Report as of FY2007 for 2006TN27B: "Ash Pond Modeling and Computer Simulation to Predict and Efficiently ControlAmmonia/Nitrates and Heavy Metals Discharge"

Publications

- Dissertations:
  - Bagchi, Bratendu,2007,Computer Modeling of Tennessee Valley Authority's Coal Based Power Plant at Kingston to Predict the Effluent to Emory River,"Ph.D. Disseration,"Department of Chemical Engineering,College of Engineering, University of Tennessee, Knoxville, TN., pp 206.

Report Follows

(6) Problem and Research Objectives:
This research is desired by TVA's Environmental Technologies Division and by the Plant Manager of TVA's Kingston Fossil Plant in order to reduce water consumption, water discharges, and to remain in compliance with EPA discharge regulations, both current and anticipated future restrictions (see attached letters of support). TVA has recently recognized that its substantial current and future efforts to reduce air pollution at all 11 fossil plants, through the gradual addition of SCR units and Scrubbers, is increasing water discharge concerns (1). Specifically discharges of ammonia/nitrates to the ash pond, potentially an alteration in the pH of the ash pond which might result in the release of selenium, arsenic and mercury from the ash, and a substantial increase of mercury oxides discharged to the ash pond. Task II of the proposed research will provide answers to how much of an increase in water quality problems TVA is facing and provide the tools for modeling the effects these changes will have on the ash pond discharges. Task I will at first provide a tool for the Kingston plant, and later for all 11 TVA plants, that can be used to reduce water consumption, reduce water discharges from the ash pond and provide a means of systematically evaluating remediation designs (Task 3).

TVA and UTK have an on-going research effort to reduce fresh water consumption at TVA Fossil Plants while maintaining compliance with all current and anticipated future emission regulations through development of a computer simulation of the Kingston Plant. This proposal expands on this research with a 2 year, more generalized effort, encompassing three major tasks; (1) developing a generalized computer simulation for plant wide water balance, including temperature and relevant pollutants (currently in progress) (2) a theoretical and experimental effort to develop models for the transport and kinetics of Hg and oxides of mercury, Se, As and ammonia in the ash ponds and the interaction of these substances with ammonia along with their distribution between the aqueous and ash phases, and (3) applying the simulation in the second year of the project to identify process modifications at Kingston to reduce fresh water consumption in an environmentally friendly manner. There are two main water streams; 40 MGD of very dirty water sent to the ash pond and 1,296 MGD of clean water used in the condensers. The ash pond is a major source of discharges and potentially a major resource. TVA's efforts to reduce air pollution thorough the addition of SCR units (for NOx) and scrubbers (particulates and SOx) have essentially converted air pollution problems into ash pond water pollution concerns with ammonia/nitrate and mercury discharges and possibly As and Se (desorption from the ash). Task 1 has been on-going for 15 months with the development in ChemCad of the entire water balance at Kingston including predictions of the quantities of pollutants produced based on coal type, boiler operation, and air pollution controls. Water recycle/reuse is the major source for reducing fresh water intake, it is essential to incorporate into the simulation thermal effects and the build up and interacts of pollutants to understand their effects on plant operation and maintain compliance with current and anticipated future emission standards. We are incorporating into the simulation models for phosphates, SOx, NOx, Hg, Se, As, ammonia and chlorine and the interactions of ammonia, chlorine and SOx with these metals. This information will be derived from three sources, i) the literature, ii) experimental data from TVA's data base developed from its 11 fossil plants, specific plant wide tests at Kingston and future plant wide tests at other TVA plants, and iii) a theoretical and experimental program (Task 2) based at ORNL specifically directed at the fate of As, Hg, Se, mercury oxides and ammonia in the ash ponds and the interactions of these substances with ammonia. The deliverables will be models for the fate and transport of these substances in the ash ponds for incorporation into the

water balance simulation. Task 2 is essential because there is insufficient information in the literature to model the interactions of these substances in the ash ponds.

Second Year Objectives: Conduct a second plant wide test at Kingston to compare with the 2004 test conducted before all of the SCR units were in place and use this test as a further verification of the Kingston plant ChemCad model. Conduct a literature search and experimental program to develop simulations for the interactions of As, Se, ammonia and ash in the ash ponds and incorporate these simulations in the Kingston plant model. Incorporate the COMSOL simulation into the model to allow for a better representation of the ash pond by incorporating its fluid dynamics. Use of the ash pond as a remediation device is a very real possibility. In the Spring 2007 semester one ChE 490/488 design group (4 seniors) are using the ChemCad model to investigate remediation options for phosphates, mercury, SOx and ammonia at the Kingston plant ash pond.

(7) Methodology and Accomplishments to Date:
2006 was a very productive year for this project due to the addition of a second graduate student (Mr. Ashwin) and a strong desire by Mr. Bagchi to graduate ahead of schedule in order to accept a very nice job offer. Mr. Bagchi defended his PhD dissertation on November 15, 2006, a copy of his dissertation is attached. The simulation was completed for the Kingston plant from a unit operations standpoint. This simulation will predict air pollutants based on the type of coal burned and boiler operating conditions and predict the quantities of pollutant removed from the flue gas based on the specific remediation units in use, (SCF, FGD, etc.). The fate of ammonia in the ash pond has been simulated using a biological model refined with experimental data. The simulation currently predicts sulfur, phosphorous, nitrates and mercury in the effluent. The interactions between ammonia, ash, and mercury was simulated through an experimental program which developed predictive thermodynamic models. The simulation is now operational and is capable of predicting a component material balance for all relevant plant streams. Simulations for arsenic and selenium are currently not available and will be developed in 2007 from experimental data.

(8) Principle Findings and Significance:
A working model of the TVA Kingston plant has been developed the model will produce a flow sheet and material and energy balances for the entire plant including the ash pond. The model is useful for predicting pollutant discharges and would be a useful tool for reducing water consumption.

(9) Future Research and Funding:
This research has been funded by a $42,000 grant from TVA (3/31/06 – 12/31/07) and TVA has made a commitment of $250,000 in matching in a 2006 proposal to DOE which was rejected. Potential future sponsors of this research are TVA, DOE, EPA and EPRI. If TVA chooses to use the Kingston model there is a high probability TVA would fund extension of the modeling work to the other 10 TVA plants.

Dr Handagama from TVA has met with the students on a weekly basis, either at the Kingston Plant, at SERF or via e-mail or phone conversations. Three plant tests were conducted at the Kingston plant site with assistance from plant personnel.

UTK supported Dr. Bienkowski and Dr. Counce (through EO1-1322) who met with the students on a daily basis.

ORNL While ORNL did not make a written commitment of support, ORNL ended up supporting this project with Dr. Southworth doing all of the mercury/ash analysis in his laboratory at ORNL.