MECHATRONICS BOOK SERIES SYSTEM DESIGN AND SIGNAL PROCESSING

VOLUME 1

Editors
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CHAPTER 29

Intelligent Wet Scrubber System for Industrial Air Pollution Control

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29.1 Introduction

Increased public awareness posed for global warming has led to greater concern over the impact of anthropogenic emissions due to industrial pollutions on the global climate. In cement industries alone, there is need to vigorously pursue several control measures which could reduce the severe and harmful impacts of the pollutants on the environment and ecosystem. Approximately 5% of global carbon emissions originate from the manufacturing of cement [8].

Several efforts have been made to curtail these problems, a *wet scrubber system* which has the potential to save 35% to 40% over the cost of conventional air pollution control devices, while meeting the new Environmental Protection Agency's (EPA) standards for the control of industrial pollutants (hydrogen fluoride (HF), hydrogen chloride (HCl) and particulate matter (PM) would be an option. A spray tower system is considered to be; the simplest and the least energy consuming of all the wet scrubbers. It is cheaper to construct and maintain and can be used to collect particles or gases or both from a gas stream. On the other hand, it is a system that needs small space requirements, causes very little pressure loss and can handle large volumes of gases [6].

During the wet scrubbing process as shown in Fig. 29.1 below, the polluted gas flows upward and the particles collide with liquid droplets produced by suitable *nozzles* located across the flow passage. The liquid droplets are formed by *atomization*, where the flow rate of the scrubbing liquid and pressure in the atomizing nozzle control the droplet size and number. A *mist eliminator* is usually placed at the top of spray tower to remove both excess clean water droplets and dirty droplets which are very small and thus may be carried upward by the gas flow.

When a particle in a polluted gas stream move towards a target liquid droplet in the scrubbing chamber, it touches or sticks to the target due to aerodynamic forces of the surrounding gas; *inertial force, F_P, drag force, F_D and Gravity force F_G*. The mechanism by which the particle touches the target droplet is termed as inertial separation mechanisms; *Impaction*, *Interception* and *Diffusion*. However, *impaction* separation mechanism is the dominant collection efficiency for particles whose diameters are larger than $5\mu m$ [11].

29.2. The Impaction Number and Efficiency

Generally, on the basis of the physical interpretation of the impaction number it is anticipated that the larger the value of the impaction number, ψ the higher the impaction or collection efficiency. The expressions for the impaction or separation number showing in Equation 29.1 below was derived from stopping distance by considering the *Stokes law* equation for the study of particles and *Newton's second law* for momentum equation in terms of the force balance on the particle [15].

$$\psi = \frac{C_f \left(U_P - U_D\right) d_P^2 \rho_P}{18 \mu_g d_D} \tag{29.1}$$