

Beaumont Environmental Systems

MACT Design Considerations

Match the Cooler/Scrubber (future of now) with the Baghouse

The first step in adding air pollution controls for an existing boiler is to add a fabric filter or retrofit a precipitator with a pulse baghouse as part of a *Multi-Pollutant Control* system.

Usually trying to use an existing precipitator casing is neither cost effective nor provides an acceptable operation. The major problem is with the precipitator hopper design. The hoppers are typically small not easily divided into modular groups with isolation between hoppers. A Pulse hopper is design for continuous emptying and not for storage in the hopper as in a precipitator where the gas does not flow into it. We want the gas to enter from the bottom of the bags for proper distribution. Side bag entry will not properly coat the bags. Another costly problem is in the sealing of the internal compartments, which encompasses welding, and soap leakage testing.

Assuming we are going to add a baghouse, we must consider current and future emission limits. These requirements will vary as State, Local and Federal requirements vary.

Particulate Emission Design

Baghouse outlets have historically been sized on grains/ACF and did not include condensibles. There is no problem until the outlet requirement below 0.003 lbs/mmBtu's which is approximately 0.012 grains/ACD including condensibles.

Below .003 lbs/mmBtu's we would use an *enhanced bag with membrane or surface treatment* to improve filtering. Another consideration will be to not use a 2-piece cage, as the bags must have center wear pieces. These are harder to install without damaging the bags, which can degrade the required high efficiency filtration. We should consider using *full size walk in plenums* to accommodate the full size cages and provide the sealing that we may not get from lift off roofs. This would limit the bags to 16 ft in length. Finally we should *lower the air-to-cloth ratio* to accommodate *high recycle rates* for future SO₂ control. Net air-to-cloth ratios of 3.0 to 3.5 are more appropriate.

Mercury Control

Typically the coal will contain 8 to 10 Lbs/Trillion Btu's of Mercury depending on the coal. The outlet requirements could be as low as 3 Lbs/Trillion Btu's and require 70% removal. Cooling prior to the baghouse (Beaumont Patent Pending) should easily give us 90% removal. The cooling approach, not only controls the Mercury, but also condensibles such as

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H₂SO₄ and the metals. Mercury is controlled by a phenomenon where SO₃ with water becomes H₂SO₄, is attached to ash, to which Mercury has an affinity. It must be followed with lime of some sort to protect the bags and lock up the Mercury. Alternative we could add a lime/activated carbon mixture to capture the Mercury in the baghouse. This is expensive and does not take care of HCl, H₂SO₄ and condensibles.

HCl Control

It appears that 0.09 Lbs/mmBtu's is the high end for existing units but outlets down to 0.02 Lbs/mmBtu's are being specified. We can expect inlet Cl levels slightly above the 0.09 levels but this would depend on the coal. We would normally assume a small amount of scrubbing is necessary now or later.

Selecting the Cooler/SO₂ Scrubber

Beaumont provides the RAP, which can be used for cooling only, Mercury control, limited scrubbing for HCl control and also for SO₂ control. The RAP has the advantage of reducing the moisture to less than ½ percent reducing corrosion problems.

Semi-Dry Scrubbing

Semi-Dry scrubbing has developed from wheel type spray dryers to rotating reactors. Our paper, Advances in Semi-dry Absorption for Multi-Pollutant Control given at the MEGA Conference – 8/22/01 details technology changes. Fluid Bed Reactors and Rotary Atomized Spray Dryer are discussed in the paper but not in this discussion.

The latest technology is the Beaumont patented RAP Flash-Drying process, which we will compare with our older SAP, spray absorption process.

