EFFECT OF RAPPING FREQUENCY ON THE EFFICIENCY OF AN ELECTROSTATIC PRECIPITATOR

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Abstract. In an effort to improve collection efficiency of an electrostatic precipitator, the rapping frequency of the collector plates and discharge wires of a single stage Wheelbrator precipitator was varied in a manner intended to produce optimum precipitator performance.

Particulate emissions were measured at both the precipitator inlet and outlet by EPA-OAP and ASME sampling trains and at the precipitator outlet by continuous sampling and recording equipment.

Tests using the continuous sampling instrumentation and the EPA-OAP and ASME trains indicated that a reduction in particulate emission rate at the outlet of the precipitator resulted from a reduction in rapping time of the collector plates and a decrease in the frequency of rapping of precipitator collecting plates.

Experimental results indicated that the performance of an electrostatic precipitator can be greatly affected by a variation in rapping frequency of the precipitator collector plates and to a lesser extent the discharge wires.

List of Nomenclature

\[ A_0 \] Collection plate area \( m^2 \).

\[ C_{ai} \] Precipitator inlet dust loading \( \frac{\text{lbs}}{1000} \text{lbs dry gas (Corrected to 50% excess air)} \).

\[ C_{ao} \] Precipitator outlet dust loading \( \frac{\text{lbs}}{1000} \text{lbs dry gas (Corrected to 50% excess air)} \).

\[ d \] Particle diameter \( \mu m \).

\[ e \] Base of Napierian logarithm.

\[ E \] Potential applied to discharge wire or electrode \( \text{kJ} \text{m}^{-1} \).

\[ p \] A factor which depends on dielectric constant of medium between particles \( 1.0 \) for air.

\[ Q \] Gas volumetric flow rate \( \text{m}^3 \text{s}^{-1} \).

\[ w \] Particle drift velocity \( \text{m s}^{-1} \).

\[ \eta_a \] Actual efficiency of precipitator.

\[ \eta_t \] Theoretical efficiency of precipitator.

\[ \mu \] Viscosity of gas \( \text{Centipoise} \).

1. Introduction

In recent years, the need for highly efficient gas cleaning equipment capable of handling large volumes of gases at elevated temperatures has increased the use of electrostatic precipitators at incinerator installations. High efficiencies (up to 99% by weight) are theoretically possible for the collection of small particles (0.2 to 10 \( \mu \)m). Nevertheless, precipitator performance can be greatly reduced by variations in type of refuse burned, gas flow rates, furnace temperatures, particulate and moisture concentrations in the inlet gas, and the rapping patterns of the precipitator collector plate and discharge wire.
Close control of the operating parameters in a municipal incinerator to produce a known variation of input to the precipitator is difficult, if not impossible to attain; however, one can control the rapping frequency.

In an effort to improve collection efficiency of an electrostatic precipitator, the rapping frequency of the collector plates and discharge wires of a single stage Wheelabrator precipitator was varied. The Wheelabrator electrostatic precipitator was installed in a 250 t day\(^{-1}\) refuse burning furnace system of the Southwest Brooklyn incinerator as part of the program to upgrade the 6 existing New York municipal incinerators.

The 28 plates and 27 sets of discharge wires are struck sequentially by a set of mechanical hammers mounted on a rotating shaft which is powered by a motor. Hammer assemblies are mounted in a staggered arrangement so that individual hammers rap only one row of collecting surfaces at a time. The electric motor is geared down to permit rapping of each of the 28 plates and 27 sets of discharge wires at least once in 4 min. Excessive duration or frequency of rapping can result in reentrainment of collected particles in the gas stream, lowering precipitator performance. Too infrequent rapping results in excessive buildup of particles on the collection plates and discharge wires. This lowers the efficiency of collection because the large voltage gradient which develops across the deposited layer decreases the charging fields and the particle drift velocity.

2. Theoretical Efficiency

The theoretical efficiency of a single-stage plate-type precipitator for uniform operating and flow conditions is given by the modified Anderson equation [1]:

\[
\eta_t = 1 - \exp\left(\frac{-WA}{Q}\right),
\]

where \(W\) is the particle drift velocity toward the collecting electrodes, \(A\) is the collected plate area, and \(Q\) is the gas volume flow rate.

The operating characteristics and geometry of the Wheelabrator precipitator at the Southwest Brooklyn incinerator are given in Table I [2].

3. Actual Efficiency

The actual efficiency of an electrostatic precipitator may be defined as:

\[
\eta_a = \frac{Cai - Cao}{Cai},
\]

where \(Cai\) is the dust loading at inlet of precipitator – lbs of particulate/1000 lbs of dry gas and \(Cao\) is the dust loading at the precipitator outlet lbs of particulate/1000 lbs of dry gas.

The dust loadings are corrected for variations in flow rate, moisture content of inlet and outlet gas and percent excess air during incinerator operation. Variations in pre-