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USE OF COAL IN BOILERS

DESIGNED FOR OIL AND GAS

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ABSTRACT

This report discusses economic, technical and environmental considerations associated with the conversion to coal firing of utility boilers designed to burn oil or gas. Basic differences between oil and gas boilers and those designed for coal are outlined. Several technologies for utilizing coal in gas or oil units are introduced, along with associated economic and environmental concerns, and some current obstacles to conversion in the utility industry today are presented.

INTRODUCTION

In 1980, the United States used 409 million barrels of oil to produce steam to generate electricity. Average price was $25.88 per barrel for a total dollar expenditure of over $10 billion. Slightly over 50% of this oil was used in only three states: Florida, California and New York.

Long term annual escalation in world oil prices is expected to be 2 to 4% above the annual inflation rate in the United States. Additional upward pressure on heavy fuel oil prices are expected from the current trend of upgrading refineries to produce higher proportions of the lighter fraction - gasoline, jet fuel, diesel fuel and home heating oil. This will reduce yields of heavy residual oil, the kind burned by most utilities to produce steam, from the current 16% to around 4%.

Deregulation of natural gas is expected to increase the price of this fuel to the same level as that of oil.

Coal prices are expected to remain below those of gas and oil for the foreseeable future.

Given this scenario, it seems only prudent to examine the considerations associated with substituting coal, in some form, for some of the oil and gas currently used in utility boilers.

Prior to 1980, most oil-to-coal conversion efforts were focused on converting or reconverting utility boilers that were designed with the capability to burn coal. In the 1960's and early 70's, many units that were burning coal were converted to oil, and many new units were designed for oil. Oil was cheap and widely available, and it facilitated easier compliance with environmental requirements.

Until fairly recently, it was generally felt throughout the utility industry that coal conversion of oil or gas designed units was not a practical concept. Steadily increasing oil prices and the present high cost of new coal capacity have resulted in a reassessment of this attitude. Today, many utilities are seriously examining the feasibility of burning coal in boilers that were never designed for it.

Before discussing coal conversion, we should have some understanding of the basic differences between a gas or oil unit and one designed for coal.

Utility boiler designs have evolved over the years so that today's units uniquely reflect the type of fuel to be burned.

Coal, being a solid fuel, is much less reactive than gas or atomized oil. In addition, the ash content of coal typically used in utility boilers is from 200 to 1000 times greater per BTU of heat generated than that of oil. Gas, of course, has virtually no ash at all.

Primarily for these two reasons, a coal fired boiler is significantly larger than one designed for oil or gas, and internal clearances are much greater in a coal designed unit.

An attempt to fire coal in an unmodified gas or oil unit would result in a multitude of problems, such as reduced heat transfer caused by ash deposits on boiler tubes, ash accumulations in the bottom of the furnace and boiler tube erosion caused by the higher mass flow rate of coal combustion products and the higher ash loading in the flue gas stream.

COAL CONVERSION TECHNOLOGIES

Let us examine what alternatives we have to enable us to utilize coal in a boiler designed for oil or gas. One option which is commercially available today is the erection of a new pulverized coal-fired boiler, adjacent to the existing oil or gas boiler, feeding steam to the existing turbine generator. Either boiler can supply steam to the turbine. This alternative minimizes conversion shutdown requirements and offers the improved reliability of an installation with redundant boilers.

Another commercially available alternative which may be considered today is the addition of pulverized coal firing capability to an existing oil fired boiler, while retaining the existing oil firing capability. The boiler operates at a reduced capacity when firing coal and may be switched to oil firing for higher loads. Provisions are made for coal handling and storage, ash removal, particulate control and soot blowing to remove ash deposits on the boiler tubes. The specific boiler design parameters and the characteristics of the coal being burned determine the unit capability on coal.

The State Energy Commission of Western Australia has implemented such a conversion at its Kwinana Units 5 and 6. These units were originally designed to fire oil and were rated at 200-MW. The units have been in successful operation firing coal and oil alternately since April 1978 and March 1979, respectively. The latest available operating data for the six months' period ending December 31, 1981 shows that coal displaced approximately 95% of the oil that would normally have been used to operate the units. The reliability record of these converted units has been above the industry average for units firing coal.

An alternative to a pulverized coal-fired boiler is a fluidized bed boiler, also erected beside the existing boiler and feeding the same turbine. Fluidized bed combustion is a process in which the coal is burned in a bed of inert ash and lime, limestone, or dolomite. The bed is held in suspension (fluidized) by the injection of air through the bottom of the bed. The lime, limestone or dolomite in the bed reacts with the sulfur dioxide produced by the burning coal to form a solid sulfate material which can easily be disposed of as a dry solid along with the coal ash. There are currently a number of fluidized bed demonstration projects in progress, and a few small industrial fluidized bed boilers have been ordered. The main advantages of fluidized bed combustion appear to be the ability to burn very poor quality coals, the ease of disposal of solid wastes in the dry state, and low nitrogen oxide emissions.

