Fuel-Flexible Gasification-Combustion Technology for Production of H_2 and Sequestration-Ready CO_2

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ABSTRACT

It is expected that in the 21st century the Nation will continue to rely on fossil fuels for electricity, transportation, and chemicals. It will be necessary to improve both the thermodynamic efficiency and environmental impact performance of fossil fuel utilization. General Electric Energy and Environmental Research Corporation (GE-EER) has developed an innovative fuel-flexible Advanced Gasification-Combustion (AGC) concept to produce H_2 and sequestration-ready CO_2 from solid fuels. The AGC module offers potential for reduced cost and increased energy efficiency relative to conventional gasification and combustion systems. GE-EER was awarded a Vision-21 program from U.S. DOE NETL to develop the AGC technology. Work on this three-year program started on October 1, 2000. The project team includes GE-EER, California Energy Commission, Southern Illinois University at Carbondale, and T. R. Miles, Technical Consultants, Inc.

In the AGC technology, coal/opportunity fuels and air are simultaneously converted into separate streams of (1) pure hydrogen that can be utilized in fuel cells, (2) sequestration-ready CO_2, and (3) high temperature/pressure oxygen depleted air to produce electricity in a gas turbine. The process produces near-zero emissions and, based on preliminary modeling work in the first quarter of this program, has an estimated process efficiency of approximately 67% based on electrical and H_2 energy outputs relative to the higher heating value of coal. The three-year R&D program will determine the operating conditions that maximize separation of CO_2 and pollutants from the vent gas, while simultaneously maximizing coal conversion efficiency and hydrogen production. The program integrates lab-, bench- and pilot-scale studies to demonstrate the AGC concept.

This is the 1st quarterly progress report for the Vision-21 AGC program supported by U.S. DOE NETL (Contract: DE-FC26-00FT40974). This report summarizes program accomplishments for the period starting October 1, 2000 and ending December 31, 2000. The report includes an introduction summarizing the AGC concept, main program tasks, objectives of this program, and provides a summary of initial program activities covering program management and preliminary progress in first year tasks including lab- and bench-scale design, facilities preparation, and process/kinetic modeling. More over, the report presents and discusses preliminary results particularly form the bench-scale design and process modeling efforts including a process flow diagram that incorporates the AGC module with other vision-21 plant components with the objective of maximizing H_2 production and process efficiency.

TABLE OF CONTENTS

INTRODUCTION

Electricity produced from hydrogen in fuel cells can be highly efficient relative to competing technologies and has the potential to be virtually pollution free. Thus fuel cells may become an ideal solution to many of this nation's energy needs if one has a satisfactory process for producing hydrogen from available energy resources such as coal, and low-cost alternative feedstocks including biomass, municipal solid waste, sewage sludge, and others.

This Vision-21 program addresses a novel, energy efficient, and near-zero pollution concept for converting a conventional fuel (coal) and opportunity fuels (e.g., biomass) into separate streams of hydrogen, oxygen-depleted air, and sequestration ready CO_2. This concept is referred to throughout this report as *Advanced Gasification-Combustion (AGC)*. When commercialized, the AGC process may become one of the cornerstone technologies to fulfill Vision-21 energy plant objectives of efficiently and economically producing energy and hydrogen with utilization of opportunity feedstocks.

The AGC technology is energy efficient because a large portion of the energy in the input coal leaves the AGC module as hydrogen and the rest as high-pressure, high-temperature gas which can power a gas turbine. The combination of producing hydrogen and electrical power via a gas turbine is highly efficient, meets all objectives of Vision-21 energy plants, and makes the process flexible. That is, the AGC module will be able to adjust the ratio at which it produces hydrogen and electricity in order to match changing demand.

The three-year Vision-21 AGC program will be conducted primarily by General Electric Energy and Environmental Research Corporation (GE-EER) under a Vision-21 contract from U.S. DOE NETL (Contact No. DE-FC26-00FT40974). Other project team members include Southern Illinois University at Carbondale (SIU-C), California Energy Commission (CEC), and T. R. Miles, Technical Consultants, Inc. The AGC project integrates lab-, bench- and pilot-scale studies to demonstrate the AGC concept. Engineering studies and analytical modeling will be performed in conjunction with the experimental program to develop the design tools necessary for scaling up the AGC technology to the demonstration phase. The remainder of this section presents objectives, concept, and main tasks of the AGC program.

Program Objectives

The primary objectives of the AGC program are to:

- Demonstrate and establish the chemistry of the AGC concept, measure kinetic parameters of individual process steps, and identify fundamental processes affecting process economics.
- Design and develop a bench- and pilot-scale systems to test the AGC concept under dynamic conditions and estimate the overall system efficiency for that design.
- Develop kinetic and dynamic computational models of the individual process steps.
- Determine operating conditions that maximize separation of CO_2 and pollutants from vent gas, while simultaneously maximizing coal/opportunity fuels conversion and H_2 production.
- Integrate the AGC module into Vision-21 plant design and optimize work cycle efficiency.
- Determine extent of technical/economical viability & commercial potential of AGC module.

