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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: **August 09, 2005**

Report for the Monthly period:
Starting Date: **July 1, 2005** **Ending Date:** **July 30, 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. Task 1: Samples of manure from Texas Agricultural Experiment Station-Research Cattle feedlot were mailed to Hazen Laboratory and received the ash, proximate, and ultimate analyses for high ash raw manure or feedlot biomass (HA-FB-Raw) and low ash raw FB (LA-FB-Raw). The ash, N, and S loading in lb per mm BTU, predicted CO_2, NOx (assuming 35% of fuel N is converted into NO) and SO2 loading in lb per mm BTU are summarized in Appendix A. The ash analyses are summarized in Appendix B.
2. Task 1: On July 12, 2005, two graduate students (Mr. Soyuz Priyadarson (now deceased), Graduate Research Assistant (GRA) at PhD level and Nick Carlin, GRA at MS level) visited Broumley Dairy Farm near Hico, Texas and collected Dairy Biomass (DB) or Dairy manure samples; they include i) separated solids from the separator at the end of the free stalls, ii) High moisture, flushed manure from the free stalls, iii) High moisture manure from the storage lagoon, iv) Partially composted (PC, 3-5 weeks) manure from windrows of solids used for cow bedding, and v) Fully composted (3-4 months) manure.
3. Task 1: The specifications for equipments: TGA-DSC and Hg^0 analyzer have been finalized. Bids were sent from different manufacturers by TAMU purchasing. Order has been placed for TGA-DSC.
4. Task 2 deals with small scale reburn experiments for NOx reduction. The laboratory layout has been changed to conduct the experiments. The modified test setup was used to conduct preliminary experiments. All equipment is performing as desired.
5. Task 2 also deals with Hg studies. In light of safety concerns, it was decided that a new combustor setup will be fabricated exclusively for conducting mercury experiments. The setup is currently in design phase. However Mr. Soyuz Priyadarson, most experienced PhD student of the research group met with an accident and passed away. It will take

sometime before suitable replacement can be found. Mr. Brandon Martin (GRA at MS level) who is in charge of task 1 on TGA experiments is temporarily assuming some responsibilities for building the Hg reactor facility.

6. Task 3 deals with pilot scale studies using the DOE-NETL facility at Pittsburgh, PA. Dr Kalyan Annamalai (KA) attended DOE sponsored Hg Contractors conference at Pittsburgh which was attended by 30 Utilities including TXU and TMPA. Most of methods of Hg capture involve the use of powdered activated (PAC) carbon either in pure form or halogenated PAC (HPAC) for the capture of Hg. The presence of Cl in fuel enhances the Hg capture as $HgCl_2$ which could be dissolved in water or wet scrubbers. None of the methods presented at the conference involve the use of trace amounts of Animal Waste Derived Biomass Fuels (AWDBF). Appendix A of Task 3 presents more details of current literature and the tasks proposed under TCEQ grant.

   John Sweeten and KA visited the DOE-NETL and met with DOE officials to discuss the pilot scale tests. Mr. Mark Freeman of DOE-NETL presented an overview of previous pilot tests on co-firing and reburn with AWDBF and KA made a presentation on the status of current research on AWDBF. After the presentation, Mr. Mark Freeman informed us that they did not get the required funding to hire sub-contractors for running the DOE-NETL pilot scale facility and hence recommended other vendors. One of the recommended vendors for pilot scale tests includes GE Environmental Services. Response had been received from GE.
7. Task 4 deals with a zero dimensional reburn model for predicting the NOx capture by biomass fuels. The subroutines for calculations in the main burner section have been completed, and currently subroutines are being written to determine the volatile matter composition of coal and feedlot biomass fuels. This is being done using the Gibbs Minimization Method. Mr. Soyuz Priyadarson (now deceased) was responsible for the most part of and NOx and Hg modeling. While it will take sometime before suitable replacement can be found, Mr. Madhu (GRA at PhD level) who is also in charge of a part of Task 4 is temporarily assuming some responsibilities for NOx modeling.
8. Task 4: Mercury modeling. The group combustion code developed by Professor Annamalai is being modified for single particle Hg modeling. The modeling will include both homogeneous and heterogeneous mercury reactions. Mr. Soyuz Priyadarson (now deceased) was responsible for the most part of Hg capture modeling. Mr. Madhu (GRA at PhD level) is temporarily assuming some responsibilities for Hg modeling.
9. Task 5: After the fuel analyses for Task 1 are complete, the economic analysis of Task 5 can be completed. Dr Wyatt Harman

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 reburn studies at DOE-NETL
Task 4: Reburn modeling to predict NOx and Mercury 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: i. Liquid dairy biomass samples were too small to perform combustion analyses. Task 2: i. New combustor needs to be fabricated specifically for mercury studies. Task 3: i. Mr. Mark Freeman of DOE informed us that they did not get the required funding to hire sub-contractors for running the DOE-NETL pilot scale facility and hence recommended other vendors. Task 4: i. Mercury modeling: Moving forward as planned, but errors in the numerical code are inevitable. Task 5: None
Proposed Solution(s) (Please report any possible solution(s) to the problem(s) that were considered/encountered)	Task1: i. Moisture percentages were determined. Since samples of the solids separated from the liquid were collected, we will use these solids for the analysis. All needed data can be obtained. Task 2: i. A new improved combustor is being designed, specifically to handle hazardous species like mercury. The new combustor will be 66% longer than the current setup; this will give a longer residence time in the furnace. A longer residence time will ensure higher particle burn fraction, lower CO concentrations etc. The insulation will be improved to enable steady state operating conditions. Task 3: Task 4: i. Hg modeling: The solution to the above mentioned problem is to make correct changes to the present numerical code and allow time to debug and resolve any problems that arise. Task 5: N/A

