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APPARATUS AND METHOD FOR EMISSION CONTROL THROUGH CONTINUOUS DRY FILTRATION SYSTEM

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ABSTRACT

A method of improving the removal of particulate matter, heavy metals, and acidic gases in waste gas emission streams through continuous filter control through the utilization of independent chambers to divert the flow of waste gas during the cleaning and precoating cycles of the chamber to optimize emission collection efficiency and prevent fugitive emissions.

INTRODUCTION

It has been observed for some time that pollution control systems that use the Dry Flue Gas Scrubber (DFGS), are inherently flawed by a characteristically less efficient treatment of flue gases than that found in the wet scrubbing processes. Even with the known lower performance the DFGS is widely used and preferred for applications by utility and industrial users, because of the lower capital cost to install and simplistic operation. Studies conducted by the EPA and World Health Organization indicate that harmful effects are suffered by the weakest segment of our society, and is exhibited by early deaths of over nine thousand infant and elderly persons each year. The government projects a capital expense of \$44 Billion Dollars will be required to install new processes to handle the higher standards with an annual cost of \$6 Billion Dollars per year to maintain and operate these systems, governmental studies also indicate it will take fifteen years to implement a fully compliant program.

The EPA data and timeline is based upon a progressively greater implantation of wet scrubbing technology necessary to meet the restrictive air emissions standards require by the governmental legislation. As wet scrubbing process seem easily capable of meeting the environmental need for utility and industrial the costs to implement and operate these

system is staggering. Suppliers of dry scrubbing technology having enjoyed years of predominance in the industry yet have been unable to find a simple and cost effective means to improve efficiency reliable systems. Until September 17, 2002, when United States Patent Office awarded patent number 6,451,091BI to the author for the invention of Apparatus and Method for Emissions Control Through Continuous Filtration System, and called the Terminator™. The invention was found by the patent office to be a matter of significant importance and as such this novel invention received an expedited patent examination and approval process. The patent office approved the application on February 5, 2002, and issued the Patent No. 6,451,091B1 approval (6½) six and one half months later. This was seen by the U. S. Patents and Trademark Office to be of significant benefit to our environmental, the economy, and when implemented can extend the life and improve the health of millions of human beings in the United States and around the world. The Kleanaire Technology Terminator™ process provides a cost effective pollution system answered control system with out utility, industrial, commercial, and become more elaborate and capital intensive to install and operate utilities and industrial source generators seek a less complicated solution to the bitter pill of ever higher emission standards. This paper presents a novel means to meet and exceed the higher environmental improvements without a complicated process, and sorbent sprays or elaborate multi level treatment processes or high maintenance or power requirements. This process under discussion is simple, easy to operate, widely used, and provides the same efficiency as the multi million dollar wet scrubber systems.

DRY SCRUBBING A FLAWED PROCESS

The Dry Flue Gas Scrubber (DFGS) technology can be acknowledged as the most widely used air pollution control scrubbing process. Many modifications have been made to enhance the original baghouse design and efficiency, however, all of the modifications have been unable to resolve a significant inefficiency in the technology. This inefficiency is the cleaning “spikes” in emissions which occur during baghouse cleaning cycles.

Most improvements have sought to use semi-dry technology, dry sorbent injectors, electrostatic precipitators, or alkaline liquid sprays installed up-stream of the baghouse to control acid emissions and improve filter coating which is known to capture particles in the one micron range within the flue gas stream. This pretreatment process has been able to decrease the load on the baghouse filters and improve overall efficiency. These elaborate pretreatment systems have achieved as high as 95% (ninety five percent) efficiency on acid removal, and the improvement of filter media types have improved particulate matter (PM) recovery reportedly as high as 99.9% (ninety nine point nine percent) efficiency. While these advancements have improved the dry scrubbing process, none have addressed what the author considers a flaw in the design of the baghouse filtration process which prohibits this process from achieving the continuous steady-state operation that is found in wet scrubbing technology.

