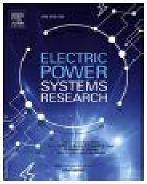
Electric Power Systems Research 203 (2022) 107634

Contents lists available at ScienceDirect

Electric Power Systems Research

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



Novel accurate modeling of dust loaded wire-duct precipitators using FDM-FMG method on one fine computational domains

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ARTICLE INFO

Keywords:
Electrostatic precipitators
Full multigrid method
Fine computational domain
Finite difference method
Ion mobility

ABSTRACT

Worldwide, electrostatic precipitators (ESP) have been extensively utilized to separate fine particles for diverse large-scale industrial applications. In this regard, this paper presents a novel approach for modeling the dust-loaded ESP on the fine computational domain where the need for a fast solver arises. Unlike the previously published numerical techniques, the finite difference method (FDM) integrated with a full multi-grid method (FMG), labeled FDM-FMG, is developed to resolve Poisson and continuity equations on one fine computational domain. For clean and dust-loaded ESP, the proposed FMG is checked versus successive over-relaxation (SOR) on fine domains where the proposed one is greatly transcendent in terms of convergence characteristics and hence the computational performance (CPU time). For the first time, two major issues are highlighted and solved: the first concerning issue is the chosen ion mobility as an important factor in the simulation results and the second one is choosing an optimal computational grid for dust loaded precipitators that grantees both low truncation and roundoff errors, results in well-matched with experimental measurements nominated in the previous publishing. The novel idea of working on various grid sizes and tracking the optimal ones gives the FDM-FMG an advantage of predicting a precise picture for the electrical situations in industrial ESP over the other numerical techniques. After all, the impact of changing the spacing between the different wires and the height of the ionized wires on the distributions of current, ion, and particle charge densities on the ground are deeply simulated and presented in dust-loaded ESP. The proposed FDM-FMG can be a promising tool for the designers and manufacturers of precipitators, thanks to its superior computational performance.

1. Introduction

Recently, the world witnessed a growth in electrical power generation which is met by an increase in the gas flows resulted from the industrial power stations. These industrial power plants cause air pollution which can be minimized by using electrostatic precipitators [1, 2]. Besides, precipitators remove the sulphuric acid produced from gold recovery technologies [3, 4]. The most widespread type of precipitator is the wire-duct electrostatic precipitator (ESP) consisting of a number of paths formed by parallel grounded plates with several wires centrally precipitators. Accordingly, the electrical problems concerning the operation during different loading conditions can be predicted. The most affecting parameters on the performance of wire-duct ESPs are wire diameter, the distance between wires as well as the height of the wire over the grounded plate. The numerical techniques implemented to model the corona problem in ESPs are classified as follows: finite difference method (FDM) [2, 6, 7], finite element method (FEM) integrated with FDM [8], boundary element method (BEM) combined with the method of characteristics (MOC) [9], BEM integrated with FDM [10], FEM [11], charge simulation method (CSM) [12], and FEM combined