LIGNITE GASIFICATION TESTING AT THE POWER SYSTEMS DEVELOPMENT FACILITY

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INTRODUCTION

Lignite coal presents opportunities as well as challenges as a feedstock for an integrated gasification combined cycle power plant. It is relatively inexpensive, easily accessible for mining, highly reactive and thus readily converted to syngas, and it is abundant—accounting for nine percent of demonstrated U.S. coal reserves (EIA, 2007). On the other hand, lignite is characterized by high moisture and ash contents and low heating value compared to higher rank coals. While these physical characteristics limit the use of lignite as a feedstock for many gasifier designs, the KBR Transport Gasifier is particularly well suited to effectively utilize lignite and other low rank coals.

The KBR Transport Gasifier was developed at the Power Systems Development Facility (PSDF), a state-of-the-art test center sponsored by the U.S. Department of Energy (DOE) and operated by Southern Company Services. The PSDF Transport Gasifier is a dry-feed, non-slagging circulating fluidized bed gasifier. Demonstration of commercial readiness of the Transport Gasification process with lignite fuel must include economic management of the high fuel moisture and ash contents. Efficient coal preparation, reliable ash removal, and optimum gasifier operating conditions are all key to this demonstration, and lignite testing at the PSDF focused on addressing these issues.

TRANSPORT GASIFICATION PROCESS DESCRIPTION

The PSDF gasification process, shown in Figure 1, features key components of an integrated gasification combined cycle (IGCC) plant. These include high pressure solids feed systems; a KBR Transport Gasifier; syngas coolers; a hot gas filter vessel, the particulate control device (PCD); continuous ash depressurization systems developed at the PSDF for ash cooling and removal; a novel piloted syngas burner; a slipstream syngas cleanup unit to test various pollutant control technologies; and a recycle syngas compressor.

The coal used as the gasifier feedstock is processed on site. The material is crushed, dried in the fluid bed dryer (high moisture fuels only), and pulverized to a nominal particle diameter between 250 and 400 microns. Coal may be fed to the gasifier using two systems, the original coal feed system and a secondary coal feed system. The original coal feed system is a lock hopper, vertical pocket feeder design with a “rotofeed” dispenser. It consists of two pressure vessels, with the coal pressurized in the upper lock vessel and then gravity fed into a pressurized dispense vessel. The material is fed out of the dispense vessel by the rotofeed dispenser, which is driven by a variable speed electric motor and delivers the material into the discharge line where it is conveyed by air or nitrogen into the gasifier. The secondary coal feeder is a developmental test unit designed to evaluate different feeder mechanisms. Types of mechanisms that can be tested with this system include auger-style, fluid bed, and a higher pressure rotary feeder. Coal is fed at a nominal rate of 4,000 lb/hr.

A sorbent feeder is available to feed material into the gasifier for in-situ sulfur capture or to address ash chemistry issues. For sulfur capture, either limestone or dolomite is fed after being crushed and pulverized to a nominal particle diameter of 10 to 100 microns. The sorbent feeder utilizes the same design as the original coal feeder, but for a lower feed rate of nominally 100 lb/hr.

The transport gasifier (a pressurized, advanced circulating fluidized bed reactor) consists of a mixing zone, riser, solids separation unit, seal leg, standpipe, and J-leg. The gasifier is equally capable of using air or oxygen as the gasification oxidant. An air or oxygen and steam mixture are fed into the mixing zone at different elevations and orientations to evenly distribute heat generated from the partial combustion of the circulating solids. The oxygen from the air or pure oxygen feed is completely consumed in this section of the gasifier. The coal and sorbent are fed at a higher elevation in the mixing zone where the atmosphere is reducing, or oxygen-free.

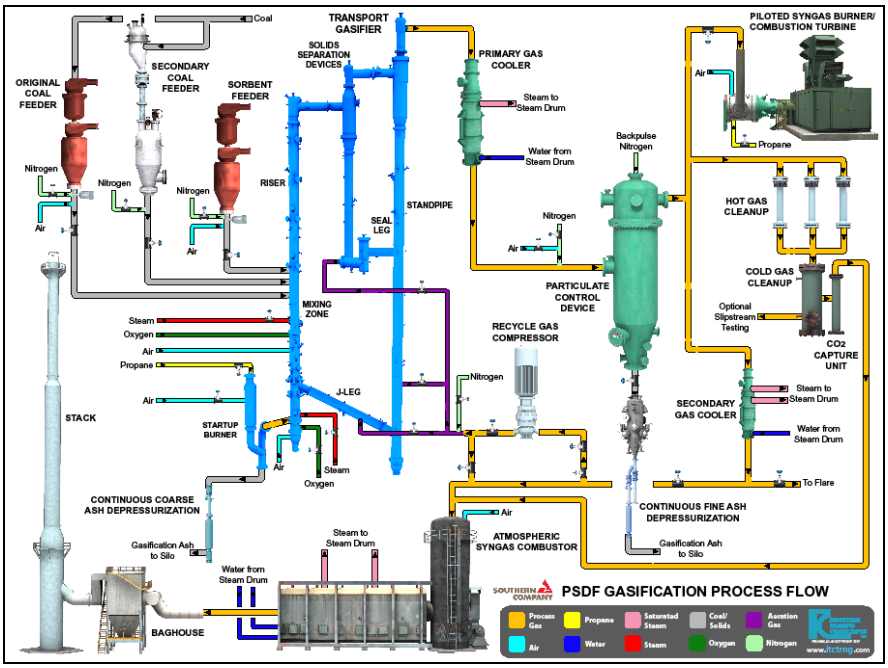

Figure 1. PSDF Gasification Process Flow Diagram.

