Performance Testing of Mercury Oxidation via Catalytic Barrier Filters

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BACKGROUND

- Coal combustion accounts for one-third of mercury emissions in United States
- EPA Clean Air Mercury Rule will reduce mercury emissions by 70% in 2018
- Oxidized mercury is much easier to remove from flue gas than is elemental mercury
- Fabric filter method reduces amount of required catalyst and overcomes diffusion limitations

ABSTRACT

The feasibility of oxidizing elemental mercury in coal combustion flue gas, using catalytic material impregnated onto fabric barrier filters was explored. Preliminary tests were performed in order to screen potential catalysts which suggested that palladium and titanium dioxide were attractive candidate catalysts. Several fabric coating methods were investigated to determine the best way to load a filter. A bench-scale test apparatus was constructed to automatically simulate cleaning pulses of a pulse-jet baghouse to determine long term integrity of the loaded catalyst. Filter samples were back pulsed up to 3000 times to determine the long term integrity of the catalyst coating. Changes in pressure drop across a catalyst-coated filter versus a bare filter were also determined. It was found that spray coating was an effective and commercially feasible technique for catalyst application. The mercury oxidation performance of the catalyst-coated filters was tested using a simulated flue gas in a bench-scale reactor under conditions similar to those found in a baghouse. Three potential catalysts were examined using an on-line mercury analyzer. A matrix of experiments was performed using potential contaminants such as SO2 and H2O. Based on these results, the most attractive catalyst candidate was selected for small pilot-scale testing using two parallel single filter baghouses attached to a 19 kW research combustor. On-line and Ontario hydro measurements of oxidation performance were performed for three coals: Illinois #6 bituminous, Eagle Butte subbituminous, and North Dakota lignite.

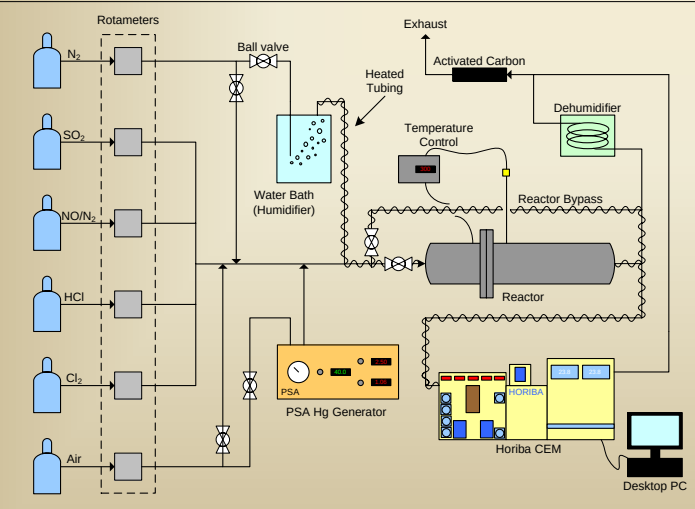
BENCH-SCALE TESTING

- Used simulated flue gas in small reactor under baghouse conditions
- Tested GE filter types RY805 and PC012
- Catalysts used: TiO_2, Au/TiO_2, Pd/Al_2O_3

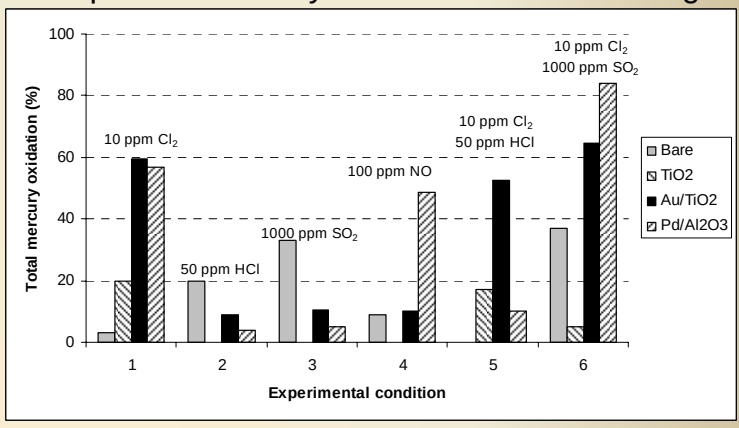
SMALL PILOT-SCALE TESTING

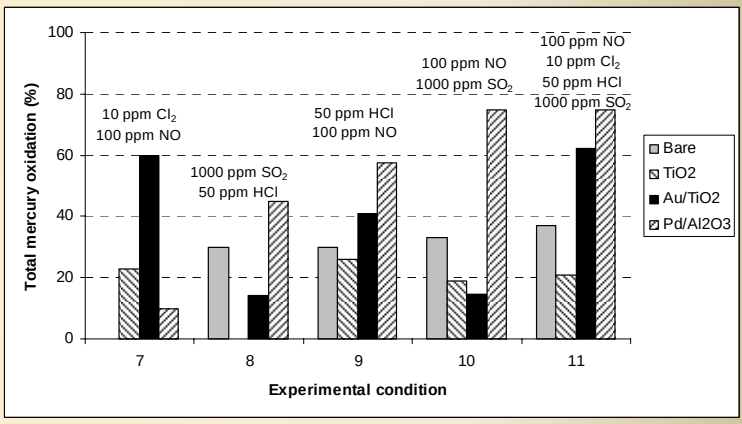
- Used 19 kW research combustor to fire three coals: Illinois #6 (bituminous), Eagle Butte (subbituminous), and Falkirk (lignite)
- Used Pd/Al_2O_3: best catalyst in bench-scale testing

Gas	Concentration	Conditions	
Cl_2	10 ppm	Reactor temperature	150 °C (300 °F)
HCl	50 ppm	Heated tubing	150 °C (300 °F)
SO_2	1000 ppm	Total gas flow rate	4 L/min (0.14 ft³/min)
NO	100 ppm	Filtering velocity	1.9 m/min (6.1 ft/min)
O_2	4%	Catalyst mass	0.2 g
H_2O	10%		
N_2	Balance		
Hg^0	20-30 μg/m³		

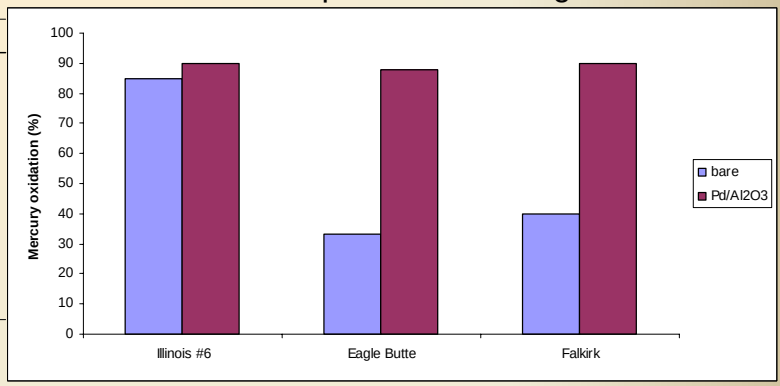


Comparison of catalysts for bench-scale testing





Small pilot-scale testing



Ontario-Hydro comparison