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Dosage of highly disperse powders by ultrasound agitated tube modules

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Abstract

The handling of fine disperse powders also includes controlled powder transport and dosage as important operations. This study discusses the potentials of highly dispersed powder dosage in small quantities. The powder transport and dosage is realized by means of a new device using ultrasound agitation of closed tube modules. Visual observations of the emerging powder flow and optical measurement investigations show experimental results for transport continuity of different powder materials. The gravimetric dosage of bulk materials is determined by using a load cell measurement technique.

Keywords: Ultrasound; Powder transport; Powder dosage; Fine particles

1. Introduction

In bulk material processes within process engineering applications, transport and dosage of fine powders in particular are important aspects. Thus, gravimetric dosing is a process-relevant factor. In this context, investigations are carried out for characterisation of powder dosage potential by means of a new transport device, namely the powder transport in ultrasonic agitated tube modules. The ultrasonic excitation of the tube wall is caused by connected piezoelectric ceramic elements, which enable a characteristic wave motion of the tube wall that leads to an axial powder transport. The transport mechanism in the tube is realized in addition to the micro-throw principle of conventional vibrational transport devices [1–4] where the basic ultrasonic transport mechanism of the device consists of an interaction and superposition of standing and travelling waves.

The transport and dosage behaviour of different fine powder fractions (13 nm$<d_p<$18 μm) has been experimentally investigated by using a discontinuous gravimetric weighing dosage method with a load cell. To determine the mass flow continuity of bulk materials, an extinction measurement technique was used and a visualisation principle for the temporal constancy detection.

2. Experimental details

2.1. Set-up for ultrasonic powder transport

A schematic diagram of the experimental powder transport set-up is shown in Fig. 1. To ensure a continuous feed supply into the transport module, a cylindrical bulk container was coupled with the circular tube module. The piezoelectric ring elements may be fixed to either end of the tube module. The oscillation of the tube system effectively prevents potential powder bridge formation in the powder reservoir and leads to a continuous powder feed into the tube module. Adhesion and deposition of powder at the tube walls has not been observed, showing the effectivity of powder dispersion in the tube module by ultrasound.

An aluminium tube module with length $l=500$ mm, outer tube diameter $d_R=40$ mm, and wall thickness of $h=2$ mm was used for the conveying of bulk materials. For fixing of the annular piezoelectric elements on the tube segment a combination between two actuators and the tube by a clamping mechanism (Fig. 2) has been used. For this

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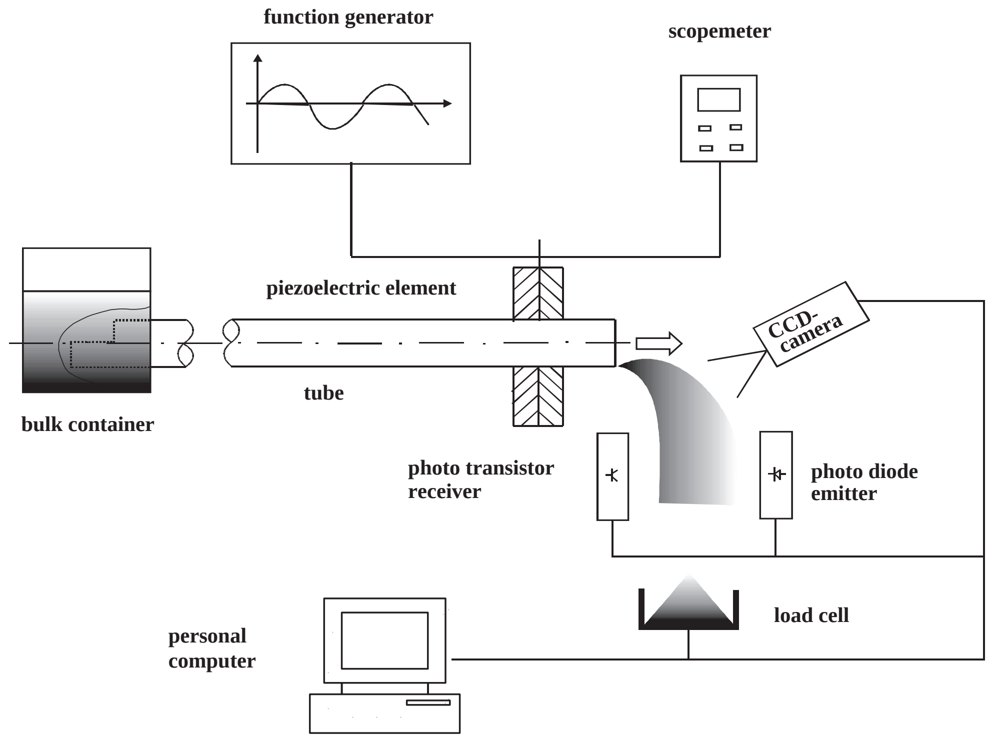

Fig. 1. Set-up for ultrasound assisted powder transport experiments.

purpose, piezoelectric rings with electrodes on the top and base annular surfaces and axial polarisation have been mounted [4–6]. Alternative mounting mechanisms are discussed in [4].

The time dependent mass flow rate at the end of the transport tube was monitored. For visual observation of the powder flow, the end of the tube module has been opened, where free flow of the powder falling under gravity out of the tube is realized. The open construction needs special attention to safety requirements, especially when using hazardeous materials as e.g. nickel powders. Therefore, a suction hood was installed above the experimental set-up to protect the operator and the surrounding against powder dust. Further on the experiments operator used protective clothing and a dust respirator.

2.2. Powder materials

Different powder materials were used in a primary particle size range from 13 nm to 18 μm with bulk densities from 0.11 g/cm^3 to 4.97 g/cm^3. The bulk materials' used and their main properties are listed in Table 1. The particles of the bulk materials are partly agglomerated due to their specific production process.

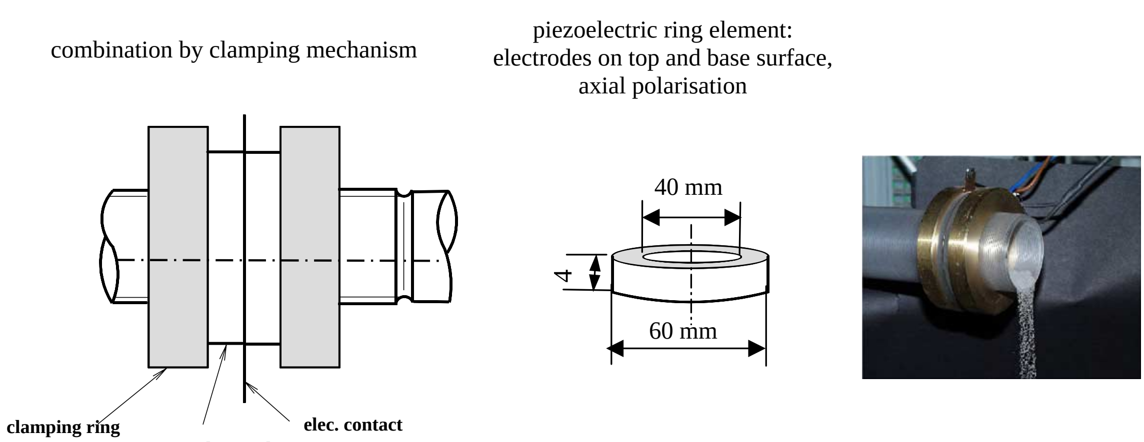

Fig. 2. Connection between actuator and tube module.