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Toms Creek IGCC Demonstration Project

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Toms Creek IGCC Demonstration Project

CONTRACT INFORMATION

Contract Number	DE-FC21-92MC29444
Contractor	TAMCO Power Partners 2300 Windy Ridge Parkway, Suite 1125 Marietta, GA 30067 (404) 984-8871
Contractor Project Manager	Michael J. Virr
Principal Investigators	-
METC Project Manager	Robert B. Reuther
Period of Performance	September 15, 1992 to December 31, 2000

OBJECTIVES

The Toms Creek Integrated Gasification Combined Cycle (IGCC) Demonstration Project was selected by DOE in September 1991 to participate in Round Four of the Clean Coal Technology Demonstration Program. The project will demonstrate a simplified IGCC process consisting of an air-blown, fluidized-bed gasifier (Tampella U-Gas), a gas cooler/steam generator, and a hot gas cleanup system in combination with a gas turbine modified for use with a low-Btu content fuel and a conventional steam bottoming cycle. The demonstration plant will be located at the Toms Creek coal mine near Coeburn, Wise County, Virginia. Participants in the project are Tampella Power Corporation and Coastal Power Production Company. The plant will use 430 tons per day of locally mined bituminous coal to produce 55 MW of power from the gasification section of the

project. A modern pulverized coal fired unit will be located adjacent to the Demonstration Project producing an additional 150 MW. A total 190 MW of power will be delivered to the electric grid at the completion of the project. In addition, 50,000 pounds per hour of steam will be exported to be used in the nearby coal preparation plant. Dolomite is used for in-bed gasifier sulfur capture and downstream cleanup is accomplished in a fluidized-bed of regenerative zinc titanate. Particulate clean-up, before the gas turbine, will be performed by high temperature candle filters (1,020°F). The demonstration plant heat rate is estimated to be 8,700 Btu/kWh. The design of the project goes through mid 1995, with site construction activities commencing late in 1995 and leading to commissioning and start-up by the end of 1997. This is followed by a three year demonstration period.

BACKGROUND INFORMATION

The Coastal Corporation is in the energy business and the Coastal Power Production Company (Coastal Power) is specifically in the power production business. As a power producer, Coastal Power is interested in more efficient energy production using fuels such as coal while simultaneously reducing emissions. An IGCC power plant would accomplish both these goals. Tampella Power, Inc. (Tampella Power) is developing a simplified IGCC process applying the U-Gas gasification technology developed by the Institute of Gas Technology (IGT) and an advanced hot gas clean-up system. An extensive research and development program is underway at Tampella Power on major aspects of the IGCC process. A pressurized gasification pilot plant of 10 MW thermal input was commissioned in October 1991 in Tampere, Finland, and an ambitious test program has been going on since. Over 550 hours of gasification test were logged up to the end of May '92.

Tampella Power's IGCC concept incorporates the pressurized fluidized-bed gasification of different solid fossil fuels, applying air-blown gasification and hot gas clean-up integrated into a power (and heat) generating combined cycle. This type of IGCC-system has the advantages of higher power generation efficiency, high power to heat ratio for cogeneration, excellent environmental performance, simple plant configuration and modularity. The investment cost of the simplified IGCC is moderate while it enjoys the availability of abundant solid fuels.

The Demonstration Project site is at the existing Tom's Creek coal mine near Coeburn, in southwest Virginia. The plant location is close to the existing coal

preparation plant. The site, coal reserves and the fuel preparation plant are owned by a subsidiary of the Coastal Corporation. The IGCC section of the power plant consists of a 430 ton/day U-Gas gasifier complete with hot gas clean-up equipment feeding a gas turbine converted to burn the low-Btu content fuel gas (typically LHV 130 Btu/scf) before exhausting to a heat recovery steam generator. Modification to the gas turbine equipment will be minimal and involve only the combustion chamber, manifold and control.

To meet the economic requirements of the project Coastal Power will build a nominal 150 MW pulverized coal power plant at the same site. The steam turbine will be common to the demonstration project and to the PC boiler to achieve some economics of scale for the project. The IGCC section of the plant will produce 55 MW electric power, and the total nominal output of the plant will be 205 MW.

