OVERALL COLLECTION EFFICIENCY OF A PLATE-WIRE ELECTROSTATIC PRECIPITATOR OPERATING ON THE REMOVAL OF PM2.5

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Abstract **–The collection efficiency of a laboratory scale plate-wire electrostatic precipitator, operating in the removal of airborne $PM_{2.5}$, was carried out. The variables investigated were the applied potential (V), the gas velocity (v_o), the diameter of the discharge electrodes ($2r_{SE}$), the distance between electrodes (2c) and of the total precipitator length (L_{NE}). The test particles were high grade alumina with median diameter of 0.6 micrometers and maximum diameter of 2.5 micrometers. The results showed, qualitatively, a good agreement with the theory of electrostatic precipitation. Quantitatively, the results were compared to predictions from two existing correlations from the literature and both underestimated the precipitator overall efficiency when using the assumption of pseudo-homogeneous electrical field strength. The predictions improved significantly when the field strength was calculated with the equation proposed by Kihm *et al.* (1985, 1987) and included a homogeneous space charge, as proposed by Riehle (1997).**

Keywords**: electrostatic precipitator, overall collection efficiency, gas cleaning, $PM_{2.5}$.**

I. INTRODUCTION

The concern with the environment is becoming more and more present in the daily life of everyone. An increasing involvement with the environmental issue is demanded from the governments, companies and, eventually, from the society as a whole. Conscious decisions need to be taken to preserve the ecosystems with minimum interference in the development of the nations. These ideas are contained in the Declaration of Rio on the Environment and Development approved in the ECO´92 (UNEP, 2005), which assumes as a principle the acquisition and improvement of the necessary scientific knowledge for promoting the sustainable development.

Of the several aspects involved in the study of air pollution, the presence in the atmosphere of particles smaller than 2.5 μm in diameter is becoming a matter of great concern. These particles, known as PM2.5 or high risk respirable particles, have been proved to be very harmful to the human health, especially to the children, the elderly and the sick (Ferin *et al.*, 1990; Oberdörster *et al.*, 1990; Pui and Chen, 1997). These particles possess a high superficial area, thus favoring the adsorption of toxic substances and increasing the potential harmful effects to the human organism (Donaldson *et al.*, 1998, Harrison and Yin, 2000). PM2.5 is directly associated to asthma, bronchitis, loss of the breathing capacity and has been pointed as responsible for the decrease of the life expectation in some areas (Donaldson *et al.*, 1998; Preining, 1998; US-EPA, 2000).

Therefore, a more rigorous control of PM2.5 is necessary and the electrostatic precipitator (ESP) stands out as an air cleaning equipment with high removal efficiency in a wide size range, including sub-micron particles (Parker, 1997).

Although relatively well studied, the behavior of the electrostatic precipitators lacks experimental data on their performance due to the high number of influential parameters, that include: particle properties (density, electrical resistivity, size distribution, etc.), process variables (gas velocity, particle concentration, etc.), construction and geometrical elements (electrode type and geometry, space between the plates and electrodes, etc.), and operational variables (applied potential, corona polarity, dc and pulse energization, cleaning frequency, etc).

Attempting to maximize the performance of the precipitators, many researchers (for example, Chang and Bai, 1999; Miller *et al.*, 1998; Navarrete *et al.*, 1997; Acha *et al.*, 1996; Abdel-Sattar, 1991) have addressed the problem of quantifying the influence of some of these variables. However, the quantity of experimental data on the performance of electrostatic precipitators is still relatively scarce, even more in PM2.5 size range (Kocik *et al.*, 2005; Bacchiega *et al.*, 2006).

The present work evaluates experimentally the influence of the gas velocity, the field strength, the diameter of the discharge electrodes and of the distance between them in the performance of a plate-wire precipitator (see basic dimensions in Fig. 1) operating in the removal of very fine particles. Theoretical predictions are presented and discussed.

II. COLLECTION EFFICIENCY

Evald Anderson's pioneer work in 1919 and Walther Deutsch in 1922, gave origin to the classic equation of collection efficiency for electrostatic precipitators, known as equation of Deutsch-Anderson (e.g. White, 1963), given by: