Journal of Electrostatics 67 (2009) 123–127

Contents lists available at ScienceDirect

Journal of Electrostatics

journal homepage: www.elsevier.com/locate/elstat

Electrohydrodynamic flow patterns in a narrow electrostatic precipitator with longitudinal or transverse wire electrode

A. Niewulis [a,*], J. Podliński [a], J. Mizeraczyk [a,b]

[a] Centre for Plasma and Laser Engineering, The Szewalski Institute of Fluid Flow Machinery, Polish Academy of Sciences, Fiszera 14, 80-952 Gdańsk, Poland
[b] Department of Marine Electronics, Gdynia Maritime University, Morska 81-87, 81-225 Gdynia, Poland

ARTICLE INFO

Article history:
Received 24 September 2008
Received in revised form
19 November 2008
Accepted 6 January 2009
Available online 24 January 2009

Keywords:
Electrostatic precipitator
Narrow ESP
EHD flow
PIV measurements

ABSTRACT

Results of 2- and 3-dimensional Particle Image Velocimetry (PIV) measurements of the flow velocity fields in narrow electrostatic precipitators (ESPs) with either a longitudinal or transverse wire electrode are presented in this work. The obtained results confirmed that the particle flow in the ESP have a strongly 3D character mainly due to applied voltage and narrow cross section of the ESP duct. It was found that several vortices were formed along and across the ESP duct. The complex character of the flow in both ESP may considerably affect the particle collection efficiency of the ESP. This issue is under investigation.

1. Introduction

The electrostatic precipitators (ESPs) in spite of high overall collection efficiency (about 99.5%) are not efficient for reduction of submicron particles [1,2]. The fine particle collection efficiency in typical ESPs is low, typically of 70–80%. The collecting of fine particles is very important, because many of them, having a size from 0.1 μm to 1 μm have a detrimental effect on human and animal health. The fine particles may contain hazardous trace elements such as lead, mercury, arsenic, zinc, biological agents and others.

The collection efficiency of ESP is strongly dependent on the dust-particle properties, electric field, space charge, particle physical parameters and electrode geometry. The interaction between the electric field, space charge and gas flow results in considerable turbulence of the flow [3–10], which seems to lower the fine particle collection efficiency. According to [8–10], the turbulence should be reduced to improve the fine particle collection efficiency. Also improving other factors, such as ESP electrode geometry or ESP operating conditions may also increase the fine particle collection efficiency. Therefore, knowledge of the flow patterns in ESPs is essential for studying the performance of ESPs.

In this paper results of 2- and 3-dimensional Particle Image Velocimetry (PIV) measurements of the flow velocity fields in narrow ESPs with either a longitudinal or *transverse* wire electrode are presented.

2. Experimental apparatus

The experimental apparatus used in the present work consisted of an ESP, high voltage supply and standard 2D or 3D PIV equipment [11] for the measurement of velocity field (Fig. 1).

The ESP with longitudinally to flow placed wire electrode was a parallelepiped (300 mm × 30 mm × 30 mm) made of a glass and the ESP with transversely to flow placed wire electrode was made of a transparent acrylic (900 mm × 40 mm × 50 mm) (Fig. 2). The collecting electrodes were two plates placed along the ESP at its bottom and top. For ESP with longitudinal wire electrode two versions of ESP were used: A and B (Fig. 2a and b). In version B plate electrodes were 120 mm long. Similarly, for ESP with transverse wire electrode versions C and D were used (Fig. 2c and d). In version D plate electrodes were 180 mm long.

The positive voltage of up to 18 kV was applied to the wire electrode through a 10 MΩ resistor, while the collecting electrodes were grounded. The experiment was carried out with cigarette smoke as a tracer particles (particles size less than 1 μm in dry air). Air flow seeded with a cigarette smoke was blown along the ESP duct with an average velocity of up to 0.9 m/s. The PIV

* Corresponding author.
E-mail address: aniewulis@imp.gda.pl (A. Niewulis).

0304-3886/$ – see front matter © 2009 Published by Elsevier B.V.
doi:10.1016/j.elstat.2009.01.001