Experimental and Numerical Evaluation of the Residence Time Characteristics on a Forward Acting Grate

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1. Introduction

A large number of technical applications for heat generation deal with forward acting grates on which waste and biomass are burnt. In order to operate these plants efficiently, a sole control of properties at the reactor outlet is not sufficient, because these measurements at the reactor outlet do not allow estimating the local properties within the reactor. Therefore, a fundamental understanding of the thermo- and fluid dynamics is indispensable in their performance, design and scale-up. Therefore, the objective is to evaluate experimentally and numerically the transport behaviour of a moving bed on a forward acting grate.

The Discrete Element Method (DEM), also called a Distinct Element Method, is probably the most often applied numerical approach to describe the trajectories of all particles in a system. Thus, DEM is a widely accepted and effective method to address engineering problems in granular and discontinuous materials, especially in granular flows, rock mechanics, and powder mechanics. Pioneering work in this domain has been carried out by Cundall [1], Haff [2], Herrmann [3] and Walton [4]. For a more detailed review the reader is referred to Peters [5].

In order to improve incineration of municipal solid waste the pilot grate furnace TAMARA is operated at the Karlsruhe Institute of Technology where experiments were carried out. The length and the width of the grate amount to L = 3.2 m and W = 0.8 m, respectively. The declination of the grate is $\alpha = 8^\circ$. The grate consists of 18 alternating fixed and moving overlapping bar rows. The length of a grate bar is l = 0.307 m and its height amounts to h = 0.075 m with an inclination of $\beta = 16^\circ$.

2. Results

The present study investigated experimentally and numerically into the residence time of a packed bed on a forward acting grate. In order to assess experimentally the transport characteristics of a forward acting grate it was operated with expanded clay and wood chips without combustion. As main influencing parameters, amplitude and frequency of the bars in conjunction with the feed rate of the grate were investigated. Due to a segregation process taking place on the grate bigger particles move faster than smaller particles. Hence, the residence time is inversely proportional to the particle size. Furthermore, experiments indicated that a varying amplitude of the grate bars has no significant effect on the transport velocity. However, increased frequencies of the grate bars lead to reduced particle velocities relative to the grate. Within the numerical approach the moving fuel bed was represented by spherical particles of different sizes. The motion of the packed bed was described by the classical Newtonian approach for each individual particle. In order to estimate a residence time of the packed bed, the Mean Velocity Method and the Tracking Method were employed. The former yielded mean residence times within a range of 49–53 min, whereas a mean residence time of app. 66 min was obtained by the latter. This difference is attributed to the distribution of residence times of individual particles and differences in the averaging procedures. Furthermore, experimental results were confirmed that the residence time of individual particles is strongly affected by its size. Larger particles move faster than smaller ones. The mean residence times estimated by Tracking Method varies in a factor of app. 2.5 from 20 to 50 min depending on the particle size as shown in fig. 1. Hence, the classical Newtonian approach in conjunction with the Tracking Method are sufficiently accurate to evaluate the mean residence time of a forward acting grate.

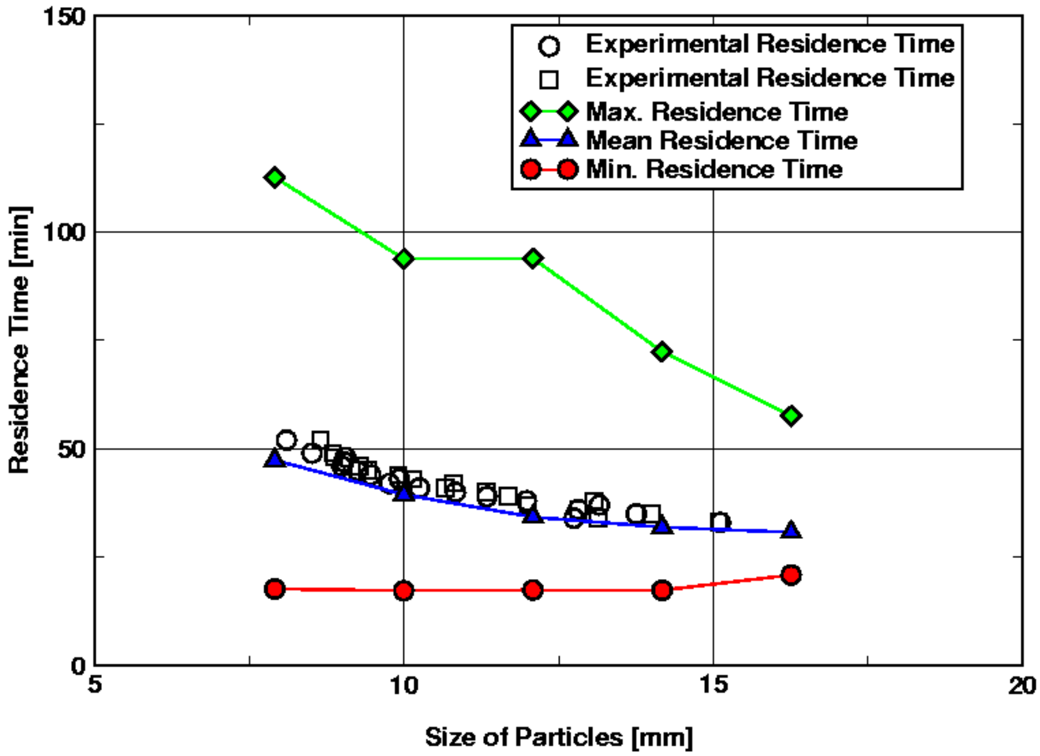

Figure 1: Distribution of residence time versus particle size

3. References

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