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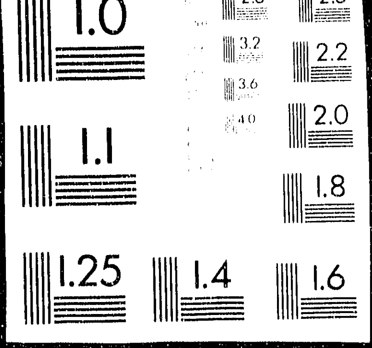

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CLEAN COAL TECHNOLOGY III (CCT III)

10 MW DEMONSTRATION OF GAS SUSPENSION ABSORPTION

DOE Cooperative Agreement
DE-FC22-90PC90542

AirPol Job Number
RD-43

TECHNICAL PROGRESS REPORT

FOURTH QUARTER, FY 1991 (7/01/91 - 9/30/91)

Cleared by Office of Patent Counsel
Chicago Operations Office
U.S. Department of Energy

Prepared by:

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EXECUTIVE SUMMARY

The 10 MW Demonstration of Gas Suspension Absorption program is designed to demonstrate the performance of the Gas Suspension Absorption System in treating the flue gas from a boiler burning high sulfur coal.

The demonstration project is divided into three major phases:

Phase I - Engineering and Design

Phase II - Procurement and Construction

Phase III - Operation and Testing

The project was previously on hold pending the re-definition of the overall project schedule. A revised schedule reflecting a one year delay of the project was established by AirPol and approved by DOE . Phase I engineering and design work was resumed as of May 1, 1991. During the reporting period the following progress was made:

Task I - Project and Contract Management

A draft of Subcontract Agreement has been prepared by TVA and commented by AirPol.

An Amendment to Cooperative Agreement has been issued by DOE to allow for a no cost extension of the project.

Task II - Process and Technology Design

Completed the preliminary GSA process calculation program.

Task III - Environmental Analysis

Work on Environmental Monitoring Plan does not start pending finalization of the TVA subcontract.

Task IV - Engineering Design

Revised General Arrangement drawings and P&ID drawing based on input and comments from TVA and FLS miljo.

ACKNOWLEDGEMENT

The planning, execution, and reporting of this project were a combined effort of many people and organizations. We wish to acknowledge the following for their outstanding effort.

U.S. Department of Energy: Sharon K. Marchant, Jerry Hebb

Tennessee Valley Authority: Dr. Chao Ming Huang, Thomas A. Burnett, Bruce A. Gold

FLS miljo: Jorgen Bigum, Jorn Touborg, Per Christensen

AirPol: Willard L. Goss, Shyam K. Nadkarni, Bindu Mistry, Stuart L. Turgel, Paul Sisler, Chuck S. Marchese

TABLE OF CONTENT

INTRODUCTION

The Clean Coal Technology Demonstration Program (CCT Program) is a government and industry co-funded technology development effort to demonstrate a new generation of innovative coal utilization processes in a series of full-scale, "showcase" facilities built across the country. These demonstrations will be on a scale large enough to generate all the data, from design, construction, and operation, for technical/economic evaluation and future commercialization of the process.

The goal of the program is to furnish the U.S. energy marketplace with a number of advanced, more efficient, and environmentally responsive coal-using technologies. These technologies will reduce and/or eliminate the economic and environmental impediments that limit the full consideration of coal as a viable future energy resource.

To achieve this goal, a multiphased effort consisting of five separate solicitations is administered by the Department of Energy. Projects selected through these solicitations will demonstrate technology options with the potential to meet the needs of energy markets and respond to relevant environmental considerations.

The third solicitation (CCT-III), issued in 1989, targeted those technologies capable of achieving significant reductions in the emission of SO_2 and/or NO_x from existing facilities to minimize environmental impacts, such as transboundary and interstate pollution, and/or provide for future energy needs in an environmentally acceptable manner.

In response to the third solicitation, AirPol Inc. submitted a proposal for the design, installation and testing of the Gas Suspension Absorption system at TVA's Shawnee Test Facility. On July 25, 1990, a Cooperative Agreement was signed by AirPol for the project entitled "10 MW Demonstration of Gas Suspension Absorption". The project was approved by Congress in October of 1990, and the Cooperative Agreement for the project was awarded by DOE on October 11, 1990.

