GENUINELY CLEAN COAL

Introduction

Sufficient, reliable sources of energy are a necessity for industrialized nations. With global energy demand rising at an unprecedented rate, the world's vast coal reserves are attracting growing interest. Despite its low cost and abundance, increasing concerns over greenhouse gases and other emissions from fossil fuels are altering the technological and regulatory environment for coal. Programs are underway to limit, reduce, and capture emissions from coal plants. This may result in the emergence of new generation technologies and the increased use of advanced emissions control technologies. In so doing, the costs and economics of coal use may change.

Types of Coal and Their Characteristics, in general:

Environmental Factors

Coal combustion produces emissions of air pollutants including sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), carbon dioxide (CO_2), and mercury (Hg). SO_2, NO_x, and PM emissions are associated with air quality impacts and acidification of water resources, or acid rain. CO_2 emissions contribute to global climate change. Mercury, which can move in multiple environmental pathways, is a neurological toxin in humans and wildlife.

A wide range of control technologies can be employed to reduce emissions of particulates, mercury, sulfur dioxide, and oxides of nitrogen.

Particulates are captured with baghouses (BH), electrostatic precipitators (ESP), and multiclones (MC). Nitrogen oxides (NO_x) compliance actions may include a mix of combustion control technologies, such as low-NOx burners (LNB) and overfire air (OFA), and end-of-pipe emission control technologies, such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR).

Sulfur dioxide (SO2) compliance actions may include switching to lower-sulfur coal, retirements, and installation of various scrubber technologies, such as flue gas desulfurization (FGD), dry lime injection (DLI), and spray dry injector (SDI). Burning low-sulfur coal can reduce SO2 emissions from an uncontrolled plant by two-thirds; installing a scrubber can reduce emissions by 90 percent or more. Mercury can be reduced to a limited extent by conventional SO2 scrubbers; more advanced controls specifically designed to reduce mercury include carbon injection (CI) and baghouse (BH) equipment.

Carbon capture and sequestration (CCS) technologies are under evaluation for their potential for removing the CO2 emissions from coal-fired power plants. The commercially available method for capturing CO2 from a conventional pulverized coal-fired boiler is the use of an amine-based system to absorb CO2 from the flue gas stream, and its subsequent regeneration to produce a nearly pure product stream. An alternative method, known as oxy-combustion, to capture CO2 is to use oxygen rather than air as the oxidant in the combustion process that yields a flue gas stream comprised primarily of CO2 and H2O. By removing the water, a nearly pure CO2 stream can be produced.

Coal combustion produces significant quantities of solid waste by-products that can be put to beneficial use. Coal combustion waste products can be used as an ingredient in the manufacture of cement, asphalt, roofing shingles, gypsum, calcium chloride, lightweight aggregate, lightweight block, and low-strength backfill.

Emerging Coal Generation Technologies

Pulverized coal system (PC) is the conventional coal burning technology used in most of the cases. In this, finely ground coal is combusted to make steam that turns turbines and generates electricity. The raw coal is fed into the pulverizer along with air heated to approximately 650˚F from the boiler. As the coal is pulverized, the hot air dries it and blows the usable fine coal powder out to be used as fuel. The powdered coal is then blown directly to a burner in the boiler. The burner mixes the powdered coal in the air suspension with additional pre-heated combustion air and forces it out of a nozzle similar in action to fuel being atomized by an automotive fuel injector. Under normal operating conditions, there is enough heat in the combustion zone to ignite all the incoming fuel.

As environmental emission regulations have been tightened, many coal plants have employed a range of operational modifications and capital equipment investments. In addition to fuel switching, i.e., low-sulfur coal, technologies are available and emerging to reduce emissions from coal burning at three different stages: pre-combustion, combustion, and post-combustion. Pre-combustion cleaning involves the removal of impurities from coal with physical, chemical or biological processes. Advanced combustion processes include improvements in existing coal combustion processes and new processes that remove pollutants from coal as it is burned. Post-combustion cleaning involves the removal of pollutants from the downstream flue gas after combustion and before exiting the stack. Many of the post-combustion pollution control technologies have been widely commercialized and have evolved into proven, mature technologies.

In recent years, technological advancements have led to substantial reductions in the cost of controlling SO_2 and NO_x emissions. Some of the most successful advancements are low-NO_x burners, Selective Catalytic Reduction (SCR), Selective Non-Catalytic Reduction (SNCR), and scrubbers. Advanced pollution controls installed on existing power plants or engineered into new facilities can provide effective and low cost ways to reduce sulfur dioxide and nitrogen emissions.

