Measurement 44 (2011) 1436–1440

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Measurement technique for the on-line detection of fines in a fluidized bed

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ARTICLE INFO

Article history:
Received 11 July 2010
Received in revised form 8 April 2011
Accepted 12 May 2011
Available online 18 May 2011

Keywords:
Fluidized bed
Fluid coking
Gas jet
Particle attrition
Fines
Triboelectric probes
Triboelectricity
Online measurement technique

ABSTRACT

In many industrial applications knowledge of the particle size distribution in a fluidized bed and in particular knowledge of the proportion of fines, is extremely important in order to maintain good fluidization quality in the bed, and to prevent too many particles from leaving the cyclones in the gas stream. A common method of monitoring particle size in a laboratory situation is to take a sample of particles from the fluidized bed and use equipment such as a laser diffraction device to analyze the sample, which can be a cumbersome procedure. The objective of this study was to develop an online tool to monitor the proportion of fines in a fluidized bed. A novel online measurement technique for the detection of fines in fluidized beds was developed, which includes a correlation that relates the triboelectric signal to the proportion of fines in the bed.

1. Introduction

During the operation of fluidized beds, the size distribution of the particles in the bed is an important operating parameter. Specifically, knowledge of the proportion of fines, which are particles that are below an acceptable particle diameter, is important to maintain good fluidization quality in the bed, and to prevent too many particles from leaving the cyclones in the gas stream. Furthermore, in an experimental setting, the measurement of the proportion of fines in a fluidized bed can be a useful tool to evaluate the performance of nozzles or devices that increase or decrease the particle size.

Currently, one of the most common methods of monitoring particle size in a laboratory situation is to take a sample of particles from the fluidized bed and using equipment such as a laser diffraction device to analyze the sample. This method can be cumbersome, especially when the fluidized bed is not equipped with easy access to the particles in order to take the sample. Another measurement method used when the generation of fines is of interest is to weigh the fines collected by a cyclone and/or filter in the fluidized bed system. This technique can also be inconvenient, since long run times are often required to accumulate enough particles in the cyclone or filter for accurate weight measurements, and it can be difficult to collect all of the solids to be weighed from the cyclone or filter. Also, neither of these methods can be used for continuous processes, and so, during operation, the size characteristics of the bed particles are unknown.

The objective of this study was to develop a method to monitor the proportion of fines in a fluidized bed that does not require a stop in operation of the system. In order to achieve this objective, triboelectric probes were chosen as the measurement apparatus. Triboelectric probes have been used to monitor solids flow in cyclones [1], in fluidized beds [2], and in jets in fluidized beds [3]. The present study adapts these methods to the on-line monitoring of the proportion of fines in a fluidized bed.

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doi:10.1016/j.measurement.2011.05.006

Nomenclature

d_{psm}	Sauter-mean diameter (m)	V_g	fluidized bed superficial velocity (m/s)
$\bar{i}$	mean triboelectric signal (V)		

Triboelectricity occurs when friction between a flowing stream and a metal surface causes the transfer of electrons between the two objects. If the metal surface is connected to the ground, a triboelectric current is obtained as electrons flow from the ground to the metal surface. A metal surface inserted into a two-phase, gas–solid flow will transfer an electrical current that is related to the local mass flux of particles colliding with it [4]. The intensity of the electrical current will vary, depending on several factors such as the size of the particles colliding with the probe [5]. According to Matsusaka et al. [6], tribocharging or contact electrification is affected by many factors, such as chemical, physical and electrical properties of the surfaces involved in the collisions, as well as the properties of the gas.

2. Experimental setup

Experiments were conducted in a fluidized bed with a height of 3.2 m and a rectangular cross section of 1.0 m by 0.3 m, as shown in Fig. 1. The solids were silica sand particles with a density of 2650 kg/m^3 and an initial Sauter-mean diameter of 200 μm, which filled the column to a height of approximately 0.3 m. The bed was normally fluidized with air at a velocity of 0.09 m/s. The air was supplied with a high pressure compressor equipped with a dryer and its relative humidity was 11%. The relative humidity of the fluidizing air greatly affects electrostatic charging in fluidized beds [7,8] and it was essential to keep it constant. Entrained particles were separated from the gas stream by two cyclones in series. Particles from the primary cyclone were continuously returned to the fluidized bed by a dipleg. Particles from the secondary cyclone were collected after each run: under most of the studied conditions, their contribution to the new particle surface was negligible.

An attrition nozzle, with an internal diameter of 2.4 mm, was placed inside the bed at a distance of 0.16 m above the gas distributor, and injected air horizontally into the fluidized particles in order to grind the particles. A constant gas mass flow rate of 0.019 kg/s was supplied from a high-pressure cylinder to the injection

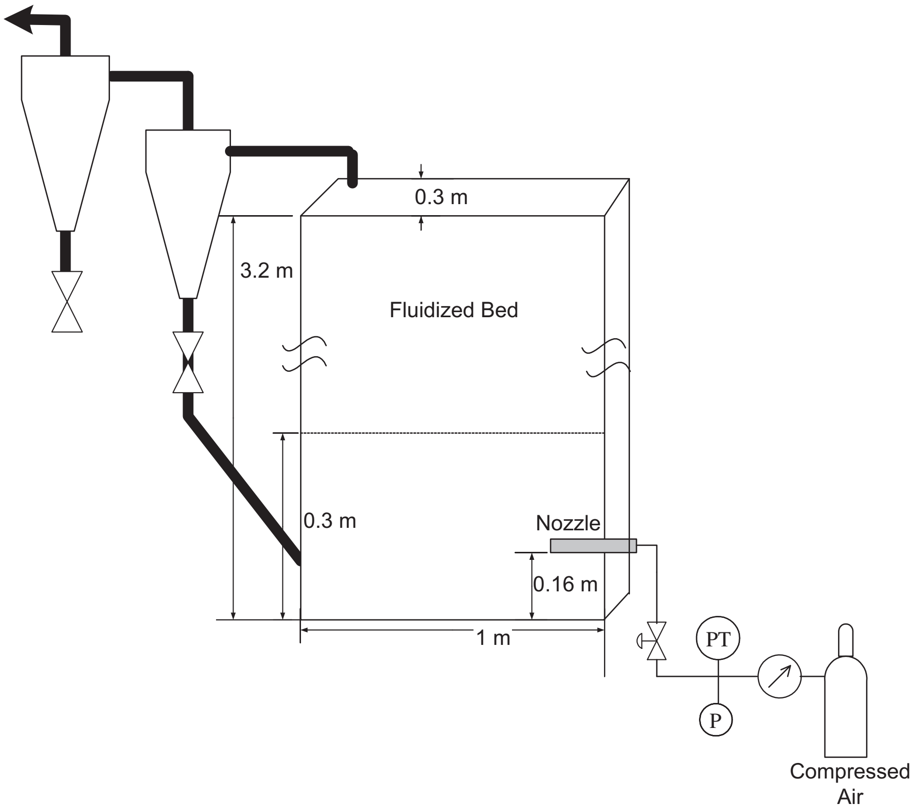

Fig. 1. Schematic diagram of fluidized bed system.