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Texas Commission on Environmental Quality
New Technology Research & Development (NTRD) Program
Monthly Project Status Report

Title: FEEDLOT BIOMASS: A REBURN FUEL FOR "MAXIMUM NOX" REDUCTION IN COAL-FIRED POWER PLANTS

Contract Number: _____*TCEQ Grant # 582-5-65591 0015*

Grantee: _____Texas Engineering Experiment Station, Texas A&M University

Date Submitted: _____June 6, 2005

Report for the **Monthly** period:

Starting Date _____May 1, 2005_____Ending Date _____May 31, 2005_____

Section I. Accomplishments (*Please provide a bulleted list of project accomplishments as well as a description of their importance to the project.)*

The overall objectives of the project are i) to develop a retrofit technology of using processed low-ash feedlot biomass (FB) as reburn fuel for potential reduction of the NOx in coal-fired power plants by 80-90% and ii) determine the possible capture of Hg for low rank coals, reduction of CO_2 and other benefits of using animal wastes (alternately known as feedlot biomass, FB) as fuels.

1. Four graduate students (3 at MS level and one at PhD level): Mr. Brandon Martin (MS Level) and Paul Goughnour (MS Level), and Mr. Madhubabu Puchakayala (PhD student) are officially on the project starting June 1, 2005. Mr. Soyuz Priyadarsan who has been a PhD student for more than 2 years is continuing to work on the current TCEQ project. The fourth MS student who will finish his by Dec 2005 will work about one month on TCEQ project related to Dairy Biomass Properties (Task 1). However he will be switched over to forth coming DOE project which deals mostly with dairy farms. He will work on calculations involving our novel concept of Energy Conversion Technology. If successful, the unit will be mountable on 18 Wheeler truck which will contain an inlet as solid waste slurry from storage tank of dairy farms and outlets for i) water back to dairy farms and ii) hot steam/power for heating and power; the concept is being developed towards disposing of lagoons and acreage requirements (2 acre per cow for dairy farms).
2. For the required equipments, budgetary quotations have been solicitated from the respective equipment manufacturers. Since, the university system/Texas regulations requires competing quotes from at least 3 unique manufacturers for each required equipment additional budgetary quotes are being still being solicitated. This requirement is only for equipments costing more than $ 5,000. Budgetary quotes have been solicitated for the following equipments (costing more than $ 5,000): a) TGA analyzer, b) Mercury Analyzer (Elemental HG only) and c) Hg Generators. The pricing for the remaining equipments (costing lass than $ 5,000) have also been obtained; a) Mass Flow Regulators, and b) Computer required for data collection and interfacing. Specifications for these equipments have been obtained. For grinding of air-dry (<10% moisture) feedlot biomass (FB) harvested from the TAES/USDA-ARS research feedlot at Bushland, required for reburn experiments (Tasks 3 and 4), the Vortec Model M-1 Impact Mill, Vortec Industries, Long Beach CA has been acquired and is being installed.
3. For Article 2.1.1 (or Task 1.1), cattle manure from fly ash surfaced feed pens (called advanced feedlot biomass, AFB since it is low ash) was collected from the TAES/ARS Environmental feed yard at Bushland, Texas from May 17-24, 2005. Approximately 40 tons of AFB was stockpiled and will be partially composted for 45 days. 700 pounds of AFB in raw form was collected prior to the start of composting. The un-composted (raw) manure was then coarsely ground in a small

hammer mill and then placed in a greenhouse to facilitate drying on June 2, 2005. Samples (n=3) of the un-composted as-collected manure were taken before and after grinding. Moisture analysis of the as-collected manure prior to grinding and drying was 20% moisture wet basis. The ending moisture will be <10% (wb). Final ash and moisture results will be collected at the completion of drying.

