Hydrodynamic flow and particle motion in dense particle suspensions during vertical ascent

P. García-Triñanes¹, J.P.K. Seville¹, B. Boissiere², R. Ansart³, M. Hémati⁴, D. Gauthier⁵, G. Flamant⁵

¹University of Surrey, Faculty of Engineering and Physical Sciences, Chemical and Process Engineering, Guildford, Surrey, United Kingdom; ²Laboratoire de Génie Chimique, INP-ENSIACET, Toulouse, France; ³Université de Toulouse; INPT, UPS Fédération de Recherche FERMAT, Toulouse, France; ⁴Fédération de Recherche FERMAT, Université de Toulouse; INPT, UPS, Toulouse, France; ⁵PROMES-CNRS, (UPR-CNRS 8521), Font Romeu Odeillo, France

INTRODUCTION

The fluidised bed holds a relevant position among up-to-date chemical and industrial processes such as drying, catalytic cracking, combustion, coating, etc. Recent developments focus on the use of fluidised particles as alternative heat transfer and storage fluids in solar energy applications due to the high dispersion level and intensive mixing of both phases that ideally leads to a uniformity of the material in the bed. The CSP project puts forward an alternative heat transfer fluid (HTF) for concentrated solar power (CSP) plants. It makes use of dense gas-particle suspensions -DPS- in tubes as HTF; these tubes set in a bundle constitute the solar absorber (receiver), placed at the top of a central receiver CSP system. This state-of-the-art HTF behaves like a liquid although it permits to extend working temperatures at temperature higher than 550°C; moreover, it may be used as an energy storage medium because of its good thermal capacity. Many important events relating to the flow of particles depend on the inherent properties of the single particles. Therefore these affect phenomena such as heat and mass transfer, segregation or attrition to name a few. The objective of this work is to improve comprehension of the particle motion in dense suspensions of particles (upward gas flow) and to contribute to the study of the hydrodynamic flow characterisation using cold setups.

EXPERIMENTS

The determination of the fluidisation properties is performed in this study by monitoring the stability of the solid flow considering a dual approach. First, taking into account the general characteristics of the hydrodynamic behaviour and assuming that the study of gas-solid systems involves the analysis of the governing parameters such as pressure drop, gas fluidisation velocity or the bed voidage (ratio of the volume of free space between the particles to the whole bed volume) and then, the properties of single particles. The bulk powders studied were SiC and γ-Al₂O₃ (A or A/B group of the Geldart classification) considering the influence of inherent particle properties such as the particle size or the surface area.

In solar energy capture systems, solar heat will be captured at the outside tube wall, and subsequently transferred to the circulating solids.

To investigate the 3D particle motion in the fluidisation system complementary studies of visualisation using the non-invasive technique PEPT (Positron Emission Particle Tracking) were carried out by using a single positron-emitting particle which yielded in-situ valuable information such as particle velocities, residence time distributions and mapping the spatial movement of the particles inside the fluidised bed and particle-wall collisions.

REFERENCES


Authors acknowledge the European Commission for co-funding the “CSP2” Project-Concentrated Solar Power in Particles e (FP7, Project N 282 932)