As the coal devolatilizes and chemical reactions occur to generate syngas, the gas and solids move up the riser and enter the solids separation unit. This unit contains two solids separation devices, which use cyclonic action to remove particles. Between the first and second solids separation devices is the seal leg, which prevents backflow of solids. The solids collected by the solids separation unit are recycled back to the gasifier mixing zone through the standpipe and J-leg. The gasifier solids inventory is controlled by removing gasification ash through the continuous coarse ash depressurization (CCAD) system, which cools and depressurizes the solids. The nominal gasifier operating temperature is 1,800°F, and the gasifier system is designed to have a maximum operating pressure of 294 psig with a thermal capacity of about 41 MBtu/hr.

The syngas exits the transport gasifier, passes through the primary gas cooler where the gas temperature is reduced to about 750°F, and enters the PCD for final particulate removal. The metal filter elements used in the PCD remove essentially all the particulate from the gas stream. The PCD utilizes a tube sheet holding up to 91 filter elements, which are attached to one of two plenums. Process gas flows into the PCD through a tangential entrance, around a shroud, and through the filter elements into the plenums. Failsafe devices are located downstream of the filter elements to stop solids leakage by plugging in the event of element failures. High pressure nitrogen back-pulsing, typically lasting 0.2 seconds, is used to clean the filters periodically to remove the accumulated gasification ash and control the pressure drop across the tube sheet. The solids fall to the bottom of the PCD and are cooled and removed through the continuous fine ash depressurization (CFAD) system.

OPERATIONAL HISTORY

System commissioning of the KBR Transport Reactor train and the first five test campaigns (TCs) were performed in combustion mode. Approximately 5,000 hours of combustion operation were completed from 1996 to 1999. The system was transitioned to gasification operation in late 1999. Four gasification commissioning tests (GCTs), each lasting nominally 250 hours, were completed by early 2001. At the conclusion of TC25, 20 gasification test campaigns were completed, each nominally 250 to 1,500 hours in duration, for a total of about 11,500 hours of coal gasification operation. The Transport Gasifier has operated successfully in both air-blown and oxygen-blown modes.

While efficient gasification operation with PRB subbituminous coal was well-demonstrated, major modifications to the Transport Gasifier were completed in early 2006 to improve gasifier performance with other coals. The changes provided new, more robust solids separation and recycle systems as well as a larger diameter riser, which resulted in higher carbon conversions and syngas quality. Gasification testing since the modifications has focused on lignite gasification, with 2,500 of the 3,250 hours of lignite gasification testing occurring in the past 3 years. Table 1 summarizes the gasification testing completed at the conclusion of TC25. The table lists the duration, number of hours on coal, fuel type, and major objectives of each test. Tests featuring lignite operation are highlighted.

Table 1. Gasification Operating History.

Test	Start Date	Duration (hrs)	Fuel Type*	Comments
GCT1	September 1999	233	PRB, Illinois #6, Alabama	First gasification testing
GCT2	April 2000	218	PRB	Stable operations
GCT3	February 2001	184	PRB	Loop seal commissioning
GCT4	March 2001	242	PRB	Final gasification commissioning test
TC06	July 2001	1,025	PRB	First long duration test campaign
TC07	April 2002	442	PRB, Alabama	Lower mixing zone commissioning
TC08	June 2002	365	PRB	First oxygen-blown testing First on-line failsafe testing
TC09	September 2002	309	Hiawatha	New mixing zone steam system
TC10	October 2002	416	PRB	Developmental coal feeder commissioning
TC11	**April 2003**	**192**	**Falkirk Lignite**	**First lignite testing**
TC12	May 2003	733	PRB	Fuel cell testing
TC13	**September 2003**	**501**	**PRB, Freedom Lignite**	**Syngas to combustion turbine, 380 hours on lignite**
TC14	February 2004	214	PRB	Syngas to combustion turbine CFAD commissioning
TC15	April 2004	200	PRB	Improved oxygen feed distribution
TC16	**July 2004**	**835**	**PRB, Freedom Lignite**	**Fuel cell testing and high pressure O_2-blown operation (181 hours on lignite)**
TC17	October 2004	313	PRB, Illinois Basin	Bituminous coal testing
TC18	June 2005	1,342	PRB	Recycle gas compressor commissioning
TC19	November 2005	518	PRB	CCAD commissioning
TC20	August 2006	870	PRB	Gasifier configuration modifications
TC21	**November 2006**	**388**	**Freedom Lignite**	**First lignite test following the gasifier modifications**
TC22	**March 2007**	**543**	**Mississippi Lignite**	**High moisture lignite testing**
TC23	**August 2007**	**481**	**PRB, Freedom Lignite**	**High sodium lignite testing, 301 hours on lignite**
TC24	February 2008	237	Utah	First bituminous coal test following the gasifier modifications
TC25	**July 2008**	**742**	**Mississippi Lignite**	**Fluid bed dryer commissioning**

*Note: PRB is a subbituminous coal; Illinois #6, Alabama, Hiawatha, Utah, and Illinois Basin coals are bituminous coals.