4. The Article 2.2.1 (or Task 2.1), deals with small scale reburn experiments for NOx reduction. The set has been disassembled and the required modifications are in progress. The ceramic refractory lining needs to be replaced, the required materials have been procured for the modifications.
5. Task 3 deals with pilot scale studies using the DOE-NETL facility at Pittsburgh, PA. A meeting is being arranged to discuss the modalities of the pilot scale testing either to be conducted at NETL or a site to be recommended by DOE-NETL. The meeting is scheduled for July 15, 2005, at the NETL facility in Pittsburgh, PA.
6. Task 4 deals with zero dimensional reburn model for predicting the NOx capture by biomass fuels. The modeling formulation including homogeneous and heterogeneous reaction kinetics of reactions, pyrolysis kinetics, and evaporation model have been performed. The programming of the numerical model has been started and is in progress. FORTRAN 77/90 is being used for the model simulation studies. A brief overview is presented in Appendix A. Appendix B presents a brief overview of previous literature on Hg and modeling. Results are not yet available.
7. Task 5: Modified the Thermolab Software so that the required inputs are the ultimate analysis of the biomass fuel (DB or FB), the moisture and ash percentages, and the composition of any additional fuel (Coal, CH_4, etc.). The program calculates flame temperature and the composition of the products (CO_2, H_2O, N_2, etc) assuming complete combustion. This can be used to predict firing rates and ash production from power plants in sub-task 2.5.1.1. Mr. Carlin Nocholas will use the software in evaluating the new energy conversion technology mentioned in item # 1
8. Task 5: The program makes parametric studies of biomass fuels fast and easy. For example, in Appendix C, calculations of the adiabatic flame temperature were made for a range of moisture and ash percentages for FB and plotted.

Indicate which part of the Grant Activities as defined in the grant agreement, the above accomplishments are related to:

Task 1: Fuel characteristics
Task 2: Small Scale Reburn Experiments for NOx reduction
Task 3: Pilot scale rebunn studies at DOE-NETL.
Task 4: Reburn modeling to predict NOx capture by biomass fuels
Task 5: Perform the economics of the use of FB as reburn fuel in coal fired power plants and cost of NOx reduction compared to other technologies.

Section II: Problems/Solutions

Problem(s) Identified (*Please report anticipated or unanticipated problem(s) encountered and its effect on the progress of the project)*	Task1: Task 2: i. The carbon steel shell needs extensive design modifications to conduct the experimental studies. ii. The existing refractory lining has severe cracks, which will compromise the performance of the setup and also a safety issue for the operators. Task 3: Task 4: i. Preliminary simulations done with the existing computer require almost 2 days for getting converged solution. Thus indicating the need for a more powerful workstation to achieve converged solutions much quicker. ii. Mercury modeling: Since the present available code is written few years back by Prof. Annamalai, it will be little difficult in understanding the code. In addition to above there are few bugs, which prevent the code from running. Task 5:
Proposed Solution(s) *(Please report any possible solution(s) to the problem(s) that were considered/encountered)*	Task1: Task 2: i. The carbon steel shell design modifications have been performed. ii. The ceramic lining has to be recast. The new lining will accommodate the new design changes needed for the new injection system and ash fouling studies. Task 3: Task 4: i. A new dedicated workstation will be procured to overcome the limitations of the existing desktop computer. ii. Spending more time on understanding the code and removing the “code bugs” will resolve the problems. It’s a matter of time, where in which all the problems mentioned above will be taken care off. Task 5:

Action(s) Conducted and Results *(Please describe the action(s) taken to resolve the problem(s) and its effect)*	Task1: Task 2: i. The required materials for the ceramic casting have been procured and are in the process of being delivered to TAMU. Task 3: Task 4: i. A cost estimate for the new dedicated workstation has been obtained. ii. Mercury modeling: A Literature review has been done on mercury as a pollutant. It covers the health effects, origin/sources, and emission statistics of mercury, mercury behavior in combustion environment, and its control technologies. iii. According to the review done, the health effects due to mercury can be very diverse and depends on the form of mercury encountered and severity and length of exposure. iv. The concentration of mercury in coal depends on the location from where the coal is produced and type of coal. v. Coal cleaning, Electrostatic precipitators, Wet Scrubbing and Dry Scrubbing, can reduce Mercury emission. vi. The coal chlorine content and ash composition, gas temperature, residence time and presence of different gases will decide the speciation of Hg in the combustion environment. vii. Coals having high percentage of chlorine results in greater percentage of oxidized mercury in flue gases. viii. SCR catalysts can be used to oxidize elemental mercury. ix. Chemically treated activated carbon is more efficient in capturing mercury than thermal treated activated carbon. x. NOx enhances the oxidation of mercury. Task 5:

