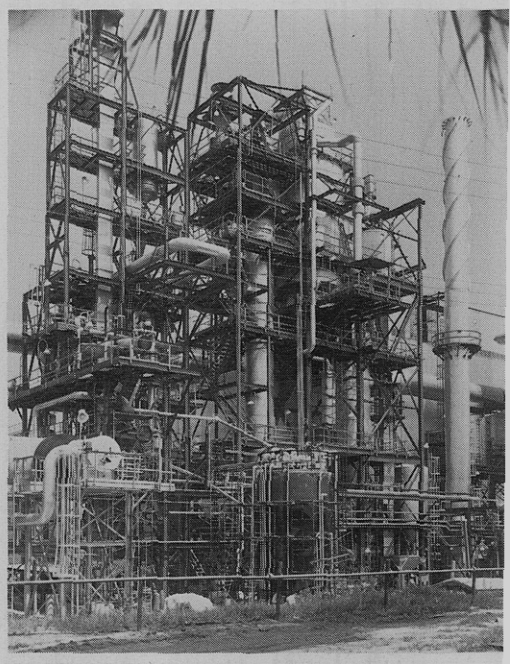
Dry scrubbing of utility emissions



Foster Wheeler process of flue gas desulfurization is now underway at a Florida utility; demonstration started this May

Second generation flue gas desulfurization (FGD) systems may still be in their infancy, but at least seven systems are being investigated (*ES&T,* April 1974, p 306). Although the dry adsorption process was listed in the developmental category then, considerable new results are paving the way for the use of this process on utility boilers. In that same listing, four regenerable processes were listed as commercially available.

The dry adsorption process is applicable to all fossil fuel-fired utilities. Primary application is found in the area of large coal-fired boilers because of the established capability of the system to handle all three pollutants associated with such boilers. The process could also be used in large size refinery units as well as chemical process plants and metals smelting operations.

Mr. G. O. Layman, manager of power production for Gulf Power Co., an affiliate of the Southern Company, says that construction on the Foster Wheeler process started on February 15, 1974; the construction was at the Scholz Steam Plant, a 40 MW plant (Chattachoochee, Fla.). The testing program began this May.

Two years earlier, in January 1973, the Southern Services Company awarded a contract to Foster Wheeler Corp. to build a 20 MW prototype dry adsorption system. The actual contract called for the design, engineering, and construction and testing of a system that would accept 50% of the flue gas produced by a 40 MW boiler firing coal with 3% S, 14% ash, and a heating value of 12,400 Btu/lb.

The system at the Scholz plant consists of a 20 MW adsorber section and a 47.5 MW regeneration and RESOX (reduction of SO_2 to elemental sulfur) section. RESOX is a trademark of the Foster Wheeler Energy Corp. The 20 MW adsorber is designed to accept 50% (half of the boiler flue gas flow) when the coal fired boiler is operating at a nominal 40 MW load.

This Scholz FGD unit is designed to meet the Florida Code for SO_2 emissions, which is 1.2 lbs/million Btu. The unit can handle coals with sulfur content as high as 5% because of the oversized design requirements of the regeneration and RESOX sections, and the inherent flexibility of the system.

Gulf Power's Layman
"regeneration—using coal to reduce SO_2 to elemental sulfur—is a real breakthrough"

Layman says that Southern Services, a private investor utility that relies on coal for more than 90% of its power generation, chose the system because it had already accomplished a very successful and lengthy pilot plant operation.

"One of the most important features of the system that has great long-range potential is the RESOX section. In this reduction step, coal directly reduces the SO_2, adsorbed by the front end of the system, to elemental sulfur." Layman adds, "It's a real breakthrough."

He explains that "all other systems . . . for reduction of SO_2 to elemental sulfur require hydrogen in some form, usually natural gas, as well as catalysts. Foster Wheeler's unique approach to using coal to act as the reductant avoids the use of a costly and scarce natural resource."