AGC Concept

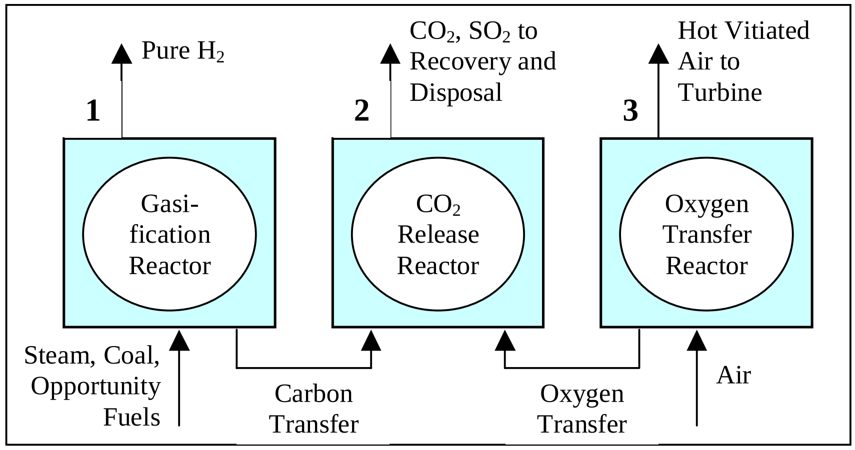

Figure 1. Conceptual design of the AGC technology.

Figure 1 shows the conceptual design of the AGC technology where three reactors are used. In Reactor 1, coal and opportunity fuels (5-10% by heat input) are gasified by steam in the presence of a CO_2-absorbing bed material. As CO_2 is scavenged, CO is also depleted from the gas phase due to the water shift reaction. As a consequence, mainly H_2 is released from Reactor 1. Only part of the solid fuels fed to Reactor 1 is gasified to produce hydrogen. The remaining char and bed material are transferred to Reactor 2 where the carbon is oxidized to supply the thermal energy necessary to regenerate the CO_2-absorbing bed material and release CO_2 as shown in Figure 1. An oxygen-transfer bed material is moved from Reactor 3 to Reactor 2 to provide the oxygen necessary to oxidize the char in Reactor 2 which in turn raises the bed temperature for decomposition and release of CO_2. Air is supplied to Reactor 3 to regenerate the oxygen-transfer bed material. Coming out of Reactor 3, the hot oxygen depleted air passes to a gas turbine to generate electricity and the hot bed materials return to Reactor 2. Ash and some bed material will be removed from the system periodically to reduce the amount of ash in the reactor and to replenish the bed materials with fresh compounds.

Project Plan

The tasks planned for the AGC project are summarized in Table 1. These tasks will be conducted over the three-year period which started October 1, 2000. Success of the AGC program depends on the efficient execution of the various research tasks outlined in Table 1 and on meeting program objectives summarized above.

PROGRAM INITIATION AND MANAGEMENT

GE-EER initiated work on the three-year AGC program on October 1, 2000. The signed U.S. DOE contract was reviewed thoroughly and contract requirements and reporting milestones where identified and noted for future on-time compliance. A conference call kickoff meeting was held with our subcontractor Southern Illinois University at Carbondale (SIU-C) during which plans for the AGC program were discussed in general. Activities at SIU-C for the first year were discussed in more detail including technical aspects of tasks, personnel, and analytical equipment. It was decided that SIU-C will prepare a work/test plan for Task 1 (lab-scale and fundamentals study) and submit to GE-EER for review and discussion.

GE-EER also conducted an internal kickoff meeting attended by project management and lead engineers identified for the program. Tasks for first year activities were discussed and assigned to the lead engineers who are responsible for drafting work plans. Preliminary work plans for process and kinetic modeling (Task 4) and bench-scale facility work (Task 2) were prepared and discussed to identify goals and objectives of the modeling activities and how the modeling results will feed into the experimental program, particularly Task 2. Timeline for conducting the work and staffing plans were also discussed. These plans may be revised as necessary as research progresses and results are reviewed.

During the first week of December 2000, preparations for the DOE NETL kickoff meeting were conducted at GE-EER and SIU-C. The kickoff meeting was held at NETL offices in Pittsburgh on Dec 13. The meeting was attended by key GE-EER, SIU-C, and U.S. DOE NETL personnel. An introduction about NETL and the Vision 21 program was presented by DOE and then presentations by GE-EER and SIU-C followed describing objectives, goals, AGC concept, preliminary results, and near-term future plans for the AGC program.

In the first quarter of this project, two reports have been submitted including a Hazardous Substance Plan on 10/30/00 and Environmental, Health, and Safety (EH&S) Approvals repot on 11/21/00. Other regular management activities planned for the AGC program include:

Table 1. Main tasks of the AGC program.