Existing baghouse filters are a monolithic manifold filter system with a common inlet and common outlet. This design does not offer a means to channel and control contaminated flue gas streams. When one or more filters are cleaned by mechanical or reverse air means, the solids discharged from the filter being cleaned is discharged through the inlet chamber into collection hoppers in the lower section of the baghouse. After the coating has been removed from the filter the efficiency of this filter is substantially lowered and vulnerable to the higher concentration of small PM particles discharged from adjacent filters that are being cleaned. It can require as much as fifteen seconds for the cleaned filter to regain its coating and begin processing contaminated flue gas in an efficient manner. During the period from when the cleaning process for a filter begins and the concentrated sorbent coating is regained, the filter section is operating at less than its maximum efficiency. Logically, the coating that is usually developed first on the cleaned fabric filter is made up of fly ash and spent sorbent dislodged from adjacent filters. This coating material improves the capture rate of the filter media but offers a low capability of absorbing acids within the untreated flue gas stream.

A correlation has been made and generally accepted that the efficiency of a filter element is improved as the pressure drop between the upstream and downstream sides increase filter media and also when the pressure across the filter is reduced then efficiency of the filter media to capture PM is also reduced. These facts would indicate that the reduction in pressure drop caused by cleaning is detrimental to efficiency.

This operating mode deficiency is demonstrated by charts prepared by the EPA during a study relating to broken bag detectors. This emissions graph in the EPA Office of Air Quality Publication OAQPS Fabric Filter Bag Leak Detection Guidance No. EPA-454/R-98-015¹ study correlate PM/sorbent thickness to efficiency, by indicating when the sorbent and or fly ash is deposited upon the filter media surface as the PM emissions are reduced as the coating thickness is increased on the surface of the filter media which improves the capture rate of particles and toxins through reaction and mechanical trapping.

Electric Power and Research Inc. EPRI has also published articles and developed patents through Dr. Ramsay Chang⁷ recognizing that sorbent coating improves filtration efficiency. This cyclic operation of the filter baghouse punctuated by emission spikes known as cleaning spikes as illustrated in figure 1.

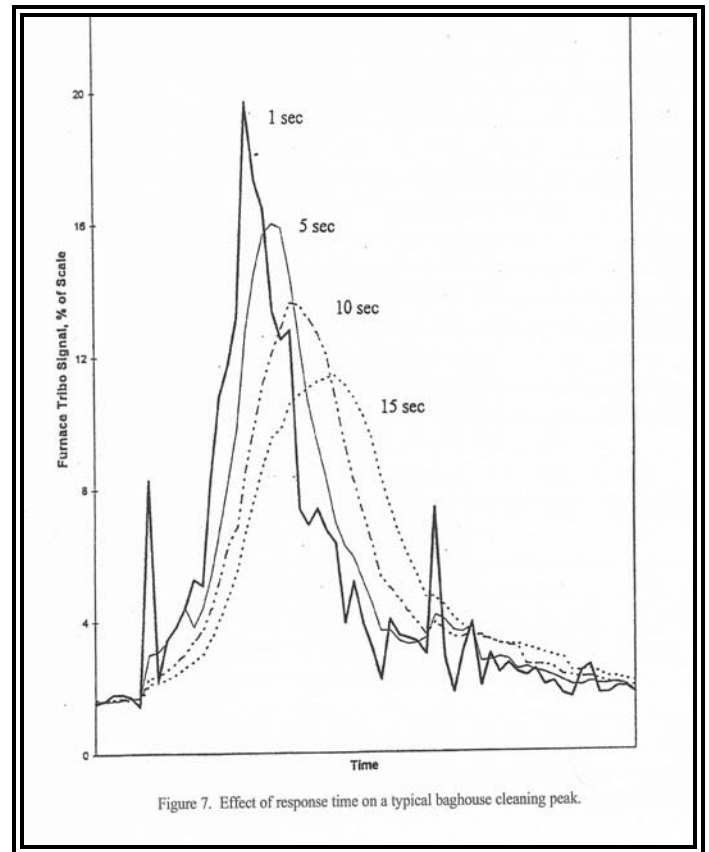


FIGURE 1. Effect of response time on a typical baghouse cleaning peak .¹

- Baghouse filters commonly capture less than 98% ninety eight percent of the PM in the flue gas stream. This is supported by measurements demonstrating a constant 2% (two percent) of scale background emission.
- The capture rate of a baghouse filter system is drastically reduced by the cleaning cycle and improves over time as PM collects on the surface of the filter cloth.

