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QUANTITATIVE ANALYSIS OF THE FLOW, MIXING, AND SIZE SEGREGATION PHENOMENA OF MUNICIPAL SOLID WASTE PARTICLES ON A TRAVELING GRATE OF WASTE-TO-ENERGY (WTE) COMBUSTION CHAMBER

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ABSTRACT

Flow, mixing, and, size segregation of Municipal Solid Waste (MSW) particles on the traveling grate of a mass-burn waste-to-energy (WTE) combustion chamber is analyzed for understanding those parameters that control the combustion processes and for designing the chamber. In order to quantify these phenomena, a full-scale physical model of the reverse acting grate was built and used for investigating the effects of the motion of the reverse acting grate under a MSW packed bed with tracer particles ranging from 6 -- 22 cm in diameter. Based on these experimental data, a stochastic model of MSW particle within the packed bed on a traveling grate was applied for simulating the MSW particle behavior. The result shows that the motion of the traveling grate, whose speed ranged from 15 to 90 reciprocations/hour, increases the mean residence time of small and medium particles by 68% and 8%, respectively, while decreasing the mean residence time of large particles by 17%. This is because of size segregation of particles known as the Brazil Nut Effect. When the ratio of particle diameter to the height of moving bar, d/h , increases from 0.46 to 1.69, the mixing diffusion coefficient, De at 60/hour., decreases from 96 to 38.4. This indicates that the height of the moving bars should be greater than the diameter of targeted particles.

KEYWORDS: Waste-to-energy (WTE), stochastic analysis, municipal solid waste (MSW), reverse acting grate, size segregation, residential time distribution (RTD)

INTRODUCTION

The complex behavior of heterogeneous municipal solid wastes (MSW) particles on the traveling grate of a mass-burn waste-to-energy (WTE) combustion chamber is the primary

concern for controlling the combustion process. The movements of particles depend on three elements: 1) MSW properties (such as particle size, shape, density, etc.), 2) geometric parameters (such as design of grate system), and 3) operational parameters (feed rate and reciprocation speed of moving bars). Therefore, modeling the behavior of each MSW particle is mathematically complicated. Some important studies of mixing phenomena on a traveling grate have been conducted in the past, but they have not considered the importance of the size distribution of MSW particles. The combustion chamber was considered as a combination of several continuously stirred reactors (CSRs) by Beckmann and Scholz [1]. In this bed model, an effective reaction coefficient was determined by data from a batch stoker test plant. Their research concluded that the model was successful for describing unsteady combustion of MSW. They also carried out residence time analysis using clay, wood and ceramic spheres in a small-scale model of the reverse acting and forward acting grates [2].

Because of the size limitation, "as-collected" MSW cannot be used in small-scale models. On the other hand, full-scale grate models have not been used for examining solid waste mixing, because of difficulties in construction. However, a full-scale model would allow investigating the motion of actual "black bag" MSW collected from local communities. This is an important consideration since the motion of "as-collected" MSW samples on a full-scale grate can represent similar geometries and actual combustion chamber conditions of commercial WTE plants. For these reasons, in this study a full-scale model of a reverse acting grate was built and actual MSW particles were used in calibrated particle tracer tests. Also, for simulating the movement of each particle more precisely, a