Status on Efficiently Burning Coal Technology at Power Plant Level

This summary will address the status of coal burning methods in electric generating plant boiler furnaces as they relate to the reduction of currently, or soon to be, regulated air pollutants [Particulate Emissions (flyash), Sulfur Dioxide (SO_2), Oxides of Nitrogen (NOx) and Mercury].

Three types of boilers will be discussed: Traveling Grate Stoker, Pulverized Coal (PC) and Circulating Fluidized Bed (CFB). Of these types, only CFBs have been constructed as primarily demonstration plants and are not in commercial widespread use . The DOE reports indicate at least 3 commercial CFB generating plants are on line .

Traveling Grate Stoker is the oldest technology and is widely used for high ash content fuels (coal, biomass) and medium range boilers. The advantage of this type boiler is in the diversity of the fuels that can be burned. Air pollution control is mostly beyond the furnace in the flue gas path and is similar to what is used in PC boilers. Boiler efficiency may be improved by reinjecting particulates (flyash) collected from the flue gas exiting the boiler and blowing them back into the furnace. This reinjection will consume any unburned fuel. Filer City Generating plant (about 60 megawatts) near Manistee is of this type. It burns wood waste from a nearby paper mill, petroleum coke, bituminous coal, and shredded tires. There is a "baghouse" dust collector and an SO_2 scrubber downstream from the furnace. NOx emissions are below limits and Ontario Hydro certified testing has proven that the elemental Mercury is nearly all absorbed in the baghouse.

Pulverized Coal Boilers are the most commonly used for generating electricity. These boilers use coal that is pulverized into a very fine dust and blown into the furnace. They are usually designed for a narrow range of specific coal types (lignite, sub-bituminous, or bituminous) and air pollution control may be achieved in a combination of methods. Particulate emissions are controlled by either a “baghouse” dust collector or an electrostatic precipitator. Sulfur dioxides may be somewhat controlled by the design coal used and mine preparation of the fuel before shipment. Flue gas de-sulfurization (sulfur scrubbing) is the most common method for SO_2 reduction. NOx may be somewhat controlled through specific low NOx burner design and furnace flue gas recirculation to reduce the coal combustion temperatures in the furnace. More recently, Selective Catalytic Reduction, SCR, is used to reduce the NOx in conjunction with burner design. Elemental mercury reduction can be partially achieved by the use of a baghouse for particulate collection or through injection of activated carbon into the furnace. In a PC boiler, one of the keys to efficiency is the percentage of unburned carbon in the fly ash. The lower the unburned carbon (less than 5% is ideal in my experience) the more completely the fuel is consumed. When higher than about 15%, coal fineness samples are taken where the fuel exits the pulverizers to see if the pulverizers need maintenance or just a little "tuning".

Holland B.P.W.'s DeYoung Plant has 3 typical PC Units of 11, 25 and 28MW. They were designed to burn bituminous coal which is more plentiful in the eastern US coal fields. They do burn a western bituminous under contract and buy some eastern bituminous on the "spot" market. Their bituminous coal is blended from their supplier with western US sub-bituminous coal. The blend is at least 80% bituminous. The plant has electrostatic precipitators for particulate (flyash) removal. It does not have requirements for SO_2 or NOx emissions, due to the age and size of the units. The proposed 78MW PC unit for DeYoung will have all of the latest technology available for air pollution emissions reduction. In addition, the current plan calls for the 11 MW unit to be demolished (along with two old retired units) to make room for the new unit. The BPW is designing the new plant (25MW, 28MW, and 78MW) so that total emissions will be less than with the current three units in operation.

The boiler steam cycle efficiency on the existing DeYoung units was established in the plant design. Since that design period, steam pressures have risen to what the industry calls "supercritical" units. Supercritical boilers have steam pressures above 3000 PSI. The higher the steam pressure the more efficient the steam cycle."Reheat" sections have been incorporated in new boiler designs since the early 1950's. In "Reheat Unit", steam is exhausted from the high pressure sections of the turbine and returned to the boiler “reheater”. The reheater increases the steam temperature back to main steam conditions and pipes it back to an intermediate pressure section of the turbine. Only steam temperature is affected, not steam pressure in a reheater. Superheated and reheated steam temperatures are limited to 1005F. Boiler tube material is the limiting factor in steam temperatures. At the J.H. Campbell Complex at Port Sheldon, Unit 2 (in service since 1967 and over 300MW output) is a supercritical boiler. Unit 3 (in service since 1980 and over 800 MW) is not a supercritical unit and has superheated steam pressure of about 2400PSI with steam temperatures of 1005F.

Circulating Fluidized Bed boilers are a PC type boiler that has been proven to reduce air pollutants in the coal combustion process in the furnace by injecting crushed limestone. The coal bed is suspended in the furnace by additional forced draft and reacts with the limestone during the combustion. The limestone absorbs the sulfur. NOx reduction is a bonus realized by the lower furnace combustion temperatures. Only three commercial plants are listed by the DOE in the USA with about 1000MW installed worldwide. Particulate and mercury emission collection would be similar to a PC boiler. A small demonstration combined cycle unit has been designed to use a Pressurized Fluidizing Bed Boiler where the fluegas pressure is used to spin a gas turbine similar to an IGCC unit. The main benefit to this type of furnace is the reduction of potential emission products in the furnace rather than after the furnace with typical add on equipment. The cost for this type unit is higher than a normal clean coal PC unit.

Integrated Gasification Combined Cycle power plants have several advantages over the other coal combustion methods by first converting the coal to a synthetic methane gas thereby eliminating the potential air pollutants before the combustion process. There is also an efficiency advantage over the others by combining the generation of electricity by a gas turbine as the initial cycle and using the gas turbine exhaust gas to generate steam in a heat recovery steam generator (HRSG) that can be used in a typical steam turbine generator as the second cycle. At this time, an IGCC plant has the highest capital cost related to construction.

There is a natural gas combined cycle unit in Zeeland that was built several years ago and is now owned by Consumers Energy. The relative high cost of natural gas limits the operation of this plant to those days when existing base load generation output has been maximized. The Midland Co-Generation Plant, that was originally designed as a two unit 1400 MW base load nuclear plant, was refitted as a natural gas combined cycle plant with 12 gas turbines of about 90 MW each. The exhaust from the gas turbines passes through a HRSG (boiler) and the steam generated is used to supply the steam turbines that were originally part of the nuclear plant.

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