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Jayanta Bhattacharya
Chief Editor

The role of green technology innovation in pollutant reduction from the electric power and thermal power industry

As one of the largest energy consuming industries, electric power and thermal power industry holds the lifeline of national economy. Although electric power and thermal power industry is the main source of industrial sulfur dioxide emissions, there are a few recent developments to reduce the impact of the electric power and thermal power industry on industrial sulfur dioxide emissions. In recent years, the electric power and thermal power industry has been promoting green technologies such as end-of-pipe flue gas treatment in coal-fired power plants, which include desulfurization and denitrification technologies and high-efficiency dust removal technologies, and the implementation of such green technologies has led to a significant reduction in the total emissions of air pollutants such as sulfur dioxide in the electric power and thermal power industry. Green technologies such as clean production technologies are characterized by reducing industrial sulfur dioxide emissions from the source and can control pollution emissions in the whole process, which can not only reduce the amount of industrial sulfur dioxide generated, but also reduce the additional investment costs and operation costs for removing pollutants, and solve problems such as secondary pollution generated because of end-of-pipe treatment, which is important for inhibiting the sulfur dioxide emissions in the electric power and thermal power industry. It can be seen that the emission reduction effect brought by green technologies is significant. Especially after the implementation of the Emission Standards for Air Pollutants from Thermal Power Plants, the emission reduction effect brought by green emission reduction technologies in the electric power and thermal power industry on industrial sulfur dioxide emissions has become increasingly evident. It can be said for sure that the pollutant reduction brought by green technologies such as cleaner production technologies is prominent in reducing pollution.

Managing waste from coal

Burning coal, such as for power generation, gives rise to a variety of wastes which must be controlled or at least accounted for. So-called ‘clean coal’ technologies are a variety of evolving responses to late 20th century environmental concerns, including that of global warming due to carbon dioxide releases to the atmosphere. However, many of the elements have in fact been applied for many years, and they will be only briefly mentioned here:

1. Coal cleaning by ‘washing’ has been standard practice in developed countries for some time. It reduces emissions of ash and sulfur dioxide when the coal is burned.
2. Electrostatic precipitators and fabric filters can remove 99% of the fly ash from the flue gases – these technologies are in widespread use.
3. Flue gas desulfurization reduces the output of sulfur dioxide to the atmosphere by up to 97%, the task depending on the level of sulfur in the coal and the extent of the reduction. It is widely used where needed in developed countries.
4. Low-NOx burners allow coal-fired plants to reduce nitrogen oxide emissions by up to 40%. Coupled with re-burning techniques NO_x can be reduced 70% and selective catalytic reduction can clean up 90% of NO_x emissions.
5. Increased efficiency of plant – up to 46% thermal efficiency now (and 50% expected in future) means that newer plants create less emissions per kWh than older ones (Table 1).
6. Advanced technologies such as integrated gasification combined cycle (IGCC) and pressurized fluidized bed combustion (PFBC) enable higher thermal efficiencies still – up to 50% in the future.
7. Ultra-clean coal (UCC) from new processing technologies

which reduce ash below 0.25% and sulfur to very low levels mean that pulverised coal might be used as fuel for very large marine engines, in place of heavy fuel oil. There are at least two UCC technologies under development. Wastes from UCC are likely to be a problem.

8. Gasification, including underground coal gasification (UCG) in situ, uses steam and oxygen to turn the coal into carbon monoxide and hydrogen.
9. Sequestration refers to disposal of liquid carbon dioxide, once captured, into deep geological strata.
10. Some of these impose operating costs and energy efficiency loss without concomitant benefit to the operator, though external costs will almost certainly be increasingly factored in through carbon taxes or similar which will change the economics of burning coal.

Post-combustion capture

Capture of carbon dioxide from flue gas streams following combustion in air is much more difficult and expensive than from natural gas streams, as the carbon dioxide concentration is only about 14% at best, with nitrogen most of the rest, and the flue gas is hot. The main process treats carbon dioxide like any other pollutant, and as flue gases are passed through an amine solution the CO_2 is absorbed. It can later be released by heating the solution. This amine scrubbing process is also used for taking CO_2 out of natural gas. There is a significant energy cost involved. For new power plants this is quoted as 20-25% of plant output, due both to reduced plant efficiency and the energy requirements of the actual process. No commercial-scale power plants are operating with this process (the US Petra Nova plant has suspended CCS – see fuller mention below). At the 1300 MWe Mountaineer power plant in West Virginia which emits 8.5Mt CO_2 annually, a \$100 million Alstom pilot project successfully treated less than 2% of the plant's off-gas for CO_2 recovery, using chilled amine technology. There were plans to capture and sequester 20% of the plant's CO_2, but this was abandoned in 2011 due to lack of government support.

World's largest post-combustion carbon capture project

Petra Nova – a commercial-scale post-combustion carbon capture project designed to remove more than 90% of the carbon dioxide (CO_2) from a 240-MW slipstream of flue gas off of the W.A. Parish generating station in Fort Bend County, Texas – has been completed in 2016.

The facility (figure), the largest installed on an existing coal-fueled power plant to date, captured its first CO_2 on September 19, 2016, and completed final performance

acceptance testing on December 29, 2016. The system had already captured and delivered more than 100,000 tonnes of CO_2 to the West Ranch oilfield for enhanced oil recovery (EOR) when the completion announcement was made on January 10, 2017.