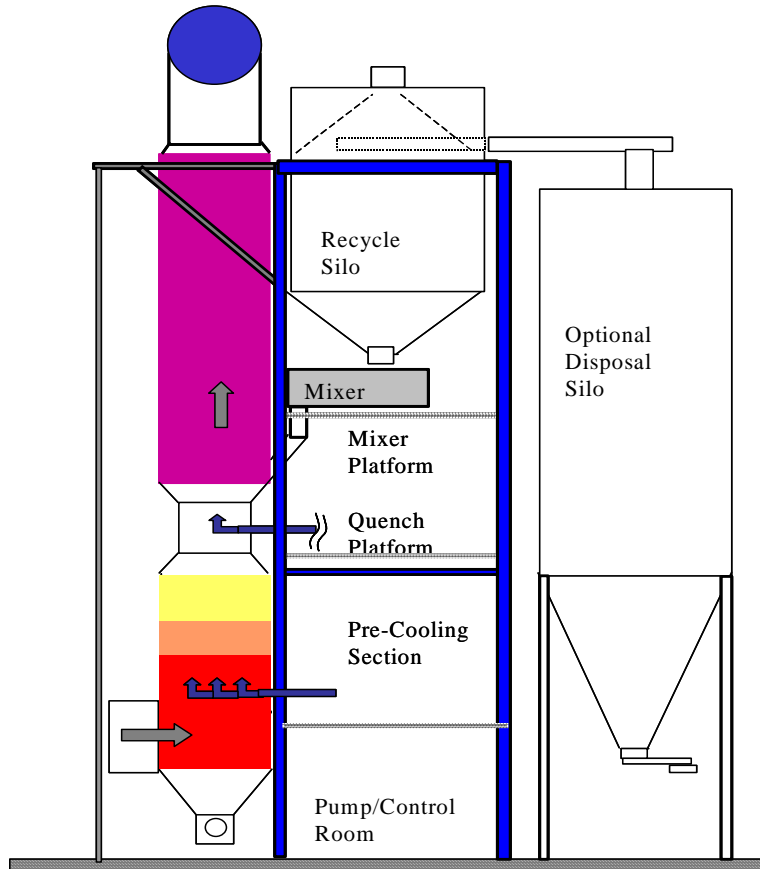
RAP Flash Drying

The operation of the RAP flash drying process is accomplished by adding lime slurry outside of the reactor. It is added as a slurry, which introduces Ca(OH)₂ as small particles that immediately are mixed and combined as a thin coating on recycle material which is then introduced into the reactor by gravity. The resulting material is 85 to 95% solids, dry and flows well.

The recycle material returned from the baghouse is quite fine with a mean size of 46 microns and 42% below 50 microns and 96% below 200 microns. This gives us 30 to 60 % more surface area than previous reactor type semi-dry scrubbers (recycling off a cyclone) and orders of magnitude increase in surface area than old style semi-dry type scrubbers. The reason is that complete drying occurs, creating less agglomeration and some de-

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agglomeration, all of the recycle material is returned from the baghouse increasing the percentage of fines and finally the mechanical recycling breaks down the material as it moves through the mechanical conveying operations.



Flash drying is more efficient and versatile than previous spray droplet or circulating bed drying:

- It requires ~1 second to dry wetted solids compared to 3-5 sec for fluid bed and 8-14 sec for nozzle and rotary disc atomization and drying;
- hence smaller reactor and smaller footprint; wetted and flash dried solids have more surface area;
- hence higher mass transfer rates of SO₂ from gas to liquid to solid;
- resulting in higher removal efficiencies at any given exit temperature, or higher exit temperatures for any targeted SO₂ removal efficiency.

This may translate into less or no corrosion and reduced or no needs for existing stack modifications; cooling can be staged to optimize mercury

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oxidation and capture, additional NO oxidation and capture without compromising SO₂ removal (see 2004 Mega Symposium paper).

Our experience on one commercial installation is SO₂ removal >95% on a 1 % sulfur coal with 200 – 400°F exit temperatures after scrubbing. This is more than a 75 F approach to adiabatic saturation. Stack wetting and downstream corrosion are less likely to occur at these temperatures. We generally recommend exit temperatures of 250°F, from the quench section, prior to scrubbing if mercury control is desired.

Control is quite straightforward; we control the addition of slurry at the mixer from stack SO₂ instrumentation. We can also add water at the mixer by specifying the RAP outlet temperature. Additional cooling will enhance removal efficiency, but only marginally. Another approach is to control the slurry concentration as the only source of water added at the mixer. The final control is the recycle rate, which is controlled by VFD drives, on the mixer and the rotary valve that supplies the dry recycle material. This is maintained by increasing recycle rate as the liquid rate is increased to the mixer.

Disposal is also quite straightforward. By returning all of the collected material from the baghouse to the recycle silo, located above the mixer, we then simply overflow the silo, transferring the overflow to the final disposal silo. The overflow screw operates continuously eliminating the need for any controls or level indicators.

The reactor can support 75% turndown for flow and has been demonstrated on 1 to 3% sulfur coals although it can be designed for lower or higher sulfur coals.

Nozzle Atomized Spray Dryer

Dual-fluid nozzle atomizers were tested in the early 1980's as a cost-saving alternative to rotary atomizers. In lieu of the motor and speed-increasing gearbox of the rotary atomizer, the nozzle requires a high-pressure feed pump and a compressor for the atomizing fluid.