Section III. **Goals and Issues for Succeeding Period**: (*Please provide a brief description of the goal(s) you hope to realize in the coming period and identify any notable challenges that can be foreseen)*

Proposed activities for month 3 (6/01/2005 – 06/31/2005)

General:

1. Procure the relevant equipments (costing less than $ 5,000).
2. Finalize the bidding procedure for the high cost equipments (costing more than $ 5,000).

Task 1:

The low ash advanced feedlot biomass will be partially composted for 45 days. To start the composting process water will be added to the manure and it will be turned with a skid loader. Temperature of the compost will be monitored for the 45 days of composting using a HOBO data logger. 700 pounds of manure will be collected upon completion of the partial composting of the low ash biomass. This manure will be pre-ground and dried to <10% moisture (wb). Final ash and moisture results will be collected at the completion of drying.

Cattle manure from soil surfaced feed pens which is typically high in ash content has yet to be collected and stockpiled. Upon collection of the high ash feedlot biomass 700 pounds will be pre-ground and dried to <10% moisture. This manure will then be partially composted for 45 days and then 700 pounds will be collected and dried to <10% moisture (wb). Final ash and moisture results will be collected at the completion of drying.

All feedlot biomass dried to <10% moisture will be micronized with a Vortec impact mill that will be located at the Environmental Quality laboratory at the TAES-ARS research facility in Bushland, Texas. The micronized manure will be used in co-fire and reburn experiments at the Texas A&M combustion laboratory in College Station, Texas. All the coal used in the reburn and co-fire experiments will also be micronized with the vortec impact mill. The expected arrival date of the Vortec Impact mill is July 2005.

Task 2:

1. Finish the setup modifications.
2. Reassemble the reburn setup.
3. Run preliminary tests to ensure proper working of the setup.

Task 3:

None is planned.

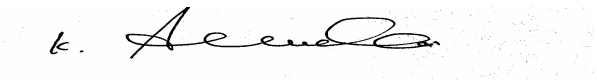
Task 4:

1. Complete the mathematical formulation of entire reburn process. Over fire process will not be included in the present zero dimensional reburn model.
2. Numerical subroutines/subprograms for the different sub-processes in the reburn process will be initiated. The extent of progress will be reported in the next monthly report.
3. **Mercury modeling**: Changes to the present numerical code for a one –dimensional study of combustion of a single particle /group combustion of coal will be made with the following features added.
    - Mercury, sulfur, chlorine, and phosphorous will be considered as the constituents of coal in addition to carbon, nitrogen, hydrogen, and oxygen that are already present.
    - A transient pyrolysis model for mercury and chlorine will be implemented. Presently, there is no literature on the pylroysis kinetics of mercury and chlorine. Due to which, a simple method where in we will be using simple proportions in determining the quantity of mercury and chlorine evolved as volatiles.

4. Volatile oxidation model for mercury and chlorine will be added. Presently, only homogenous reactions will be considered. Here we are considering the oxidation of mercury and chlorine separately. Reactions between mercury and chlorine are not considered.

Task 5:

1. Obtain specifics of current power plant operations (Required power output, efficiencies, setup, CO_2 emission, etc.).
2. Perform additional calculations required for Task 5.
3. Obtain relative costs of manure biomass handling and transportation to convert Thermolab Software results into dollar amounts.
4. Obtain comparative economics data on current operations of power plants.



_____ _____ Date:___*06/06/05*_____

Authorized Project Representative's Signature

NOTE*: Please attach any additional information that you feel should be a part of your report or that may be required to meet the deliverable requirements for tasks completed during this reporting period.*