LIGNITE DRYING

The coal preparation system originally installed at the PSDF was designed to process bituminous coal, which contains about 10 weight percent moisture. During initial testing of lower rank fuels to develop fuel flexibility with the Transport Gasification process, operation of the preparation and feed systems was problematic. Several system modifications (first implemented in 2000) improved operation and allowed for effective processing of tested sub-bituminous and lignite coals. However, when high moisture Mississippi lignite was first tested in March 2007, the coal preparation system could not sufficiently dry the coal because of its higher relative amount of intrinsically bound moisture and the short residence time for drying in the system. The resulting relatively high as-fed coal moisture content, averaging 28 weight percent, caused numerous coal feed operational problems. To improve coal feeding with high moisture coals, a fluid bed dryer was installed to increase residence time for drying and decrease the coal moisture content to 20 weight percent or less.

The fluid bed dryer system, manufactured by Schwing Bioset, was designed in early 2007. Construction and installation was completed in March 2008, and the initial commissioning was completed in May 2008. Figure 2 is a photograph of the fluid bed dryer system showing the major components.

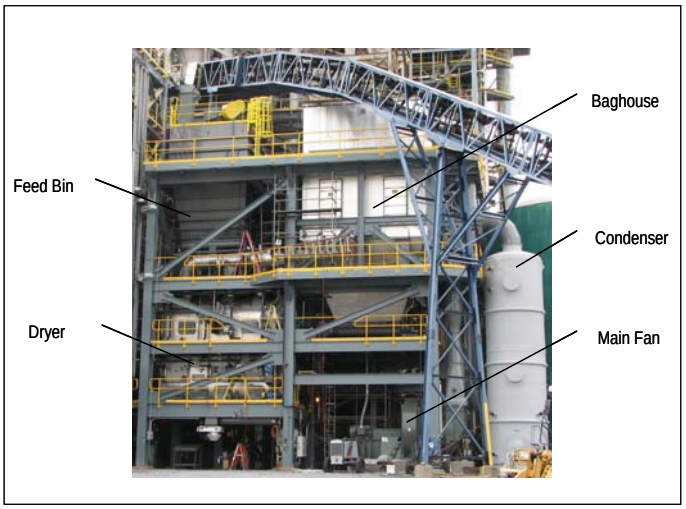

Figure 2. PSDF Fluid Bed Dryer System.

The fluid bed technology selected operates with high thermal efficiency and requires 25 to 38 percent less energy per amount of water removed than conventional drying methods (1,250 to 1,350 BTU/lb of water evaporated, compared to 1,800 to 2,000 Btu/lb of water evaporated for drying methods such as. rotary drum, flash, and belt dryers). Because the fluid beddryer does not incorporate any internal moving parts, operation and maintenance costs are minimal.

Figure 3 provides a flow diagram of the PSDF fluid bed dryer system. After processing through a crusher, the coal is fed into the dryer feed bin and then from the dryer feed bin directly to the dryer by a variable rate feed system. Nitrogen is used for drying and fluidization and is heated in a finned tube heat exchanger prior to entering the dryer. As the nitrogen and moist coal mix, the moisture transfers from the coal to the nitrogen. Three in-bed heat exchangers promote additional drying as the fluidized coal flows around and through the heat exchangers resulting in efficient utilization of drying energy.

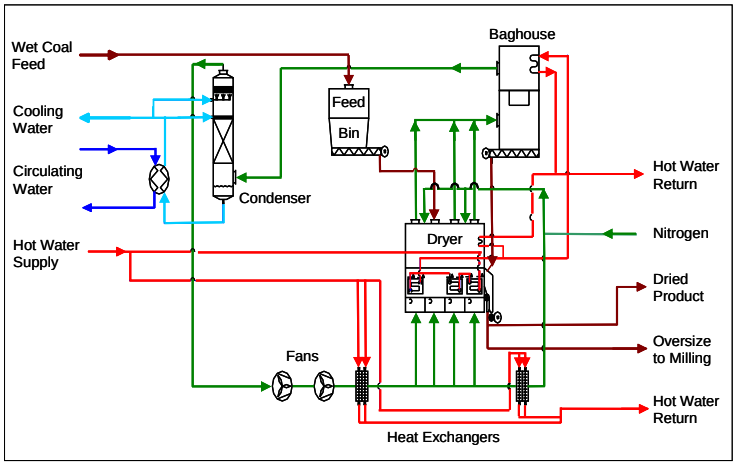

Figure 3. Fluid Bed Dryer System Flow Diagram.

