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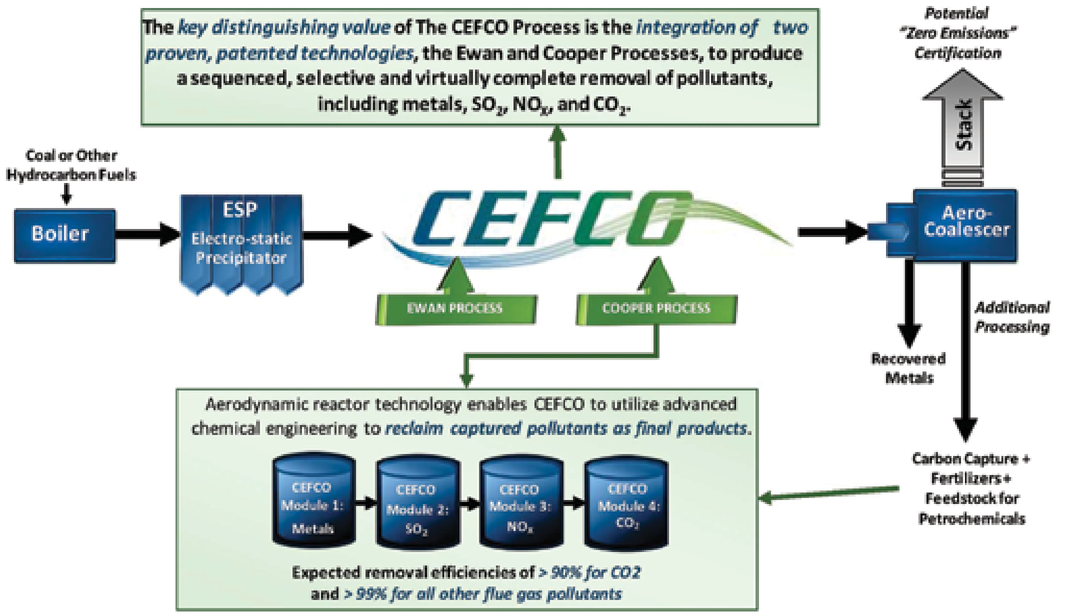
Ewan and Cooper processes unite in 'paradigm shifting' patent

A freshly patented technology aimed at removing over 99 per cent of flue emissions and over 90 per cent of CO_2, the CEFCO Process is being presented as a comprehensive Maximum Achievable Control Technology (MACT) solution to enable coal and oil fired plants to meet tightening US emission standards.



The CEFCO Process integrates the Ewan and Cooper processes with a goal of cutting emissions while capturing pollutants as sellable end-products Source: CEFCO

The US Environmental Protection Agency (EPA) is expected to propose an emission standard for hazardous air pollutants from coal and oil fired generating units in March 2011 that require MACT (Maximum Available Control Standards) in accordance with the Clean Air Act. A standard for CO_2 emissions control is also imminent.

The utility industry's technology decisions to address these challenges can now take into consideration the CEFCO (Clean Energy and Fuel Company) Process, for which the US Patent and Trademark Office recognized 36 claims on 27 September, 2010. Its innovative, cost-effective technology is recognized for compliance with MACT standards for removal of acidic gases, trace metals and fine particulate matter (even below 2.5 microns) from incineration of toxic and radioactive waste, for which it has been used for 25 years, but the process is now presented as a comprehensive MACT solution for compliance in the power and cement industries and also for CO_2 capture with significantly lower parasitic load burden or energy burden.