In addition to FGD, the process has the potential for NOx and fly ash removal. Also, it produces a commercial grade elemental sulfur as a by-product from the regeneration section (see box).

The process

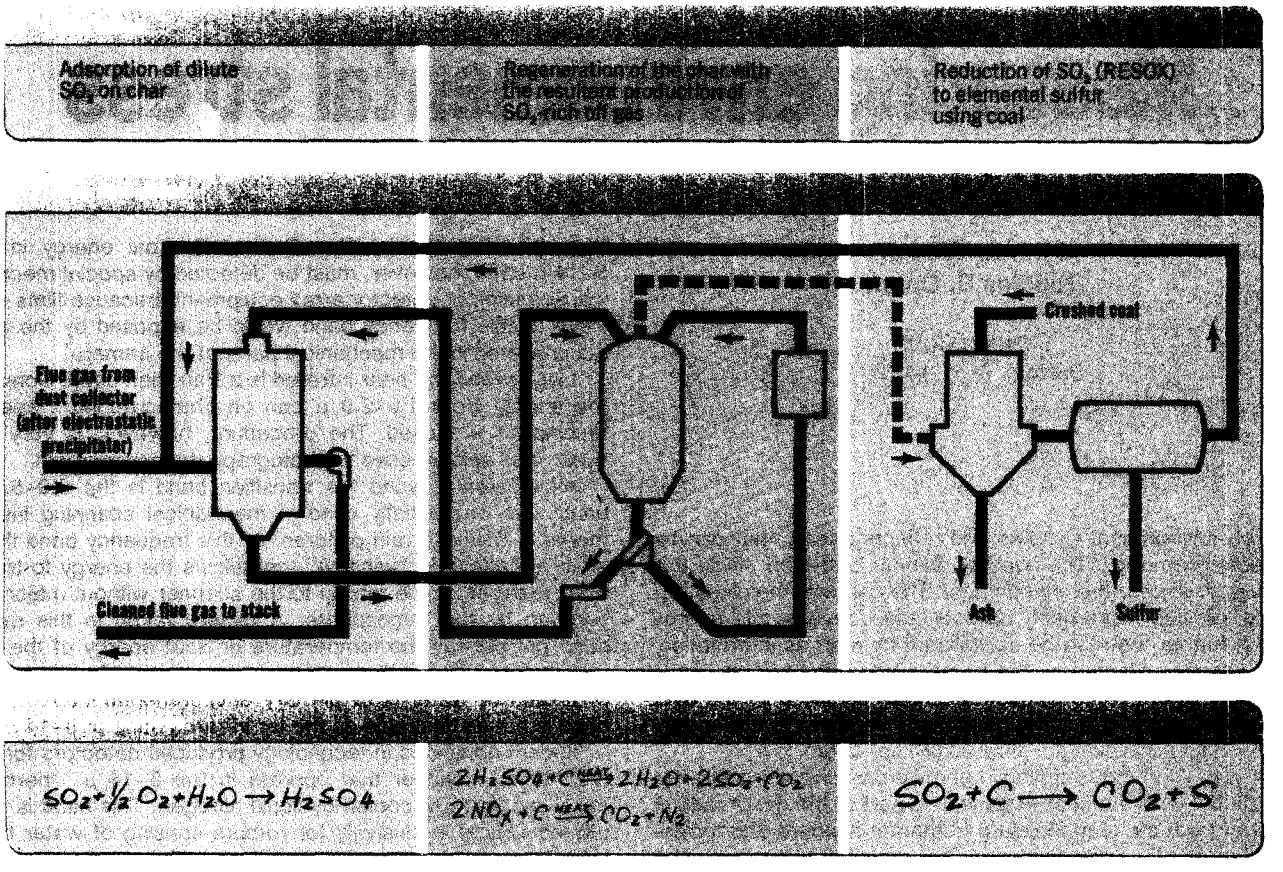
Foster Wheeler, a designer and manufacturer of steam-generating equipment and a process plants contractor, has been licensed for the dry adsorption SO_2 removal process. The removal process was developed by Bergbau-Forschung (B-F), the central research institute for the German coal mining industry. Bench scale work at B-F began in 1966. Based on this pilot plant work, SOx removal of up to 95% has been achieved. But Foster Wheeler independently developed the backend system, RESOX, for the reduction of SO_2 to elemental sulfur.

