RETROFIT OF A PACKAGE BOILER TO UTILIZE PRODUCER GAS

H. L. Campbell
Dravo Corporation

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Hugh L. Campbell
Technical Manager, Gasification Systems
Dravo Engineers, Inc.
Pittsburgh, PA 15222
United States of America

Abstract

A coal gasification facility has been constructed in an industrial park in northeastern Pennsylvania. The facility is designed to produce low Btu gas from local anthracite coal and offer prospective industries an attractive alternate fuel source.

An industry currently located in the industrial park has converted a package boiler designed for No. 2 fuel oil to low Btu gas (LBG). This paper describes the gasification facility, explains the purposes of the facility, and examines the initial results of converting a package boiler, designed for fuel oil, to firing with LBG.

The sulfur and nitrogen oxide discharges from the boiler when operating on producer gas are discussed.

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The Boiler Retrofit Project

A Cleaver Brooks package boiler originally designed to operate on No. 2 fuel oil has been converted to utilize low Btu gas (LBG) from anthracite coal. The conversion is part of a novel industrial development project in which LBG is produced, cleaned, cooled, compressed, and distributed to a variety of industries in an industrial park.

Introduction

The package boiler, which is the subject of this report, provides steam for process and heating requirements for Inland Container's corrugated plant in the Humboldt Industrial Park, near Hazleton, Pennsylvania. This Park is owned by CAN-DO, Incorporated, a not-for-profit industrial development organization allied with the Greater Hazleton Chamber of Commerce.

The boiler in this case is unique in that it is a "first," the first boiler anywhere to be converted from fuel oil to LBG.

The gasification facility which provides gas for this boiler also represents a "first;" this is the first time that a coal gasification facility was constructed to provide gas from coal to a variety of industrial users. Some descriptions of the events which led to this series of "firsts" is in order.

Industrial Park Application

The industrial development organization of the Greater Hazleton, Pennsylvania, area has had one of the more successful records of attracting industry to northeastern Pennsylvania. This organization, "CAN-DO," proposed in 1974 to build an anthracite gasification facility in its new industrial park near Hazleton. A feasibility study on this proposal, funded by the Appalachia Regional Commission (ARC), was conducted in 1975;[1] but despite an encouraging report, the project was dormant for several years.

In 1978, the Economic Development Administration (EDA) and the ARC offered to CAN-DO an 80 percent grant to design and construct a gasification facility as proposed. The major purpose of this grant offer was to create jobs, using a low cost domestic energy source to attract new industry to the Humboldt Park.

The following year, CAN-DO had secured additional grants and loans for the funds necessary for design and construction. An additional participation was secured from the DOE to offset the costs of initial operation of the facility. CAN-DO retained EBECO Associates, Hazleton, to design and oversee construction of the project.

The gasification facility design and construction were completed in 1981 and initial testing of the facility was completed by EBECO in April of that year. Early this year, gas was produced commercially and delivered to Inland Container Corporation.

Process Description[2]

The gasification facility utilizes two Wellman-Galusha® fixed bed gasifiers having a combined output of more than 1 billion Btu per day. The building which houses the gasifiers and process equipment is large enough to accommodate an additional two 10 ft. diameter gasifiers as the Park grows.

Hot raw gas leaving the gasifier passes through a cyclone which removes some of the particulate and is then cooled in a waste heat boiler. Steam generated in the boiler is used later in the process. The cooled gas is then scrubbed in a primary scrubber, compressed, and scrubbed again in a Venturi scrubber.

The gas leaving the secondary scrubber is now cooled and compressed but is also saturated with water. To remove this moisture, the gas is chilled in a heat exchanger. Cold water used for chilling the gas is pumped from an absorption refrigerator which is powered by the steam produced in the waste heat boiler.

In a final processing step, the remaining steam is piped to steam coils in the gas stream, reheating the gas prior to distribution.

Industrial Use of the Gas

The first user of LBG from the new facility was the Inland Container Corporation, which operates a corrugated box plant in the Park. The Inland plant contains two Cleaver Brooks package boilers, each with an approximate capacity of 14,000 lbs. per hour of steam at 450 psi. These boilers were designed to use No. 2 fuel oil as burner fuel.