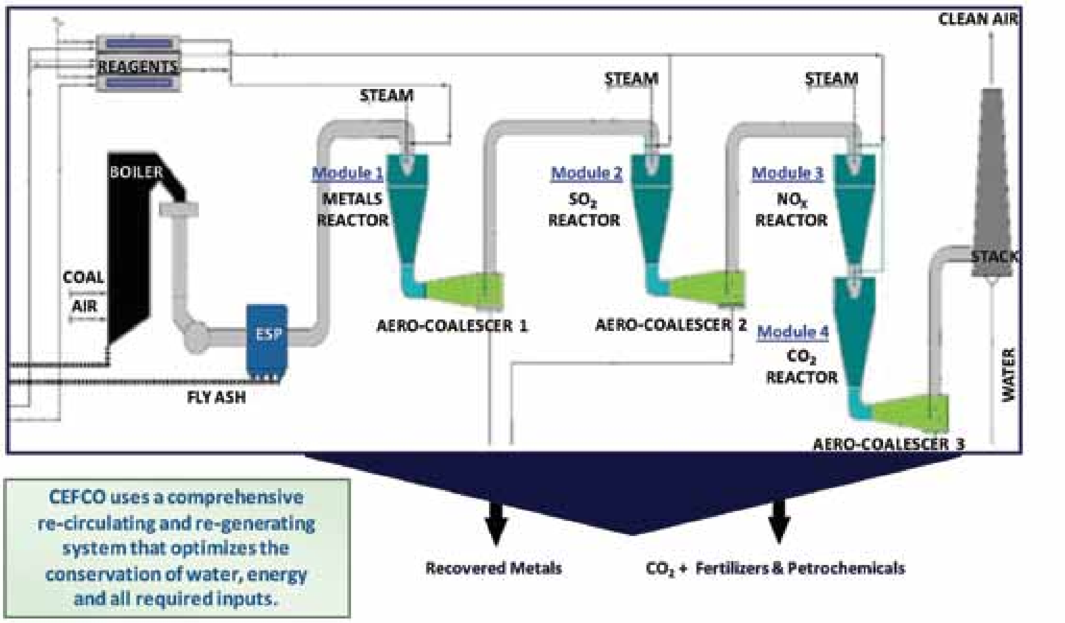
The CEFCO Process is a major improvement in air quality control system (AQCS) efficiency and CO_2 capture levels compared with the currently available technologies. It integrates and enhances two proven and previously patented technologies enabling the selective capture and removal of over 99 per cent of flue gas emissions and over 90 per cent of CO_2 with a total of less than 10 per cent for parasitic load burden – or energy penalty – while offering capital and operating costs significantly below those for conventional AQCS technologies.

The first component of CEFCO technology, invented by Thomas K. Ewan and his team of aerophysicists, applies a sequence of reactors and aero-coalescers, designed on aerodynamic principles, that strips emissions of all metals, fine particulates, SOx, NOx and CO_2 and captures them as clean segregated and recovered end-products. Ewan's 'free-jet collision scrubber' technology complies with the EPA's Hazardous Waste Combustors MACT standards established as part of 1990 Clean Air Act Amendments. The second component of the CEFCO Process is a chemical process invented by Hal B. H. Cooper, which uses chemical reagents for the selective conversion of each targeted compound in succession, resulting in captured and converted forms of recovered metals, potassium sulphate and potassium nitrate fertilizers, and pure CO_2 from a bicarbonate solution.

Ewan Technology, successfully used by US Department of Energy (DOE)/Department of Defense (DOD), applies supersonic and/or sub-sonic nozzles in combination to produce shockwaves and free-jet collisions that enable the removal of waste emissions. Ewan Technology (called the shockwave 'free-jet collision scrubbing' in EPA literature) is extremely effective: its success had been proven by its adoption by the DOE Nuclear Regulatory Commission since the late 1970s. Furthermore, the EPA affirmed and codified it later in the publication 'Guide to Phase 1 Hazardous Waste Combustors (HWC) MACT Compliance' dated 22 May, 2002.

Its operating principle is best described by the US EPA as stated in its review, analysis and selection of the 'Free-Jet' Technology in Section 3.4.2.2 of the 'Technical Support Document for HWC MACT Standards', Vol. I: Description of Source Categories (dated February 1996), as follows:

"When a gas stream is saturated with water and then cooled, a portion of the moisture will condense, and the fine particles in the gas stream serve as condensation nuclei. As moisture condenses on the particles, they grow in mass and are more easily collected by conventional impaction.