Project Team Structure

Tampella Power Corporation and Coastal Power Production Company have formed a general partnership called TAMCO Power Partners for the execution of the demonstration project (See Figure 1.). Tampella Power Corporation of Williamsport, Pennsylvania is a subsidiary of Tampella Power Inc., a major international supplier of chemical recovery boilers, fluidized bed boilers and air pollution control equipment. Tampella Power will provide the coal gasification plant for the project and will commercially develop the demonstrated technology. Coastal Power Production Company of Roanoke, Virginia is a subsidiary of The Coastal Corporation, which is a natural gas, coal, oil and independent power production

company with annual revenues in 1991 of over \$9.5 billion. Coastal Power has three (3) operating natural gas combined cycle plants in operation with a total output of 330 MW. Coastal Power will design, construct, and operate the power plant. Other Coastal subsidiaries will provide the site, fuel, and ash disposal facilities for the project. The TAMCO General Partnership Agreement provides for the commercial terms between the partners, including site lease, coal supply, coal gas and steam sales, utility services and performance for the gasification system. The partnership is also the interface to the DOE and is the signatory of the Cooperative Agreement.

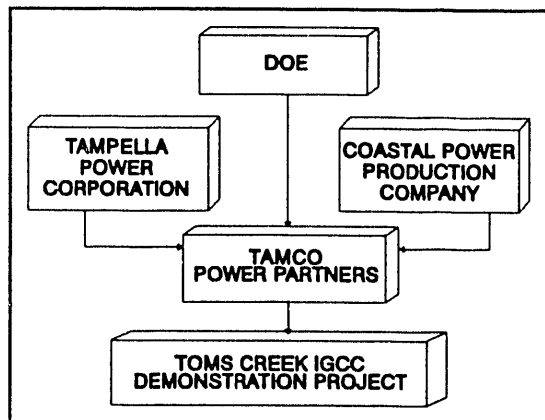


Figure 1. Toms Creek Project Team

PROJECT DESCRIPTION

The U-Gas process is a pressurized fluidized bed coal gasification process which produces low to medium Btu content fuel gas from a variety of feedstocks including highly caking, high sulfur, and high ash coals. A simplified schematic diagram of the U-Gas gasifier is shown in Figure 2.

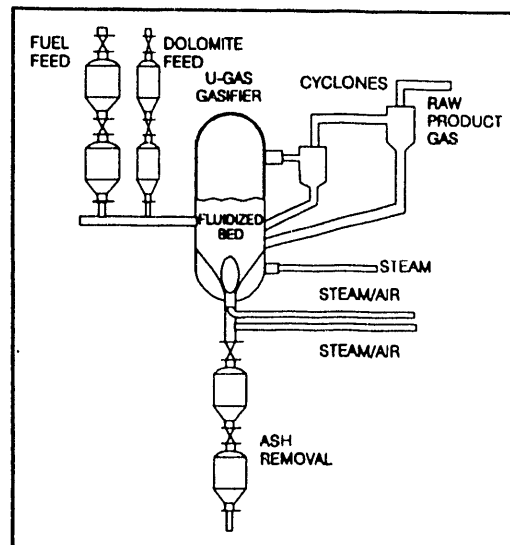


Figure 2. The U-Gas Process Gasifier

The Gasifier

The crushed ($\frac{1}{4}$ " x 0) coal is first dried to below 5% moisture in a dryer. The coal and dolomite are then fed to the lockhopper system before being fed pneumatically to the gasifier. Within the fluid bed gasifier the coal is cracked, devolatilized and gasified with the fluidizing medium of air and steam. The coal reacts with air and steam at a temperature of 1,650-1840°F. The temperature within the bed depends on the type of coal and is controlled to maintain non-slagging conditions for the ash. Coal is gasified rapidly in the gasifier and produces a gas mixture of carbon monoxide, carbon dioxide, methane, hydrogen, water vapor and about 50% nitrogen, in addition to hydrogen sulfide, ammonia, and other trace impurities. In the reducing environment of the gasifier nearly all of the sulfur present in the coal converts to hydrogen sulfide before it reacts with dolomite.

The fluidizing gas is introduced into the reactor through the gas distributor plate

and through the ash discharge device. The U-Gas feature of controlling the oxidizing zone achieves a low level of carbon losses which enables a very high overall carbon conversion of higher than 97%. The fines elutriated from the fluidized bed are separated from the product gas in two stages of external cyclones. The fines from both stages are returned to the fluidized bed. The product gas is virtually free of tars and oils due to the relatively high temperature in the upper stage of the gasifier (1,840°F).

Sulfur Removal System

The main sulfur compound in the gasifier gas is hydrogen sulfide. In Tampella Power's IGCC process desulfurization is accomplished in two stages, which results in a total sulfur removal of over 99% (See Figure 3).

The bulk of sulfur is removed in the fluidized bed gasifier by means of dolomite. Hydrogen sulfide reacts with calcium carbonate and/or calcium oxide forming calcium sulfide. This compound is unstable and has to be stabilized. This is accomplished by oxidizing it to calcium sulfate within the gasifier for safe disposal.

