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EHD flow in a wide electrode spacing spike–plate electrostatic precipitator under positive polarity

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Abstract

In this work, results of two- and three-dimensional particle image velocimetry (PIV) measurements of the flow velocity fields in a wide spacing spike–plate electrostatic precipitator (ESP) under positive polarity are presented. A DC voltage of positive polarity (up to 28 kV) was applied to the spike electrode. The average gas flow velocity was 0.6 m/s. The PIV measurements were carried out in four planes perpendicular to the plate electrodes. Three parallel planes passed along the ESP while one plane passed across the ESP duct. The results show that electrohydrodynamic (EHD) secondary flow with relatively strong vortices exist in the ESP. The EHD secondary flow pattern depends on applied voltage and measuring plane position in respect to the spike tip. The strongest vortices occur in the plane passing through the tip of the upstream-directed spike. These relatively strong EHD vortices may hinder collection of the particles in the diameter range of 0.1–1 μm in the wide electrode spacing spike–plate ESPs.

Keywords: Electrostatic precipitator; EHD flow; PIV measurements

1. Introduction

Electrostatic precipitators (ESPs) are being widely used as dust particle collectors due to their high total particle collection efficiency (99.9%) with a low-pressure drop. However, the collection efficiency of particles of submicron size is relatively low [1].

An ESP modeling and measurements performed downstream of full-scale ESPs show that the dust particle collection efficiency depends on the gas flow velocity, applied voltage, particle physical parameters, electrode geometry and on the EHD secondary flow [2–4]. The most difficult to collect are particles in diameter range of 0.1–1 μm, with a maximum for particles having a diameter of about 0.5 μm.

The influence of the EHD secondary flow on the collection efficiency has been debated for decades. The results of the modelling of particle collection efficiency [2] suggest that the particle collection could be significantly improved if the EHD secondary flow were eliminated. Consequently, improvements in the geometry and operating conditions in ESPs should be performed to reduce the EHD secondary flow in them.

One of the proposals for eliminating the EHD secondary flow in ESPs is the use of a spike discharge electrode. However, there is a lack of information on the EHD secondary flow in the ESPs with such an electrode arrangement.

Recently, the particle image velocimetry (PIV) technique has become a powerful tool for measuring the flow patterns in ESPs. In [5,6] the PIV measurements were focused on the existence of EHD secondary flow in wide electrode spacing ESPs under positive polarity, which, according to the modelling presented by Kogelschatz et al. [2], influences the collection efficiency of submicron particles. The relatively wider spacing ESP operation was chosen since such an ESP can be applied to the collection of high resistivity dust particles [1]. The ESP operation under positive polarity was used because of the relatively low ozone generations and the potential for the reduction of NO_x and SO_x.

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