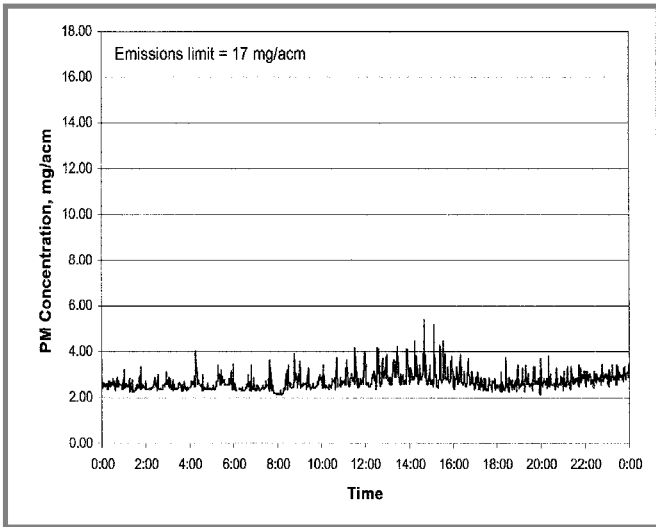


Figure 2. Light scattering monitor data for a typical day²

Figure 2. Illustrates PM emissions during a typical day from a typical Two 375 mm/Btu/hr traveling-grate, and stoker-fired boilers are operated at this facility. Each boiler is rated at a nominal steam flow of 275,000 lbs/hr at 950°F and 1,540 psig. The boilers are fired with bituminous coal that averages 13,000 Btu per pound. The boilers were constructed in 1990 and are subject to 40 CFR 60, Subpart Da. The boilers include mechanical separators in the boiler back-pass section for cinder collection and re-injection into the furnace area. A separate dust collector is located after the air heater section for heavy fly ash collection. The ash from the traveling grate is collected at the front of the boiler for removal to the ash storage silos. Each boiler is equipped with a dry flue gas desulfurization (FGD) system for SO₂ control and a pulse-jet fabric filter for PM control. The FGD uses a motor-driven atomizer to spray a lime slurry mixture into the gas path to neutralize acid mists from the boiler gas. The particulate from the slurry injection and the fine fly ash from the combustion process are collected in the baghouse. The FGD is designed to reduce the average sulfur dioxide concentration by at least 90 percent. The baghouse is designed to collect at least 99 percent of the total particulate in the boiler gas. Exhaust from both baghouses is routed to a common stack that exhausts to the atmosphere.

As can be seen from chart in figure 2. the test DFGS has a minimal PM concentration from 2.25 mg/acm to 5.50 mg/acm emitted on a continuous basis. Concurrent with the PM emissions it has also been observed that other pollutants are usually found to increase along with PM emissions.

The Spike-Free Technology

To remove the cleaning spikes Kleanaire Technology uses a method and a device called the Terminator™. The device employs long known methods difficult to implement with out pretreatment methods such as electric static precipitators, or pre-filter systems adding to cost. The process under discussion advances the art of air pollution control by implementation of a clean atmosphere for coating without a pretreatment system. The Terminator™ makes the following improvements possible:

- A thin coating can now be applied to the surface of any filter media under selection, which is known to improve filter capture rates of PM to high levels.
- The efficient use of sodium bicarbonate as a reagent sorbent alkaline proven in the incineration arena to be highly effective in PM, acids, metals, voc and PM on levels that rival active carbon at less cost.
- A clean-air precoating application system which is able to apply selective sorbent upon individual filter sections for the development of a sorbent coating without allowing polluted gases to pass through, thereby eliminating cleaning spikes.
- Definitive air flow control through individual filter segments which are able to lower air flow rates during precoating and preventing:
 - Injected sorbent particles from being drawn through the fabric of the woven filter media fabric by high air velocities after cleaning.
 - Filter cloth wear from abrasion between the filter media and the support cage resulting in longer filter life.
- Having multiple sorbent injection points provides the capability to,
 - Apply sodium bicarbonate or activated carbon as a precoat to reduce cost and increase efficiency.
 - Apply powered limestone as body feed sorbent supplied during flue gas processing.
 - Apply a 1~4 mil thickness of precoat outside of hot, polluted flue gas stream known to protect filter media from heat and deterioration from acids.