Action(s) Conducted and Results (Please describe the action(s) taken to resolve the problem(s) and its effect)	Task1: i. Determined that fuel samples are sufficient to obtain needed analyses. Informed analysis company how to perform analyses. Task 2: i. Continued designing the new combustor for mercury studies. Task 3: i. DOE recommended a few vendors for pilot scale tests Response had been received from GE Environmental Services. Task 4: i. The code which is written for the combustion of an isolated coal particle has been modified to implement the chemistry of mercury and chlorine. ii. The pyrolysis model for mercury and chlorine has been implemented. iii.On a trial basis to test the model, a single gas phase reaction between mercury and chlorine is been implemented ($Hg + Cl \rightarrow HgCl$). This reaction is very fast compared to the reaction $Hg + Cl_2 \rightarrow HgCl_2$. Task 5: N/A

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 (08/01/2005 – 08/31/2005)

General:

Task 1:
Purchase TGA and begin equipment setup.
Begin training in the use of the TGA (Assuming TGA is delivered before the end of the period).
Perform preliminary testing on old samples to complete training (Assuming TGA is delivered before the end of the period).

Task 2:
Learn to operate all instrumentation for taking needed measurements in burner.
Design experimentation matrix for completing NOx experiments.
Use fuel data from Task 1 to calculate operating conditions for experiments.
Finalize the new combustor design, start fabrication work.

Task 3:
Finalize the date and venue for the meeting to be held at DOE-NETL, Pittsburgh, PA.

Task 4:
The oxidation of mercury is basically an 8-step reaction. We will implement a global one step reaction between mercury and chlorine. To implement this we may change the pyrolysis product of chlorine like HCl. The reasons being that the reaction between HCl and Hg is comparatively faster than the reaction $Hg + Cl_2 \rightarrow HgCl_2$.

Implement the heterogeneous reaction between Cl and Hg on the surface of the coal particle.

Task 5:
Begin the economic analysis for use of Dairy Biomass such as estimating firing rates, ash production, and CO_2 savings.

_____ _____ Date:___08/09/05_____
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.

Table of LIST OF ACRONYMS

AB: Agricultural Biomass

AC: Activated Carbon
ACI: activated carbon injection
APCD: Air Pollution Control Devices
APH: Air Pre-heater
AW: Agricultural Wastes
ARS: Agricultural Research Station
ATP: Texas Advanced Technology Program
AWDF: Animal Waste Derived Biomass Fuels
CAFO: Concentrated Animal Feeding Operations
CAIR: Clean air Interstate Rule
CAMR: Clean Air Mercury Rule
CB; Cattle biomass
CO_2: Carbon Dioxide
DAF: Dry Ash Free
DB: Dairy Biomass
DOE: Department of Energy
DSC: Differential Scanning Calorimeter
EER; Energy and Environmental research Corporation
EGR: Exhaust Gas Recirculation
EPA: Environmental Protection Agency
ESP: electrostatic Precipitator
FB: Feedlot biomass (Cattle manure or Cattle Biomass CB)
FC: Fixed Carbon
FGD: flue gas Desulfurizer
FR: Feed Ration
GRA: Graduate Research Assistant
HA-FB-Raw: High Ash Feedlot Biomass Raw form
HA-FB-PC: High Ash Feedlot Biomass Partially Composted

AHP: high ash/High Phosphorus feedlot biomass
HP: High Phosphorus
HHV: Higher Heating Value
HV: Heating value
LA-FB-Raw: Low Ash Feedlot Biomass
LA-FB-PC: Low Ash Feedlot Biomass Partially Composted
LALP: Low ash/Low Phosphorus feedlot biomass
LAHP: Low ash/High Phosphorus feedlot biomass
LOI: Loss on ignition or % carbon in bottom and fly ash
LP: Low Phosphorus
MAF: Moisture Ash Free, Dry Ash Free
mmBTU: million BTU
MMF: Mineral Matter Free
NETL: National Energy Technology Laboratory
N2: Nitrogen
NOx: Oxides of Nitrogen
O2: Oxygen
PAC: powdered activated carbon
PCD: particulate control devices
PM: particulate matter
RM; Raw Manure
S: Sulfur
SCR: Selective catalytic reduction
SR: Stoichiometric ratio, Air: Fuel/ $(\text{Air: Fuel})_{\text{stoich}}$
TAMU: Texas A&M University
TAES: Texas Agricultural Extension Service
TGA: Thermo-Gravimetric Analysis
TMPA: Texas Municipal Power Agency
TXU: Texas Utilities
USDA: US Dept of Agriculture
VM: Volatile matter