This low-cost retrofit project will demonstrate the Gas Suspension Absorption which is expected to remove more than 90% of the SO_2 from coal-fired flue gas, while achieving a high utilization of reagent lime. The host site facility will be the Shawnee Test Facility (STF), located at the Tennessee Valley Authority's Shawnee Fossil Plant in West Paducah, Kentucky.

Over the past 15 years the Shawnee Test Facility has served as a testground for flue gas desulfurization (FGD) systems. At the present time a semi-dry process employing 10 MW capacity spray dryer is being tested at the facility. Upon completion of the current spray dryer test, the GSA system will be tested for a period of eleven (11) months.

The Gas Suspension Absorber was initially developed as a calciner for limestone used for cement production. It has been used successfully to clean the gases from commercial waste to energy plants in Denmark where it has also captured chloride emissions. The GSA system brings coal combustion gases into contact with a suspended mixture of solids, including sulfur-absorbing lime. After the lime absorbs the sulfur pollutants, the solids are separated from the gases in a cyclone device and recirculated back into the system where they capture additional sulfur pollutant. The cleaned flue gases are sent through a dust collector before being released into the atmosphere. The key to the system's superior economic performance with high sulfur coals is the recirculation of solids. Typically, a solid particle will pass through the system about one hundred times before leaving the system. Another advantage of the GSA system is that a single spray nozzle is used to inject fresh lime slurry.

The GSA system is expected to be the answer to the need of the U.S. industry for an effective, economic and space efficient solution to the SO_2 pollution problem.

PROJECT DESCRIPTION

This project will be the first North American demonstration of the Gas Suspension Absorption (GSA) system in its application for flue gas desulfurization. The purpose of this project is to demonstrate the high sulfur dioxide (SO_2) removal efficiency as well as the cost effectiveness of the GSA system. GSA is a novel concept for flue gas desulfurization developed by F. L. Smidth miljo (FLS miljo). The GSA system is distinguished in the European market by its low capital cost, high SO_2 removal efficiency and low operating cost.

A 10 MW GSA demonstration system shall be installed and tested at the Tennessee Valley Authority (TVA) Shawnee Fossil Plant at West Paducah, Kentucky. The new GSA system will replace the existing Spray Dryer that was installed previously as a test unit. The experience gained in designing, manufacturing and constructing the GSA equipments through executing this project will be used for future commercialization of the GSA system. Results of the operation and experimental testing will be used to further improve the GSA design and operation.

The specific technical objectives of the GSA demonstration project are to:

- Effectively demonstrate SO_2 removal in excess of 90% using high sulfur U.S. coal.
- Optimize recycle and design parameters to increase efficiencies of lime reagent utilization and SO_2 removal.
- Compare removal efficiency and cost with existing Spray Dryer/Electrostatic Precipitator technology.

In order to accomplish these objectives, the demonstration project is divided into phases and tasks as shown in the Work Breakdown Structure (WBS) below:

Phase I - Engineering and Design

- Task I - Project and Contract Management
- Task II - Process and Technology Design
- Task III - Environmental Analysis
- Task IV - Engineering Design

Phase II - Procurement and Construction

- Task I - Project and Contract Management
- Task II - Procurement and Furnish Material
- Task III - Construction and Commissioning

Phase III - Operation and Testing

Task I	-	Project Management
Task II	-	Start-up and Training
Task III	-	Experimental Testing and Reporting

According to the revised project schedule the design phase will be complete in December of 1991, the construction phase will be complete by the end of September of 1992, and the testing phase will end in September of 1993.

PROJECT STATUS

A. Task I - Project and Contract Management

Project Management - AirPol continued to provide overall project management by interfacing with DOE on all aspects of the project, and coordinating the site-related activities with TVA.

AirPol has submitted project reports as specified in the Federal Assistance Reporting Checklist as attached to the Cooperative Agreement. A computerized spread sheet has been used to track the cost and progress of the project.

Schedule Update - Amendment No. M001 to the Cooperative Agreement was issued by DOE on August 29, 1991. This Amendment was executed to allow AirPol a no cost extension of the project schedule from 26 months to 35 months.

Cost Plan was revised to reflect the change of project schedule.

