PRM ENERGY Gasification Systems

Cargill

CLEAN HEAT, STEAM AND ELECTRICITY FROM RICE HULL GASIFICATION

Riceland Case Studies

A CASE STUDY OF TWO BIOMASS GASIFICATION SYSTEMS CONVERTING 650 TONS/DAY OF RICE HULLS TO PRME NATURALLYGAS™

PRME Biomass Fired Engine Generator System

PRME/ENERIA Biomass Fired Caterpillar Engine Generator System

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CLEAN HEAT, STEAM AND ELECTRICITY FROM RICE HULL GASIFICATION

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ABSTRACT

PRM Energy Systems, Inc, completed the installation of a 330-ton/day biomass gasification system for Cargill Rice Milling of Greenville, Mississippi in 1995.

The PRME Biomass Gasification system converts unground rice hulls/straw and other biomass fuels to PRME Naturally™Gas which is burned in the boiler furnace delivering 115 million Btus/hr to an existing boiler/power island to produce 6.5 MW of electricity and 15,000 PPH of process steam for the rice parboiling facility.

The PRME Biomass Gasification system includes: the fuel metering bin and structure, the refractory lined Model KC 218 Reactor/Gasifier, the combustion tube and chamber, the gasifier cooling water system, ash discharge/cooling assembly, multi- zone gasification air supply, multi- zone combustion air supply, rotary feeders and instrumentation required to provide automatic control over the process.

THE FACILITY

PRM Energy Systems, Inc. has completed the installation of a 330 ton/day biomass gasification system for Cargill Rice Milling of Greenville, Mississippi.

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115 million Btus/hr to an existing boiler/power island to produce 6.5 MW of electricity and 15,000 PPH of process steam for the rice parboiling facility.

The major components of the system were fabricated and shipped on August 24, 1995 by river barge down the Arkansas river to the Port of Greenville, Mississippi. The barge arrived at Greenville on August 29th. Components were off-loaded onto trucks and transported approximately 5 miles to the Cargill site and erected directly onto the foundations. The combustion tube refractory was installed in the fabrication shop and the gasifier refractories were gunned in place on site. Erection of the gasifiers and combustion tube was completed on October 14th. Installation of control instrumentation was essentially complete and bakeout of refractory was completed on October 24th. Boilout of the boiler and blowdown/testing of steam lines started on November 1st and continued until December 5th, when the turbine was placed into service.

Two bolted metal bins, each with a capacity of 150 tons, were supplied by Cargill for rice hull storage and feeding to the PRME metering bin. Cargill also supplied the ash conveying system which receives the rice hull ash from the water cooled ash cooling conveyor and transports the ash to the ash storage and loadout bin.

The ***PRME*** Biomass Gasification system includes: the fuel metering bin and structure, the patented KC Reactor/Gasifier, the combustion tube and chamber, the gasifier cooling water system, water cooled ash discharge conveyors, multi- zone gasification air supply, multi- zone combustion air supply, rotary feeders and instrumentation required to provide automatic control over the process.

The KC Reactor/Gasifier consists of a high temperature refractory lined cylindrical steel shell that is mounted in a vertical position on heavy structural steel supports. The lower portion of the reactor contains an appropriately sized fixed grate. The cross sectional area of the upper portion of the gasifier is reduced to provide the turbulence required to ensure proper mixing of the product gas and the combustion air that is introduced into this area of the gas combustion tube. The refractory lining consists of the appropriate thickness of insulating castable and high-temperature dense castable that is applied by gunning after the shell is erected. The lining is secured by stainless steel anchor clips attached to the shell.

Fuel is metered to the gasifier from the fabricated steel metering bin. The bin is equipped with level controls, an infeed leveling conveyor and a variable speed outfeed conveyor that delivers fuel to the gasifier. The speed of the outfeed conveyor is automatically adjusted by the gasifier control system to maintain a pre-set first stage gasification zone temperature. The discharge from the outfeed conveyor is directed through an impact weigh metering device that provides precise indication and control of the fuel feed rate. The feed system is installed complete with the necessary support steel, platforms and access ladders. The first stage temperature setpoint is manually adjusted to compensate for the average moisture content of the fuel being gasified.