A second dry adsorption unit has been installed by Bergbau-Forschung, the licensor, at the Kellerman Power Plant of STEAG in Lünen, W. Ger. The unit will treat 10% of the flue gas from a 350 MW unit that will be burning coal of about 2% sulfur content. Here, a modified Claus unit will be used to process the SO_2-rich off gas. RESOX was developed by Foster Wheeler after B-F had gone ahead with the decision to install the modified Claus unit.

How it works

The adsorption section is based on the well-known suitability of activated char as an adsorption and filter media.

Dry scrubbing removes SO_2, fly ash, and NOx[a]



[a] Removal efficiency: 95%—SO_2, 90-95%—fly ash, 40-60%—NOx

The adsorber consists of vertical columns of parallel louvre beds that support and contain the char. The char moves slowly downward in mass flow while the pollutant-laden gases pass through the adsorber char bed in cross flow at 250–300°F. Sulfur dioxide, oxygen and water vapor contained in the flue gas are adsorbed into the char pores. Adsorbed SO_2 then reacts with the O_2 and H_2O to form H_2SO_4, which is firmly retained in the interior pore system of the char pellets. Oxides of nitrogen are also adsorbed by the char pellets. Clean gases, which are unchanged in temperature, are exhausted to the stack via an induced draft fan.

As the char progresses slowly down the adsorber, it becomes saturated and must be regenerated. It is heated in the regenerator vessel to 1200°F in an inert atmosphere. Sand at 1500°F is mixed with char to bring the char to 1200°F. All the reactions that have occurred in the adsorber are reversed at this elevated temperature (see box). Sulfuric acid is reduced to SO_2, oxides of nitrogen dissociate to oxygen and nitrogen, and CO_2 is produced as a result of chemically combining carbon in the char with the oxygen liberated from the reduction reactions. The regeneration section yields adsorbed SO_2 in concentrated form, approximately 20% by volume. This SO_2-rich gas stream is sent to the RESOX section for reduction to elemental sulfur.

In the RESOX section, a Foster Wheeler proprietary process, SO_2-rich gas is passed through a vessel containing crushed coal. Here, SO_2 is reduced to gaseous elemental sulfur and the liberated oxygen combines with a portion of the coal to form carbon dioxide. Reduction in the RESOX reactor is done at 1200–1500°F. The gases leaving the reactor enter a condenser where gaseous sulfur is condensed and the tail gas recycled back to the adsorber to remove residual sulfur values, thus providing a closed-loop system.

This dry scrubbing process offers a number of advantages over conventional wet scrubbing. These include:

- significant NOx and fly ash removal
- no slurry handling or pH controls required
- no stack reheat is required; the flue gas enters and leaves at the same temperature
- reduced power requirements stemming from the special size and shape of the char pellets, and the adsorber louvres design gives low pressure drop on the gas side
- the char adsorbing material used in the process has a high ignition temperature of about 700°F that ensures safe operation in the 250–300°F designed temperature range
- a regenerable system with a saleable by-product (The char can be used for many cycles, the average life of a pellet being six months. Commercial grade sulfur is produced by the RESOX system)
- less space (The system uses considerably less space than a wet scrubbing system by virtue of its vertical integration concept and absence of sludge conditioning requirement.)

How much does it cost?

Installed capital costs are somewhat sensitive to the sulfur content of the fuel and the SO_2 percent removal to meet local codes. However, they range from $25–35/kW for low sulfur level that requires a low removal efficiency to $70–75/kW for high sulfur fuel that requires a high removal efficiency. Costs are competitive with wet scrubbing systems and may be lower depending on the price of recovered sulfur and the final cost of sludge disposal.