Coal oil mixtures (COM) offer another conversion alternative for oil designed boilers. This option could be attractive for units where insufficient space exists for coal handling and storage. The COM can either be prepared on site, or purchased from a COM supplier. Coal oil mixtures with up to 50% coal by weight have been successfully burned. In a 50% coal oil mixture, however, only 40% of the heat is supplied by the coal. Therefore, only limited displacement of oil is achieved, and much of the economic advantages of firing coal are lost.

A coal-water mixture (CWM) is similar to COM, but uses water instead of oil. Therefore, it eliminates the major disadvantage of coal oil mixtures. Efficiency of the boiler is reduced due to the water content in the fuel. Limited laboratory and pilot tests indicate that mixtures of 70% pulverized coal in water are stable and can be burned. The only reported utility test-burn of a coal-water slurry was carried out in the Werner Station of the Jersey Central Power and Light Company where a 30% moisture slurry was supplied to cyclone boilers with satisfactory results. Additional investigations of the concept are in progress at this time.

Coal gasification and liquefaction technologies offer promise for clean burning fuels which may be used in oil and gas designed boilers and are produced at a competitive price. A number of "second generation" gasification processes are currently in various stages of demonstration, including programs by Texaco, Shell-Koppers, British Gas, Lurgi, and Combustion Engineering.

Two scenarios can be considered for application of coal derived gaseous fuels to existing boilers. The first is what is called an "over-the-fence" system. In this scheme, the gasifier is located away from the power plant and serves only to supply gas to the units being converted. The second scenario involves an integrated scheme whereby the gasifier is located adjacent to the boiler to be converted and the two systems share feedwater, steam, compressed air and fuel, with the effluent from the gasifier supplying additional thermal energy to the steam cycle.

Direct coal liquefaction processes currently under development use catalytic hydroliquefaction or solvent extraction to convert high sulfur, high ash coals to nearly ash-free, low sulfur liquid fuel. None of these processes is yet commercially available.

ENVIRONMENTAL CONSIDERATIONS

Units in the United States that undergo conversion or modification to fire coal will be required to comply with applicable Federal, state and local ambient air quality regulations, although these regulations are by no means clear. Conversion to coal will certainly mandate the addition of an electrostatic precipitator, treatment of coal-pile run-off water, and fugitive dust control. A flue gas desulfurization system may also be required.

The emissions of a converted boiler will be no greater than, and in many cases substantially less than, the emissions of the unconverted unit.

ECONOMICS OF COAL CONVERSION

Each conversion of an oil or a gas designed unit to coal firing is unit specific and site specific. An economic evaluation of a conversion candidate involves many considerations such as the characteristics of the utility system on which the unit is located, cost of replacement power while the unit is being converted, and environmental restrictions applicable to the area in which the unit is located.

It is possible, however, to make some general economic comparisons between oil firing and the commercially available coal conversion alternatives. The author's company has made such comparisons, using oil firing as a base case and comparing this with conversion to COM, conversion to pulverized coal firing, and erection of a new coal fired boiler. A summary of the results of these evaluations are shown below.

Alternative	Payback, yrs.
Oil Firing	base
COM	3.3
Pulverized Coal	1.5 - 2.4
New Coal Boiler	3.2

The fuel costs used in the above analysis correspond to oil at $30 per barrel and coal at $40 per ton. The comparisons consider potential oil substitution possible with each conversion alternative, and the analysis includes fixed charges on investment, fuel costs, and operating maintenance costs.

The results of our work clearly indicate that oil designed utility steam generating units can be converted to fire coal, and that current and projected prices of oil and coal make such conversions economically attractive.

OBSTACLES TO CONVERSION

Although the conversion of oil or gas designed units to coal has been shown to be technically and economically attractive and environmentally acceptable, there still remain a number of obstacles to conversion. Given the financial condition of the utility industry in general today, and record high interest rates, it may be difficult for a utility to generate the necessary capital for a coal conversion. Furthermore, if the necessary capital is available, there is no guarantee that the state regulatory agency with jurisdiction over the utility will allow the company to recover its costs of conversion through the appropriate rate relief.

The environmental concerns relate primarily to delay and cost factors, since coal can be burned in most areas of the country without violating ambient air quality standards.

These problems notwithstanding, a number of utilities are actively investigating coal conversion of their oil or gas generating units. Florida Power and Light Company has converted one of the units at their Sanford Generating Station located in Sanford, Florida, near Orlando, to burn a coal-oil-mixture. The utility has overcome most of its initial problems with this conversion and, to date, the operation of the converted unit has been quite successful.

If some of the above problems can be satisfactorily resolved, I believe that the utility industry in this country will see an increasing number of coal conversions in the years ahead.