The nitrogen at the top of the dryer is nearly saturated with water vapor. A slip stream of gas that bypasses the dryer is sent through a second finned tube heat exchanger to reheat the exit vapor preventing condensation of the gases in the exhaust duct or the baghouse. The gases pass through a baghouse, where entrained particulate is extracted from the gas stream and is conveyed to the dryer product outlet where it is mixed with the dried coal.

Exhaust gas from the baghouse enters a direct contact spray condenser, where the evaporated moisture from the lignite is condensed and extracted. A quench-water recirculation pump takes water from the condenser basin and discharges it above a packed bed to cool the process gas and condense the evaporated water. This condensed water goes to the process wastewater stream at the PSDF, but could be recycled in a commercial facility. The water from the condenser basin is circulated through a heat exchanger to maintain a constant cooling water temperature. A cooling tower is used to provide cooling water to the shell and tube heat exchanger. The quenched nitrogen stream exits the condenser and passes through primary and secondary process blowers. Some gas may be exhausted to the atmosphere to control system pressure. The crushed and dried coal is then fed to a pulverizer system where it is mechanically ground and stored in a silo until ready for use as gasifier feedstock.

The source of thermal energy for the dryer heat exchangers is a high temperature water heater operating at temperatures ranging from 250-300°F. The operating conditions selected emulate waste heat streams at a commercial facility, further enhancing efficiency of the operation.

Table 2 shows the fluid bed dryer operating performance during the initial off-line commissioning. Testing revealed that while particle attrition in the dryer reduced the coal mass median diameter (MMD) particle size, the percentage of oversize particles was higher than desired for coal feed system operation. Thus, the material was sent to the pulverizers for final product sizing.

Table 2. Performance of Fluid Bed Dryer during Commissioning

	Average
Lignite Processed, Tons	1,152
Dryer Feed Rate, lb/hr	13,100
Inlet Coal Moisture Content, wt %	44
Outlet Coal Moisture Content, wt %	21
Inlet Coal MMD, micron	1,100
Outlet Coal MMD, micron	890
Outlet Coal Oversize (>1,180 micron) Content, wt %	40
Outlet Coal Fine (<45 micron) Content, wt %	5

Parametric testing consistently demonstrated the positive relationship between bed outlet temperature and coal moisture content, and the operating data established the desired range of bed operating temperatures. Figure 4 plots the moisture content of the fluid bed dryer product versus the bed temperature. As expected, testing also showed that lower hot water supply temperature resulted in a higher required mass flow rate of hot water but did not impact coal moisture content. Waste heat streams available at a commercial IGCC facility would be able to meet temperature and flow rate requirements.

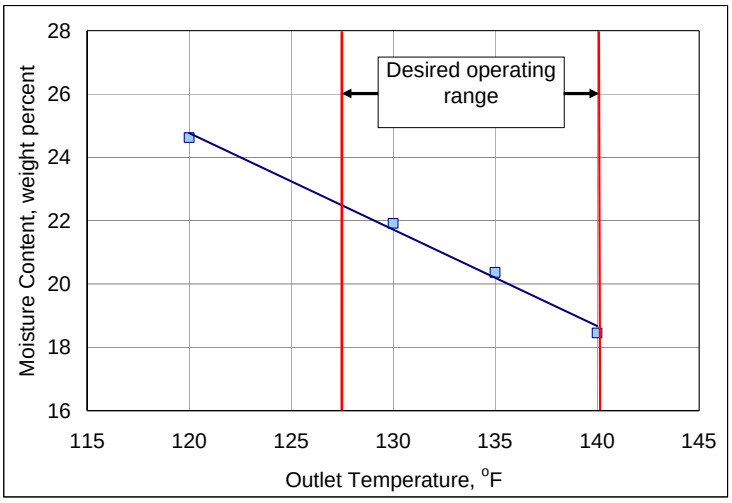

Figure 4. Product Moisture Content versus Fluid Bed Dryer Outlet Temperature.

The oversize (reject) removal rate was about 4 to 5 percent of the dryer feed rate, providing stable dryer fluidization and bed differential pressure. The heating value of the reject material was similar to the dried product, making recovery and utilization of this stream desirable in a commercial facility. Oxygen and carbon monoxide analyzers were employed to ensure safe operation of the process and provided accurate readings throughout commissioning activities.

Table 3 shows the fluid bed dryer operating performance during gasification testing. The system performed well and produced dried product consistent with observations during commissioning.

Table 3. Performance of Fluid Bed Dryer during Gasification Testing.