TVA Subcontract - On July 26, 1991 a draft agreement for the AirPol-TVA Subcontract was submitted by TVA to AirPol. The draft was reviewed and commented by AirPol and was issued to DOE for comments.

FLS miljo Technology Transfer Agreement - The draft agreement was finalized and sent to FLS miljo for signing on September 19, 1991.

B. Task II - Process and Technology Design

AirPol Process Department completed a preliminary computer program for the GSA process calculation. The GSA process calculation program, when completed, will be able to perform the following computations:

- Flue gas composition from a given coal analysis ;
- The stoichiometric ratio;
- Air, water and slurry requirements;
- The flue gas composition, flow rate, temperature, pressure, enthalpy, density and humidity at the inlet and outlet of all equipment;
- Heat loss from GSA, filter and stack;
- Sizing of reactor, venture, and cyclone;
- Power consumptions.

The GSA process calculation program has been developed independently by AirPol Process Department based on GSA chemistry. The program will be further refined through review and consultation with FLS miljo.

A Preliminary Test Plan (Attachment 1) was prepared to identify the objectives of the test, describe the general test approach and enumerate the tests to be performed. The Preliminary Test Plan will be used as the basis for developing the Final Test Plan.

C. Task III - Environmental Analysis

It was determined that the work related to Environmental Monitoring Plan would best be performed by TVA. However, the work cannot be started until the subcontract with TVA is in place.

D. Task IV - Engineering Design

General arrangement - General arrangement drawings were revised to incorporate following changes per TVA and FLS miljo comments.

- o Re-routed the inlet ductwork to the north side of the roadway to avoid the problem of headroom limitation above the roadway.
- o Re-arranged the location of the GSA installation so as to avoid interference with the underground cable box. this re-arrangement necessitated an overall revision to the entire General Arrangement drawing.
- o Modified the geometry of all duct splitting and junction points to allow for smoother gas flow and to reduce duct pressure loss.
- o Added sampling ports and test platforms per TVA request.

The revised General Arrangement drawings were issued to TVA and FLS miljo for their final comments.

Instrumentation and Control - The Process and Instrumentation Diagram was revised to incorporate comments made by FLS miljo.

The following two alternative ways to control the GSA for this project are being evaluated:

1. Use three separate control units to control the three loops required for GSA operation. Use a small programable logic control (PLC) to perform the start and shut-down operation.
2. Use the existing Foxboro Control for the three control

loops. Add an on and off switch panel for the start-up and shut-down operations.

Equipment Design - Detailed design of GSA reactor and cyclone has been completed and checked.

With information obtained from various manufacturers, it has been determined that the feeder box can be made satisfactorily in the United States.

Structural Design - The structural design was revised due to the overall change of the general arrangement of the GSA system.

Access System - The access system was rearranged to suit the new general arrangement.

Ductwork - Detailed design of ductwork was in progress based on the revised general arrangement drawings.

PLAN FOR NEXT QUARTER

A. Task I - Project and Contract Management

Project Management - Continue monitoring project cost and produce reports according to the Federal Assistance Reporting Checklist.

Continue monitoring the progress of the project and update the project schedule accordingly.

Finalize Subcontract Agreement with TVA and Technology Transfer Agreement with FLS miljo.

B. Task II - Process and Technology Design

Process Engineering Design - AirPol Process Department to complete compiling the GSA process calculation program and conduct process calculation for the subject project.

Meeting with FLS miljo to review the process calculation program.

C. Task III - Environmental Analysis

Environmental Monitoring Plan - An Environmental Monitoring Plan (EMP) will be prepared to describe the collection and dissemination of significant technology, project, and site-specific environmental data.

D. Task IV - Engineering Design

General Arrangement - AirPol Engineering Department will finalize general arrangement drawings by incorporating comments from TVA and FLS miljo on the revised General Arrangement drawings.

Equipment Design - Complete design and specification of all GSA equipments.

Instrumentation and Control - Finalize control arrangement and finalize electrical design package (by FLS miljo).

Design of Auxiliary Equipment - complete design of the support structure, platform and stairs and ductwork.

Attachment 1

Preliminary Test Plan

AirPol Inc.

