HYDRODYNAMIC BEHAVIOUR OF COAL AND BOTTOM ASH MIXTURES IN A FLUIDIZED BED GASIFIER

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Binary fluidization finds wide application in a variety of gas-solid catalytic and non-catalytic industrial processing systems. One of the principal applications of such systems are in combustion and gasification of solid fuels (coal, pet coke, and biomass), wherein the fuel and the inorganic residue ("ash") form a system of binary fluidization. Even though the fluid bed gasification of coal *per se* is a relatively well-known operation, however the technology for high ash coal (>30% ash in the native coal) is still in its nascent stage. Existing knowhow on such operations cannot predict interactions of a constantly depleting coal inventory and constantly evolving ash inventory.

With this backdrop we attempt here to study the dynamic behavior of coal and ash in a fluidized bed. In order to simulate a realistic bed composition of a gasifier, hydrodynamic characteristics were studied under various proportions of coal and ash on laboratory scale cold flow setup. A three-dimensional transient CFD model was set up to predict the dynamic and time-averaged profiles of coal and ash concentrations. The same were validated against chordal averaged solids holdup (coal and ash) characteristics measured using γ-ray densitometry, with a single collimated source (Cs-137) aligned with a scintillation NaI detector. The other part of the validation, involving the comparison of measured solids velocity profiles and CFD-predicted ones, is accomplished by implementing the Radioactive Particle Tracking (RPT) technique. In the latter technique, a single radioactive particle designed to mimic a single typical coal particle is tracked for a long time in the vessel using strategically placed scintillation detectors, and its position-time history is processed to yield the solids velocity field.

The fluidization experiments were performed on a laboratory scale fluidized bed of 13.8 cm ID employing dry air as fluidizing medium. The bed material was a mixture of coal and bottom ash. This entails to mimicking a possible state of fluidization by 'freezing' the properties of bed inventory. For present study, 46Sc tracer embedded in a PVC bead was used as solid tracer.

Figure 1 exhibits the instantaneous tracer locations in the test section in Cartesian coordinates for a limited period of 100s. The results indicate that the particle movements in fluidized beds are highly dynamic and chaotic in nature. Such randomness enhances mixing and is particularly exploited for operations such as in gasifiers or boilers which demands faster transport of energy (heat). From RPT, the mean velocities were evaluated by ensemble averaging instantaneous velocities. As the principal direction of convection is axial, the mean axial velocity tends to be higher in core and gradually decreases outwards (Figure 2a). In fact, negative velocities were also observed for locations very close to the wall. This could be possibly attributed to inability of the upward flowing air to carry the solids further due to their very low velocities near wall. The azimuthal averaged r.m.s axial velocity also exhibited a similar trend, due to conceivably a leaner core and relatively greater accumulation of coal-ash mixture in the vicinity of the wall (Figure 2b).

The final presentation will show some of these results as well as our attempts at CFD validation of these results.

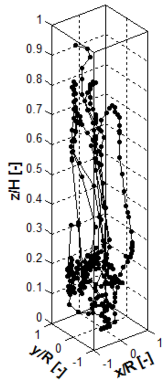
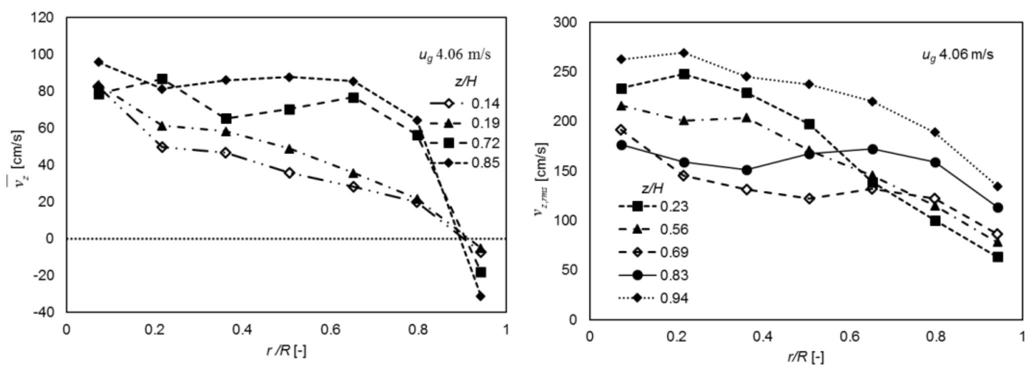


Figure 1. Instantaneous tracer position in the test section



(a) *(b)*

Figure 2. Azimuthally average, time averaged (a) axial and (b) rms velocity