The configuration of the modules of the CEFCO process enables different emissions to be removed in sequence Source: CEFCO

Therefore, the condensation enhances the scrubbing system's collection of fine particles, acid gases and metals.

3.4.2.2 Free-Jet

Free jet scrubbers have the same basic configuration of venturi type scrubbers (i.e., quench, scrubber, and moisture separator). The energy for moving the gases through the system and cleaning the gases is provided by the injection of a compressible fluid (typically steam or air) from a supersonic ejector nozzle which is located inside the flue gas duct. The amount of fluid added through the ejector is proportional to the mass of gas flowing through the system. The turndown capacity of the system is high because the ejector supplies the energy required to move the gases through the system. At the exit of the ejector nozzle, water is injected into the high velocity flow. The velocity of the steam or air breaks the water into small droplets. The flue gas and ejector fluid mixture then passes through a subsonic nozzle in which additional water spray is injected. Finally, the gas passes into an expansion section where free jet mixing takes place, aiding in further particulate agglomeration and capture. The primary advantage is improved capture efficiency compared with conventional venturi scrubbers and lower total energy requirements . . ."

The first component of the CEFCO Process based on Ewan Technology consists of a series of aerodynamically designed free-jet nozzles that enable intimate mixing of reagents and pollutants by creating extremely turbulent flow conditions in the form of shockwaves and 'free-jet collisions'. It next provides for near-instant molecular surface chemistry-based reactions as a result of the free-jet collisions with steam propelled by the nozzles at supersonic speed generating shockwaves within the supersonic free-jets.

These shockwaves are extremely intense energy and pressure waves, acting like a solid body colliding with all the molecules of the flue gas. Atomizing nozzles ally with the supersonic shockwaves to direct small liquid droplets of selective reagent solutions into the supersonic shockwave region. When these droplets come into contact with the supersonic shockwaves, they are broken down into extremely small droplets, initially shaped as ribbons or strings.

Once these droplets contact the target molecules, they react rapidly. These droplets, along with the surrounding gaseous stream, are then accelerated, with the shockwaves acting as a motive force, into a second in-line subsonic nozzle. Gaseous streams passing through the subsonic nozzle undergo a rapid expansion into a sub-atmospheric zone inside the aerodynamic reactor. The turbulent flow conditions created by such rapid expansion allow the small liquid droplets to grow in size, through repeated collisions, nucleation and moisture condensation.

Within the induced sub-atmospheric zone of rapid temperature and pressure drop inside the reactor, extremely rapid chemical reactions take place that use and absorb the tremendous energy generated by the shockwaves together with the rapid pressure drop.

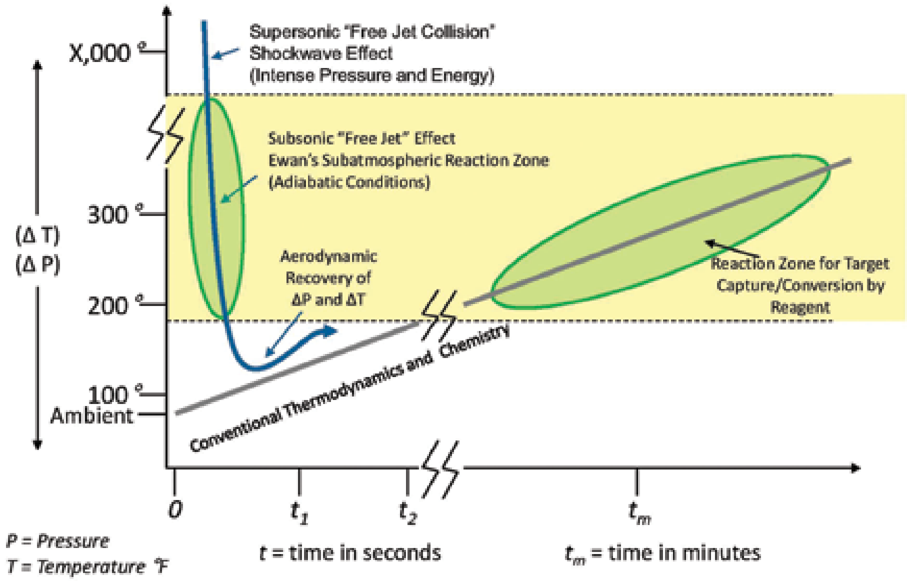
This condition designed for super-efficient chemical reactions substitutes the traditional input of high heat and pressure and/or catalyst for producing comparable results. The reaction products are encapsulated in liquid water droplets through impaction and steam condensation. The encapsulated droplets of reaction products grow in size and are stripped from the flue gas in an aero-coalescer.