Task	Task Description
Lab-Scale Experiments – Fundamentals *Task 1*	Design & assembly Demonstration of chemical processes Sulfur chemistry
Bench-Scale Test Facility & Testing *Tasks 2 & 3*	Bench test facility design Subsystems procurement & assembly Bench test facility shakedown Reactor design testing Parametric evaluation Fuel-flexibility evaluation Pilot operation support
Engineering & Modeling Studies *Task 4*	Opportunity fuels resource assessment Preliminary economic assessment Kinetic & process modeling Integration into Vision-21 plant Pilot plant control development
Pilot Plant Design, Assembly, & Demonstration *Tasks 5, 6, & 7*	Process design Subsystems specification/procurement Reactor design & review Reactors manufacture Components testing Pilot plant assembly Operational shakedown modifications Operational evaluation Fuel-flexibility evaluation Performance testing
Vision 21 Plant Systems Analysis *Task 8*	Preliminary Vision-21 module design Vision-21 plant integration Economic & market assessment
Project Management *Task 9*	Management, reporting, & technology transfer

- meetings and conference calls to discuss progress, difficulties, staffing, and to brain storm and make decisions on outstanding issues;
- monthly job-cost monitoring to assure work remains within budget;
- monthly progress reports to DOE Project Officer COR; and
- quarterly reports and a final report to be submitted during the three-year program period.

Technology transfer is planned to be accomplished for this program through attending professional conferences/meetings and presenting ongoing results from the AGC project. Abstracts were submitted to two conferences so far including the Clearwater Conference (March

5-8, 2001, Clearwater, FL) and the 11th ICCS to be held between Sep 30 – Oct 5, 2001 in San Francisco. The abstract for the Clearwater Conference 2001 has been accepted and an AGC paper will be presented on Wednesday, March 7, 2001 in the morning session. Abstracts for the 11th ICCS are still under review and results will be announced in February 2001.

EXPERIMENTAL

In the first quarter, the experimental effort for the AGC project started by formulating preliminary work plans for Tasks 1 and 2 and proceeding with design activities and preparation of the lab- and bench-scale facilities. Activities performed within these two tasks are discussed in this section.

Lab-Scale/Fundamentals (Task 1) Activities

The primary objective of Task 1 is to perform a laboratory-scale demonstration of the individual chemical and physical processes involved in GE-EER's fuel-flexible AGC technology. This task is primarily being conducted by SIU-C. SIU-C has begun work on this task including facility preparation and preparation of preliminary work plan and will be developing a detailed work plan for the complete effort based on initial work results. Specific objectives of Task 1 are to:

- support bench-scale studies;
- assist in process optimization and engineering analysis;
- identify key kinetic and thermodynamic limitations of the process; and
- verify the process at laboratory scale.

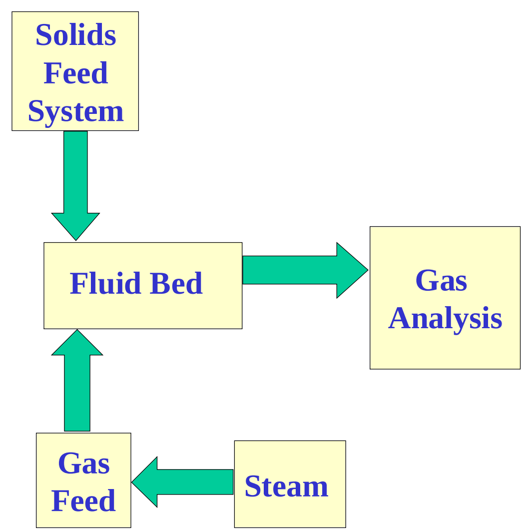

Figure 2. Simplified process flow diagram for laboratory-scale system.

SIU-C has completed a preliminary design of the lab-scale facility. The system components are shown in a simplified process flow diagram in Figure 2. This figure depicts the solids handling system, the steam generator, gas feed, fluidized bed reactor, and gas analysis components of the system. A critical component of this facility is the solids handling system, which is needed for solids feeding at high pressure. Figure 3 shows SIU-C's design of the solids handling facility that will be used to feed coal to the system. The system uses inert gas and a series of shut-off valves to transfer coal to the reactor at high pressure.

Some important parameters for the test effort have been identified. Testing will include an assessment of the impacts of the following parameters on process operation:

- Coal characteristics
  - Sulfur chemistry

- Coal type
- Inherent analysis
- Particle size

- System operating conditions
  - Temperature
  - Pressure

The next steps in Task 1 include finalizing the system design, beginning assembly of the system, and testing.

Bench-Scale Facility (Task 2) Activities

The objective of Task 2 is to design, assemble and shakedown the bench-scale experimental facility. Work conducted in this quarter has focused on the design of the bench-scale experimental set-up. Although the design effort is currently still in progress, significant issues affecting the mass balance, reactor design, process design, subsystem specifications, experimental procedures and available data/test have been identified. Approaches to resolving issues are currently being developed or finalized. A summary of preliminary work conducted and planned to finalize the mass and energy balance, design calculations, reactor design, process design, experimental procedures and data analysis procedures is provided below.

