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**Development of a Coal Quality
Expert**

to:

**U.S. Department of Energy
Pittsburgh Energy Technology
Center
Pittsburgh, Pennsylvania**

DE-FC22-90PC89663

**Technical Progress Report No. 11
FINAL**

Development of a Coal Quality Expert

U.S. Department of Energy
Pittsburgh Energy Technology Center
Pittsburgh, Pennsylvania

DE-FC22-90PC89663

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INTRODUCTION

This is the eleventh Technical Progress Report, describing work performed under DOE Contract No. DE-FC22-90PC89663, "Development of a Coal Quality Expert." The contract is a Cooperative Agreement between the U.S. Department of Energy, CQ Inc., and ABB Combustion Engineering, Inc. This report covers the period from October 1 through December 31, 1992. Five companies and five host utilities have teamed with CQ Inc. and ABB/CE to perform the work on this project. The work falls under DOE's Clean Coal Technology Program category of "Advanced Coal Cleaning." The 51-month project will provide the utility industry with a PC expert system to confidently and inexpensively evaluate the potential for coal cleaning, blending, and switching options to reduce emissions while producing lowest cost electricity. Specifically, this project will:

- Enhance the existing Coal Quality Information System (CQIS) database and Coal Quality Impact Model (CQIM) to allow confident assessment of the effects of cleaning on specific boiler cost and performance.
- Develop and validate a methodology, Coal Quality Expert (CQE) which allows accurate and detailed predictions of coal quality impacts on total power plant capital cost, operating cost, and performance based upon inputs from inexpensive bench-scale tests.

The project consists of the following seven tasks:

- Task 1 - Project Management
- Task 2 - Coal Cleanability Characterization
- Task 3 - Pilot-Scale Combustion Testing
- Task 4 - Utility Boiler Field Testing
- Task 5 - CQIM Completion and Development of CQE Specification
- Task 6 - Develop CQE
- Task 7 - CQE Workstation Testing and Validation

WORK PERFORMED

During the past quarter, Tasks 3, 4, 5, and 6 were active. Task 3 Pilot Scale Combustion Testing activity included data analysis of pilot- and bench-scale combustion samples in support of the development of CQE slagging and fouling models. Under Task 4, field testing at the fourth host utility site--Alabama Power Company's Gaston Unit 5--was completed in October with the testing of the alternate coal. Test planning was initiated for the remaining two field tests to be performed in 1993.

Tasks 5 and 6 activities were directed at overall CQE program definition, design and development of CQE base classes and objects, continued formulation of CQE algorithms and submodels, and development of the user interface prototype.

Task 3 - Pilot-Scale Combustion Testing

Task 3 provides detailed characterization of fuel properties of the test coals and in-depth evaluation of their performance characteristics under controlled pilot-scale combustion testing. Results from this task provide fundamental information required to develop some of the improved algorithms for the CQE. Both bench-scale fuel characterization and test furnace performance evaluations are being performed under this task.

All pilot-scale combustion tests under this task have been completed. Topical reports for the coals evaluated under the Public Service Oklahoma's Northeastern Unit 4 and Northern States Power's King Unit 1 test series have been issued. Work continued during the past quarter on preparation of the final report for the Mississippi Power Company's Watson Unit 4 tests (to be completed first quarter 1993) and analyzing pilot-scale combustion data from the Alabama Power Company's Gaston tests; a topical report for the Gaston study will also be issued in 1993.

Bench-scale testing and data analyses continued in support of the development of the slagging and fouling models. Data obtained from the analysis of samples of deposits, inflame solids, fly ash, and coal from CQE pilot-scale and drop tube combustion tests were evaluated for use in devising and verifying the slagging and fouling algorithms.

Task 4 - Utility Boiler Field Testing

During the past quarter, full-scale combustion testing was completed at the fourth utility host site--Alabama Power Company's (APC) Gaston Unit 5--with the testing of the alternate coal; the baseline coal test was previously conducted in the fall of 1991.

Due to scheduling problems and other uncertainties, the original utility sites for the final two full-scale combustion test burns had to be replaced. New England Power Service Company's (NEPSCO) Brayton Point Units 3 and 2 will now host Field Tests 5 and 6, replacing Duquesne Light Company's Cheswick Station and Penelec/NYSEG's Homer City Unit 2, respectively. Test planning for these two sites was initiated during the past quarter, with a preliminary test schedule established as follows:

- NEPSCO Brayton Point 3 March 1993
- NEPSCO Brayton Point 2 April 1993

Alabama Power Company Gaston Unit 5

APC's Gaston 5 is the fourth of six test sites selected for utility boiler field testing under this program. It is located in Wilsonville, Alabama, and consists of a pressurized Combustion Engineering (CE) 880-MWg, twin-furnace, tangentially fired boiler which was commissioned in 1974. The boiler nameplate rating is 6.351×10^6 lb/hr of steam flow at 1000°F superheat temperature and 3,500 psig throttle pressure. The unit is a once through design with a total of 56 burners for the two furnaces; each furnace section has seven burner elevations. The unit is equipped with a hotside electrostatic precipitator with a design specific collection area of 287 ft²/1000 acfm.

Burn tests were conducted to assess the coal quality impacts on boiler performance and emissions resulting from the burning of the typical, or baseline, coal and an alternate coal. Testing of the baseline coal--a 2% sulfur Alabama coal from the North River Mine--was performed in September and October of 1991. Combustion testing of the alternate coal--a lower sulfur coal from West Virginia--occurred in October 1992.