DOE/TVA 10 MW DEMONSTRATION OF GSA

PRELIMINARY TEST PLAN

Frank E. Hsu, February 4, 1992

The Testing and Operation Phase (Phase III) of the GSA demonstration project is designed to evaluate the performance of the GSA system when treating the fly ash-laden flue gas from a boiler burning a high-sulfur coal.

The major objectives of the Testing and Operation Phase are:

1. To optimize operating variables.

2. To establish stoichiometric ratio for inlet acid gases, acid gases removed as well as for the outlet acid gases.

3. To evaluate erosion and corrosion information at various locations in the system.

4. To demonstrate 90% or greater SO_2 removal efficiency of GSA system.

A. General Testing and Operation Approach

1. The instrument and controls must be capable of setting each variable to a fixed point and be able to hold the set point during individual test runs.

2. The following three primary control logic loops will function independently to facilitate optimization of variables:

2.1 Based on inlet SO_2 (concentration is not expected to fluctuate for a given coal), set slurry rate for each series of tests for predetermined slurry concentrations.

2.2 Based on inlet volume (flow rate is not expected to fluctuate), set cyclone underflow reinjection to GSA for each series of tests.

2.3 Based on preset cyclone outlet temperature (not expected to vary), set water rate to GSA for each series of tests for predetermined Approach to Saturation Temperature (AST) .

Note: A series of tests shall be designed to inject dry lime directly into the GSA when the following condition occurs:

When additional cooling water cannot be added because cyclone outlet temperature is already lower than set temperature, and slurry feed rate is at its maximum, but the required SO_2 removal is not achieved.

B. Tests to be Performed

1. Screening of Variables - All variables will be initially set according to the design baseline values. Each of the variables from this baseline will be adjusted one at a time to produce the optimum SO_2 removal. Upon completion of these tests the optimum set point for all variables will be obtained.

Variables affecting the GSA system are:

1. Inlet gas volume;
2. Inlet SO_2 loading;
3. Inlet Hcl loading;
4. Inlet humidity;
5. Inlet gas temperature;

Note: the above variables are not expected to fluctuate.

6. Reinjection of waste into the reactor;
7. Recirculation of reactor flue gas;
8. Lime slurry concentration and feed rate;
9. Reactor outlet saturation temperature and approach to saturation temperature;
10. Cooling water rate;
11. Minimum operating temperature requirement of the filter (ESP);
12. GSA outlet SO_2 loading;
13. ESP outlet SO_2 loading;
14. Calcium Chloride addition;
15. Boiler bottom ash analysis;
16. Baghouse fly ash analysis.

Note: Depending upon items 6 thru 10, saturation temperature of the mixture at reactor outlet will vary. Based on the limitation set by item 11, reactor outlet is expected to be set at the minimum possible temperature approaching saturation.

Item 6, reinjection of waste is a function of inlet gas flow which can change depending on item 7, flue gas recirculation.

System outlet SO_2 loading (item 12) is a function of item 8, 11 and 14.

2. Feed-backward System Tests - Test the GSA system by controlling the lime feed rate by outlet SO2/Hcl loading instead of inlet loading.

C. Data Collection - Following data shall be sampled and recorded for the tests:

1. Gas flow at inlet of the system;
2. SO_2 and Hcl loading at system inlet, ESP inlet and ESP outlet;
3. O_2 at system inlet and ESP outlet;
4. Temperature at system inlet, reactor outlet and ESP outlet;
5. Particulate loading at GSA inlet, ESP inlet and ESP outlet;
6. Slurry flow (for stoichiometric lime to acid ratio calculation);
7. Slurry concentration;
8. Water flow;
9. Dew point temperature at ESP outlet (for Approach to Saturation Temperature calculation)
10. Coal analysis;
11. Flue gas analysis;
12. Lime analysis;
13. By-product rate;
14. By-product analysis;
15. Water analysis;
16. Power consumption;
17. Corrosion and erosion rate.

D. Data Analysis

Monthly reports will be provided by TVA describing the tests performed and discussing the test results. Data collected from the tests will be analyzed for the optimizing process.

E. Demonstration Run

Based on the finding during the optimization phase, the GSA system will be operated at optimum operating points for a four-week consecutive period to demonstrate the reliability of GSA system operation as well as GSA's SO_2 removal capability. All control instruments will be switched to automatic mode with set points determined from the optimizing tests.

END

DATE
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6/15/92