Termination Chambers

A simplified version of the Terminator™ device is diagramed in figure 3. As the minimum number of chambers required for processing is three. Figure 3. Illustrates the three phases of operation of the filter baghouse system. Each chamber is bracketed by inlet and outlet dampers controlled by a Process Logic Controller (PLC) that monitors the pressure within each chamber and stage process to channel treated and untreated flue gas streams through the baghouse filter chambers. The logic of the controller maintains a delicate airflow balance that permits the introduction of untreated flue gas into a clean chamber without breaching the pre-coating surface after the filter has been cleaned.

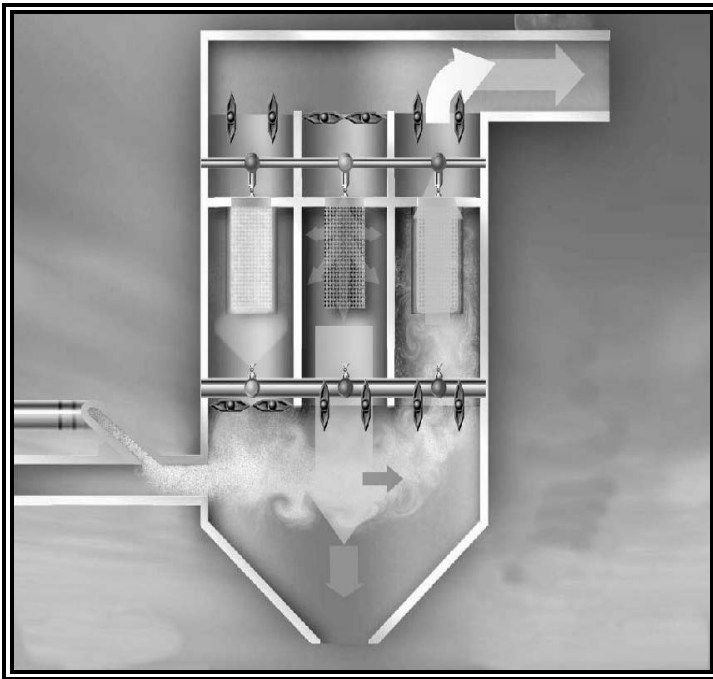


FIGURE 3. Terminator™ chambered pollution control system able to simultaneously clean, precoat, and operate all cycles without breaching, fugitive emission cleaning spikes.

The Terminator™ filter chambers operation (figure 4.) depicts a filter chamber being cleaned. While this process differs only slight from existing cleaning processes the

Terminator™ is novel in its ability to purge fine dust particles (PM) and acid gases trapped in the chamber prior to the precoat application. This decontamination measure is utilized to provide an extend safety measure of fugitive emissions at no additional cost to operations.

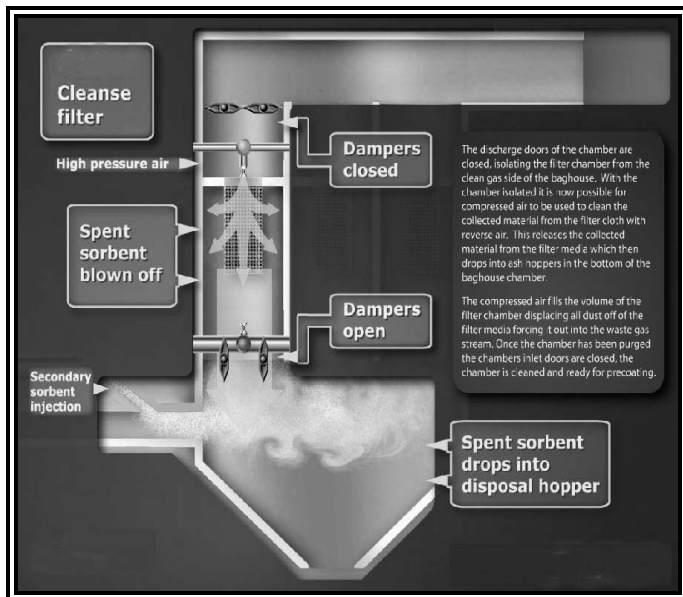


FIGURE 4. Terminator cleaning cycle upper dampers close to seal discharge side of filter during cleaning and purging. Chamber enclosures permits filter segment to be isolated from adjacent filters to prevent carry over collection and channels collected fly-ash and spent sorbent to collection hopper below.