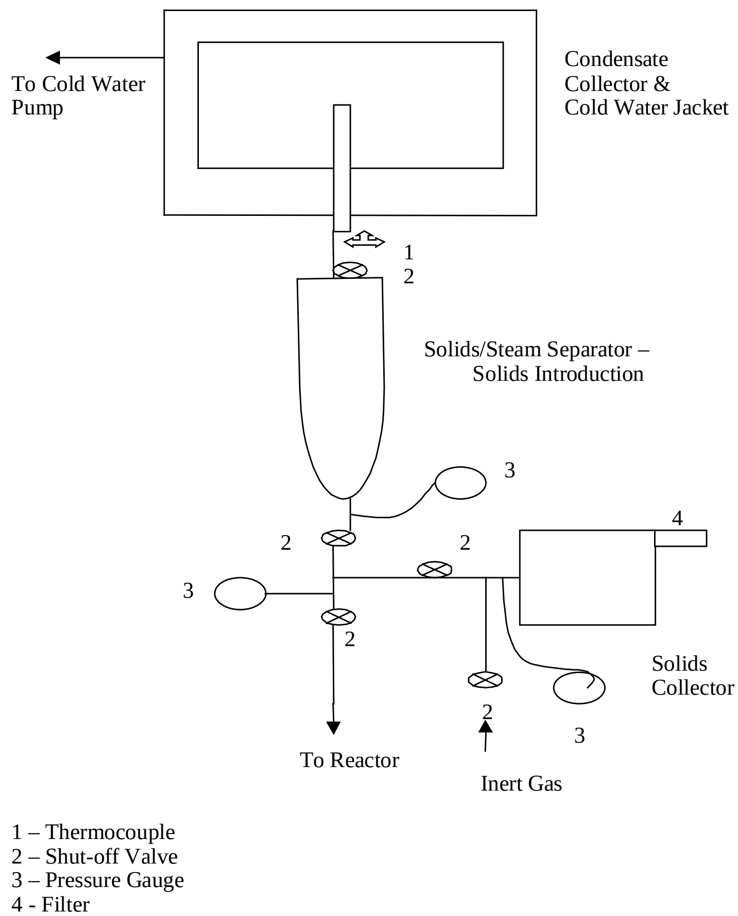

Figure 3. Design of solids handling system for laboratory-scale reactor

<u>Mass and Energy Balance</u>

A mass and energy balance was completed for the integrated three-reactor system. This mass and energy balance serves as a reference point for the bench-scale operating conditions. Specific operating conditions will be developed for each type of test, and will include calculation methodologies for determining the amount of each bed material, the amount of coal fuel, steam and air flow rates, test duration, and other operating parameters such as operating pressures and temperatures.

<u>Bench-Scale Reactor Design</u>

The reactor is designed for high pressure (up to 30 atm), high temperature (up to 1000˚C) operation. The main seal on the reactor is a flange that will be located outside of the furnace hot zone. The reactor will have both a fixed outer housing and a removable inner sleeve to facilitate inspection and easy replacement of the bed contents as needed. The reactor is also to be equipped with temperature and pressure monitoring, coal feed ports and bed sampling ports.

Experimental Facility Process Design

The process is designed to allow flow of air, nitrogen and steam as needed, with valves and flow meters and pressure gauges controlling the operation. The process design includes instrumentation to verify proper operation of the system. A preliminary process flow diagram for the bench-scale facility is provided as Figure 4.