Fuel is introduced into the gasifier by a water-cooled screw conveyor that discharges into the drying and heating zone of the gasifier. The gasification process is controlled by the proportioned application of gasification and combustion air in a manner that supports efficient gasification. Residence time in the gasifier is varied by a residence control system that is adjusted to achieve the desired carbon content of the ash discharged from the gasifier. The use of mechanical bed agitation, precise gasification air control and zoning produces a clean, combustible gas that can be burned in the combustion tube and chamber for drying applications or in the radiant section of a boiler. The gasification rate is controlled by the demand of the dryer or boiler.

The hydrocarbons contained in the gases are thermally cracked and burned in the combustion tube and chamber. The resulting clean hot air can be cooled and blended with recirculating air to maintain the desired temperature in drying applications or directed to a boiler for final combustion. At the Cargill project, the biogas is combusted in the boiler furnace. The gas combustion tube includes an emergency vent stack to safely exhaust gas to the atmosphere in the event of a failure of the induced draft fan.

The unique design of the KC Reactor/gasifier makes it possible to remove practically all of the ash and particulate matter from the bottom of the gasifier, continuously and automatically. Particulate carryover that occurs with other types of solid fuel combustion systems is greatly reduced The extremely low particulate concentration in the gases leaving the gasifier makes it possible to direct fire a boiler without hot gas cleanup and to comply with particulate emission regulations without the use of expensive emission control equipment.

Various components of the gasifier are water cooled to insure reliable operation and longevity.

The power generating center is equipped with a standard high pressure heat recovery type water tube boiler, 450 psig/650^{0}F, with a refractory lined furnace section where the final combustion of the biomass gases takes place, a high pressure condensing steam turbine/generator, economiser, condenser, deaerator, cooling tower and all of the auxiliary piping, valves, pumps, motors, drives, fans and controls necessary for a completely functional power center.

The gasifier and power center are equipped with all of the instrumentation and control devices required for complete, automatic operation of the system. The metering bin feed system, gasifier system and the ash discharge system all have an interlock control scheme functioning through the process controller. These interlocks are designed to shut down each system if a malfunction occurs that could cause damage to the gasifier. The metering bin level controls are interfaced with the feed stock storage bins to provide a uniform feed rate to the metering bin.

The gasifier instrumentation and control system provides sequential operation of the gasifier feed and ash discharge systems, PID control loops which adjust conditions within the gasifier to achieve efficient gasification of the feedstock, temperature and pressure

transmitters which signal the process controller, and a video display terminal for operator interface with the control system, motor control centers and wiring. The instruments are integrated with the main boiler master control.

PRME provides trained service personnel to supervise the erection, start-up and commissioning of the equipment and train the clients operators in the proper operation and maintenance of the ***PRME*** system. The training program includes classroom and on-site training as well as supervision of operators during initial operation of the system. Additional training and supervision can be provided at additional cost should the client deem that it is required.

PRME has biomass gasification systems operating in Malaysia, Australia, Costa Rica, Italy and the United States.

A CASE STUDY
OF
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ABSTRACT

Riceland Foods, Inc., and Riviana Foods, Inc., have employed the PRM Energy Systems' biomass gasification technology into two rice hull energy conversion facilities located at Riceland's huge complexes in Stuttgart and Jonesboro, Arkansas.

The Stuttgart plant utilizes the combustible NaturallyGas™ produced from 525 tons/day of rice hulls to direct fire two packaged water tube boilers which generate high pressure, superheated steam for a 15MW extraction/condensing steam turbine. Utilizing a condensate return reboiler, process steam can also be delivered to Riceland's soybean processing complex. Riceland has constructed its own electrical transmission lines to interconnect the power plant with the rice milling facilities located approximately 1 ½ miles away. In addition to utilizing fresh rice hulls from the downtown mills, Riceland is reclaiming up to 100 tons/day of rice hulls from a storage pile located approximately 1 mile from the power plant.

The Jonesboro plant directs NaturallyGas™ produced from 140 tons/day of rice hulls to a packaged water tube boiler and a gas-to-air heat exchanger to supply approximately 15,000 PPH of process steam to Riceland's large rice parboiling complex and hot air to three rotary parboiled rice dryers.

This paper describes the biomass feed stock resource, the gasification process, utilizing the produced NaturallyGas™ to generate heat, steam and electricity and the major items of equipment and controls used in the construction of each facility.