	Average
Lignite Processed, Tons	2,800
Dryer Feed Rate, lb/hr	13,000
Inlet Coal Moisture Content, wt %	42
Outlet Coal Moisture Content, wt %	20
Inlet Coal MMD, micron	1,080
Outlet Coal MMD, micron	830
Outlet Coal Oversize (>1,180 micron) Content, wt %	40
Outlet Coal Fine (<45 micron) Content, wt %	10

The lignite processed in the fluid bed dryer was then pulverized in the coal mill pulverizers to reduce the amount of oversize material. The pulverizers reduced the MMD to about 460 microns and the weight percent of oversize particles to about 23 weight percent. Figure 4 compares the particle size distribution curves for the fluid bed dryer product and the pulverized material. The additional pulverizing slightly increased the amount of fine material, which averaged about 14 weight percent. In addition, the pulverizers were operated without heat input from the electric heaters resulting in minimal added moisture reduction (lignite moisture content averaged 18 weight percent). The reduction in required heat input would result in increased thermal efficiency in a commercial facility as well.

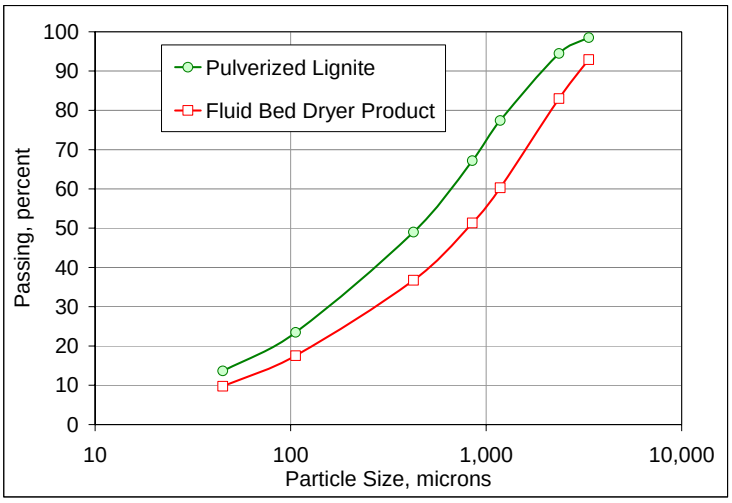

Figure 4. Particle Size Distributions of Pulverized Lignite and of Lignite Processed in Fluid Bed Dryer.

Figure 5 compares the processed as-fed moisture content of the Mississippi high moisture lignite before and after installation of the dryer. The coal moisture content after installation of the dryer was consistently maintained below the desired level of 20 weight percent.

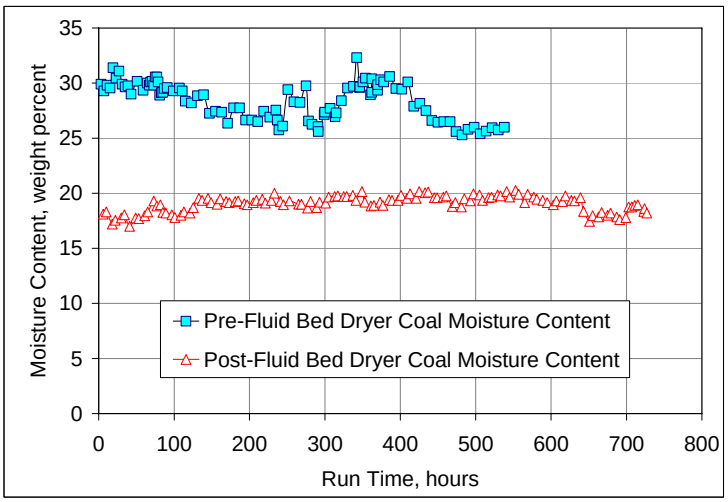

Figure 5. Moisture Content of As-Fed Lignite before and after Fluid Bed Dryer Installation.

COAL FEEDING

The high moisture content of lignite is especially problematic for dry, pressurized feed systems. The lock hopper systems in conventional solids feeders alternate between atmospheric pressure and system pressure. Coal moisture binds particles together, inhibiting flow from the lock hopper to the pressurized dispensing vessel. Other coal characteristics, such as particle size and morphology (generally specific to coal type), can effect coal feeder operation, but comparisons of high moisture lignite feed system operation both before and after the fluid bed dryer installation suggests that moisture content was the leading factor affecting coal feeder performance.

Figure 6 illustrates the original coal feeder operating envelope for coal particle size versus coal moisture content. The operating envelope (shown in green) represents reliable coal feeder operation during recent test campaigns. The coal particle size and moisture content ranges from test campaign TC22 (high moisture lignite operation prior to installation of the fluid bed dryer) were outside the reliable coal feeder operating envelope. However, most of the data from test campaign TC25, which featured high moisture lignite operation after installing the fluid bed dryer, fell within the operating envelope for reliable feeding. Reliable coal feeder operation during TC24 with bituminous coal extended the operating envelope to include very low moisture contents.