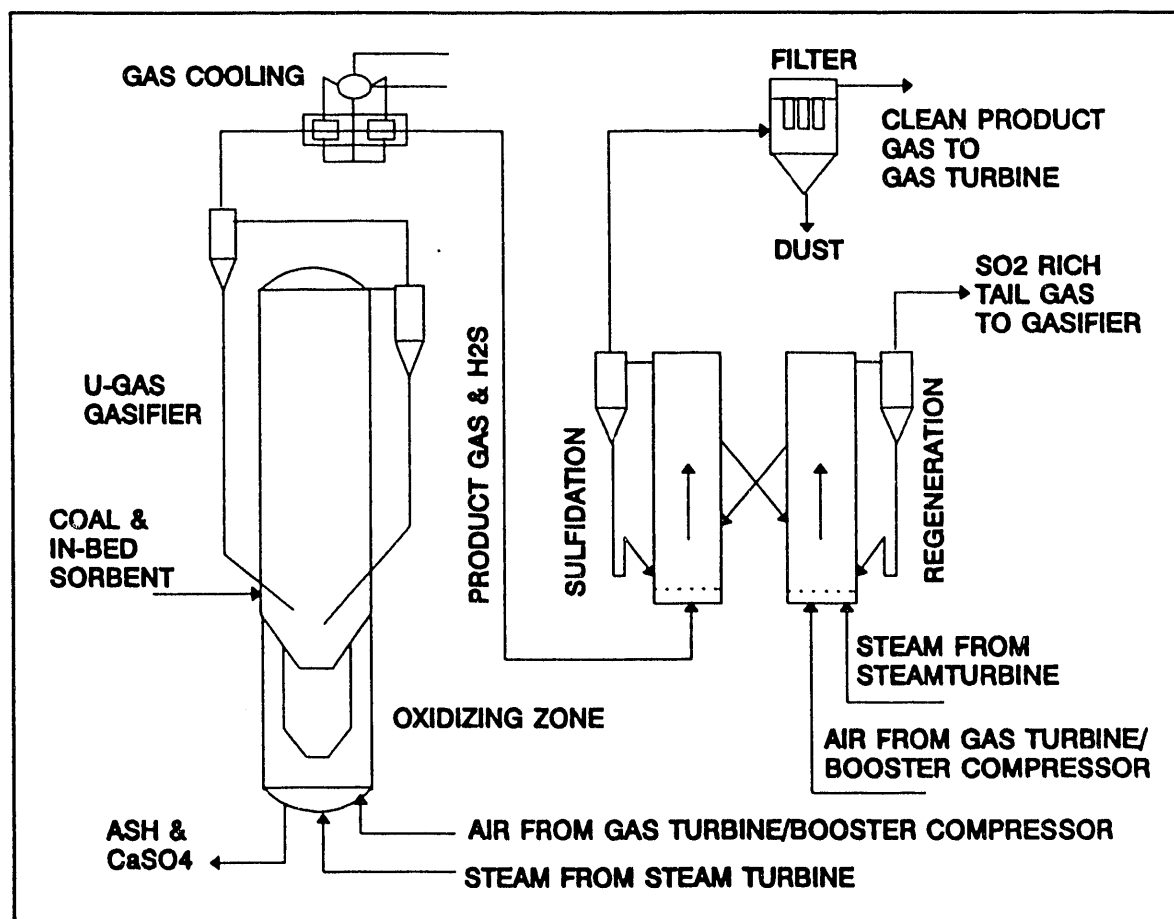


Figure 3. Hot Gas Clean Up Flowsheet

Regenerable Zn/Ti-based sorbents will be used for the post-gasification stage sulfur removal. Tampella Power has developed a two fluidized-bed reactor system for the sulfidation-regeneration cycle. Fuel gas is contacted with Zn/Ti-sorbent in the first reactor, where sulfur is captured by zinc oxide (sulfidation). Sulfided sorbent is regenerated in the second reactor using air for oxidation and steam for temperature control of the highly exothermic reaction (regeneration). The sulfur dioxide-rich regenerator offgas is recycled back to the gasifier to be captured in-situ by dolomite.

Nitrogen Compounds

The fuel nitrogen in the coal forms ammonia and a smaller amount of hydrogen cyanide in the gasifier. Since the gasification temperature is high in the U-Gas process, the ammonia is partly decomposed in the gasifier. To reduce the ammonia/NO_x conversion, a staged combustion system is used in the gas turbine, which is under development by several gas turbine manufacturers.