Keywords: Biomass, Gasification, Rice Hulls, NaturallyGas™

BACKGROUND

PRM Energy Systems, Inc., 504 Windamere Terrace, Hot Springs, Arkansas, was incorporated in 1983. The technology for the gasification system was developed and patented under the direction of Ronald W. Bailey while President of Producers Rice Mill Inc., (1967-88). The first two gasifiers were installed in 1982-83 to gasify rice hulls to produce process heat and steam for a large rice parboiling facility. The energy from the gasification of rice hulls in the PRME© gasifier displaces natural gas in the dryers and boiler.

Riceland Foods, Inc., is head quartered in Stuttgart, Arkansas, and handles approximately 110 million bushels of rice and grain at processing facilities in Arkansas, Texas, Louisiana and Mississippi. Riceland is a Fortune 500 company and the world's largest rice processor with major rice milling and parboiling complexes located in Stuttgart and Jonesboro, Arkansas.

Traditionally, Riceland marketed rice hulls into specialty markets, poultry litter and by grinding and mixing with rice bran to produce rice mill feed for poultry and animals. In 1995, Riceland began construction on an innovative process to extract high quality oil from rice bran. The successful extraction and marketing of the rice bran oil resulted in less bran for mixing into rice mill feed and excess rice hulls. Riceland's search and solution for effective utilization of rice hulls led to the installation of the PRME© rice hull gasification/energy systems at Stuttgart and Jonesboro.

Each gasification/energy system was designed to qualify for the Section 29 Alternative Fuel Tax Credit and had to be operable by December 30, 1996, one year from the signing of the contracts. Riceland chose Riviana Foods, Inc. to partner in each facility. PRME© chose Thermal Systems Engineering, Inc. to perform the preliminary design and engineering. Close coordination between all parties resulted in start-up of both facilities by the deadline.

THE STUTTGART FACILITY

Components and Construction

The Stuttgart energy facility site is located at Riceland's soybean processing complex, which is approximately 1.5 miles from the rice milling facilities. The soybean complex uses up to 100,000 PPH of process steam and 6 to 8 MW of electricity. Locating the rice hull energy system at the soybean plant gives Riceland the flexibility to produce both process steam and electricity. In order to serve the rice mills with electricity, Riceland constructed its own transmission lines from the soybean plant to the rice mills.

A soybean waste water sludge pond was drained, excavated and back filled to create the site for the energy facility. PRME© began the search for appropriate used boilers and turbine/generators while Thermal Systems churned out the process design details.

Packaged water tube boilers were located in Chicago, purchased, loaded and shipped to Stuttgart for refurbishing. A 15 MW extraction steam turbine/generator/condenser was purchased in Massachusetts and refurbished in Stuttgart and Dallas. Riceland began pouring foundations while PRME© arranged fabrication of the Model KC©-318 Gasifier system. Thermal Systems was designing, assembling and programming the complete control system for the 525 ton per day facility.

Riceland constructed the rice hull truck unloading, receiving and storage bins to receive up to 600 tons per day from their rice hull by products plant and the outdoor storage pile.

The biomass gasification system included: the fuel metering bin and structure, the refractory lined Model KC©-318 Gasifier, the biogas combustion tube and chamber, the gasifier cooling water system, water cooled ash discharge assembly, multi-zone gasification air supply, multi-zone combustion air supply, rotary feeders and instrumentation required to provide automatic control over the process.

The KC© Gasifier consists of a high temperature refractory lined cylindrical steel shell that is mounted in a vertical position on heavy structural steel supports. The lower portion of the gasifier contains an 18 ft. diameter fixed grate. The cross sectional area of the upper portion of the gasifier is reduced to provide the turbulence required to ensure proper mixing of the product gas and the combustion air that is introduced into this area of the gas combustion tube. The refractory lining consists of 2 inches of insulating castable and 6 inches of high temperature dense castable that is applied by gunning after the shell is erected. The lining is secured by stainless steel anchor clips attached to the shell.

Various components of the gasifier are water cooled to insure reliable operation and longevity.

The power generating center is equipped with two refurbished gas fired, packaged water tube boilers augmented with ash removal hoppers and soot blowers. High pressure steam, 650 psig/750^{0}F, is delivered to the steam turbine/generator which generates up to 13MW, depending upon the process steam requirement. Process steam for the soybean plant is produced in a separate reboiler from condensate return from the soybean process by extracting steam from the turbine.

The gasifier and power center are equipped with all of the instrumentation and control devices required for complete, automatic operation of the system. The metering bin feed system, gasifier system and the ash discharge system all have an interlock control scheme functioning through the process controller. These interlocks are designed to shut down each system if a malfunction occurs that could cause damage to the gasifier.