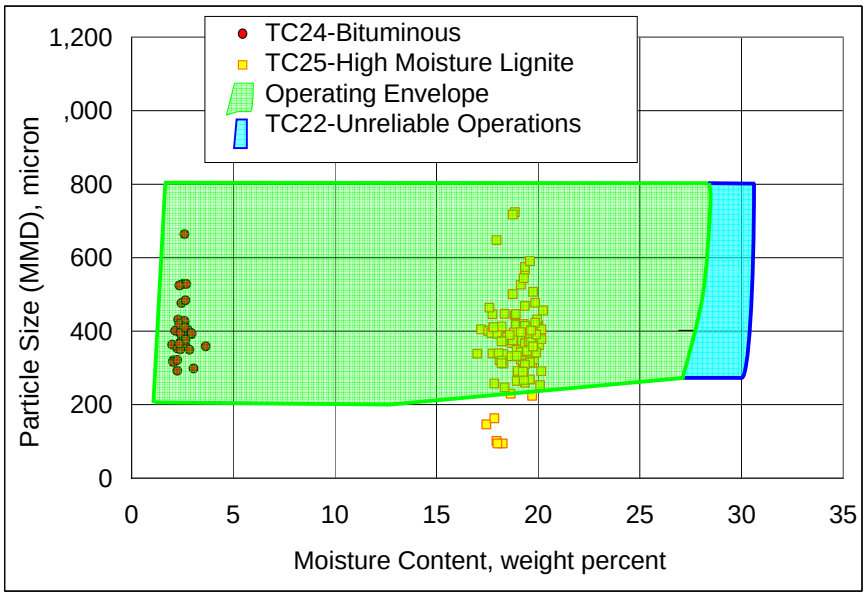

Figure 6. Original Coal Feeder Operating Envelope.

ASH HANDLING

Lignite coal with a high ash content makes it particularly important that ash handling systems be designed optimally. The particulate control system experiences higher loading proportional to higher ash content and must operate at a high collection efficiency to protect downstream equipment. The ash removal system must be reliable with low operating and maintenance costs for the system as a whole to produce the lowest cost of electricity.

The particulate control device (PCD) performs the critical task of removing particulate from the syngas to prevent damage of the combustion turbine and other downstream equipment in an IGCC process. The PCD used at the PSDF operates reliably and routinely demonstrates collection efficiency greater than 99.999 percent.

Because of its relatively low drag (resistance to flow), lignite ash has characteristics more favorable for PCD performance than ash from bituminous or subbituminous coal. Despite the high particulate concentration of syngas entering the PCD and subsequent elevated area loading on the filter elements, the pressure drop across the PCD operating with lignite ash is low due to the low drag values.

Lignite fine ash typically has lower carbon content than subbituminous and bituminous coal. Ash with less non-carbonate carbon content has lower drag, resulting in lower pressure drop at a given set of conditions (Dahlin 2007). Also, fine ash with lower non-carbonate carbon content reduces the likelihood of a thermal excursion in the PCD if exposed to oxygen during upset conditions. Transient drag is a measure of flow resistance from filter dustcakes that is back pulsed off the PCD filter elements. Figure 7 illustrates the relationship between carbon content, coal type, and transient drag. Note the lower pressure drop in North Dakota lignite during TC21, which is likely a result of the morphology of the ash. The North Dakota lignite tested produced fine ash with less angularity in the particles (Dahlin 2007).

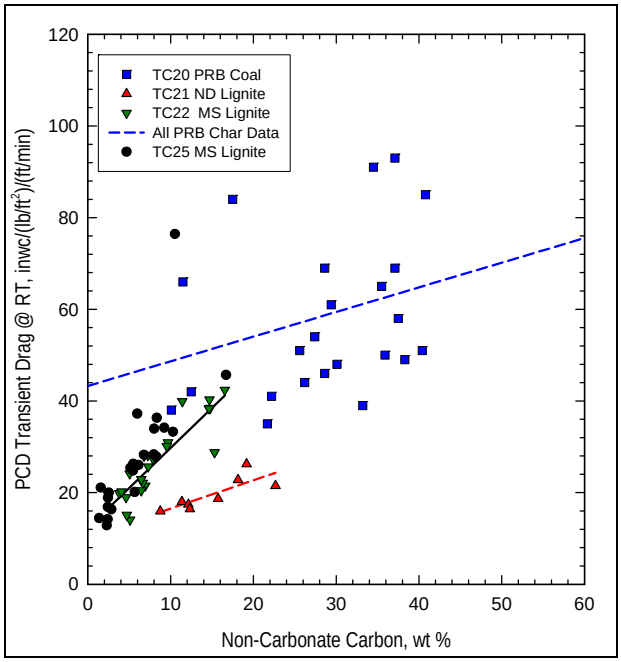

Figure 7. PCD Transient Drag versus Carbon Content of In-Situ Samples.

Reliable ash removal is integral to transport gasification of any coal but particularly important for coals with high ash content such as those tested at the PSDF. Ash is removed from the gasifier loop in the continuous coarse ash depressurization (CCAD) unit and removed from the PCD in the continuous fine ash depressurization (CFAD) unit. These PSDF proprietary systems have no moving parts and do not require a pressurizing gas. Solids transport is accomplished by using entrained gas, and only a small amount of solids-free gas is vented. These ash removal systems have together operated over 9,000 hours with very high reliability over a range of particle size distributions. Figure 8 shows the range of particle sizes removed successfully by the CFAD and CCAD systems.

