Catalytic Filter Technology Provides Important Flexibility for Controlling PM, NOx, SOx, O-HAPS

Catalyst-embedded ceramic filters offer a way to remove NOx at lower temperatures, while simultaneously removing PM, SOx, and HCl. The technology also removes organic hazardous air pollutants, THC, dioxins, and mercury.

Applications include the Cement NESHAP; Boiler MACT; incinerator CISWI MACT; Hazardous Waste MACT; glass furnaces; ceramics manufacturing, including fracking proppants, kilns, and thermal oxidizer clean-up.

Typically, PM is removed to ultralow levels (≤5 mg per Nm3, 0.002 grains per dscf); other pollutants are eliminated at levels >90%.

Filter Types: Standard and Catalyst

Standard UltraTemp filters remove PM or PM plus acid gases and metals, including mercury; UltraCat catalyst filters remove those, plus O-HAPS, dioxins and NOx.

Catalyst filters feature the same fibrous construction as the standard version, but have nanobits of catalyst embedded throughout the filter walls. Distribution across the entire wall thickness, as opposed to just a catalyst layer, creates a very large catalytic surface area. The walls that contain the catalyst are about 3/4 inches thick. Ammonia is injected upstream of the filters and reacts with the NOx at the surface of the micronized catalyst to destroy the compound (Figure 1).
An analysis comparing the effectiveness of this nanocatalyst with that of conventional catalysts was summarized in a paper by Schoubye and Jensen of Haldor Topsoe A/S:

"The catalyst particles are micro-porous, and, due to their small size, they catalyze the gas-phase reactions without diffusion restriction (i.e., almost 100% utilization of the catalyst's intrinsic \activity), as opposed to pellet or monolithic catalysts. In industry, conventional catalyst types typically operate with 5-15% catalyst effectiveness in the SCR of NOx by NH3 and with even lower catalyst utilization in dioxin destruction."

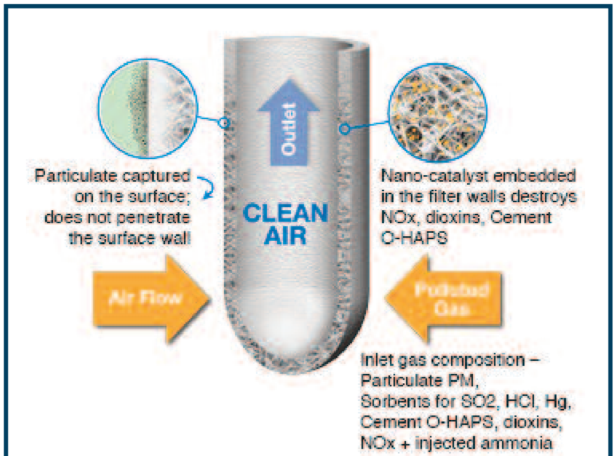

Figure 1. Catalytic filter schematic.

Another remarkable feature is low temperature activation. Substantial NOx removal is initiated at 350°F, with over 90% removal as the temperature exceeds 450°F.

System Design Criteria

Filters are placed in a housing module configured like a reverse pulse jet baghouse. Polluted airstream enters the bottom of the housing. Process PM and reacted acid gas sorbent PM are captured on the filter surfaces, while NOX and injected aqua ammonia are transformed to nitrogen gas and water vapor. O-HAPS (Cement NESHAP) and dioxins are broken down without ammonia additions. Cleaned air passes through the center of the filter tubes and out of the space above (Figures 1-3).

The modular housing design allows filters to be configured for the largest gas flow volumes. The system's modular nature also provides redundancy so a single module can be taken offline while the other modules receive the flow.

Placing multiple plenums in parallel provides redundancy. If one plenum is taken offline for service, others treat the entire flow at a temporarily higher pressure with no change in performance.

Particulate is captured on the face of the filter and does not penetrate the filter. At start-up, the pressure drop is 6" w.g. Over the filter's life, the pressure undergoes a gradual increase, averaging 3% annually. Filter life is generally over 10 years. Conventional reverse pulse jet methods are used for filter cleaning.

Standard Filter: Typical Pollutant Control

Particulate: The typical level of particulate at the outlet of the ceramic filters is ≤ 0.002 grains/dscf (5 mg/Nm^3).

With the exception of mercury, heavy metals are captured at the same rates as other particulate (> 99%).

SO_2, SO_3, HCl, other acid gases: Ceramic filters use dry injection of calcium or sodium-based sorbents for acid gas removal. Injected in the duct upstream of the filter modules, the additional sorbent particulate is captured with its pollutant gas. The reaction of the sorbent with the acid gas creates a solid particle that is captured on the filters alongside the unreacted sorbent and process particulate. The reaction occurs within the duct prior to the filter and on the cake on the filter surface.

The sorbent cake on the filters increases exposure of the SO_2 or HCl, and increases removal rate. For a given removal efficiency, filters require significantly less sorbent than ESPs, which minimizes sorbent costs.