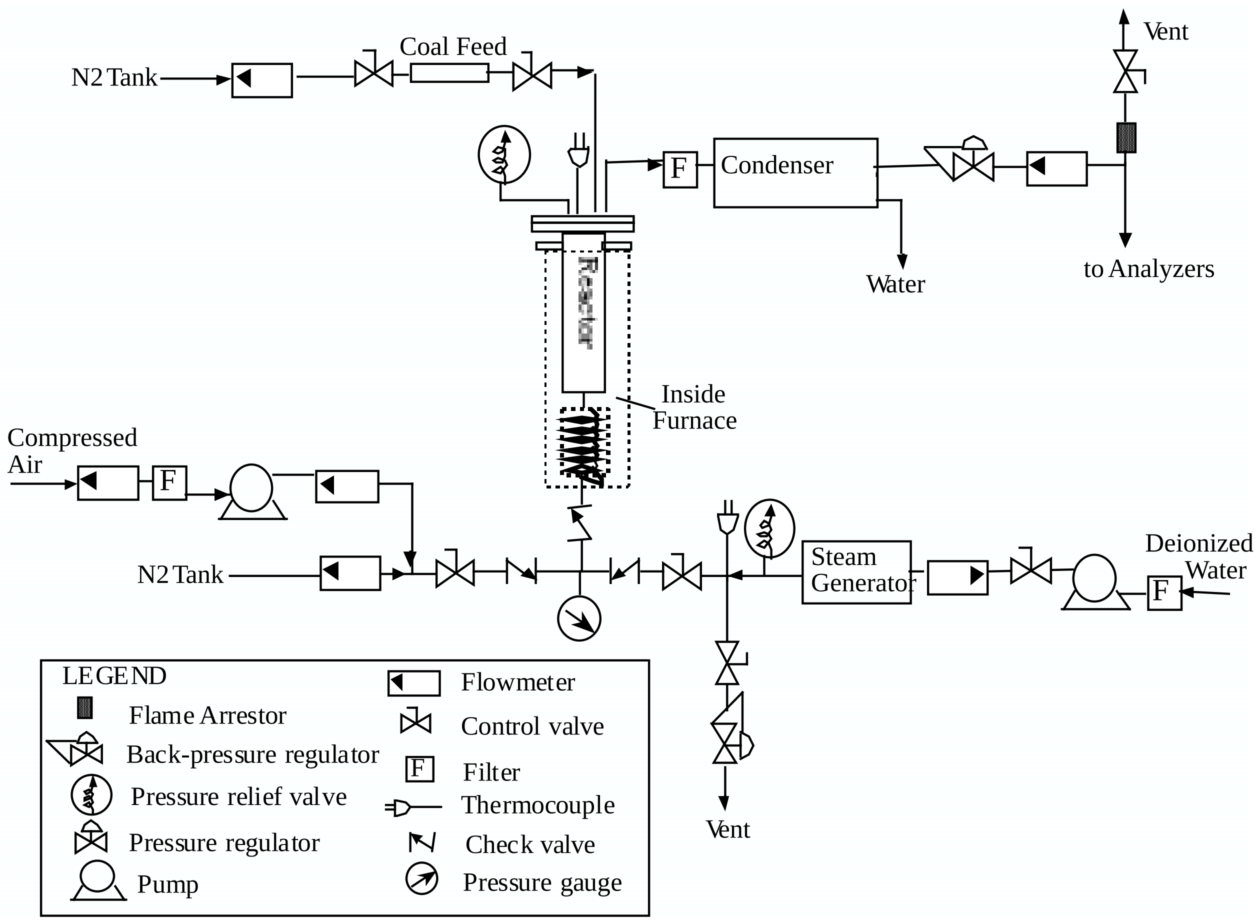

Figure 4. Preliminary process flow diagram for bench-scale experimental facility.

The process requires the use of several subsystems to ensure consistent operation. The experimental facility includes several subsystems such as: a high pressure air supply system, a steam generator, a coal feed system, a system for maintaining pressure in the reactor, and a system for conditioning the product gas stream and analyzing its composition. A complete set of specifications for these subsystems is being developed, and vendors are being contacted to identify parts.

Experimental Procedures

Experimental procedures will be developed for each type of test to ensure that the operation, monitoring, sampling and diagnostics are conducted in a manner consistent with the test objectives. A simplified procedure for a coal gasification test performed in the gasification reactor (Reactor 1) is provided in Table 2. The experimental procedures also have the important purpose of ensuring the safety of those conducting the tests. A series of failure mode and effect analyses will be conducted to identify critical issues and action items to ensure safe and appropriate operation of the system.

Table 2. Preliminary coal gasification test procedure.

A	Fill reactor with material
B	Seal reactor and test for leaks
C	Preheat reactor to operating temperature under flowing N_2
D	Bring reactor to operating pressure with N_2 flow
E	Stabilize steam flow rate, pressure and temperature while venting steam
F	Ensure that data acquisition system (DAS) and continuous emission monitors (CEM) are online and recording data
G	Load coal into reactor using coal delivery system
H	Switch from N_2 to steam flow through the reactor
I	Maintain steam flow until all coal is gasified or some predetermined time
J	Switch from steam to N_2 flow through the reactor
K	Turn off furnace and allow reactor to cool
L	Remove reactor from furnace
M	Recover bed for analysis

Data Analysis Procedures

The system design will facilitate the measurement of several variables. These include the outlet gas concentrations of H_2, CO, CO_2, O_2, total hydrocarbons, and SO_2. Some measurements will be taken continuously using continuous emission monitors (CEMS) and others will be taken intermittently, such as gas chromatography (GC) analysis of the outlet gas. A wide array of analysis techniques is available for determining the physical properties of the solid fluidized bed particles, both before and after testing. We will work closely with SIU-C to identify appropriate analysis methods for each type of test.

Data analysis procedures are being developed for the measurements taken during each type of test. These procedures will aid in calculation of such quantities as the amount of O_2 consumed during the oxygen-transfer step in Reactor 3, the amount of CO_2 released in Reactor 2, and the amount of CO_2 absorbed and H_2 produced in Reactor 1.

MODELING

The main objectives of process and kinetic modeling are to provide information necessary for pilot-scale design and scale-up of the AGC technology, and to determine the operating conditions that maximize the separation of CO_2 and pollutants from the vent gas, while simultaneously maximizing coal conversion efficiency and H_2 production. This section presents a summary of the ongoing work in these modeling tasks.

Process Modeling

A computer model was developed to perform analytical calculations for all the unit operations in the multi-bed reactor system. The model is interfaced with the NASA thermodynamic code (McBride and Gordon, 1993) for calculation of reaction equilibrium and constituent compositions. The model can be used to determine the process efficiency as a function of different parameters, such as feed flow rates, system pressure, and the recirculation rate of solids. The model can also be used for optimizing process design. The model performs mass and energy balances for each component of a process flow diagram (PFD) and for the whole system.

Fluidization Calculations for the Multi-Bed Reactor System

The fluidization calculations are performed to determine the fluidization limits, such as minimum fluidization, slugging, and entrainment limits. These calculations are also used to determine the expanded bed heights, expanded bed void fractions and pressure drops.

Inputs to the model are the fluidizing gas composition, bed temperature, pressure, bed diameter, unexpanded bed height, particle diameter, particle density, and particle sphericity. The model performs calculations for a fluidizing gas consisting of at least one of the following seven components: CO_2, CO, H_2O, CH_4, H_2, O_2, and N_2.

