ICSET

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COMBUSTION:

MERCURY SORBENTS, SOLVENTS AND ADDITIVES EVALUATION TESTING FACILITIES

ADDRESSING ENVIRONMENTAL NEEDS THROUGH RESEARCH AND DEVELOPMENT

Several states have enacted Hg emission regulations that are more stringent than the CAMR milestones (e. g, Massachusetts 95% removal efficiency or an emission standard of 0.0025 lbs/GW h by 2012). To ensure compliance with these regulations, as well as future federal regulation, coal-fired power plants need to know their current emission levels. With this knowledge, decisions regarding the implementation of various air pollution control devices (APCDs, such as ESP, FF, SCR and FGD) to control Hg, as well as their intended targets, need be made. All of these APCDs have co- benefits for Hg capture but not always at the desired level. To gain additional Hg capture efficiency, other alternatives for Hg control have been demonstrated. Currently, the injection of sorbent materials, in conjunction with the aforementioned APCDs (such as ESP and FF), is a leading mercury control technology. Some of the most widely used adsorbents are powdered activated carbons (PACs), which are modified to enhance the affinity of their surfaces to Hg. Alternatively, additives for mercury oxidation is also preferred in conjunction with FGD for enhancement of mercury capture. However, there are some species occurred in the flue gas that can interfere/compete with mercury adsorption on activated carbon and oxidation in the flue gas, such as NO, SO_2 and SO_3. Therefore, while an activated carbon or other additives may perform well in laboratory experiments that do not contain these species in the simulated flue gas, its performance at a power plant is likely to be reduced because of these inhibiting species. ICSET has developed two different sorbent (solvent, additives) testing facilities to evaluate the mercury sorbent capture efficiency at coal-fired power plant with the real flue gas during development. The results of mercury capture efficiency from ICSET testing facility are very similar to that of full-scale tests.

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Developed Technologies in Combustion

1. Patented HBr Injection Technologies for Mercury Emission Control
2. Slipstream Honeycomb Catalyst And Sorbent Injection Facility and Capabilities
3. Bench-scale Fixed Bed Catalyst Evaluation Facility
4. Chemical Looping Combustion
5. Carbon Capture & Sequestration.

1. Drop tube furnace (0.001 MW DTF) at ICSET

A drop tube furnace **(DTF 0.001MW, 1.9" tube)** to simulate the effect of sorbent injection on mercury emission control at the inlet of an ESP in a utility boiler has been set up at ICSET, Figure1..

The drop tube furnace, by which the adsorbent injection test will be conducted, is best described as a lab-scale solid-gas multiphase flow reactor with an adsorbent injection facility on its top and a separation and sampling comb in its downstream. The adsorbent will be fed in by an accurate screw feeder and entrained in the reactor by "real" flue gas. With the assistance of a pressure balance line, which is located between the adsorbent hopper and injection port, the injection rate will be unaffected by pressure fluctuation inside the reactor. The "real" flue gas is extracted from duct through a venturi educator. The flow rate can be monitored by a pressure differential indicator. The adsorbents undergo the adsorption process by interacting with mercury in the reactor. The main body of the reactor is 2" in I.D. The material, which is used to make this reactor furnace, is a stainless steel pipe, which is reported and verified to be inert to mercury transformation. The temperature inside the furnace is controlled by a two-channel temperature controller, generally at 150^oC to simulate ESP conditions. The system is well insulated to keep the system temperature constant. A custom-made mini stainless steel cyclone and inertial probe set up a gas solid separation combination, which has high separation efficiency for particle diameter less than 10um. During tests, the injection rate will be kept at 4lb.Mmacf, and residence time at 1 second.

The specific goals of this facility will include:

- Evaluation of mercury removal efficiency by sorbent injection;
- Evaluation of mercury oxidation and removal efficiency by injection of additives and solvents;
- Evaluation of varied flue gas composition on mercury capture or oxidation efficiency by sorbents
- Characterization of coals, fly ashes or adsorbents and measurement of flue gas compositions.

Based on the general injection location in the utility boiler, the injection conditions for DTF facility will be pre-set to the following specifications:

- Test atmosphere: The atmosphere will be dependent on the specific coal flue gas. O_2, CO_2, SO_2, NO and HCl will be monitored during testing and controlled to simulate the desired conditions
- Residence time: 1-2 s
- Average temperature: 150^oC, (290^oF on average), typically temperature at the inlet of ESP
- Mixture ratio of ash and adsorbent for dilution: (15-150):1

2. Entrained Reaction Facility (0.1 MW ERF) at ICSET

This pilot-scale slipstream reactor has been designed and manufactured to simulate the "full-scale" applications of a system, Figure 3. The adsorbent is dropped from an accurate feeder into a vessel and is fluidized with a small amount of air and allowed to flow to the 4-way ports in the slipstream reactor. This particular unit is 19.5 feet tall and the interior is 6 inches square in shape. Approximately 18 inches below the top of the unit, 4 injection ports are located 2.5 inches off the corners in an opposing fashion. This arrangement offers the best mixing of the adsorbent before entering into the flue gas stream. The precise control of the adsorbent injection rate has been achieved through a screw feeder. The screw feeder is pre-calibrated to ensure proper injection rates. The space velocity can be controlled by the ID Fan to simulate the 1.25 second residence time of the adsorbent inside the slipstream reactor at the designed temperature (about 300 ^oF).

To ensure the control and even distribution of adsorbent, two static mixers have been built and installed at different locations in the slipstream reactor. The first static mixer is located one duct-diameter below the adsorbent injection ports to ensure homogeneous distribution of adsorbent. The second mixer was installed at the middle of the slipstream reactor to enhance the mixing of adsorbent with flue gas inside slipstream reactor. The specific locations of the sampling ports are relative to the locations of the adsorbent injection port. The “inlet” refers to the location just before the adsorbent injection port, and the “outlet” is under the bottom of the slipstream reactor and before the ID Fan.