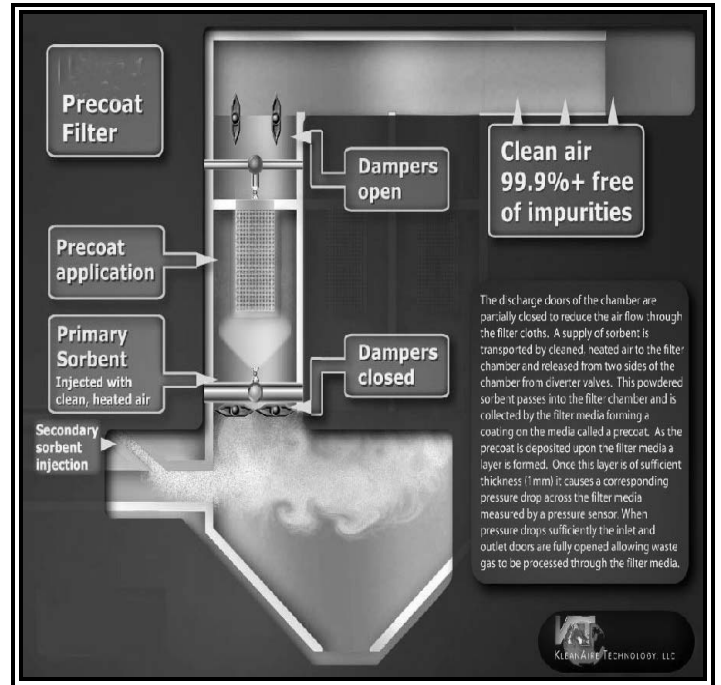


FIGURE 5. Precoating Cycle begins when lower dampers are closed And upper dampers are opened then a selected sorbent e.g., (sodium bicarbonate, limestone, or activated carbon) is used depending upon the practical emissions processing requirements for the application.

Once a filter chamber has been cleaned and purged of untreated flue gases, the precoat cycle as illustrated in Figure 5 begins. This process begins by a closure of the lower inlet damper doors to isolate the precoat chamber from the flue gas stream. Once the lower damper doors are closed, the upper damper doors are opened placing the chamber under a draft. Diverter valves are opened and sorbent (sodium bicarbonate powder in this case) is introduced into two sides of the chamber down. As the outlet stream of the baghouse is under an induced draft from a fan the sorbent injected into the chamber is drawn onto the surface of the filter media and the upper dampers are modulated to control the pressure drop across the filter segment to prevent airflows from exceeding recommended levels. This improvement reduces filter wear from friction generated between the filter and the supporting cages. As the pressure drop increases across the filter segment, the dampers are opened completely to ready the process for the filtration operating cycle to begin.

Figure 6. Illustrates the filtration cycle begins when the chamber's lower inlet dampers are opened which places the chamber in the flue gas stream. The flue gas stream is supplied with sorbent upstream in the combustor ductwork and sorbent is supplied directly to the filter chamber. This allows a dual sorbent selection choice to the operator so that small amounts of highly reactive sorbents can be used in an effective manner while other less reactive sorbents can be used in larger quantities. This process allows greater control of sorbent type and effective application.