A detailed algorithm of the fluidization calculations is presented in a topical report submitted by GE-EER under another DOE contract (DE-FG26-99FT40682). In summary, the density and viscosity of the fluidizing gas mixture are first calculated at high pressure and temperature. These values are then used to calculate the fluidized bed properties. The important outputs are the expanded bed height, expanded bed void fraction, bed pressure drop, minimum fluidization velocity, minimum slugging velocity, and terminal velocity.

Analytical Calculations for All Unit Operations

The individual unit operations in the entire hydrogen/power plant are modeled to evaluate the performance of the entire system. The unit operations—which include reactors, boilers, expanders, compressors, heat exchangers and other equipment—are modeled using explicit analytical descriptions that account for non-idealities such as heat loss and non-isentropic expansion. The mass and energy balances are maintained around each unit operation. Recycle loops were converged by supplying initial estimates for the recycle-loop-stream parameters and then iterating until the temperature and composition of the recycle-loop-streams remained essentially constant. Inputs to the model include information about each unit, such as heat exchanger thermal efficiency, expander efficiency, etc. The reactors were initially modeled assuming that thermodynamic equilibrium is reached.

This model was used to estimate system efficiency for a process flow diagram that maximizes H_2 production while also maximizing process efficiency. These calculations and results are presented and discussed in the Results and Discussion section of this report.

Kinetic Modeling

A preliminary work plan for kinetic modeling in Task 4 was prepared, reviewed, and discussed to identify goals and objectives of the kinetic modeling approach, timeline for conducting the work, and staffing needs/plans. Kinetic modeling is an important tool in providing information necessary for pilot-scale design and scale-up of the AGC technology, and for determining the operating conditions that maximize the separation of CO_2 and pollutants from the vent gas, while simultaneously maximizing coal conversion efficiency and H_2 production. It is expected that in the course of the project, kinetic models describing the following processes will be developed:

- Coal gasification (including devolatilization and char gasification), char oxidation, CO_2 and H_2S capture in the gasification reactor (Reactor 1),
- CO_2 release in Reactor 2, and
- Oxygen transfer in Reactor 3.

These models will describe reactions between one of the solid phase components and species in the gas phase. Gas phase reactions/composition will be assumed to correspond to equilibrium. These models will be then combined into an integrated model that can be used for AGC optimization. Details of the planned kinetic modeling work and potential reaction processes are under development and will be presented in the next quarterly report.

RESULTS AND DISCUSSION

Since this report reflects progress in the first quarter of the AGC project, most of the work performed encompassed preparation of work plans, facilities, modeling approaches, and identifying parts, materials, and equipment needs. Therefore, the main results obtained in the first quarter reflect some design calculations (Task 2) and preliminary work on process modeling (Task 4) as summarized below.

Design Calculations Example (Task 2)

An important consideration in fluidized bed design is the identification of two limiting flow rates: the flow rate for minimum fluidization and the flow rate for bed entrainment. GE-EER has developed a fluidization model (described above in the Modeling section) to calculate limiting flow rates for the fluidization gas. An example of the limiting flow rate for steam fed to a 5.08 cm (2”) diameter gasification reactor operating at Reactor 1 conditions is presented in Figure 5 as a function of bed particle diameter. The allowable particle diameters have previously been identified as 100-300 micrometers, based on SIU-C testing. The acceptable range of steam flow rates for these particle sizes is shown in Figure 5. During testing, the steam flow rate will be set based on the particle sizes present in the bed.

