A novel endoscopic-laser piv/dia technique for studying high-temperature gas-solid fluidized bed reactor

A NOVEL ENDOSCOPIC-LASER PIV/DIA TECHNIQUE FOR STUDYING HIGH-TEMPERATURE GAS-SOLID FLUIDIZED BED REACTOR

Congress: ECCE10
Topic: Particulate solids/solids processing

Presenting author: Fausto Gallucci
Authors and affiliations : Ildefonso Campos Velarde:Chemical Engineering and Chemistry,Eindhoven University of Technology,Eindhoven,Netherlands|Fausto Gallucci:Chemical Engineering and Chemistry,Eindhoven University of Technology,Eindhoven,Netherlands|Martin van Sint Annaland:Chemical Engineering and Chemistry,Eindhoven University of Technology,Eindhoven,Netherlands

Abstract:
In gas-solid fluidized bed reactors, there is a strong interplay between the bubble movement and the solids motion. While the solids movement depends on the bubbles rising through the bed, the bubble diameter and bubble rise velocity, the local bubble fraction depends strongly on the solids velocity and the solids interactions. Therefore, it is important to obtain information on the hydrodynamics of both phases simultaneously. Most of the experimental research on the hydrodynamics of fluidized beds in open literature is focused either on measuring properties of the solids phase or of the gas phase. A great number of studies on fluidized bed reactors at different temperatures have been carried out with both invasive and non-invasive experimental techniques.
To enable investigation of the hydrodynamics of gas-solid fluidized bed reactors at high-temperature and reactive conditions, a new non-invasive experimental technique has been developed, based on the extension of Particle Image Velocimetry (PIV) coupled with Digital Image Analysis (DIA) using dedicated high-temperature endoscopes for image recording and laser illumination. The new endoscopic-laser PIV/DIA technique (ePIV/DIA) allows to determine simultaneously whole-field porosity distributions and solids flux profiles combined with bubble size and velocity distributions with high spatial and temporal resolution in pseudo-2D columns.
The use of the optical endoscope induces a marginal barrel distortion of the images, but increases the spatial gradients in the velocity field estimation, which requires increasing the size of the interrogation area. The high-intensity spot and the circular intensity profiles caused by the use of the optical endoscope and the high power laser are efficiently corrected by the averaged intensity plot obtained with DIA. Thus, the use of the optical endoscope and the high power laser can be used to extend PIV/DIA to elevated temperatures.
A first demonstration of the capability of the developed HT-ePIV/DIA up to 450 °C has been achieved. Measurements above 300 °C showed that the fluidization behavior is largely influenced by the operating temperature, despite the fact that the experiments were carried out at the same relative excess velocity, where specially the bubble shape and the extent of particle raining were affected. In summary, HT-ePIV/DIA is a reliable technique that allows to carry out a systematic investigation, e.g. fluidization of different types and sizes of particles and different gases at higher temperatures, in order to further study the influence of temperature on the hydrodynamics of gas-solids fluidized beds.

Reference 1:
Reference 2 :
Reference 3 :
Reference 4 :

Highlight 1: - A novel non-invasive experimental technique has been developed and validated
Highlight 2: - To allow high T operations the PIV is carried out with endoscopes and lasers
Highlight 3: - Hydrodynamics of fluidized beds can be studied at high T and under reactive conditions