Use of a Circulating Fluid Bed for Flue Gas Desulfurization

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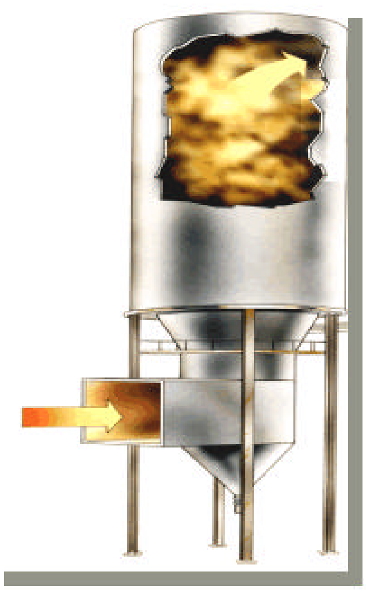
Abstract

U.S. utilities are faced with new economic challenges to remain competitive in light of deregulation initiatives. In addition, regulatory requirements are forcing many of these utilities to reduce sulfur dioxide emissions and be prepared to reduce additional pollutants such as mercury vapor and fine particulate from coal-burning plants.

Technology choices for regulatory compliance are either wet or dry flue gas desulfurization (FGD) systems. Wet scrubbers are more capital intensive but are the technology of choice for large power plants where single vessel capacity and operating costs can be more favorable. The lower cost dry FGD system is likely to play a greater role in compliance strategies for Phase II of the revised CAAA of 1990. The technology described here has been in commercial use in the European power industry since 1987 and more recently since 1995 in the N. American power industry.



The Lurgi Lentjes N. America dry FGD technology employs a circulating fluid bed (CFB) of fly ash and scrubber by-product to achieve a high particle density. Hydrated lime injected into the circulating bed adsorbs sulfur dioxide and trioxide with very reasonable utilization of the lime, due to its high residence time in the recirculating bed. Fine particles entering the system are formed into larger agglomerates through collision with the bed particles. A conventional electrostatic precipitator or fabric filter can then readily capture the larger particles leaving the bed.

An additional advantage is the multi-pollutant control capability of this technology. It is of great interest to the regulatory authorities as well as the utility industry. The U.S. department of energy (DOE) has selected this technology from twenty-four proposals, to demonstrate cost effective simultaneous control of mercury, acid gases (HF, HCl, SO_3), fine particulate, and other HAPs in a single vessel. This demonstration is scheduled for completion, at the 100-megawatt size, in the next couple of years.

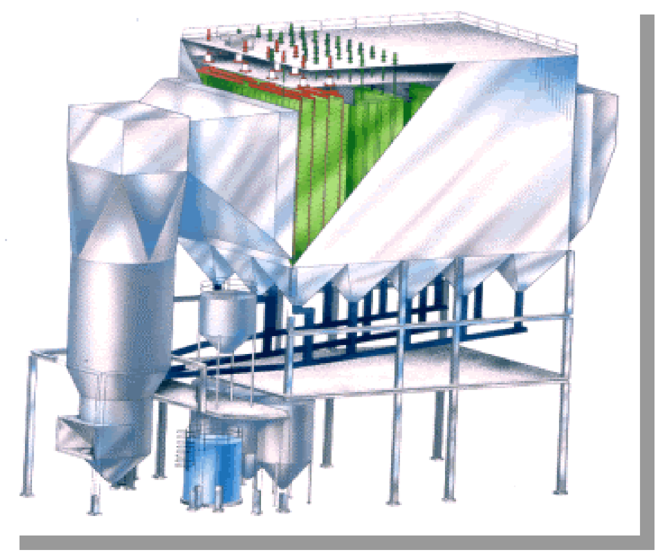
Introduction

Lurgi Lentjes N. A. is part of the global technology company mg engineering, a leading international supplier of technological solutions to the power, chemical, and metallurgical industries. As an operating company under Lurgi Lentjes AG, they provide N. America a link to the innovative solutions of a $1.0 B (US) worldwide power plant and gas cleaning technology company.

Their gaseous environmental solutions consist of high and low dust denitrification, wet and dry flue gas desulfurization utilizing limestone, ammonia, seawater, quick and hydrated lime. The particulate control solutions consist of fabric filters and electrostatic precipitators. Since 1910, they have provided global EPC services and have secured 20% of the total worldwide air pollution control market.