Advanced power generation technologies are complete electric power generating systems that offer superior efficiency and environmental performance over conventional coal-burning systems. These new processes, such as circulating fluidized bed (CFB) combustion, can improve both efficiency and emission control. Another category of advanced coal technologies involves the conversion of coal into another form of fuel, e.g., gas or liquid. In most of these cases, the new fuel form provides both energy and environmental benefits by reducing the pollutants emitted from combusting the new fuel as compared to coal. Integrated gasification combined cycle (IGCC) is an example of this type of technology.

a. Circulating Fluidized Bed (CFB) – CFB combustion evolved from efforts to control pollutant emissions without external emission controls, such as scrubbers. The CFB technology suspends solid fuels on upward-blowing jets of air during the combustion process, resulting in a turbulent mixing of gas and solids. The tumbling action, much like a bubbling fluid, provides more effective chemical reactions and heat transfer. The technology allows burning at temperatures well below the threshold where NO_x form. In addition, the mixing action of CFB brings the flue gases into contact with a sulfur-absorbing chemical, such as limestone or dolomite, capturing more than 95 percent of the sulfur pollutants inside the boiler. The popularity of fluidized bed combustion is due not only to its capability of meeting SO_2 and NO_x emission standards without the need for expensive add-on controls but also technology’s fuel flexibility. Almost any combustible material, from coal to municipal waste, can be used for fuel.

b. Integrated Gasification Combined Cycle – Another emerging combustion technology, integrated gasification combined cycle (IGCC), converts coal to a gaseous form similar to natural gas before being burned. This advanced technology converts coal into a combustible synthetic gas by reaction with oxygen and heat/steam. Emissions from these plants are very low compared to other coal technologies because the gas is cleaned prior to combustion, burned in a gas turbine, and the resulting exhaust gases are used to produce steam that then drives a steam turbine. Typically 60 to 70 percent of the power comes from the gas turbine with IGCC. The result is an IGCC configuration that provides ultra-low pollution levels and, in addition, carbon-capture technologies can more readily be built on to the back end of IGCC plants than traditional pulverized coal combustion technologies.

On the front end of IGCC is a gasification technology. Worldwide, there are 117 operating plants that include 385 gasifiers. Products from the syn-gas produced from gasification include chemicals, liquid fuels, and electric power.

c. Super Critical Steam – The use of supercritical (SC) and ultra-supercritical (USC) steam, heated to a higher temperature than conventional boilers, has the potential to achieve greater generation efficiency, resulting in more output per unit of fuel as well as fewer pollutants. Efficiencies of 40 percent and higher have been demonstrated. SC and USC plants require the use of more durable metals and alloys in order to withstand the higher operating temperatures. Although several SC and USC coal plants have been constructed and operated in the United States, some have experienced operating difficulties due to the high tolerances required. In more recently constructed plants in Japan and elsewhere, anecdotal reports indicate that SC and USC plants have operated more reliably with fewer outages than earlier designs.

d. Oxy-combustion (Oxy-Coal) – Oxy-combustion, or oxy-coal involves the combustion of coal in a mixture of oxygen and re-circulated flue gas. The main benefits of oxy-combustion technology with CCS are:

* Reduction of carbon dioxide emissions up to nearly 96.9 percent removal

* Reduction of SO2

* Potential for enhancement of mercury removal in the baghouse and advanced SO2 controls

Because it uses conventional equipment already proven in the power generation industry, the oxy-combustion technology can readily be applied to new coal-fired power plants. Plant control during startup, shutdown, and load following is very similar to a conventional PC plant. Finally, the key process principles have been proven in the past including air separation and flue gas recycle (FGR).

However, several challenges to oxy-combustion have also been identified:

* Air infiltration into the boiler dilutes the resulting flue gases. This could potentially be minimized by improved boiler materials, sealants, control technologies, and membranes.

* Combustion of fuels in a purified oxygen stream would occur at temperatures too high for existing boiler or turbine materials. This issue is being addressed by diluting the oxygen via the FGR, which results in an increase of the auxiliary power load and decreases efficiency. Further developments aim at increasing the efficiency of the FGR and improved boiler materials.

* The current capital and operating costs of specialized components are high.

* Plant efficiency is reduced by the use of the auxiliary load of FGR and air separation equipment.

Conclusion

With introduction of improved and emerging technology, the efficiency and cleanliness of coal-fired power stations is improving. Genuinely clean coal – i.e.: one that emits close to zero CO_2 thanks to carbon capture and storage technology – is not expected to become economically viable before twenty years, are now viable. Thus, coal is making a comeback as a cheap and reliable source of energy.

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