Figure. Petra Nova. Sixteen-foot diameter ductwork takes flue gas from the coal plant to the carbon capture facility where the CO_2 is removed from the flue gas by the amine solution in the tall absorption tower and then separated from the amine as 99.9% pure CO_2 in the smaller regenerator tower to the right before being compressed and delivered to the oil field. *Courtesy: Business Wire.*

Petra Nova is expected to capture about 1.4 million metric tonnes of CO_2 per year. Hilcorp Energy Co., operator of the West Ranch oilfield, will use the CO_2 to boost production at the field. The company expects production will increase from about 300 barrels per day before beginning EOR to as much as 15,000 barrels per day using captured CO_2 delivered via an 80-mile-long pipeline.”To date we have drilled nearly 100 new wells in the West Ranch field and have implemented a robust CO_2 and ground water monitoring program,” said Jeffery D. Hildebrand, chairman and CEO of Hilcorp Energy. “We are excited about this project, and expect to see a meaningful increase in oil production at West Ranch in the near future.”

Carbon dioxide removal technology using amine absorption

The amine-based chemical absorption process has been used for CO_2 and H_2S removal— acid gas removal— from gas-treating plants since 1950s and are considered to be by far the most developed CO_2 capture process. CO_2 is absorbed typically using amines to form a soluble carbonate salt. The absorber operates below 60°C and ambient pressure. This reaction is reversible and the CO_2 can be released by heating the solution with the carbonate salt in a separate stripping column. The CO_2 stripping occurs at 120°C and pressures ranging between 1.8 and 3 bar [6], as illustrated in the step 2 in Fig.1.

Nowadays, amine-based chemical absorption are used as a potential technology that can be applied to reduce carbon dioxide emissions in industrial processes such us fossil fuels power plants, cement production and iron and steel manufacturing. Post-combustion is the nearest close-to-market and industrially developed carbon capture and storage (CCS) technology. Specifically, the alkanolamines are volatile, cheap and safe to handle compounds and are commonly classified by the degree of substitution on the central nitrogen; a single substitution denoting a primary amine; a double substitution, a secondary amine; and a triple substitution, a tertiary amine. Each of the above-mentioned alkanolamines has at least one hydroxyl group and one amino group. In general, the hydroxyl group serves to reduce vapor pressure and increases the solubility in water, while the amine group provides the necessary alkalinity in aqueous solutions to promote the reaction with acid gases. Therefore, the molecular structures of primary and secondary amines are the non-fully substituted alkanolamines and they have hydrogen atoms at the non-substituted valent sites on the central nitrogen, whereas the tertiary amines are fully substituted on the central nitrogen. This structural characteristic plays an important role in the acid gas removal capabilities of the various treating solvents.

The project will use the KM-CDR Process developed jointly by Mitsubishi Heavy Industries (MHI) and Kansai Electric Power Co. MHI has since 2006 conducted small-scale (10 metric tonnes per day [mtpd]) demonstration testing for CO_2 capture from coal-fired flue gas with J-POWER. In December 2013, it wrapped up a three-year 500-mtpd capture demonstration test at Alabama Power’s Plant Barry. By comparison, the Petra Nova project will have a CO_2 capture capacity of 4,776 mtpd.

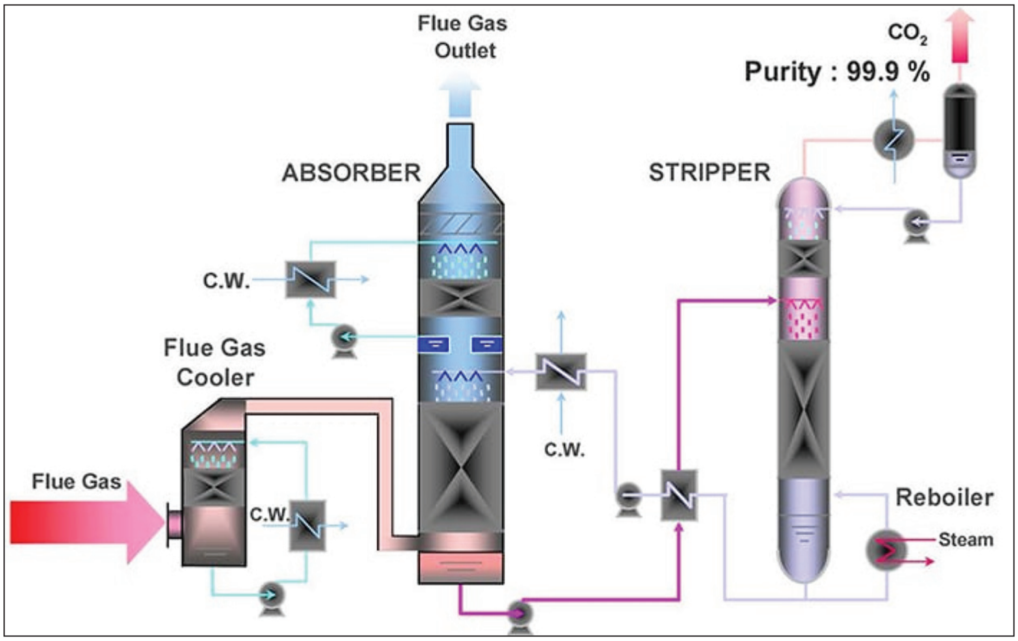

Fig.1

Reference

https://www.powermag.com/worlds-largest-post-combustion-carbon-capture-project-completed/