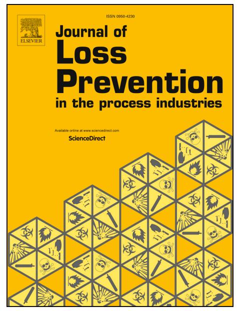

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Measurement of Electrostatic Charging During Pneumatic Conveying of Powders

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Abstract

The accumulation of static electricity during powder transport is **a possible** ignition source for explosions and, thus, a hazard for operation safety in process industry. However, due to its high sensitivity to initial and boundary conditions, the process of charge build-up is challenging to study experimentally and many of the underlying mechanisms are still not well understood. Aiming at bridging this gap, in this paper we present the results of our experimental study on the influence of a range of parameters on the triboelectric charging of powders and transport pipes. The experiments were conducted in a recently assembled test-rig that facilitates the control of the ambient conditions to a high degree. **According to our measurements, the powder charge increases if the conveying air velocity is increased. However, at a certain velocity the powder experiences a maximum charge whereas for higher velocities the charge subsequently drops.** The air velocity that maximized the powder charge depends on the pipe material, diameter and powder loading. Further, a larger pipe diameter showed to enhance the charging process significantly. The results were highly repeatable and in good comparison with theoretical predictions.

Keywords: electrostatics, triboelectric charging, fluid-solid mixture, powder handling, particle-laden flow

1. Introduction

The prevention of an accidental explosion and the mitigation of its effects constitute essential elements of process engineering. For this reason, it is crucial to comply with safety regulations in order to minimize the damage to humans and the facilities. Even though the complete elimination of the risk of an accidental explosion cannot be guaranteed in practice, all measures aim to reduce the risk of an explosion to a level which is acceptable to the operator.

Well known operational sources of ignition are open flames, hot surfaces and spark discharges. Accumulation of static electricity, in particular, is a hazard in process industry because it can lead to spark discharges. In the first instance, the grounding of all electrically conductive components and products must be ensured and the charging of insulating materials must be avoided (IEC/TS 60079-32-1, 2013, TRGS 727, 2016). However, the use and processing of insulating materials, which mainly include plastics, is inevitable in industrial plants. In the form of powders and granules, plastics are subject to various process engineering operations such as, among others, pneumatic transport through piping systems. During this process, the large specific surface area of the bulk material can result in high electrostatic charges which might be difficult to remove by grounding (Krämer, 2000).

Unfortunately, explosions caused by the discharge of electrified powders are quite common even to this day (Glor, 2001). On the one hand, this is related to the fact that electrostatic charge is not visible until a discharge occurs. On the other hand, the results concerning the charge accumulation gathered through research are inconsistent (Matsusaka et al., 2010), not reproducible (Krämer, 2000) and, consequently, many concepts underlying charge build-up are still being debated (Wei and Gu, 2015).

The main reason for these differing results can be attributed to the strong sensitivity of the electrostatics phenomenon on the boundary and initial conditions. These include the initial charge of the particles. Its influence was investigated experimentally by Masui and Murata (1983) and Yamamoto and Scarlett (1986) who shot single particles on a solid target and measured the charge exchange during the impact. They found that the charge carried by the particle prior to the impact defines the amount and even the sign of the exchanged charge. Subsequently, Matsuyama et al. (2003) demonstrated that this dependency does not only involve the amount of initial charge but even its local distribution on the particles surface. These findings were recently corroborated by the theoretical considerations of Grosshans and Papalexandris (2016c) who went on to derive a model for the non-uniform contact charging of particles. However, the initial charge is very difficult to control or measure in an experiment dealing with powder transport. Even if the powder is left at rest for a sufficient amount of time so as to ensure the discharge of possible charge to the ambiance, it may become electrified when it is fed to the system. For example, a feeding via a hopper results in collisions between the particles and the hopper, leading to an unknown amount of charge.

An alternative is to pile up an amount of powder at the beginning of a pipe, as done by Watano et al. (2003) and Watano

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