

Preface

Mercury (Hg) is considered as a global pollutant and is one of the most toxic heavy metals commonly found in the global environment including lithosphere, hydrosphere, atmosphere and biosphere, which has a long residence time in the atmosphere from 0.5 to 2 years. Coal combustion, waste incineration, metal mining, refining and manufacturing and chlorine-alkali production are currently major anthropogenic source categories in the industrialized world.

Coal-fired power plants have been considered to be the primary anthropogenic source of mercury into the atmosphere. After inhalation of Hg by human beings, elemental Hg vapor rapidly diffuses through the alveolar membrane and is absorbed through the lungs, and has a bad effect on the nervous system, particularly with regard to early-life neurodevelopment. Therefore, the research on mercury in America and Europe has been widely conducted. Anthropogenic emissions of mercury still increase in Asia because of increased burning of coal and increased industrialization.

During coal combustion at a coal-fired power plant, the mercury (Hg) in coal is volatilized and converted to elemental mercury (Hg^0) vapor in the high temperature regions of coal-fired boilers. As the flue gas is cooled, a series of complex reactions begin to convert Hg^0 to oxidized mercury (Hg^{2+}) compounds and/or Hg compounds (Hg_p) that are in a solid-phase at flue gas cleaning temperatures or Hg that is adsorbed onto the surface of other particles. Coal Fired Derived Flue Gas Mercury Measurement mainly includes Ontario Hydro Method (OHM), Semi-Continuous Emission Monitor (Hg-SCEM) and Appendix K. The comparison between different mercury emission measurement methods have been investigated in detail in this book.

The authors have investigated the effect of halogen on mercury speciation; Cl_2 , HCl, and HBr gases were injected in the slipstream reactor by the control of a mass flow controller (MFC). HI and HF were injected using HI and HF solutions. Moreover, the constituents of flue gas including SOx, NOx, O_2 , H_2O and fly ash have been certified to play an important role in mercury reactions in flue gases from coal combustion in air.

A cost-effective mercury emission control technology is required to reduce the global emission of mercury. Oxidized mercury can be removed in the wet flue gas desulfurization (WFGD) facilities of coal combustion processes, and particle-bound mercury can be captured along with fly ash in electrostatic precipitators (ESP) or baghouses. Due to Hg^0 being difficult to control for its insolubility in water, the mercury control technologies are to convert or transfer Hg^0 into oxidized mercury or particle-bounded mercury, which are easier to be controlled by existing APCDs at coal-fired power stations. By comparison, the direct oxidation method of injecting a type of oxidant, such as modified activated carbon, fly ash and some novel sorbents, into flue gas to oxidize Hg^0 appeared to be a simpler method.

In this book, the authors set up a lab-scale multiphase flow reactor and a pilot-scale slipstream reactor and conducted such evaluation on the two scales. After that, some kinds of sorbents were injected at a full-scale power station. The experimental results show that the lab- and pilot-scale reactor systems can provide accurate information of sorbent evaluation under flue gas atmosphere. SO_2 in the flue gas was shown to inhibit mercury oxidation and capture. The sorbents have higher mercury capturing efficiency with higher injection rate and longer residence time when other conditions were held constant. In the pilot-scale, four injection ports vertical to the flue gas flow direction could help improve mixture of sorbent and flue gas so that the mercury removal efficiency became higher. The pilot-scale data can be used to predict the full-scale results. Some of the chemical and physical mechanisms responsible for the mercury removal of the sorbents were identified.

We also have designed a pilot-scale coal-combustion furnace and constructed to study the mercury speciation and transformations in the flue gas under different conditions. Its purpose was to study the effect of chlorine compounds on mercury speciation and transformation. The addition of chloride additive makes the percentage of both gaseous bivalent and gaseous elemental mercury in the total mercury decline at some degree, and percentage of particle mercury increase correspondingly. However, with the increase in additives, the increasing trend of particle mercury became flat gradually and the decreasing of elemental mercury becomes gentle gradually.

Another effective method is the oxidation of elemental mercury with oxidants such as HCl or Cl_2 or ozone over a catalyst followed by the removal of oxidized mercury (Hg^{2+}) with scrubber solution in the WFGD facilities. The extent of Hg^0 oxidation is affected by the presence of coexisting gases such as NH_3 , NO , SO_2 and concentration of the oxidant (HCl). Most mercury control technologies have been developed and tested on conventional pulverized coal (pc)-fired power plants. In the next decade, mercury emissions control will be improved on the basis of the existing technologies, which include fuel/raw material pretreatment, existing air pollution control devices (APCDs), mercury adsorption, and mercury oxidation.

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