SIMILARITIES BETWEEN GAS-SOLID FLUIDIZATION IN THE PRESENCE OF INTERPARTICLE FORCES AT HIGH TEMPERATURE AND INDUCED BY A POLYMER COATING APPROACH

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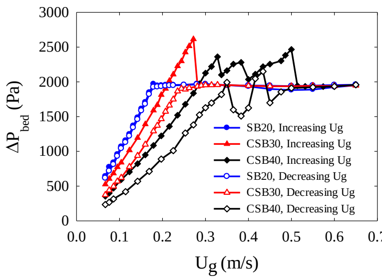
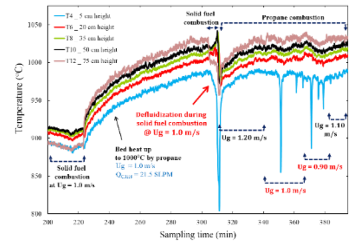
The hydrodynamics of gas-solid fluidized beds at high temperature is a critical factor in their design and operation. Nevertheless, the present understanding is far from satisfactory due to the lack of insight about the relative importance of interparticle forces (IPFs) and hydrodynamic forces. Owing to the global trend of processing lower quality feedstock in high temperature gas-solid fluidized beds, which can result in the accumulation of low melting point eutectics in the bed, focusing on the evolution of IPFs at elevated temperatures is essential. The harsh experimental conditions at high temperature only allow for the application of a limited number of measurement techniques for the purpose of hydrodynamic study. A polymer coating approach (1), however, can be adopted to reproduce the conditions of a high temperature gas-solid fluidized bed at near-ambient conditions. This technique employs inert base particles coated with a polymer having a low glass transition temperature. With this method, varying degrees of IPFs can be deliberately and accurately adjusted in the bed through controlling the inlet air temperature. This study aimed to explore the capability of the polymer coating approach in highlighting the influence of IPFs on the bed behavior in a much friendlier environment compared to a high temperature fluidized bed.

The polymer coating approach was employed in the first experimental step to attain fluidized beds with different levels of IPFs at near-ambient conditions. The second experimental step focused on the hydrodynamics of gas-solid fluidized beds at elevated temperatures in the presence of IPFs. Similarities can be observed between the results of the two parts of this study (Figures 1–6), i.e., in both cases, the minimum fluidization velocity and the bubble size growth rate with the superficial gas velocity in the bubbling regime increased with IPFs while the average in-bed differential pressure drop in the bubbling regime decreased with IPFs. The polymer coating approach is therefore capable of simulating the conditions of a high temperature fluidized bed operated under the influence of IPFs at near-ambient conditions. The agglomeration phenomenon happening in high temperature cohesive beds, however, would not be mimicked by this approach since the reptation time of the PMMA/PEA polymer is longer than the idle time of the process. The idle time, which is the time that particles spend in the emulsion phase, represents the effective contact period for the agglomeration process to advance in the bed and is longer than the agglomeration time.

REFERENCES

J. Shabanian, F. Fotovat, J. Bouffard, and J. Chaouki. Fluidization behavior in a gas-solid fluidized bed with thermally induced inter-particle forces, in: Proceedings of the 10th International Conference on Circulating Fluidized Beds and Fluidization Technology (CFB-10), 2011, US.

<table>
<tr><th>Polymer coating approach</th><th>High temperature</th></tr>
<tr><td>
</td><td>
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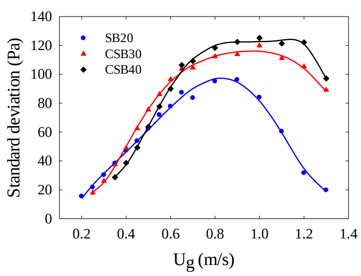
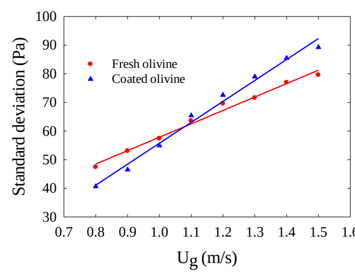
<tr><td>Fig 1. Total bed pressure drop profile during increasing and decreasing velocity passes. SB20: sugar beads at 20oC, CSB30 and CSB40: coated sugar beads at 30 and 40oC, respectively. Fresh sugar beads: dp=580 μm, ρp=1556 kg/m3.

Observation: The minimum fluidization velocity increased with IPFs.</td><td>Fig 2. Temperature profile for a bed of coated silica sand particles with eutectics having a high level of IPFs. Fresh silica sand: dp=820 μm, ρp=2650 kg/m3.

Observation: The minimum fluidization velocity increased with IPFs.</td></tr>
<tr><td>
</td><td>
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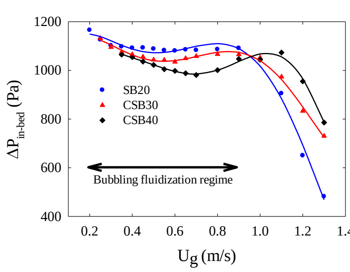
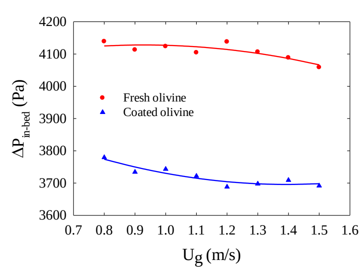
<tr><td>Fig 3. Influence of IPFs on the standard deviation of in-bed gauge pressure signals.

Observation: The growth rate of bubble size with Ug increased with IPFs. A trend inversion occurred in the bubbling fluidization regime.</td><td>Fig 4. Influence of IPFs on the standard deviation of in-bed gauge pressure signals. The level of IPFs for a bed of coated olivine particles with eutectics was at medium. Operating temperature: 1000oC. Fresh olivine: dp=565 μm, ρp=3287 kg/m3.

Observation: The growth rate of bubble size with Ug increased with IPFs. A trend inversion occurred in the bubbling fluidization regime.</td></tr>
<tr><td>
</td><td>
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<tr><td>Fig 5. Average in-bed differential pressure drop for fluidized beds with different levels of IPFs.

Observation: The average in-bed differential pressure drop decreased with IPFs in the bubbling fluidization regime.</td><td>Fig 6. Influence of IPFs on the average in-bed differential pressure drop at high temperature (1000oC).

Observation: The average in-bed differential pressure drop decreased with IPFs in the bubbling fluidization regime.</td></tr>
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