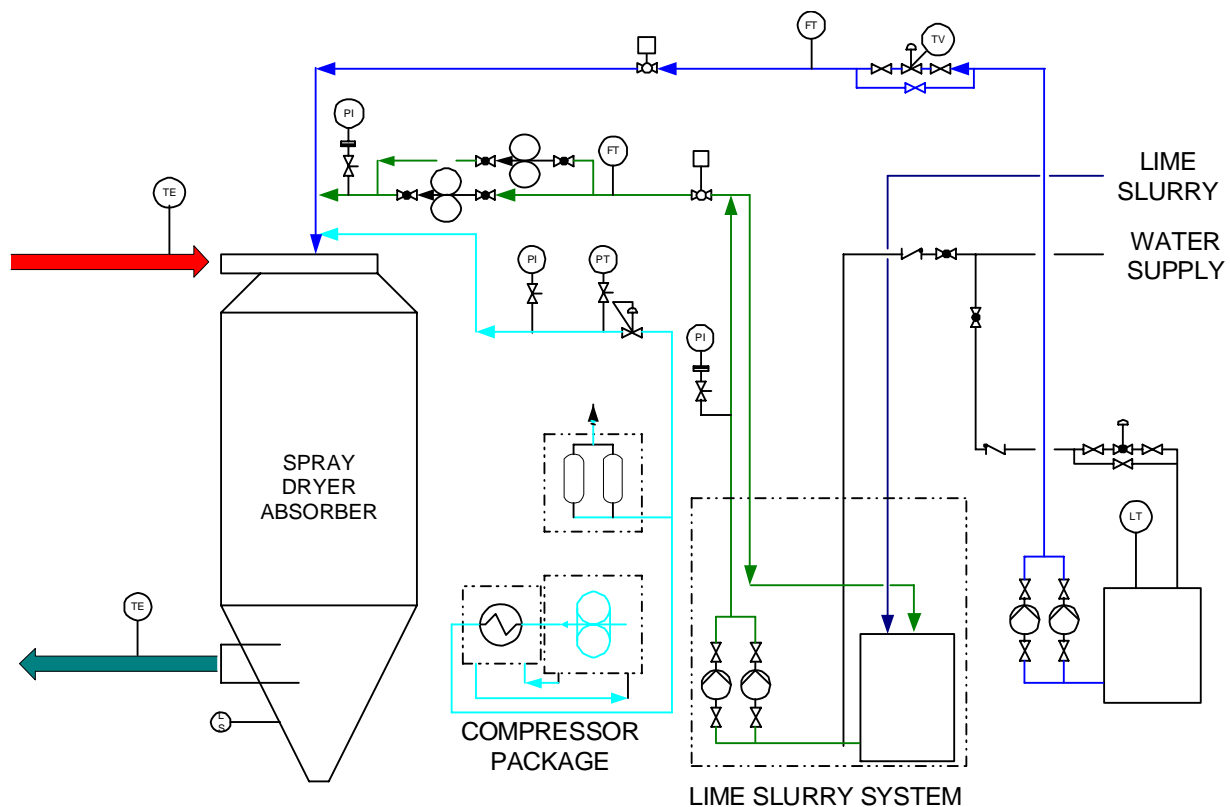
The process consists of a large chamber in which an absorbent liquid is sprayed and mixed with incoming flue gas. The water in the spray is evaporated, while the calcium hydroxide reacts with acid gases to form dry particulate products that are collected in a downstream filter or precipitator. The drying vessel consists of a large cylindrical chamber, conical hopper, gas distribution device, and gas outlet duct. In all but the smallest systems,

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multiple atomizers are installed in the roof of the vessel and spray vertically downward into the vessel.

The dual-fluid atomizer consists of a lance assembly with feed and compressed air pipes. They include machined tips, mixing sections, and impact devices in some of the designs. Some designs include ceramic internals for abrasion resistance. Due to the high pressures involved, the absorbent liquid leaves the nozzle at a high velocity, and therefore causes accelerated abrasion of the internals.

Problems encountered and addressed, in varying degrees, for this nozzle type design include undersized drying chambers (build-up), nozzle abrasion, nozzle plugging, and efficiency.



RAP Advantages

- The RAP system is furnished with 2 stage treatment allowing for the gas cooling/conditioning prior to slurry addition. This allows for condensing and Mercury control. This is nit available in other SAP systems.

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- The RAP system can turn down by 75% for the single Reactor design. The flow velocity in the RAP Reactor can be 25 to 50 % higher than other designs, which makes the unit smaller and allows for the greater turndown without drop. Dropout can occur in the SAP system due to the lower internal velocities.
- Higher removal efficiencies (up to 99%), higher utilization (20% less lime required), higher outlet stack temperatures. This reduces potential corrosion and necessary stack modifications. Older systems to reach the 90% removal rate, requires temperatures approaching saturation, have 18 to 22% moisture levels at the baghouse, and require 20 to 25% more lime.
- Compared to other reactor or fluid bed systems the RAP has lower system pressure drop due to the use of a simple straight through reactor. A SAP will typically operate at similar pressure drops to the RAP.
- Lower maintenance requirements, as there are no sprays within the reactor. A SAP usually recycles material through the slurry spray system and suffers from plugging and erosion in the spray nozzles. This requires daily cleaning of the nozzles and replacement on a monthly basis.
- Drying time is reduced as the reactor performs flash drying without the delay encountered in spray type reactors to mix the slurry and the recycle material. Typically the drying time is less than 1 second as compared to 10 seconds in the SAP.
- Reduced drying time allows for shorter reactors as well as smaller diameter reactors, which occupy less space.
- Build-up is minimized, as there are no sprays in the gas stream. SAP designs usually require semi-annual outages to chip out the build-up.
- Much less compressed air is required due to using external sprays, smaller material handling systems and no need for air conveying. The SAP systems require large amounts of atomizing air and high pump energy.
- Finally the manpower requirements are much less. Typically one man for each of 2 shifts to walk the site is required for RAP systems. SAP systems require 2 to 3 men for each of the 3 shifts.