Alkali Metals

Volatilized alkali metal compounds such as sodium and potassium chlorides and hydroxides are formed in the gasification of coal. The alkali metal compounds in combination with sulfur are harmful to the gas turbine blades, causing hot corrosion and deposition. In Tampella Power's IGCC process, the product gas is cooled to 1,020°F before the gas turbine. At this temperature the alkali vapors will have condensed on the particles and will be removed by the candle filter.

Particle Removal

The bulk of the particles elutriated from the gasifier is removed from the gas stream in two stages of cyclones. The dust loading of the product gas after the cyclones is typically $0.2 - 0.3 \times 10^{-3}$ lb/scf. Rigid ceramic filters will be used for particle control. Silicon carbide filter elements of candle shape have been developed and tested extensively and are considered to be close to a commercial application. The candle filters are cleaned on-line by pulsing with nitrogen or steam.

Greenhouse Gases

Greenhouse gases of main concern are carbon dioxide, methane and nitrous oxide. In the IGCC-process methane produced during the gasification burns in the combustor of the gas turbine. Nitrous oxide does not form in the reducing atmosphere of the gasifier and its formation is not expected at the high temperatures encountered in the gas turbine combustor. The emission of carbon dioxide cannot be totally avoided. The only way to reduce CO₂ emissions is to improve the efficiency of power generation and this is one of the main features of the IGCC technology. The Tom's Creek Plant will have an efficiency of 40% and later plants have an aim of 47%, resulting in an improvement of some 10-15% in terms of lower carbon dioxide emission.

Overview of Process Development

The Toms Creek IGCC Demonstration Project utilizes the U-Gas coal gasification process, which was developed by IGT in a multi-phase program beginning in 1974. The heart of the U-Gas process is an air-blown, pressurized

fluidized-bed coal gasifier. The development of this process utilized knowledge from earlier low and medium-Btu content coal-to-fuel-gas projects at IGT that date back to 1950. The U-Gas process feasibility was demonstrated initially using metallurgical coke and char as feed in a low-pressure pilot plant. The pilot plant was subsequently modified to feed coals, and trial tests were made with subbituminous and bituminous coals. Eventually process feasibility was proved using high-sulfur content, caking bituminous coal as feed, and data were developed for scale-up and design of a commercial plant. Necessary environmental data were also collected and the reactor dynamic response was investigated. This pilot plant had an operating pressure limitation of 50 psig. Due to interest in high-pressure operation for several applications, a high-pressure gasifier was built as a process development unit in 1984. Significant gasification data were obtained in this plant for gasification of subbituminous coal and lignite up to 450 psig. Data were also gathered in this unit under steam-air gasification of a bituminous coal with in-situ desulfurization. In support of several demonstration plant designs, several tests were also conducted in the low-pressure pilot plant with different design feedstocks.

Thus, the pilot plant has been successfully operated on a variety of coals including highly caking, high ash, and high sulfur coals. The process has demonstrated its capability to gasify and produce ash agglomerates from raw coal. The operation of the pilot plant has firmly established process feasibility; safe, repeatable, and reliable operability; and has provided a strong data base for the design of larger plants such as the Toms Creek IGCC Demonstration Project. Successful demonstration of this project will help move

the process into the commercial marketplace.

The Toms Creek IGCC Project also utilizes a hot gas cleanup system consisting of removal of sulfur-containing gases and particulate from the hot gas. An integrated pilot plant has also been built by Tampella in Finland to test the combination of gasification and hot gas clean-up. This plant will be used to test the coal for the Toms Creek Project to provide design and environmental data. It is expected to carry out tests with Virginia coal and dolomite in the spring of 1993.

PROJECT TECHNICAL DESCRIPTION

Site and Coal

The greenfield project is developed on a site adjacent to an existing coal preparation plant at Toms Creek. The existing coal refuse disposal facilities will be utilized for ash disposal. Coal for the project will be supplied by the Coastal subsidiary who owns the reserves and prepares the coal. The design coal will be a bituminous, low sulfur (1-1.5% S) coal with a heating value of 13,400 Btu/lb (HHV, dry). At least two high sulfur coals will also be tested during the demonstration period. At least one (1) coal will have a free swelling index greater than five (5).

Process

A schematic plant flow sheet is shown in Figure 4. Crushed and dried coal, 430 tons per day and dolomite are fed through a lock hopper system to the pressurized fluidized-bed gasifier.