The Bush administration is emphasizing use of existing coal-fired plants as a short-term means of mitigating power supply problems. Simultaneously, there is need to further reduce emissions of SO_2 from these plants. Actual emissions for 2001 exceeded allocations for the same year by approximately 1.4 million tons.[1] If no further reductions occur, actual emissions will exceed allocations by more than 1.9 million tons annually as allocations are further reduced by half a million tons in 2010. Initially the bank of saved allowances from phase I will be used to offset actual emissions that are expected to remain above the national goal. As these saved or "banked" allowances are depleted, the allowed and actual emissions are expected to converge. Industry and regulatory experts predict the crossover point to be the year 2010. To support this FGD market, Lurgi terminated its previous licensing agreement in the U.S. and opened the LLNA offices in Columbia, Maryland.

The average unit size in the phase II market is smaller than phase I and this favors the "circulating" type of dry scrubber technology from LLNA. This paper presents a history of the circulating scrubber technology and a cost comparison from the owner's perspective.



Process

The technology herein employs a circulating fluid bed of flyash and desulfurization byproducts to achieve a high particle density. This circulating bed can be used at various temperatures to accommodate physical adsorption and chemical absorption mechanisms, thus achieving multi-pollutant control. For example, hydrated lime and ammonia can be injected at 400°C with iron oxide/sulfate to reduce NOx to nitrogen and water while oxidizing SO2 to

[1] EPA Clean Air Market Programs. These figures exclude the annual EPA auction of allowances.

SO3 to be absorbed by the calcium hydroxide. Alternatively, hydrated lime and activated carbon can be injected at 150°C with water. In this case, the calcium hydroxide will absorb the SO2 and SO3 while the activated carbon (and flyash) will adsorb mercury vapor. Very high utilization of the reactants is realized due to the long residence time in the recirculating bed. Fine particles entering the system are formed into larger agglomerates through collision with the bed particles. Conventional precipitators or baghouses can then readily capture the larger particles leaving the bed.

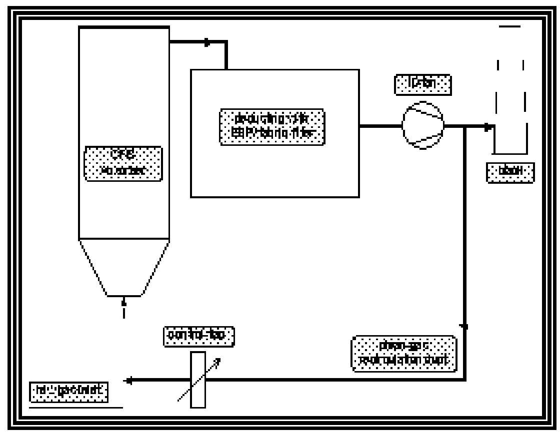
History

The basic design parameters evolved from the same research efforts in the 50's and 60's that created fluid bed boilers for coal burning. It was first used in the 70's as a gas absorber in the alumina industry for control of HF emissions, and then on municipal waster incinerators in the early 80's for control of HF, HCl, and SO_2. The initial 50-megawatt (Mgwt) demonstration for control of SO2 on coal-fired boiler flue gas was in 1984 in Schwandorff, Germany. This utility boiler fired 2.5% S lignite and a removal efficiency of 95% was demonstrated with hydrated lime as the reagent. The existing electrostatic precipitator (ESP) was used during this one-year demonstration.

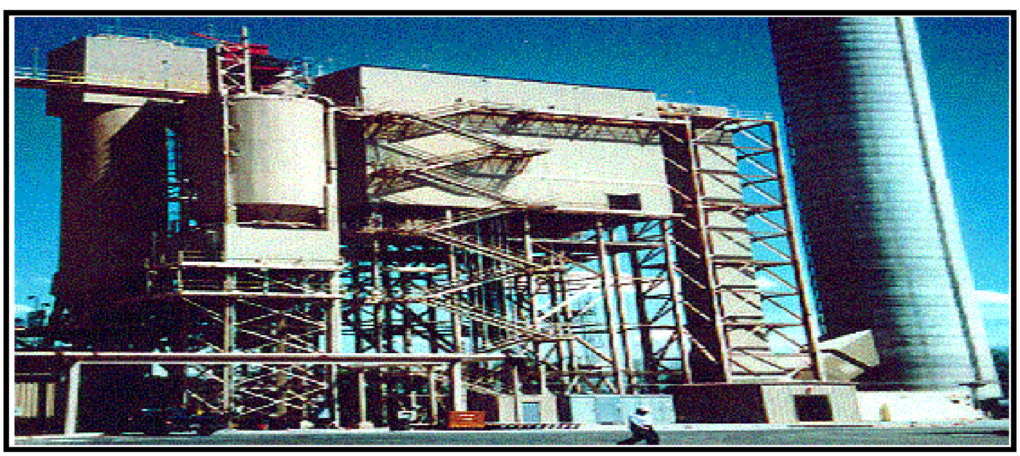
In 1985 the first multiple venture design for a gas flow rate of 685,000 Nm^3/hr successfully achieved 97% desulfurization efficiency using hydrated lime at the power plant in Borken, Germany. The boiler was burning Lignite with a flue gas containing 13,000 mg/Nm^3. The very high SO_3 content of the flue gas was reduced to limits that were not measurable.