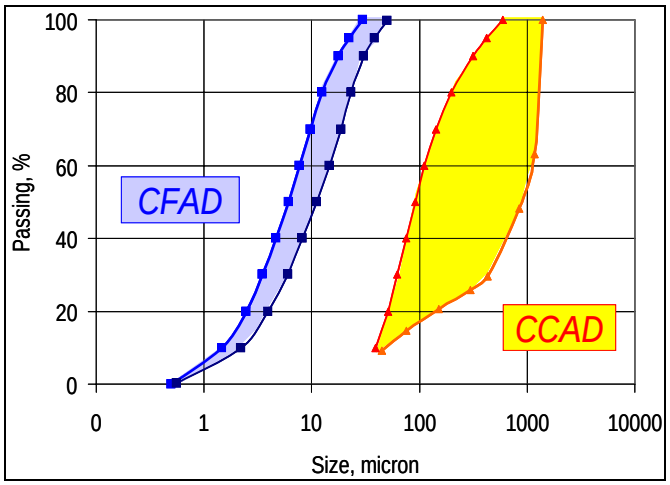

Figure 8. CFAD and CCAD Particle Size Distributions.

Both CCAD and CFAD controls are automated and require limited operator intervention. Logic is also used to automatically detect when solids flow is inhibited, which triggers adjacent nitrogen addition to pulse and restart flow.

GASIFIER OPTIMIZATION

Operation of the Transport Gasifier was improved with the 2006 configuration modifications. During the first test campaign following the modifications, the system was successfully commissioned and tested with PRB coal, achieving the most stable gasifier operations to date, and demonstrating improvements in the solids collection efficiency, syngas heating value, and

carbon conversion. Subsequent testing on lignite coal showed a significant improvement in carbon conversion and thermal efficiency, showing the collective effect of gasifier improvements and optimization of operating conditions.

Recent testing at the PSDF has been focused on lignite coals, including lignite with high moisture and sodium content. Table 4 lists the lignite coals and operating parameters for lignite testing in the last six years. Data for testing completed before the gasifier modifications is highlighted in grey, and data after the modifications in yellow. The table shows significantly improved gasifier performance with the North Dakota lignites following the modifications.

Table 4 also shows very high carbon conversion and thermal efficiency for lignite operation in which sodium content does not limit gasifier temperatures (to prevent agglomerations). Further optimization may be possible.

Table 4. Gasifier Performance during Lignite Testing.

Lignite Type	Test Date (Test Campaign)	Na_2O in Ash (weight %)	Maximum Temperature, °F	Carbon Conversion, %	Thermal Efficiency, %	Additives	Deposits Formed
North Dakota Low Sodium Lignite	9/03 (TC13)	2.3-2.4	1,770	95.2	80.9	limestone	no
	11/06 (TC21)	1.0-1.6	1,800	97.5	87.8	no	no
North Dakota High Sodium Lignite	9/03 (TC13)	9.0-9.9	1,650	86.4	71.3	limestone	yes
	7/04 (TC16)	7.4-8.7	1,600	84.8	70.9	dolomite	no
	12/06 (TC21a)	6.8-8.9	1,650	92.2	83.1	no	yes
	1/07 (TC21b)	7.8-9.6	1,550	96.0	81.9	dolomite	yes
	8/07 (TC23)	9.5-10.3	1,700	94.4	83.4	meta-kaolin	no
Mississippi Lignite	03/07 (TC22)	0.2-0.7	1,790	97.2	84.1	no	no
	07/08, (TC25)	0.3-0.7	1,820	98.5	88.3	no	no

Gasifier operating parameters must be well established that prevent agglomeration of ash. High alkali metals, notably sodium, in certain coals make this a top concern requiring the use of an additive to prevent ash agglomeration. Experience at the PSDF shows sodium oxide levels in lignite ash above five weight percent presents a challenge for non-slagging gasification. At temperatures required to achieve high carbon conversion, sodium vaporizes, reacts with silica, and forms sticky sodium silicates. Sodium silicate then binds ash together, forming agglomerations that inhibit solids circulation. Several approaches to prevent this agglomeration mechanism have been tried at the PSDF.

The addition of high sodium coal at normal gasifier temperatures, 1700-1800 °F, formed deposits during a 2003 test run (TC13). High levels of silica used for initial bed inventory and level control in addition to silica in coal ash reacted with sodium vapor created, resulting in unstable temperature control and poor gasifier solids circulation. Laboratory evaluation began to determine an effective additive that could physically block contact between the silica and sodium or react with the silica to prevent formation of sticky sodium silicates, thus, preventing agglomeration. These tests showed dolomite effective in physically blocking sodium silicate formation when coupled with low temperatures (less than 1700°F) and complete displacement of sand from startup with PRB ash. During a test run in 2004 (TC16) on high sodium lignite, this approach was effective in preventing agglomeration, although the carbon conversion did suffer from lower operating temperatures.

