Direct simulation Monte Carlo method for acoustic agglomeration of $PM_{2.5}$ under standing-wave conditions

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The $PM_{2.5}$ emissions from coal-fired power plants, industrial processes and vehicles have caused adverse health effects to individuals. Because of their tiny sizes, it is difficult for the conventional particulate removal devices like bag filters and electrostatic precipitators (ESPs), to effectively capture $PM_{2.5}$ from the flue gas. Consequently, large amount of the fine particles are emitted into the atmosphere. It has been expected that the collection efficiency of $PM_{2.5}$ by conventional particulate removal devices can be improved by means of preconditioning technologies such as acoustic agglomeration (Liu *et al*, 2011; Ramin and Etienne, 2015). Through acoustic agglomeration the particle number concentration decreases and the average particle size increases, the large-sized particle aggregates can then be removed by the particulate removal devices.

Although acoustic agglomeration has been studied for decades, its dynamic process has not yet been well understood. Therefore, in this work we aim at modelling and simulating the acoustic agglomeration process on the basis of the direct simulation Monte Carlo method, which has shown great advantages in investigating the collision and agglomeration of particles in gas-solid two-phase flows (He *et al*, 2015; Hussain *et al*, 2013). In our model the acoustic agglomeration mechanisms of orthokinetic interaction and gravity are included in the equations of particle motion, while contributions of the other mechanisms, i.e. acoustic wake, mutual radiation pressure effect and Brownian diffusion, are implemented using a simple additive combination of the agglomeration kernels.

Based on the model described above, the processes of acoustic agglomeration are intensively studied. The effects of different mechanisms on the acoustic agglomeration are obtained, and the influences of the acoustic intensity, the frequency (see Fig. 1) and the particle size distribution on the acoustic agglomeration of $PM_{2.5}$ under the standing-wave conditions are examined. Furthermore, we also give the snapshots of acoustic agglomeration.

The simulation results suggest that the orthokinetic interaction and the gravity dominate the acoustic agglomeration, and that the efficiency of acoustic agglomeration increases with increases in the acoustic intensity, the frequency, the average particle size. Moreover, the snapshots show clearly that the drifting behavior of the particles subjected to acoustic standing-wave filed.

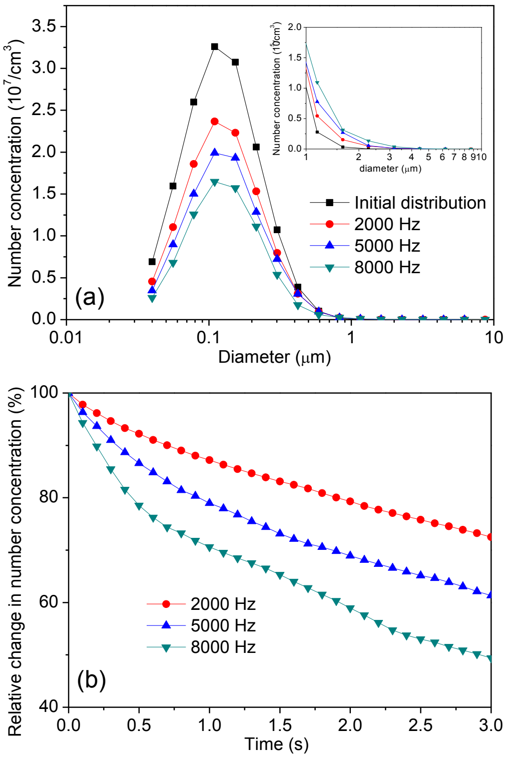

Figure 1. $PM_{2.5}$ agglomeration under different acoustic frequencies

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