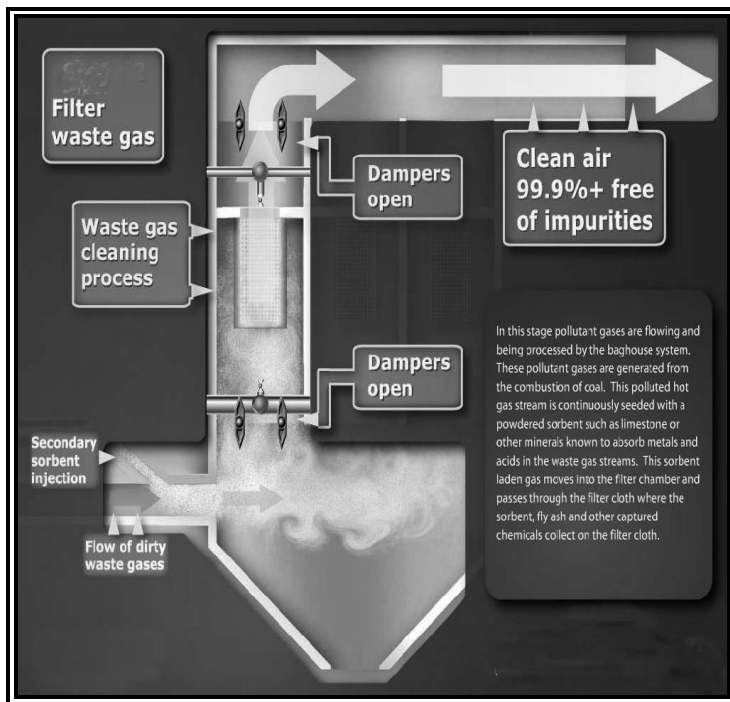


FIGURE 6. Filtering Cycle begins once a precoat layer has been established upon the filter media. In addition, a pressure drop is developed across the coated filter media, then the lower damper doors are opened and untreated flue gas is introduced into the filter chamber and remains so until a higher-pressure drop, setting is achieved and the filter goes into a cleaning mode.

The method used in the Terminator™ process was previously tested and the results were published in the Incineration Conference Proceedings May 1993⁴. The results of test conducted on a 750 PPH hazardous waste incinerator provided the basis for the development of the Terminator™ design. Currently, the process itself has been tested while the Terminator™ technology has not been built. Kleanaire Technology is in the process of arranging utility trials with a utility partner under the SBIR program.

TESTS RESULTS

D. Aviña et al., published data in a paper entitled “Air Pollution Control Filter Operation to Reduce HCL, CDD/CDF, Metals and Particulate Emissions, May 7, 1993⁴. This paper demonstrated stack test data from three tests obtained from a 750 pound per day medical waste incinerator in Fort Lupton, CO. This data and other comparative test data from nine EPA test sites compared this data with three tests. The test data supported the theory that emissions reductions ranging from 1 to 2 orders of magnitude could be obtained in a common baghouse through the use of a precoat application installed with a reduced PM and toxic-content when applying the coating. These tests also indicated that if clean air is utilized with the pre-coat application, pollutants could be significantly reduced from flue gas streams. Other work completed by R. Chang et al., Pilot Scale Evaluation of Activated Carbon for the Removal of Mercury at Coal-Fired Utility Power Plants, and R. Chang (U.S. Patent No. 5,505,766)⁷ establishes that a sorbent coating and toxic reduction in the conveying air is a significant factor in mercury removal. Dr. Chang also found that the use of a pre filter or electrostatic precipitator to unload at least 90% of the PM while the coating was being applied to the secondary

baghouse filter obtains an improvement in filter baghouse efficiency.

CONCLUSION

This investigation discloses a flaw in the DFGS process and identifies an improvement that could provide answers to many utility operator needs. The technology presented will reduce operating costs, improve the environment, and have a positive effect on the health of a large segment of the population. The author has developed this technology for the utility and industrial source generator. Low installed cost, low cost to operate and maintain, and high efficiencies were the critical to quality points used in the development of this technology. Arrangements to fund further field trials with utilities are currently being sought in order to establish the operating parameters and provide further data on anticipated efficiencies. Many tests have been conducted to investigate pre-filter efficiency and all have found a major improvement in efficiency, as the Kleanaire Technology eliminates the need for pre-filtering and the associated complications a new system is born to provide a cost effective answer to emission control problems. .

ACKNOWLEDGMENTS

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7. R. Chang et al., **“Method For Removal Pollutants form A Combustor Flue Gas and Stream for Same”**
U.S. Patent No. 5,505,766 Dated April 9, 1996.