The other technology component is the Cooper Process, which reacts with, and recovers, nitrogen and sulphur oxides from the flue gas and chemically converts them into fertilizer-grade sulphates and nitrates. The recovered pure CO_2 can also be liberated from a bicarbonate-carbonate solution and sequestered and used in a variety of applications, including feedstock for bio-diesel fuels.

The process utilizes a recirculating and regenerative reagent system that minimizes the use of reagents and conserves water. The Cooper Process has been studied and reported upon by Morrison-Knudsen (now URS/Washington Division) and assessed by BCP-Wardrop Engineering as documented in a 2003 report for Saskatchewan Power of Canada confirming the production of end-products and capture of pure CO_2.

This CEFCO Process is a net generator of water rather than a net consumer as it liberates water from fossil-fuels through: (1) the chemical reactions of the hydroxide and carbon dioxide making the bicarbonate/carbonate solution that is recovered after exiting the aero-coalescer; (2) the water input in the chemical feed streams recovered through condensation from the liberated and concentrated pure CO_2 gas stream during the decarbonation and recovery step, and; (3) capture of the moisture condensation from the stack gas.

Water can then be recycled to the plant and utilized as sanitary water within the plant or further filtered to become plant process water. In the circulating and recycling mode, the CEFCO Process may make it possible to minimize new input water requirements for industrial applications which employ air cooling. Where production of fertilizer is not required and only metals and/or carbon dioxide capture is desired, the process can also utilize local brackish or saline water to supply some of its chemical makeup requirements, and in doing so will upgrade the quality of the water to purified water, which can then be recycled and reused for agricultural, industrial and energy-related purposes.



Comparison of parasitic load and energy penalty

Source: CEFCO

The CEFCO Process optimizes the use of water, energy and all other required inputs – including the chemical reagents – through a modular design suitable for any fossil fuelled power plant. The process design employs a four-module system for each of the four major emissions groups. The CEFCO Process also can be customized and constructed selectively, eliminating one or more of the four modules that comprise a complete flue gas cleaning process, to achieve a desired combination of modules or a specific-purpose modular system for the capture of carbon dioxide. Thus, the CEFCO Process is expected to be much more economical and have much lower parasitic load and energy penalty than conventional mechanical, chemical and thermodynamic reaction processes.

The CEFCO Process will improve overall operating costs through the reduction in compliance costs for fossil fuelled power plant operations and the elimination of compliance costs associated with carbon and other emissions (renewable energy credits). While emission control solutions are traditionally viewed as 'cost centres' for most energy intensive facilities, users of the CEFCO system could consider emission compliance as 'profit centres'.

The CEFCO Process is extremely efficient in that flue gas moves very rapidly throughout the entire assembly, with shorter reaction times than those of traditional bulk-phase or 'near-batch' processes. The retention time for each reaction is governed by the speed of the flue gas travelling through the respective distances of the sequential reaction zones within the appropriately designed aerodynamic reactor system.

All of the targeted reaction zones are governed by at least five major parameters: time, velocity, temperature, pressure and pH. The manipulation of these parameters facilitates selective reactions and, therefore, selectively targeted compound capture. Based on the known parameters, trace metals, fine particulate matter including those below 2.5 microns, the sulphur and nitrogen oxides and CO_2 can be removed in separate reaction chambers. Thus it can be designed to either capture all four groups of pollutants within one line, or customized to remove selected pollutants in separate subsystem modules.