Gasifier modifications were made in 2006 to improve solids collection efficiency and increase residence time. A high sodium lignite run (TC21) in the same year revealed that dolomite was ineffective in the new gasifier design in preventing agglomeration (see Figure 9). Higher solids collection efficiency resulted in increased solids retention and longer residence

time for silica to contact sodium vapor and agglomerate. A different additive would be required that went beyond the physical blocking of silica and sodium, so laboratory tests were performed to find a suitable additive (Dahlin 2009). Results indicated several additives suitable for capturing sodium with meta-kaolin, a half-calcined form of kaolinite, surfacing as an effective additive for testing. A test in 2007 (TC23) was performed where meta-kaolin feed was 0.04 to 0.09 pounds of meta-kaolin per pound of coal feed. The nominal particle-size classification was minus 14 mesh with a mean size of 920 microns. No agglomeration was observed in the gasifier during the test. Figure 10 shows ash samples with meta-kaolin particles dominating the bed material, and no signs of agglomeration. The EDX spectra, shown in Figure 11, reveals capture of sodium by meta-kaolin.

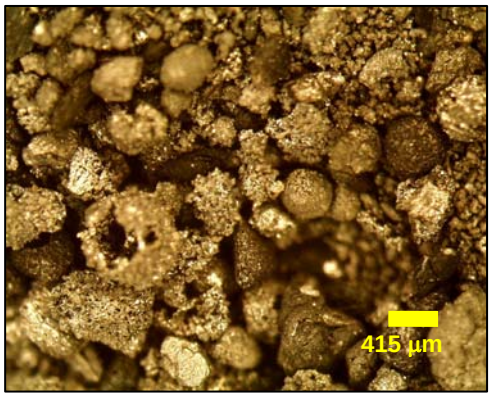

Figure 9. Agglomerated bed material from high sodium lignite operations with no additive in 2006 (TC21).

Figure 10. Bed material from 2007 test run (TC23) with large meta-kaolin particles dominating material and no evidence of agglomeration.

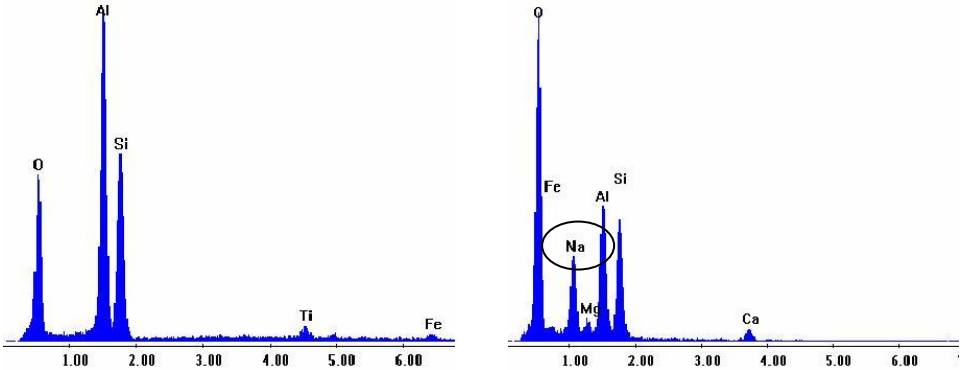

Figure 11. EDX spectra from raw meta-kaolin (left) and meta-kaolin particle in gasifier standpipe sample (right) (Note evidence of sodium capture in meta-kaolin from gasifier standpipe ash)

The lower surface area of the larger meta-kaolin particles (920 microns MMD) reduced particle contact, preventing ash consolidation. Ash from the gasifier clearly showed no signs of agglomeration. However, smaller ash, nominally 15-µm mean size, that carried out of the gasifier and to the primary gas cooler partially plugged the heat exchanger tubing. The gasifier was started on PRB, and the transition to high sodium lignite resulted in an immediate increase in pressure drop and loss of heat exchanger surface area. Concentration of smaller particles in the gasifier outlet is inherent to the design, making the solids in this stream prone to agglomeration. This problem may be unavoidable in the transport gasifier at the test conditions of the run, and commercial application of this feed scheme would require a different gas cooler, potentially quench cooling.

CONCLUSIONS

Lignite can be a cost-effective feedstock for IGCC when challenges to its use are addressed properly. Drying by waste heat improves system efficiency, keeps operating costs to a minimum, and dramatically improves feeder performance. Operation with the Transport Gasification process minimizes energy losses by using dry feed systems, hot gas filtration, non-slagging ash removal. When ash chemistry makes ash agglomeration likely, use of an effective agglomeration inhibitor allows for operation at high carbon conversion and efficiency. Ash handling with CCAD and CFAD systems is robust and reliable for

handling higher ash loading, and the PCD reliably protects downstream equipment from solids carryover. Application of these technologies by Southern Company utilizing Mississippi lignite in a 582 MW IGCC facility in Kemper County, Mississippi is currently in the approval process and scheduled for construction starting in 2010.

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