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Carbon Adsorber Fouling: Removal of Ammonium Bisulfate

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CHEMICAL AND LIFE SCIENCE

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CAPSTONE DESIGN EXPO 2015

BACKGROUND

High Temperature Fluidized Bed (HTFB) incinerators are a highly efficient combustion process. However, they produce an exhaust gas that must be treated to satisfy air quality regulations before it may be emitted into the atmosphere. Adsorbers located downstream of the HTFB are filled with sulfur-impregnated carbon, i.e. "activated carbon," and are the final stage in the treatment process. They are used primarily to capture elemental mercury present in the gas stream. Unfortunately, several HTFB process plants have occurrences of a buildup of an unknown compound within the activated carbon bed adsorbers, thus fouling the adsorber. Buildup of this compound on the carbon surface increases the pressure drop across the adsorber, as well as decreases the efficiency of the unit by inhibiting mercury capture. Process shutdown for maintenance is currently the limited solution to temporarily remediate the problem.

HYPOTHESIS

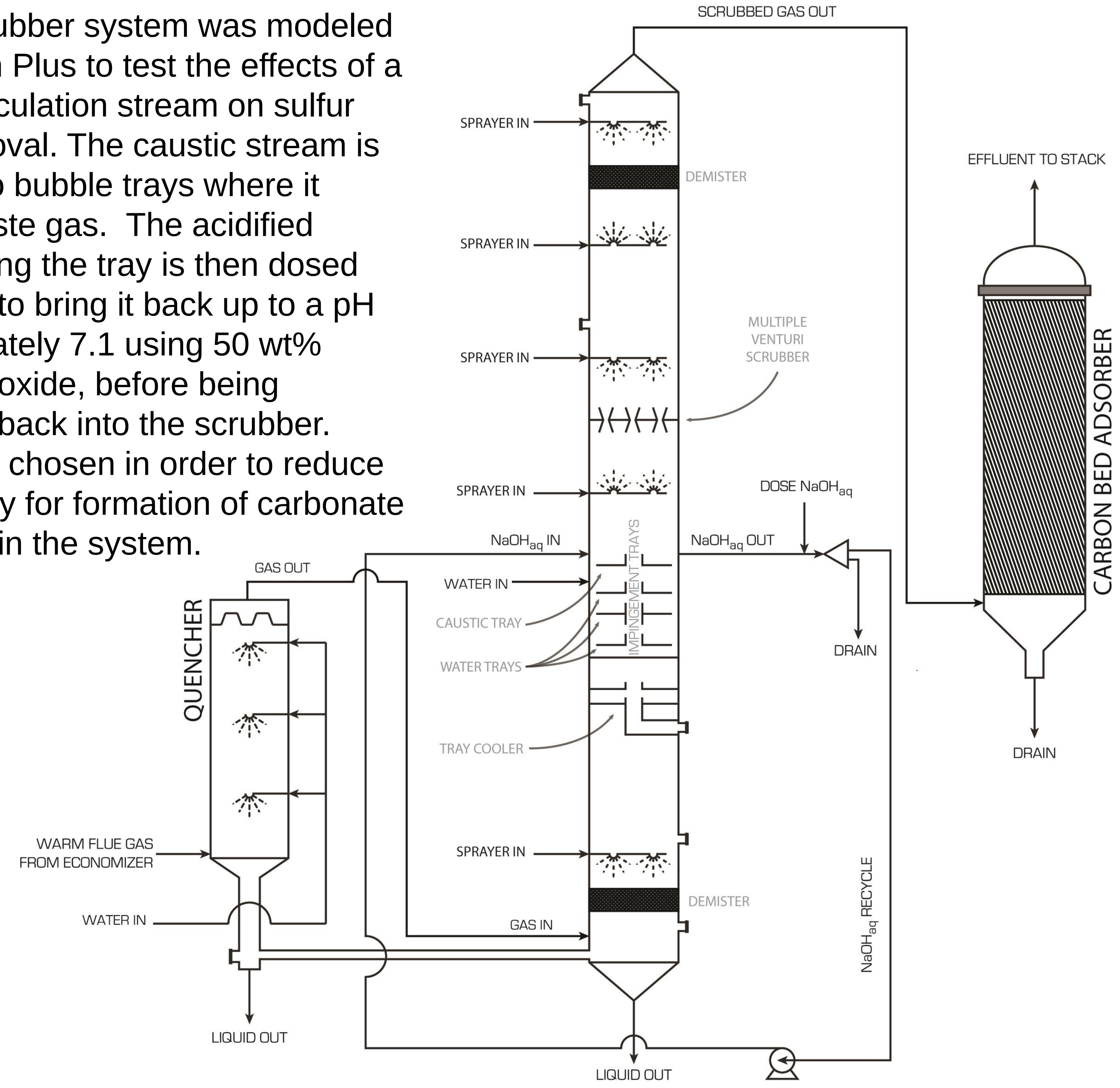
Sulfur oxides are commonplace in incineration processes. A fraction of these, specifically sulfur trioxide, readily reacts with water to form sulfuric acid. It is believed that sulfuric acid aerosols existing in the system flue gas react with ammonia present in the wastewater treatment plant effluent, which is being used as scrubber service water in the gas treatment process. This reaction generates ammonium bisulfate aerosols. Aerosols remaining the in gas stream that were not eliminated by the wet scrubber deposit on the surface of the activated carbon in the adsorbers downstream. The result is adsorber fouling.