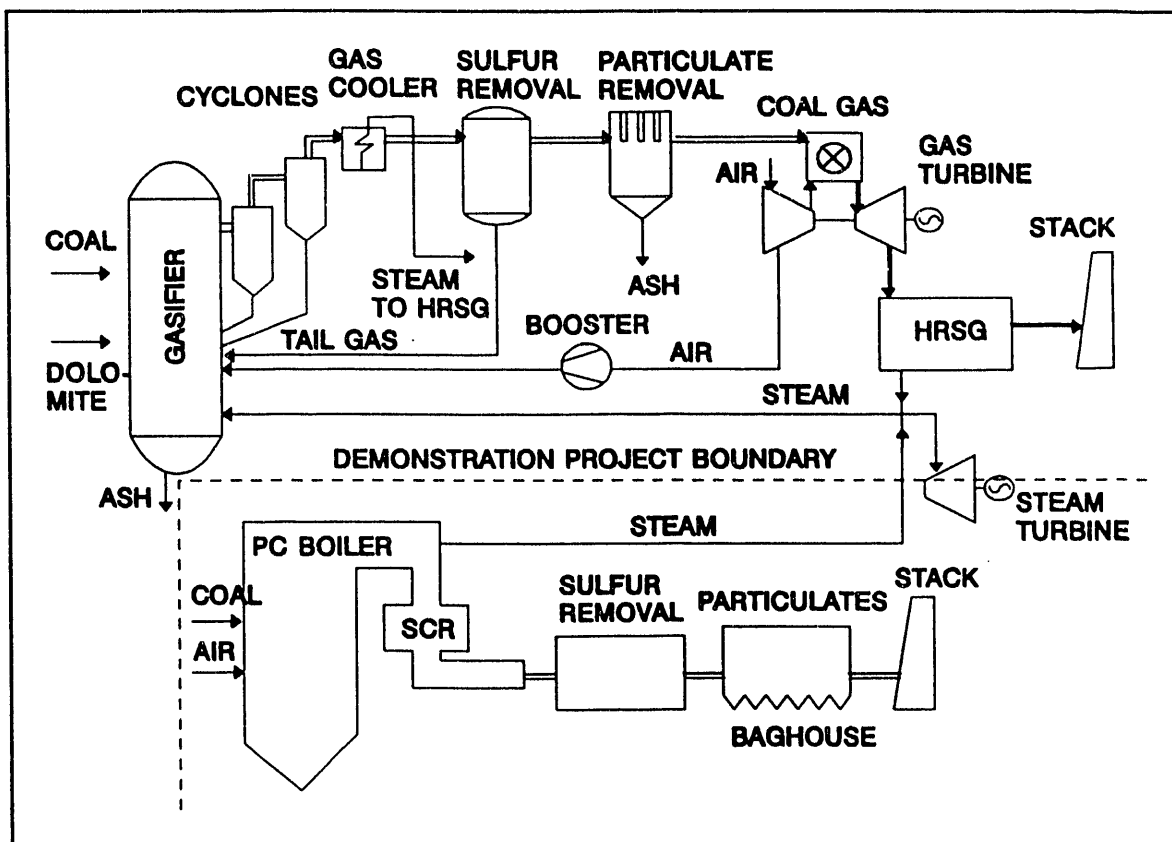


Figure 4. Toms Creek Project Flowsheet

The gasification air is supplied by the gas turbine through a booster compressor/heat exchanger system and the gasification steam is extracted from the steam turbine. Two cyclones are used for primary particle removal. After exiting the cyclones the product gas is cooled to 1020°F in a fire tube type evaporating gas cooler, which is connected to the heat recovery steam generator (HRSG). The external sulfur removal system is located after the gas cooler and as a last step the ceramic candle filter unit purifies the product gas to meet gas turbine and environmental requirements. After filtration the product gas of about 130 Btu/SCF LHV is fed into the gas turbine.

The gas turbine is equipped with air extraction for gasification and is complete with an electrical generator to produce 35 MW of electric power and followed by the HRSG. The HRSG supplies high pressure steam to the steam turbine/generator which is also connected with the pulverized coal boiler, which is outside the scope of the demonstration project. The total power produced by the steam turbine is 176 MW and the total net power delivered to the utility grid is 189 MW. The integrated steam flow sheet is shown in Figure 5.

PROJECT PHASES	1992	1993	1994	1995	1996	1997	1998	1999	2000
PHASE I									
DESIGN									
Project Definition									
Detail Design									
PHASE II									
CONSTRUCTION									
Procurement/Mfg									
Field construction									
PHASE III									
OPERATION									
Initial Operation									
Final Demonstration									

Figure 6. Toms Creek Demonstration Project Schedule

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