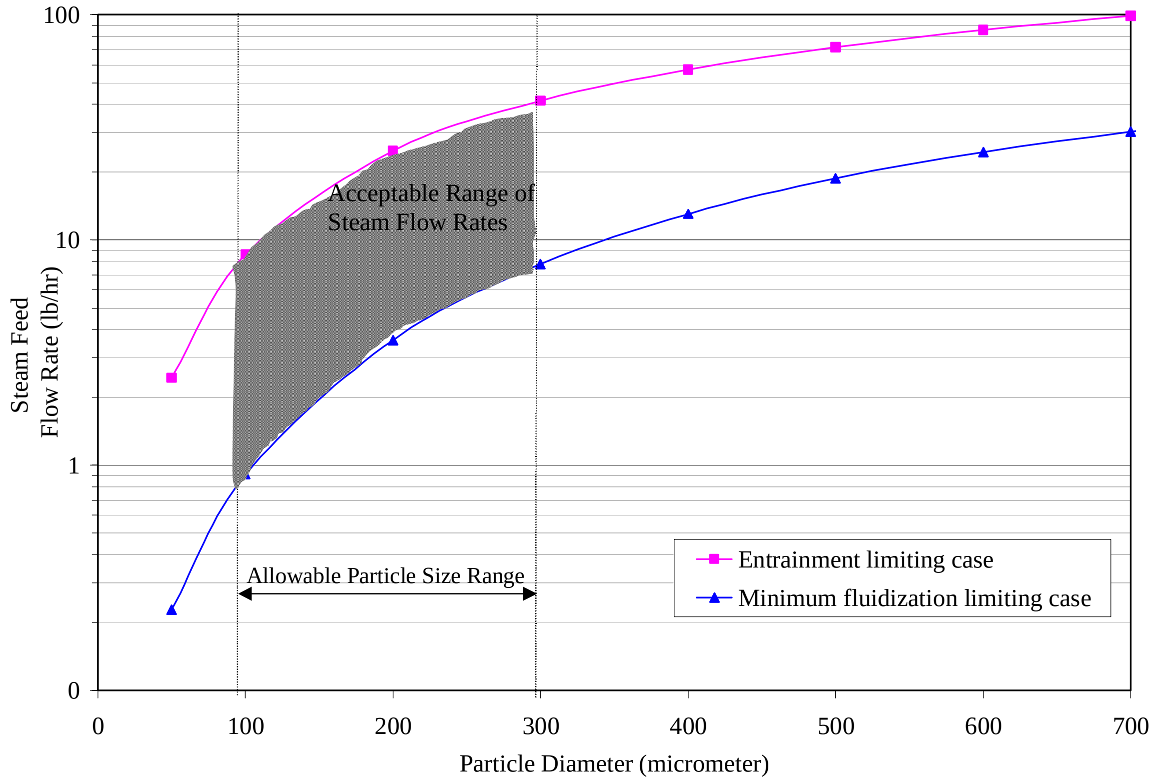

Figure 5. Limiting flow rates for steam fed to Reactor #1 as a function of bed particle diameter.

Process Modeling (Task 4)

The overall objective of the analysis was to assess the realistic engineering feasibility of the proposed process. This was accomplished by running the computational model of the process. The output from the model was a detailed process flow diagram and an analysis of the optimal process configuration. For this configuration, the model was then exercised to determine system performance.

<u>Process Configurations</u>

Vision-21 plants can be configured for a variety of purposes, such as production of hydrogen, chemicals, electricity utilizing a fuel cell, electricity utilizing turbines, or combinations of these, plus steam and heat. In the process flow diagram (PFD) presented in Figure 6, the Vision-21 plant (including the AGC module) was designed to maximize the production of hydrogen from coal and also maximize process efficiency. The excess heat available from the AGC module will be used to generate electricity using turbines.

The model was used to study several different configurations of the integrated system, including the three-bed reactors and other components such as compressors, turbines and heat exchangers. The example configuration in Figure 6 was chosen to be consistent with Vision-21 goals for efficiency.

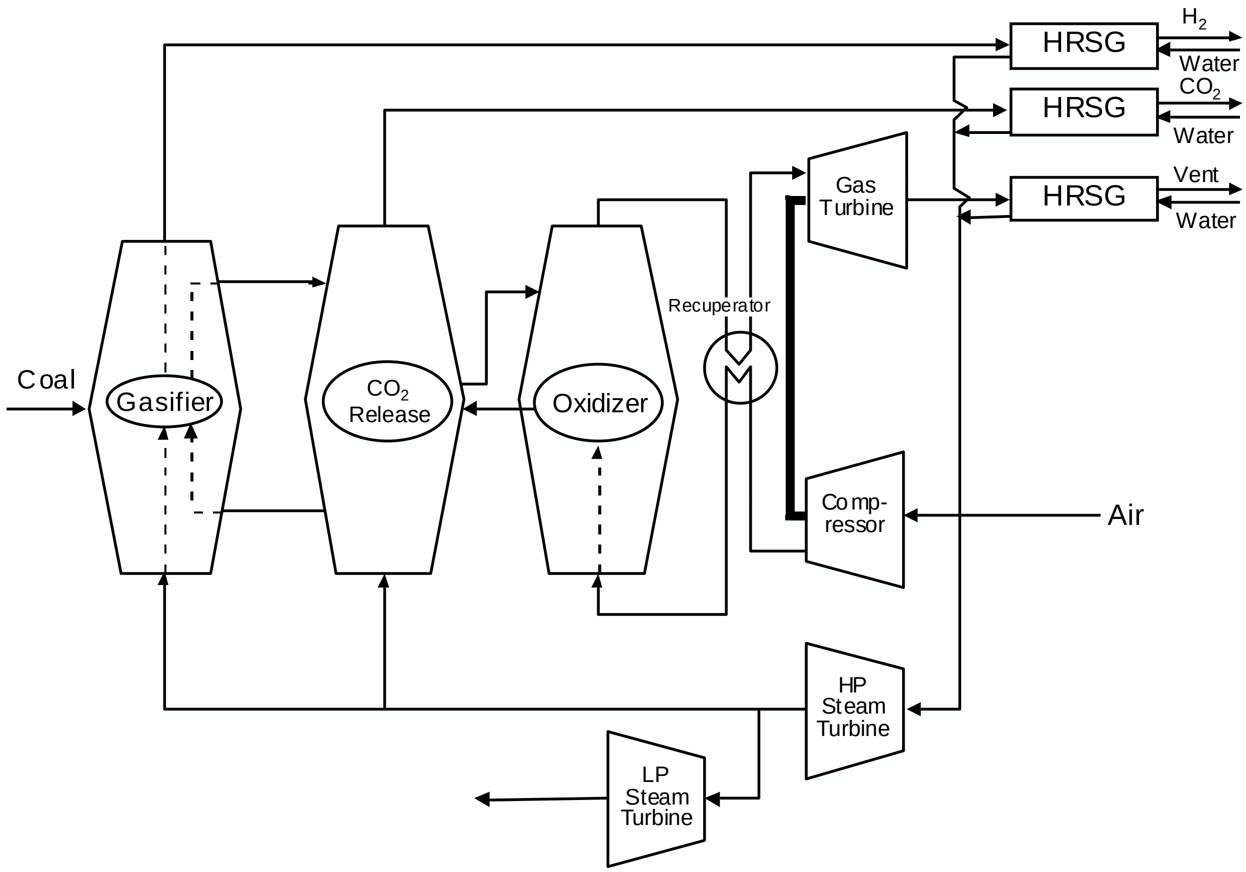

Figure 6. Process flow diagram incorporating the AGC module with other unit operations.