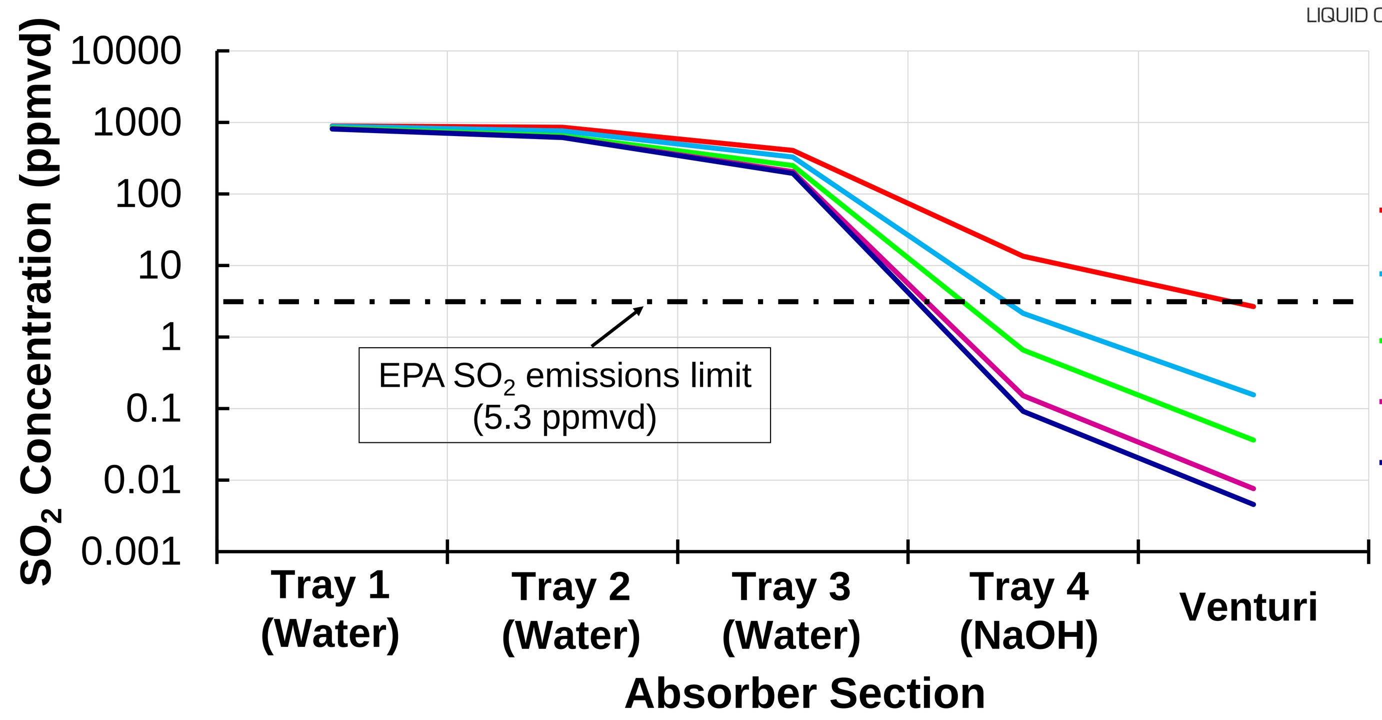
SPECIFIC AIMS

- Identify the precipitating compound
- Investigate root cause of problem
- Design and model a system that could potentially rectify the issue

DESIGN & MODELING

The gas scrubber system was modeled within Aspen Plus to test the effects of a caustic recirculation stream on sulfur dioxide removal. The caustic stream is injected onto bubble trays where it contacts waste gas. The acidified stream leaving the tray is then dosed with caustic to bring it back up to a pH of approximately 7.1 using 50 wt% sodium hydroxide, before being recirculated back into the scrubber. This pH was chosen in order to reduce the possibility for formation of carbonate species within the system.





Recirculation Rate	Dosing Rate	Inlet Temp.
100 gpm	3.4 gph	800 ºF
100 gpm	2.9 gph	650 ºF
100 gpm	2.5 gph	500 ºF
150 gpm	3.1 gph	500 ºF
200 gpm	3.7 gph	500 ºF

Effect of caustic recirculation rate, dosing rate, and quencher inlet gas temperature on SO_2 concentration through absorber

RESULTS & CONCLUSIONS

- Positive identification of ammonium bisulfate as the precipitating compound by analysis through X-ray diffraction
- Based upon a recirculation pH of 7.1, a minimum caustic recirculation flowrate of approximately 100 gpm will be necessary to meet the EPA sulfur dioxide limit of 5.3 ppmvd
- Higher recirculation flowrates will result in smaller pH differences across the scrubber tray, but will require higher sodium hydroxide dosing rates
- Increased inlet gas temperatures will result in the need for increased sodium hydroxide dosing
- The addition of a caustic scrubbing system along with demisting sections and wet electrostatic precipitation units will greatly reduce amount of acidic gas and aerosol species within the system resulting in increased system reliability, lower ammonium bisulfate production, and even lower stack emissions

ECONOMIC IMPACT

- Removal of acidic sulfur oxide species by caustic addition should prevent formation of ammonium bisulfate and need for shutdown to clean fouled adsorbers
- The need for costly rerouting of sludge directly to landfills during process shutdown is avoided

RECOMMENDATIONS

- A caustic dosing system should be integrated into the wet scrubber to neutralize acidic sulfur oxide species present in the flue gas at a rate of 2.5 to 4.6 gph
- Utilize model predictions to optimize dosing regiment to maintain a caustic injection pH of ~7.1 based on actual system performance
- Perform cost analysis for caustic optimization routine

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Make it real.