CEFCO employs a gas/liquid phase separation device called an aero-coalescer following each aerodynamic reactor. In the aero-coalescer, after each pollutant is captured in its respective module the compound-containing droplets are converted into a downward flowing liquid stream and are separated in a coalescing apparatus from the continuously moving gaseous stream which exits the top portion of the aero-coalescer.

In the aero-coalescer, the gas-phase regains significant pressure and energy, and continues to flow onward to the next set of reaction chambers. This innovation in coalescing technology is the means by which CEFCO avoids the common separation issue of 'flashing' and re-entrainment of the captured liquid product back into the flue gas stream. Since each emission is removed in sequence without co-mingling, the final flue gas processed through the system will emerge as a near-zero emission stack gas.

The same aerodynamic mechanism used to capture and remove metals, fine particulates, SOx and NOx will be used to capture and remove CO_2 by controlling the reaction time, pH, temperature and concentration of the chemical reagents used. The CEFCO Process is designed with the optimum conservation of energy consideration. The space requirement is designed to be a fraction of that of current design configurations available since the multi-chambered reaction system reduces the combined reaction retention-times to fewer than five seconds for capturing all major groups of emissions.

Consequently, operating costs and 'parasitic loads' and 'energy penalty' are projected to be significantly lower than with current CCS and AQCS methods, while the system also provides a solution that will enable any existing fossil fuelled power plant to operate essentially emissions free, while generating saleable, high grade end-product streams from the captured compounds. The application of aerospace science as the enabling technology – rather than conventional best available control technologies relying primarily on thermo-chemistry – results in cleaner, faster, cheaper, safer, more reliable, effective and efficient solutions to emissions management, especially when compared with current or proposed CO_2 capture technologies.

The commercial credibility of the CEFCO Process has recently been enhanced by a manufacturing licence agreement with a recognized AQCS equipment manufacturer. In July 2010, CEFCO Global Clean Energy, LLC, appointed Peerless Manufacturing Company to become its licensed manufacturer in the USA. CEFCO is now looking to appoint experienced and qualified licensed manufacturers and distributors for its CEFCO Process in Canada and in Europe.

PATENT STATUS AND BACKGROUND

CEFCO's patent application under the title 'Process and Apparatus for Carbon Capture and the Elimination of Multi-Pollutants in Flue Gas from Fossil Fuel Fired Sources and the Recovery of Multiple By-Products' was published on 16 October, 2008, by the US Patent and Trademark Office (USPTO), and on October 23, 2008, by the European Patent Organization (EPO) under procedures of the Patent Cooperation Treaty (PCT). To date there is no known challenge to the patent-pending status in all respective jurisdictions.

On July 9, 2009, the EPO under the PCT procedures issued the International Preliminary Report on Patentability (IPRP) stating that all of the claims of the patent application are considered "novel, involve an inventive step, and have a valid industrial application". Corresponding applications for PCT member countries have been filed. The IPRP on 'patentability' was expected to have a positive influence on the USPTO (also a member of the PCT) as well as on all of the member countries' national applications.

On 27 September, 2010, the USPTO allowed a new 'paradigm-shift' patent with 36 claims for the CEFCO Process. Such a huge patent with so many claims may rank as a historic master teaching patent for years to come.

CONCLUSION

It is expected that the CEFCO Process will become recognized as a MACT solution for compliance with regulations regarding the targeted emissions of the fossil fuelled power industry, and will allow these operations to meet or exceed EPA and other governmental authority regulations, and provide a revenue-generating stream for users through the sale of captured trace metals, fertilizers and CO_2, together with their related environmental or renewable energy credits. The CEFCO Process should be considered a significant development and a paradigm shift regarding emissions management and compliance. It is believed that the CEFCO Process will become recognized in the near future as an all-pollutant and carbon dioxide capture MACT technology.

This article is jointly authored by Robert Tang, president and CEO of CEFCO Clean Energy, and Anupam Sanyal, president of International Environmental & Energy Consultants Inc. For more information on this technology, please visit www.cefcoglobal.com