
(klb/hr)	395	432	442
(kg/s)	49.8	54.4	55.7
Economizer Gas Outlet			
Temperature (F)	419	428	355
(C)	215	220	179
Air Flow to Combustor			
(klb/hr)	593	593	649
(kg/s)	74.7	74.7	81.8
Combustion Efficiency			
(%)	99.4	N/A	99.0
Excess Air (%)	20.1	13.3	25.0
SO2 Retention (%)	92.6	93.1	90.0
Ca/S Molar Ratio			
(as tested)	2.05	2.17	---
Ca/S Predicted			
at 90% Retention	1.82	1.87	1.64
NOx Emissions			
(lb/106 Btu)	0.18	0.15	0.50
(mg/MJ)	77.4	64.5	214.0

The higher firing rate during the February, 1992 test was due to increased gas turbine compressor capacity with a cooler ambient temperature and operation at an excess air level below the design value of 25%.

TIDD TEST PROGRAM

The Tidd Plant has completed several optimization tests, including the performance of the fuel nozzle, coal water paste moisture content, ash production, the impact of freeboard injection. Future tests include testing of different coals and sorbents. However, it is important to note that while the Tidd Plant has achieved many of its original performance objectives, current emission standards, coupled with the projected performance of competing technologies, have caused us to reassess the goals of the PFBC program, particularly with regard to sulfur removal. Although 90 percent sulfur removal at a calcium to sulfur ratio of 2.0 was acceptable when AEP's PFBC program was conceived, it is now apparent that 95 percent sulfur removal at a much lower calcium to sulfur ratio will be necessary for this technology to be competitive in the utility marketplace at the turn of the century. The Tidd test program has been redirected to attain this goal. One method of achieving this improved sorbent utilization may be by additional sorbent feed points. The existing sorbent feed system at Tidd is a dilute-phase pneumatic transport system which admits all of the sorbent into the bed via two injection nozzles. It is theorized that the sulfur removal would be enhanced by adding sorbent fines directly with the paste to improve the concentration of available sorbent in close proximity with the SO_2 released from the burning coal.

A series of tests in which sorbent is admitted in the coal water paste was run to evaluate the potential effects on plant equipment and unit performance, including effects of the CWP preparation system mixing, pumpability of the CWP, and the potential for in-bed agglomerations. These tests were conducted as a prerequisite to installing a permanent system to receive sorbent fines and inject them with the paste.

The following observations were made during these tests.

(1) No significant sinter production occurred during the tests.
(2) No major problems with paste pumpability were encountered when feeding sorbent with the paste, even at extremely high ratios of sorbent to dry coal in the paste.
(3) Sorbent utilization showed no significant improvement over baseline, with fines only in the paste, and deteriorated when the prepared sorbent was injected with the paste. Further testing will be required to verify and expand on these observations.
(4) When pneumatic sorbent injection was taken

out of service, and all of the sorbent was fed with the paste, bed temperature distributions and cyclone string oxygen distributions became more even.

(5) Gas turbine opacity dropped when feeding sorbent with the paste, indicating less ultra fine ash in the gas exiting the cyclones.

(6) During inspection after the unit shutdown, no evidence of any in-bed tube bundle deposits was found.

A system was installed in early 1993 to allow a continuous feed of sorbent to the CWP mixer. Tests will be conducted to evaluate an optimum quantity and size consist of the sorbent to be fed with the paste using this system.

The remainder of the three-year Tidd test program will focus on achieving better sorbent utilization as well as completing process evaluation and feedstock testing as planned. In fact, helping to establish and validate the design basis for future commercial PFBC plants will become a significant part of the remaining test effort at Tidd. AEP is currently investigating a possible extension of the planned three-year demonstration period to accommodate this program change and to ensure that sufficient operating time remains to properly evaluate the performance of the HGCU test facility.

CONCLUSION

The Tidd PFBC Demonstration Plant has completed over 3200 hours of coal-fired operation and has met its environmental performance objectives. With the 100-hour run at full load and the 31-day continuous run, the unit has met its reliability objectives. Also, with the exception of the deficiency in gas turbine power output, the PFBC power island equipment has met all performance guarantees.

The main operating problems can be attributed to the coal preparation and cyclone ash removal systems. Our experience to date emphasizes the importance of proper coal preparation to achieve reliable coal injection and proper coal combustion within the bed. Of similar importance is performance of the cyclone ash removal system to ensure that the exhaust gas is sufficiently clean for gas turbine survivability.

While refinement of all PFBC systems is likely, the cyclone ash removal and coal preparation systems, coupled with improved sulfur removal at a low calcium to sulfur molar ratio, will require the most significant efforts for commercialization of PFBC technology.

The continued testing at Tidd is expected to provide important input to the 340 MWe Commercial PFBC Plant slated for initial operation around 2002. AEP is now in the midst of a four-year "value engineering" program for this future plant. The first two years of the program are focusing on optimization of PFBC fundamental technology. The second two years will focus on integration of the PFBC power island with the balance of plant, and will result in development of a definitive plant design and cost estimate.

By drawing on vendor expertise and experience from Tidd and other operating PFBC units throughout the world, we expect this four-year study and testing period to lower the cost of the first commercial PFBC unit to a level typically associated with a third-of-a-kind rather than a first-of-a-kind plant, and make PFBC a truly viable alternative to both conventional coal-fired electric power generation and other clean coal technologies.

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