Operation

Fuel is metered to the gasifier from the fabricated steel metering bin. The bin is equipped with level controls, an infeed leveling conveyor and a variable speed outfeed conveyor that delivers fuel to the gasifier. The speed of the outfeed conveyor is automatically adjusted by the gasifier control system to maintain a preset first stage gasification zone temperature. The discharge from the outfeed conveyor is directed through an impact weigh metering device that provides precise indication and control of the fuel feed rate. The feed system was installed complete with the necessary support steel, platforms and access ladders. The first stage temperature set point is manually adjusted to compensate for the average moisture content of the fuel being gasified.

Fuel is introduced into the gasifier by a water-cooled screw conveyor that discharges into the drying and heating zone of the gasifier. The gasification process is controlled by the proportioned application of gasification and combustion air in a manner that supports efficient gasification. Residence time in the gasifier is varied by a residence control system that is adjusted to achieve the desired carbon content of the ash discharged from the gasifier. The gasifier and boiler system operate at a slightly negative pressure provided by the induced draft fan. The biogas combustion tube includes an emergency vent stack to safely exhaust gas to the atmosphere in the event of a failure of the induced draft fan.

The unique design of the KC© Gasifier makes it possible to remove practically all of the ash and particulate matter from the bottom of the gasifier, continuously and automatically. Particulate carryover that occurs with other types of solid fuel combustion systems is dramatically reduced. Proper operation of the system makes it possible to direct fire a boiler without hot gas cleanup and to comply with particulate emission regulations normally without the use of expensive emission control equipment.

Conclusion

The Riceland/Riviana facility at Stuttgart is currently the largest of many rice hull gasification systems installed by PRME©. Rice hulls are a unique, high alkali fuel, high in ash content and high in silica content. Strict adherence to proper operating parameters, temperatures and pressures must be observed for successful rice hull gasification.

THE JONESBORO FACILITY

Components and Construction

The Jonesboro rice hull energy system is located at Riceland's white rice and parboiling complex in Jonesboro, Arkansas. The energy system is designed to convert 150 tons per day of unground rice hulls to a combustible gas that is used to fire a 15,000 PPH process steam boiler and three (3) rotary parboiled rice dryers.

The Jonesboro facility was planned, designed and constructed simultaneously with the Stuttgart energy center. A site adjacent to Riceland's parboil/drying facility was chosen for the PRME© KC©-18 gasifier to facilitate the supplying of clean hot air to the rotary dryers.

The rice parboiling process requires the soaking and steam pressure cooking of the rice before the hull is removed. During the process, the rice kernel becomes saturated with moisture and expands causing some partial exposure of the rice kernel. Because of this partial exposure, the rice kernel becomes vulnerable to any minute particulate that may be present in the first stage drying; therefore, to protect the exposed rice kernel from possible contamination during this critical drying stage, a portion of the gasifier flue gas is directed to a gas-to-air heat exchanger to heat ambient air to the proper drying temperature. The balance of the gasifier flue gas is directed to a used modified natural gas/oil fired boiler, as in the Stuttgart plant, to produce the required process steam for the parboiling process.

With the exception of some foundation and structural modifications for Jonesboro seismic requirements, the PRME© Model KC©-18 gasifier is the same design as the gasifiers at Stuttgart.

Operation

The operation of the Jonesboro gasification system is essentially the same as for the Stuttgart facility with the exception of the gas to air heat exchanger. This application requires that the biogas produced from the rice hulls be fully combusted in the refractory lined biogas combustion tube and chamber before reaching the heat exchanger. The Jonesboro PLC based control system includes field instrumentation devices to monitor and control hot air drying temperatures to the parboiled rice drying system.

Conclusion

Startup and operation of the Jonesboro rice hull energy system was completed prior to the deadline. The gas-to-air heat exchanger design and air flows were computer modeled to target an 80 percent gas savings in the three large parboiled rice rotary dryers.

PRME BIOMASS FIRED

ENGINE GENERATOR SYSTEM

PRME 4.0MWe Biomass Fired Engine Generator System

This Simple, Clean, Efficient and Economical Biomass Power System can be yours today! Turn your rice husks, wood wastes and other agricultural residues into clean energy with the PRME Gasification System and the world's most respected IC engine/generator. We will put our 25 years of proven performance to work for you. Systems are available from 1 to 25MWe. Contact us today!

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Operating on PRME NaturallyGas™
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