Inland Container chose to retrofit the boilers for use on LBG and commissioned the boiler manufacturer, Cleaver Brooks, to modify the boilers. In another in a series of "firsts" associated with this project, this was the first experience Cleaver Brooks has had with LBG burners.

Retrofit Considerations

In order to ensure that conversion to LBG would not adversely affect production, it was decided by Inland that the new burner would have dual fuel capability, that is the capability of burning either fuel oil or LBG. Since this was a first effort, the retrofit was limited to changing the burner configuration only, and no other changes were to be made to the boiler.

The boiler utilizes an air chest, and Cleaver Brooks designed a finned LBG burner baffle which would be incorporated in this space. The existing oil burner is retained, and is located in the center of the new LBG baffle.

The LBG gas line to the burner is eight-inch diameter pipe with two safety shut-off valves, a manual shut off, and a variable control valve. The control valve is modulated by a mechanical linkage connected to the existing control motor.

Initial Performance

The conversion of one of the Cleaver Brooks boilers was completed by January of this year, and LBG was supplied the following month. The first few weeks of operation on LBG were erratic at best. Fluctuations in gas supply, which occurred as operators were learning to control gas flow, were exacerbated by fluctuations in steam demand, and time and patience were required to adjust the air and gas flow to the new burner. Representatives from Cleaver Brooks, working with the Inland plant engineer, were able, however, to make initial burner adjustments which provided stable performance.

Testing Program

In April of this year, Dravo and EBECO began a testing program with Inland to evaluate existing parameters, and develop recommendations to optimize boiler performance on LBG. Initial measurements by EBECO[3] indicate that the maximum input to the boiler was 6.6 MM Btu/hr. Increasing the LBG input above 6.6 MM Btu/hr. produced a rumbling in the firebox. Furnace pressures were measured, and it was found that at this input, the furnace pressure was only 78 percent of furnace pressure at full output on fuel oil. This indicates that back pressure due to flue passage restrictions was not the restricting factor. It is suggested that improved mixing at the burner nozzle will eliminate this condition and allow increased throughput.

For optimum performance of the boiler, it was decided that furnace draft should be increased. To improve draft, Inland increased the height of the exhaust stack from four feet above rooftop, to ten feet. Sample ports were incorporated in the stack extensions. These sample ports were utilized for the tests described below, and will continue to be used as the testing program continues.

The first phase of the testing program was an analysis of the LBG into the boiler, and an accompanying analysis of the stack gases leaving the boiler. It had been determined previously that the best boiler performance was obtained when excess air was kept to a minimum. Once Cleaver Brooks had established optimum air/fuel settings, the first test series was conducted.

The gas supplied to the boiler had the following composition:[4]

Gas	Volume %
Nitrogen	49.50
Oxygen	0.16
Argon	0.65
Carbon Dioxide	0.65*
Hydrogen	13.50
Methane	0.26
Carbon Monoxide	35.20
Carbonyl Sulfide	.0138

*Low concentration of CO_2 suggests removal during scrubbing.

The flue gas from the boiler was also analyzed. Of most interest in that analysis is the concentrations of SO_2 and NO_x. (It will be recalled that the gas is produced from anthracite coal having an average sulfur content of 0.6 percent.) The flue gas from the boiler burning LBG had the following concentrations:

NO_x	$<1.27 \times 10^{-9}$ lbs./SCF
SO_2	8.6×10^{-5} lbs./SCF

Both these values are well within emission limitations for the respective pollutants, again emphasizing that the production of LBG from coal is an environmentally preferred method of utilizing coal resources.

Conclusion

This is the preliminary phase of a program to evaluate the problems of retrofitting an oil fired package boiler to LBG. Dravo plans to continue to monitor this application, and work with Cleaver Brooks, Inland, and EBECO to test and modify the existing boiler so as to produce optimum efficiency. So far the results are encouraging. Inland reports that the modified boiler is operating at about 80 percent of its rated capacity. For a "first" conversion to a fuel produced from the "first of a kind" facility, that is, indeed, a promising beginning.

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