The first dry hydrator for quicklime was combined with the CFB system in 1986, thus reducing the cost of reagent per ton of SO2 removed. The Siersdorf plant of EBV was retrofitted with two scrubber vessels each sized to handle 363,000 Nm^3/hr of flue gas containing 2,700 mg of SO_2. The plant alternated operations between coal and mine gas, thus experiencing rapid fluctuations of 50% in SO2 concentration. To maintain 93% desulfurization efficiency, the hydrator was designed to vary the throughput of quick lime as the demand for reagent fluctuated. Another unique design feature of this plant, is the way the steam is exhausted from the hydrator. Hot flue gas from before the scrubber is used to "pick up" the hydrator steam and the combined flow of flue gas & steam is returned back to the inlet of the scrubber to be treated in the scrubbing process and released through the unit stack. This design feature virtually eliminates the need to shutdown the hydrator and remove the deposits resulting from the wet-dry interface in the venturi scrubbers typically used.

In 1988 a single vessel was retrofitted to service two process steam boilers at the Adam Opel facility in Russelsheim, Germany. The combined gas flow of 180,000 Nm3 required a desulfurization efficiency of 92%, which was easily achieved. The new design feature at this plant was the ability to follow an 8:1 gas flow turndown with the use of clean gas recirculation. A side stream of clean gas from the discharge of the I.D. Fan is recirculated to the inlet of the scrubber, thus maintaining the appropriate gas velocity regardless of boiler and load combinations. The pressure differential between fan discharge (+) and the scrubber inlet (-) enables recirculation of clean gas using only a small duct and simple flow control damper.

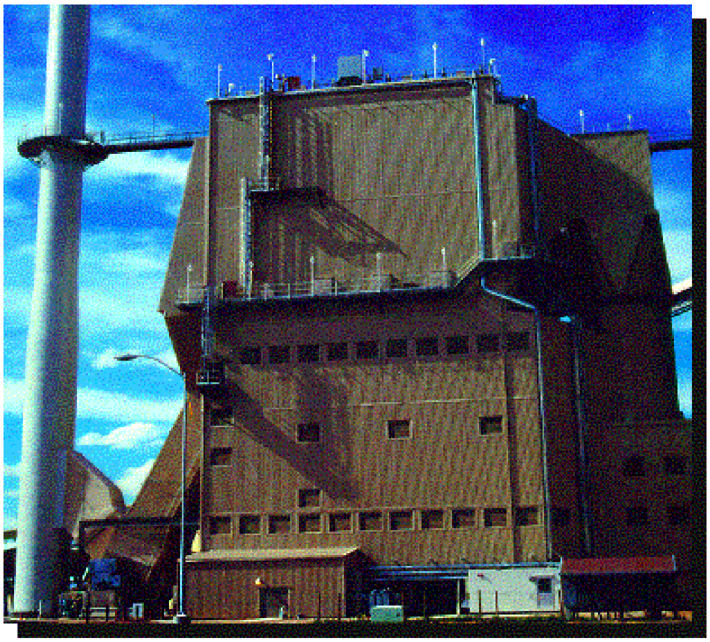


The technology was introduced in the U.S. through a N. American licensee in 1990. The first U.S. unit became commercial in 1995. It is a 44-mgwt cogeneration facility in N. Carolina burning Appalachian coal with 1.5% sulfur and it is the first combined use of SNCR for de-NOx, CFB for de-SOx, and a pulse type baghouse for particulate control. The most unique feature of this plant is the Owner's ability to objectively evaluate the CFB technology on boiler No. 2 side by side with the



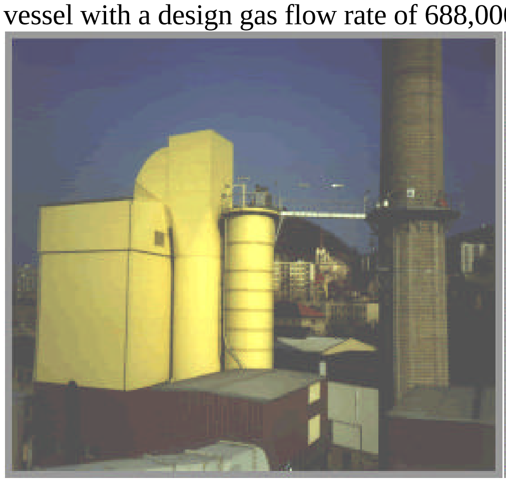
spray dryer absorber (SDA) technology on boiler No. 1. This comparison is presented later in this paper.

