ECVT IMAGING OF GAS-SOLID FLOWS IN A 90^{O} BEND

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Summary

A 3-D Electrical Capacitance Volume Tomography (ECVT) sensor is developed here for the measurement of gas-solid flows in a 90-dgree bend at the exit region of a CFB riser. The instantaneous 3-D flow structure and the volumetric solids holdup in the bend are quantitatively measured using ECVT. The experimental results indicated that the solids reflection and volumetric solids holdup distribution in the exit region was affected by the geometry of the bend and the operating conditions of the CFB.

Keywords

Multiphase and particulate reactors

Introduction

Gas-solid flows have been employed extensively in industrial operations[1, 2]. Bend vessels are commonly used in solids handling systems such as an exit vessel of a riser in a gas-solid circulating fluidize bed (CFB) and elbows to change the solids transport direction in solids pneumatic conveying. The details of the gas-solid flow behaviors in such bends are of great importance for the design of the CFB reactors and pneumatic conveying systems. Due to the lack of advanced imaging technologies in the past, the visualizations of the three-dimensional gas-solid flow patterns and the measurements of the volumetric solids holdup in the bends were rarely reported. Non-intrusive techniques are widely applied for the measurements of gas-solid flows. In this regard, ECVT has emerged as a practical technology for realistic measurements without interfering with the flow. ECVT has provided the means for imaging gas-solid flows in complex geometries due to the flexibility of its sensors [3-5]. In this paper, an advanced ECVT sensor system is devised for imaging gas-solid flows in exit regions. The developed sensor is used for the measurements of gas-solid flows in a 90^{o} bend at the exit region of a CFB riser for the first time. The instantaneous 3-D dynamic gas-solid flow structure and the volumetric solids holdup in the bed are analyzed based on ECVT images. The effect of the bend geometry and the operating conditions of the CFB on the solids reflection from the top of the bend wall and the volumetric solids holdup distribution in the exit region are also probed.

Experimental Setup

Figure 1 is a schematic diagram of the gas-solid circulating fluidized bed. The CFB unit, made of Plexiglas, consists of a 0.1-m ID riser with a height of 6.32m, a 90^{o} bend, a cyclone system, a solids storage hopper, a standpipe and an L-valve. The FCC particles (Galdart group A) with a mean diameter of 60 μm and a particle density of 1400 kg/m^3 and air are used as the fluidized particles and fluidizing gas. Figure 2 is a schematic diagram of the ECVT system. It consists of a three-dimensional capacitance sensor, a data acquisition system and a computer system for data recoding and reconstruction. The 3D-NN-MOIRT[3] reconstruction technique is used for retrieval of reconstructed images. The two-layer bend shape ECVT sensor, shown in Figure 3 (a), is developed to fit the bend-shape vessel. The sensor has two layers with 6 electrodes in each for a total of twelve channels. Figure 3 (b) is the actual image of the ECVT sensor mounted on the testing apparatus.

Results and Discussion

An experiment to monitor the solids discharge from the bend vessel was performed to test the sensor. The outlet of the bend was first sealed and solids were filled to the bend. Figure 4 shows the tomographic images of the solids discharge by gravity from the bend after the seal was removed. Red and blue colors represent high and low solids concentrations, respectively. The quantitative tomograpic images show movement of the bulk solids and the volumetric solids holdup distribution in the

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bend. More results and discussion will be presented in the full paper.

Conclusions

Electrical Capacitance Volume Tomography is an effective imaging tool in multi-phase flow systems. ECVT is applied for the first time here for the measurement of the gas-solid flows in a 90^o bend at the exit region of a CFB riser. The instantaneous quantitative 3-D flow structure and the volumetric solids holdup in the bend at the exit region of the CFB riser were analyzed. The geometry of the bend and the operating conditions of the CFB has clear effects on the flow pattern and solid holdup in the bend.

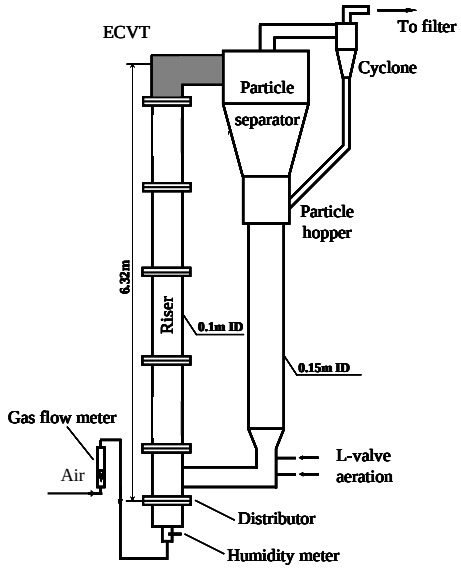


Figure 1. Schematic diagram of the gas-solid circulating fluidized bed

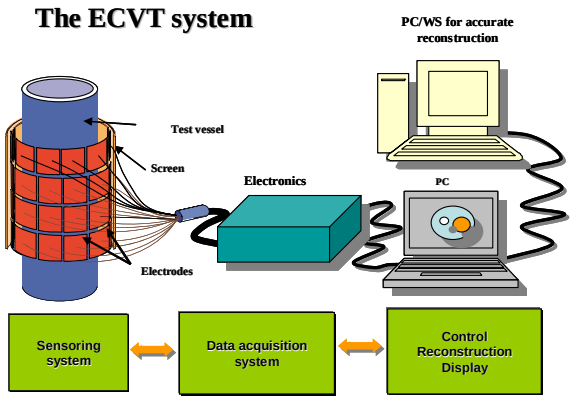
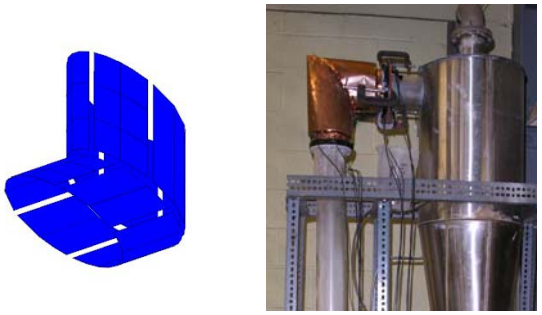
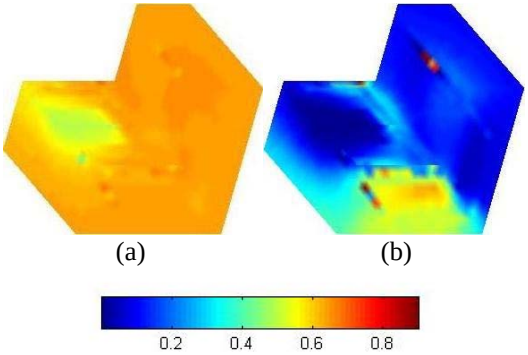


Figure 2. Schematic diagram of the ECVT system



(a) (b)

Figure 3. Bend-shape ECVT sensor: (a) sensor configuration; (b) actual sensor image



(a) (b)

(c)

Figure 4. Three-dimensional view of 3-D solids concentration in a bend-shape vessel: (a) t=0; (b) t=0.175 s; (c) solids concentration color bar

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