The multi-bed reactor system in Figure 6 operates at 30 bar. Coal and steam are fed to the gasification reactor (Reactor 1), steam is fed to the CO_2 release reactor (Reactor 2), and air is fed to the oxygen-transfer reactor (Reactor 3) as shown in Figures 1 and 6. The multi-bed circulating fluidized system generates three separate streams of H_2, CO_2 and vitiated-air. The PFD in Figure 6 shows how to incorporate the AGC module output streams with other unit operations including a recuperator, a compressor, heat recovery steam generators (HRSG), and turbines.

The H_2 and CO_2 streams are fed to HRSG. The vitiated-air stream is sent to a recuperator and then cleaned to remove particulate matter. The vitiated-air stream is then sent to a gas turbine which is operated at a 30:1 compression ratio. It is assumed that the efficiency of the gas turbine is 92%. The gas turbine exhaust now at close to atmospheric pressure, is cooled in a HRSG unit, producing steam at 380 bar. It is assumed that the HRSG units operate at a thermal efficiency of 90%. The H_2 and CO_2 streams are available at 30 bar downstream of the HRSG units for distribution and sequestration, respectively. The 380 bar steam is sent to a high pressure steam turbine. The high pressure steam turbine exhaust at 30 bar is then available for injection in Reactors 1 and 2. The remaining steam is sent to a low pressure steam turbine. The integrated plant is modeled by performing mass and energy balances across all the units.

System Performance

The system performance was analyzed and the following parameters were calculated:

- H_2 purity of product stream (dry basis) of 94.5%,
- fraction of CO_2 recovered of 96.4%, and
- overall process efficiency of 67%.

The hydrogen purity was calculated on a dry molar basis. The fraction of CO_2 recovered was calculated as the ratio between the moles of CO_2 separated and the moles of coal fed. The overall process efficiency is defined as the ratio between the energy recovered to the higher heating value (HHV) of the coal fed. The energy recovered is the sum of HHV of the H_2 produced and the electricity generated by the entire process.

CONCLUSIONS

It is too early to make conclusions regarding the entire program, but work progress so far is encouraging and preliminary results point to continued future progress in the development of the AGC concept. The system performance parameters estimated by the process model, including an approximate process efficiency of 67%, are also hopeful. It is also worth noting that no major difficulties were encountered in the first quarter.

FURUTE WORK

The near-term/first year research plans for the AGC project are summarized in Table 3. These plans encompass continuing process and kinetic modeling, conducting literature search, engineering design calculations, process instrumentation design, bench-scale set-up, and testing.

Activities for the second quarter for the bench-scale (Task 2) will focus on finalizing designs, documenting procedures, procuring equipment and subsystems, and assembling the system. Specific activities anticipated in the next quarter include:

- Finalize reactor and process design.
- Finalize selection of system components.
- Complete procurement of necessary system components and subsystems.
- Complete pre-project safety report.
- Finalize operating procedures for system.
- Document final design calculation procedures.
- Document procedures and prepare templates for data analysis calculations.
- Install and test individual subsystems.
- Assemble system.

Regarding modeling, next quarter activities will focus on finalizing a detailed kinetics modeling plan and starting the modeling procedure, and also on continued progress in updating and fine-tuning the process model to develop updated curves for the operational limits of the bench-scale system. The process model will assist in bench-scale system design calculations including reactor bed particle sizes, flow rates, and other operating parameters.

Other activities for the next quarter include progress in Task 1 including finalizing the lab-scale system design, beginning assembly of the system components, and testing. Staffing needs for the AGC project will be a priority in the 2nd quarter both at GE-EER and at SIU-C so that work progress can continue as planned.

Table 3. Near-term research plan for the AGC project.

Process & Kinetic Modeling	Literature Search	Engineering Design Calculations	Process & Instrumentation Design	Bench-Scale Setup	Testing
• Complete model and continue simulations assuming equilibrium	• CO_2 sorption/ desorption reactions	• Minimum Fluidization, slugging, & entrainment regimes	• Process & Instrumentation drawings	• Selection & ordering of parts	• Test plans
• Run model to determine process conditions	• High P Screw feeders	• Catalyst Bed design	• Specifications for critical components	• Setup of bench-scale system	• Run experiments
• Model kinetics	• Moving solids between reactors	• Distributor plate design	• Flow ranges for feed flows & outlet flows	• Lab-view programming	
• Integrate kinetic model with process model	• Fluidization	• Reactor design			
	• Reactions between iron oxide & CO, H_2, & O_2	• Screw feeder design			
	• Gasification of coal & char	• Mechanical stress calculations			

REFERENCES

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