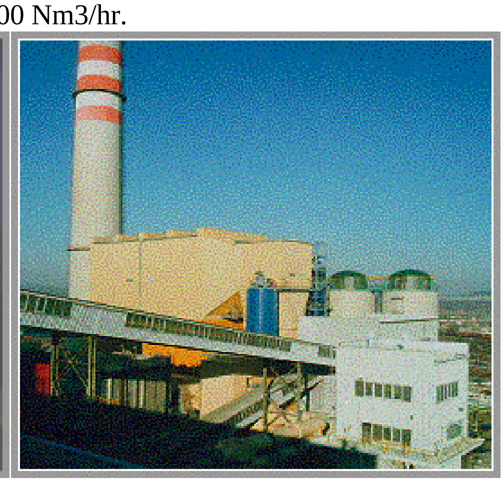
The first unit in the U.S. with a precipitator was commissioned also in 1995. This mine-mouth plant burns western sub-bituminous coal with an average sulfur content of 0.75%



and the CFB technology successfully demonstrated 98% desulfurization. This high removal efficiency combined with the low sulfur content of the coal resulted in a clean gas SO_2 concentration of less than 30 mg/Nm^3. This plant also offered Lurgi an opportunity to compare the particulate emission performance of a baghouse and a precipitator downstream of the fluid bed scrubber. There is essentially no difference with a precipitator designed to meet today's more stringent emission requirements.

The most recent units in the Czeck Republic, Plzen and Setuza have the recirculating byproduct and fresh lime injected into the gas stream on the underside of the venturi(s). This patented design modification improves bed stability and byproduct dispersion with a slight improvement in lime utilization. The Plzen unit also represents the largest operating vessel with a design gas flow rate of 688,000 Nm3/hr.





Lurgi Lentjes NA is poised to increase the unit capacity of the CFB technology with the latest units to be constructed in North America. This plant will be the first commercial unit in the world to use a high temperature circulating fluid bed for coal combustion in series with a low temperature circulating fluid bed for gas cleaning. This 500 Mgwt power plant is currently in the early commissioning phase in Puerto Rico. It consists of two lines; each designed for 971,000 Nm^3/hr with a clean gas SO_2 concentration of less than 25 mg/Nm^3. Most of the sulfur will be captured with inexpensive limestone in the boiler's high temperature environment, and then the "polishing" step occurs in the low temperature environment of the gas cleaning equipment. Little, if any, reagent in addition to the limestone will be required as the polishing scrubber reactivates the calcined limestone in the flyash.

Cost Comparison

Generally, the capital cost of the CFB system is 50-60% of a comparable wet scrubbing system. O&M, excluding reagent, is typically 35-50% that of a wet scrubbing system for labor, parts, and parasitic power. Reagent is 36% higher than wet lime scrubbing and 200% higher than wet limestone scrubbing. Byproduct disposal is site specific and can range from expensive landfills to haul for free arrangements with lightweight aggregate or flowable-fill contractors, and wallboard plants. The selection of wet verses dry scrubbing is therefore driven by the relative magnitude of capital verses O&M cost. Larger plants with higher sulfur fuels tend to select wet while smaller plants favor the dry technologies. The crossover point is changing due more stringent regulations and the potential multi-pollutant control requirements of the future.

The comparison of dry CFB verses dry SDA is best addressed by looking at the history of one facility that operates and maintains both technologies. All costs are for the year 2000.

		UNIT 1 (SDA)	**UNIT 2 (CFB)**
Outside Contractors for Cleaning and Repairs	$US	$188,327	$52,090
FGD Cleaning	$US	$11,960	$0
Electrical Parts	$US	$5,344	$2,918
Instrumentation Parts	$US	$21,222	$6,565
Mechanical Parts	$US	$89,864	$6,963
		$316,717	**$68,536**

Conclusion

Arguably, power generators in the United States must find ways to reduce recent (2001) emissions of sulfur dioxide by 1.9 millions tons annually, and they are motivated to get it done by 2010. This represents an additional 2.5 million tons of lime, or 3.24 million tons of limestone annually, or more likely some combination of the two. They will evaluate carefully the capital and operating costs issues of the proven technical solutions. They will balance these cost issues against the need for reliability and flexibility in an ever increasingly more competitive industry.

The combined resources of the lime industry and Lurgi Lentjes NA present an enhanced potential for success as phase II strategies are developed. Some prime issues for joint efforts are:

- Transportation logistics can be as much as 35% of the delivered cost of lime to the generating plants.
- Knowledge of lime based CFB scrubbing technology is not as wide spread as the knowledge of spray dryers or limestone based wet scrubbing.
- Strategic alliances exist within our separate business units and the power industry. We could mutually benefit through these alliances.