3. MERCURY MEASUREMENT SYSTEM:

1. PS Analytical SCEM system:
2. LECO AMA-254 Advanced Mercury Analyzer:
3. Flue Gas Analyzers: O2, CO2, CO, SOx, NOx, HCl
4. Materialization Characterization: BET,XRD, SEM-EDX

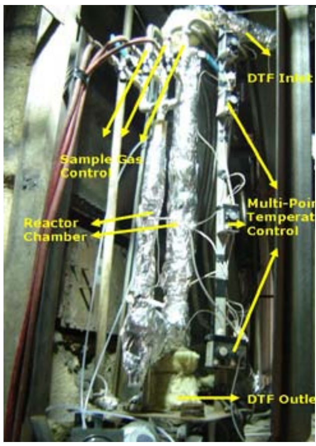
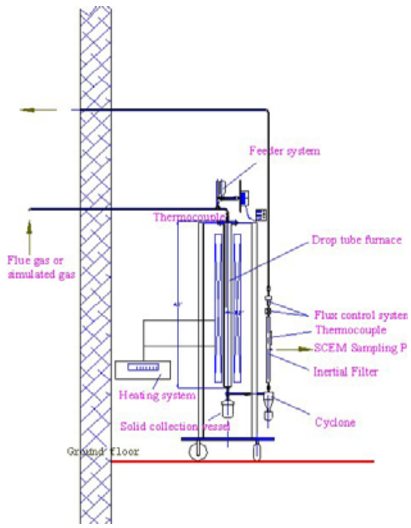


Figure1. Drop Tube Furnace



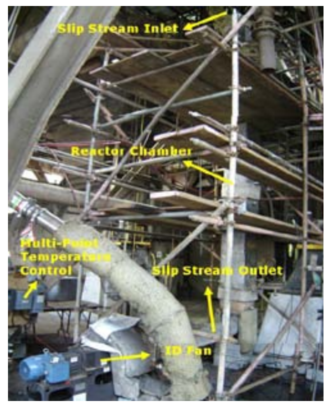
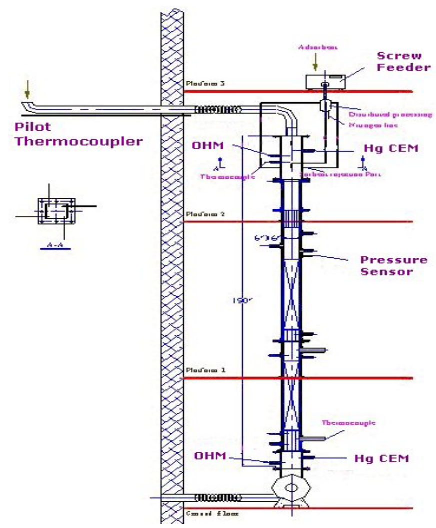


Figure2. Entrained Reaction Facilities



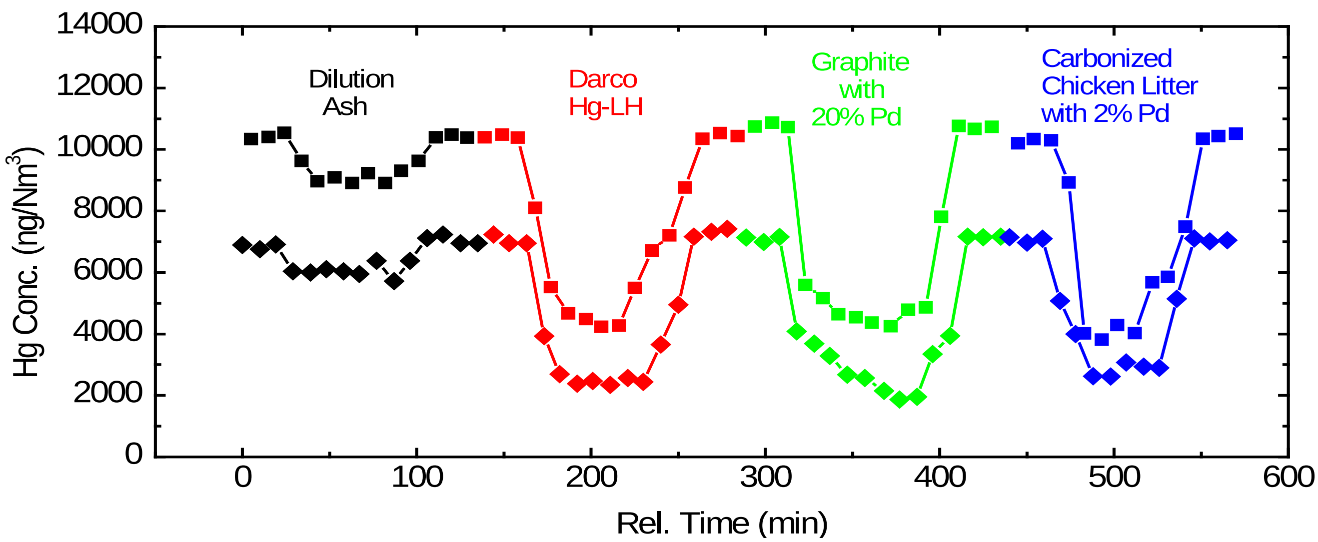


Figure 3. Onsite mercury capture data for selected samples with an adsorbent injection rate of 4 lb/MMacf (squares Hg(T); diamonds Hg(0))

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