General Information Pertaining to Using Charged Water Droplets to Scrub Fine Particulate from a Dirty Gas Stream

General Info:

The idea of using charged droplets of water to scrub fine particulate was explored in the 1970s, when the EPA funded research into charged droplet scrubbing at MIT and the University of Washington.

The results of this early research were mixed. While theory predicted removal efficiencies far greater than those of electrostatic precipitators, laboratory and pilot scale tests showed poor performance. Because of these disappointing initial results, the EPA curtailed spending on charged-droplet fine particulate research.

Researchers in other countries, particularly France, continued efforts to build charged-droplet wet scrubbers for fine particulate, but none of these efforts led to successful commercial applications.

Between 1950 to 1980, many U.S. and foreign patents were issued for devices that claimed to use charged droplets to remove aerosol particles. However, none of these devices achieved commercial success.

There were four fundamental reasons for the poor performance of these experimental efforts:

- The charge per droplet was too low.
- The density of charged droplets was not high enough.
- The energy required to charge the droplets was too high.
- The mechanical components were unreliable, expensive, and not amenable to scaling.

Until the development of the Cloud Chamber wet scrubber, the cleaning potential of charged-droplet scrubbing of fine particulate remained unrealized. The important technological breakthrough of the Cloud Chamber system is in its ability to economically generate large quantities of droplets that are precisely right in size and high charge.

Development of “Cloud Chamber Wet Scrubber Technology”

Dr. Clyde Richards, the atmospheric physicist who holds the patents for Cloud Chamber technology, began his research into charged droplets during graduate studies at the University of Arizona.

While investigating the role of charged droplets in initiating lightning, a corollary question arose about how thunderstorms clean the air of fine suspended particles. Dr. Richards’ approach was to understand the microphysics of this natural scrubbing process, and improve upon it.

For twelve years, he worked independently, eventually establishing Atmospheric Physics, Inc. He developed a computer simulation that calculates the trajectory of a particle as it passes a charged droplet and corroborated the simulation results with results from previous charged droplet research.

Using simulation, Dr. Richards calculated the fine particulate collection efficiency of a single droplet while varying droplet size, droplet charge, droplet speed, particle size, particle charge, and ambient electric field.

Based on these data, he applied scaling laws to accurately predict fine particulate removal efficiencies for different conditions and configurations. The results of these predictions permitted the optimization of droplet size and droplet charge that is unique to the Cloud Chamber Wet Scrubber.

The most significant results were the discovery of the optimal droplet size and charge and the mechanism by which even submicron neutral particles (most naturally produced fine particulate) could be effectively removed.

Upon completion of the theoretical research, attention was turned to finding a means of producing large quantities of optimally sized, highly charged droplets, and of thoroughly mixing the droplets and exhaust gas.

The main task was to produce a reliable system that provided the necessary residence time and liquid-to-gas ratio. Insight into growing ultrafine particles also emerged from the research. A final stroke of physics insight yielded an inexpensive and reliable method of producing the charged droplets.

Pilot tests and patents followed, leading to numerous successful commercial installations of Cloud Chamber technology. These installations have operated continuously at efficiencies over 99% on submicron particulate, while requiring virtually no maintenance.