Technology Applications, Inc.
Mike Mansfield Advanced Technology Center

Technologies for the Future
Responsible Solutions for Today

Plasma Technology Testing Facility— Offgas Cleanup System

MSE Technology Applications, Inc. (MSE), developed an offgas cleanup system to support the plasma arc technology testing program at MSE's test facility in Butte, Montana. Plasma arc treatment produces offgas with high particulate loadings [approximately 0.35 to 4.0 grains/dry standard cubic feet (dscf)], high oxides of nitrogen (NO_x) content [5,000 to 10,000 parts per million (ppm)], acid gas components hydrochloric acid (HCl) and sulfur dioxide (SO_2), and volatile heavy metals that must be removed before the offgas is discharged to the atmosphere. Offgas exits the plasma system at temperatures as high as 1,800 °F and must be cooled as part of the treatment process.

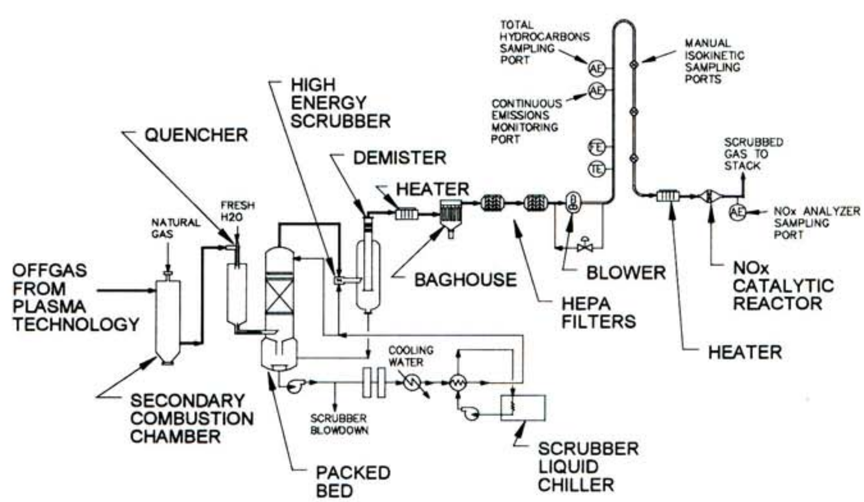
Major components of the offgas system are:

- secondary combustion chamber (SCC);
- quencher;
- packed bed contact condenser/absorber;
- scrubber liquid chiller;
- high energy atomizing scrubber/agglomerator;
- demister;
- electric heater;
- baghouse;
- roughing filter, high-efficiency particulate air filter (HEPA), activated carbon bed, HEPA filter combined filtration train;
- induced draft blower;
- offgas sampling station;
- electric reheater; and
- NO_x catalytic reactor.

Combustion gases from the plasma process are drawn into the SCC. A natural gas-fired burner connected to the SCC is used to maintain a temperature high enough (1,800 °F, minimum) to ensure complete combustion of any residual organic materials.

The offgas then enters the quencher where fresh water is used to reduce the temperature to approximately 150 °F and bring the offgas to saturation conditions. Fresh water is used to eliminate the possibility of submicron particulate formation in the gas stream by "spray drying" of the concentrated dissolved and entrained solids in the recycled scrubber liquor.

Cooled and saturated offgas then enters the packed bed absorber/condenser where it contacts a caustic solution (scrubber liquor) to absorb the acid gas



Offgas system process schematic.

components HCl and SO_2, scrub some entrained particulate, and condense moisture. The gas then enters the nucleator section to promote growth of fine particulate clusters and exits at 50 °F.

The bottom of the packed bed absorber/condenser is the sump tank for the liquor used in the scrubbing system. Heat is removed from the scrubber liquor by contact, through a heat exchanger, with chilled propylene glycol. The propylene glycol is cooled by the scrubber liquid chiller.

Next, the offgas enters the high energy scrubber/agglomerator, where high-pressure nitrogen flows through a sonic nozzle in which a flow of scrubber liquor is aspirated. The liquid is broken into micron-sized droplets, which are then entrained in the offgas. Droplets collide with themselves, aerosols, and particulate in the offgas and tend to grow larger. The agglomerator provides residence time for the completion of the agglomeration process (i.e., combination of fine particulate with droplets into clusters large enough to be removed from the gas stream).

Gas then flows into the demister, first flowing tangentially into a large cylinder, which tends to separate most of the injected liquor containing the particulate clusters. The gas then flows into the bottom of a concentric cylinder that contains a chevron demister, followed by a mesh demister. Demisters remove the remaining droplets, and water removed by the demister flows back into the sump of the absorber.

Some submicron aerosols may remain in the gas stream exiting the demister. To prevent these from eventually blinding downstream gas filtration equipment, the offgas is reheated above its dewpoint in an electric heater.

Gas then enters a baghouse to remove any remaining dry dust. The baghouse guards downstream HEPA filters from high loadings of dust that may occur if the scrubber system fails.

Treated gas then flows into a filter housing containing a roughing and HEPA filter, followed by a housing containing an activated carbon bed, followed by another HEPA filter.

The HEPA filters are rated at 95% removal efficiency for dust 0.3 microns and larger. The activated carbon bed is required by nuclear standards to remove volatile isotopes of various elements, such as iodine. The activated carbon bed also adsorbs parts per million quantities of organic compounds that escape destruction in the plasma technology's secondary combustion chamber.

After leaving the filters, gas enters the suction of the induced draft blower. Discharge gas from the blowers flows through a sample station where gas samples are drawn for Environmental Protection Agency (EPA) isokinetic-type samples and continuous emission monitors (CEMs). Isokinetic sampling includes EPA Methods 5, Modified 5, 12, and Volatile Organic Sampling Train. The CEMS includes samplings for carbon monoxide (CO), oxygen (O_2), carbon dioxide (CO_2), total hydrocarbons (THC), and NO_x.

The final process equipment consists of a reheater and a catalytic reactor for NO_x removal. The offgas stream is heated to 480 °F to provide the activation energy needed to initiate the NO_x removal reactions. At this temperature, aqueous ammonia is injected, which reacts on the catalyst with NO and NO_2 to form elemental nitrogen and water.

Tests to date indicate the offgas cleanup system has demonstrated a chlorine removal efficiency of greater than 98%, particulate removal below 0.003 grains/dscf (compared to a regulatory level of 0.08 grains/dscf), and NO_x removal of greater than 90%.

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