A typical analysis of the alternate coal is shown in Table 1. The reduced sulfur emission potential (1.5 lbs SO₂/MBtu as compared to 3.8 lbs SO₂/MBtu for the baseline coal) and

lower grindability (46 HGI as compared to 57 HGI for the baseline coal) of the alternate coal was of major interest during the test burn; from a boiler operating standpoint, other potential concerns for burning the alternate coal included reduced ESP collection efficiency, higher opacity levels, and aggravated fouling and/or slagging.

The alternate coal test burn was performed over the period October 12-30, 1992. Following a brief series of diagnostic tests, the alternate coal test burn was conducted according to the matrix shown as Table 2. In addition to a detailed emissions and performance characterization at full load, tests were performed at varying levels of load and excess air. Tests of specific interest to APC were performed to examine in more detail the slagging and carbon burnout characteristics of the coal when operating the unit under particularly demanding operating conditions. Sample and data analyses are underway.

**Task 5 - CQIM Completion and
Development of CQE
Specification**

The primary objectives of this task are to:

- Improve and enhance the Coal Quality Impact Model (CQIM)
- Identify and assemble all models and data bases to be incorporated into the CQE
- Develop the specification for the CQE.

Work continued on the development of the boiler, slagging (SLAGGO), and fouling (FOULER) models. Those organizations involved in developing algorithms and models for CQE--Black & Veatch, Decision Focus Inc., ABB Combustion Engineering, PSI Technology Company, and the University of North Dakota Energy and Environmental Research Center--continued to interact to ensure that the approach being taken by all was consistent with the overall objective.

The ash formation and thermal property models for SLAGGO were completed, while development of the deposition and heat transfer models continued. A preliminary version of FOULER was completed; it develops deposition strength and removability relationships as a

Table 2. APC Gaston Unit 5 Test Matrix. *(Alternate Coal)*

Test	Load (MWg)	O ₂	Test Condition/Objective	Tests
<u>Alternate Coal (West Virginia Heartland)</u>				
62	884	Norm	Full Load Operation	B,C,F
63	884	Max	Full Load Operation with Max O ₂	B,C,F
64,76	884	Low	Full Load Operation with Low O ₂	B,C,F
65	884	Norm	Full Load with D Mill Off	B,C,F,M
66	884	Low	Full Load with D Mill Off (Low O ₂)	B,C,F,M
67	450	Norm	Low Load Operation	B,C,F
68	450	Low	Low Load Operation with Low O ₂	B,C,F
69	920	Norm	Maximum Load Test	B,C,F,O
70	920	Low	Maximum Load Test with Low O ₂	B,C,F
71-73	884	Norm	Detailed Full Load Characterization	B,C,F,E,O
74	884	Varied	Full Load Operation with Varied O ₂	B,C,F
75	884	Norm	Full Load with Varied W/F	B,C,F
77	660	Norm	3/4 Load Test	B,C,F
78	660	Low	3/4 Load Test with Low O ₂	B,C,F
79-81	884	Norm	Full Load - Burner Tilt Variation	B,C,F
82	884	Norm	Full Load with A Mill Off	B,C,F,M
83-85	884	Norm	Slagging Tests	B,C,F,O

Notes:

B - Boiler monitoring (control room, gaseous, opacity, etc.)

C - Combustion performance (LOI or gas traverse)

M - Mill monitoring (fineness, vibration, rejects, etc.)

F - Furnace measurements (furnace exit gas temp, O₂, and CO)

E - ESP measurements (V/I, loading, size distribution)

O - Waterwall O₂

function of time, while providing a mass deposition rate over a specific load curve.

Plans were initiated to develop a prototype interface between FOULER and B&V's boiler model, and to integrate FOULER into the overall CQE model. FOULER was tested using dummy input data sets, and it produced predicted results--such as the rates of deposit accumulation, strength development, and deposit removal--without any major errors. Additional experiments were conducted to verify the fouling algorithm submodels. Sacrificial probe deposits obtained during combustion tests were analyzed using SEMPC to verify deposit composition predicted by the slagging algorithm.

Decision Focus continued the development and data acquisition efforts for the coal purchase and transport algorithms:

- Coal Cleaning Model
- Coal Blending Model
- Coal Handling Model
- Fuel Transportation Model
- Fuel Search and Sort

Fuel Search and Sort can access data from a number of sources--CQE database, CQIM, CQIS, or ASCII files--and search/sort according to run-of-mine coal characteristics, coal washability data, or blended coal characteristics.

Task 6 - Develop CQE

Progress was made in the design, refinement of design, and development of some of the more important classes required in developing CQE. Efforts focused on the interaction of the objects necessary to complete a fuel impact analysis. Work began on the development of a prototype for the initial menu and screens for the CQE user interface.

Black & Veatch continued discussions with Aion to resolve the technical integration problems that exist between Borland's C++ compiler and Aion's knowledge-based system. Although the release of C++ has been delayed until the first quarter of 1993, a beta version was made available for OS/2 so that the CQE software development team could start their programming efforts. In November, ONTOS delivered header files for ONTOS DB 2.2+, the first step in providing a Borland/OS/2 version of their data base management system (DBMS).

TECHNOLOGY TRANSFER

Scott Stallard of Black & Veatch presented a paper titled "The Coal Quality Expert: Designing for Maximum Flexibility" at the Power-Gen '92 Conference held in Orlando, Florida, November 17-19, 1992.

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