With sorbent injection, SO_2 removal is above 90%. SO_3 and HCl are preferentially removed at higher rates than SO_2. Sorbent injection of powdered activated carbon is an option for mercury control. The mercury chemistry and temperature of the application determine the formulation of PAC used and the resulting effectiveness.

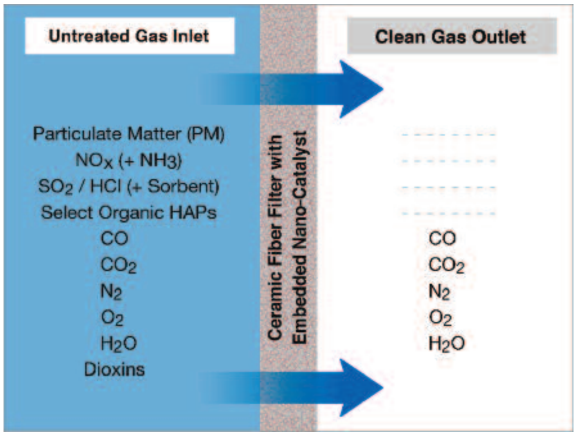

Figure 2. Catalyst filters simultaneously treat multiple pollutants.

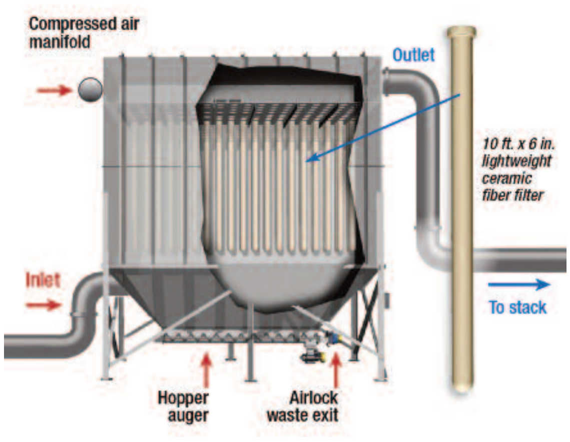

Figure 3. A single housing module containing 3m filter elements.

surface, and gas-phase poisons. A common problem with "honeycomb block" SCR is that the catalyst becomes blinded and poisoned, reducing effectiveness and necessitating replacement. Ceramic catalyst filters address these issues. Particles, including solid-phase metals, are captured on the surface of the filters.

The filter catalyst is distributed throughout the filter walls and is protected inside the filter. This virtually eliminates particulate-type interactions and extends catalyst life. Regarding gas phase, the proprietary catalyst formulation is engineered for extremely low conversion of SO_2 to SO_3 and is virtually immune to HCl.

The reaction of the ammonia and NOx at the micronized catalyst surface is the same as conventional SCR, but benefits from more contact time because the gas mixture doesn't have to diffuse in and out of the block catalyst pores.

Eliminating the diffusion restriction helps reduce the slippage of untreated gases; NOx destruction greater than 90% is common. Ammonia slip is under 10 ppmv.

Cement O-HAP THC: The filters destroy formaldehyde and other O-HAPS. The significant reduction of O-HAPs results in an adjustment of total allowable THC according to NESHAP. This direct approach for O-HAPS reduction is very cost effective compared to PAC injection or thermal oxidation.

Catalytic filters virtually eliminate ammonia slip if SNCR is used in the kiln. Excess ammonia slip is consumed by the filters while acting as a polishing step for NOx removal. This is an important secondary benefit when the filter system is used to collect PM, remove HCl, and/or destroy O-HAPS. Thus the need for a fabric filter baghouse or ESP is eliminated.

Dioxins: Dioxins are destroyed similarly by the catalytic filter.

Operating Temperatures

For PM plus SO /HCl, the range is 300 to 1,200°F.

One important feature of the NOx filters is an operating range that is lower in temperature compared to conventional SCR. Conventional SCR requires 550°F for efficient removal, while the micronized catalyst becomes active at 350°F (Table 1).

O-HAP destruction becomes effective as temperatures approach 400°F and increases rapidly.

Table 1. Temperature ranges by pollutants being removed.

UltraCat Filter	Pollutants	Temp Range
Non-catalytic	PM, SOx, HCl, Hg	300°F - 1,200°F
Catalytic	PM, SOx, HCl, Hg, NOx, O-HAPs, Dioxins	350°F - 750°F

Catalytic Filters for NOx, O-HAP THC, Dioxins

Catalytic filters have the same composition and capabilities as the non-catalytic filters for PM, acid gases and Hg. The difference is the micronized catalyst into the filter walls.

NOx: All catalysts can be compromised by particulate blinding of the catalyst surface, chemical interactions with particulate on the

Proven Solution

Ceramic filters have been used by the U.S. military at munitions destruction facilities for 20 years; hundreds of ceramic filter systems are operating worldwide. With the additional capability of NOx control, ceramic filter systems are the technology of choice for many applications.