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Original Research Paper

Tribo-electrification of particles under sudden change of fluid flow in the junction between branch pipe and straight pipe

Ken-ichiro Tanoue [a,*], Yuuki Suedomi [a], Hirotaka Honda [a], Hayato Nuno [a], Tatsuo Nishimura [a], Hiroaki Masuda [b]

[a] Department of Mechanical Engineering, Graduate School of Science and Engineering, Yamaguchi University, Tokiwadai 2-16-1, Ube 755-8611, Japan
[b] Cooperative Research Center of Life Sciences, Kobe Gakuin University, Chuo-ku Kojima 1-1-3, Kobe 650-8586, Japan

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ABSTRACT

An experimental investigation of the tribo-electrification of glass beads fed by an ejector has been conducted by measuring both the current generated at the pipe wall and the specific-charge measured by a Faraday cage under sudden change of fluid flow in the junction between a stainless-steel branch pipe and a stainless-steel straight pipe. In measuring a current per unit mass, for $D_{p,50} \geqslant 206$ μm at the branch pipe section the current has a positive value as expected by the contact potential difference between glass beads and stainless-steel. On the other hand, for $D_{p,50} \leqslant 105$ μm at the branch and straight pipe section, the current has a negative value couldn't be explained solely by the contact potential difference. In measuring a specific-charge by the Faraday cage, the specific-charge has a negative highest value at the ejector. The negative specific-charge decreases along the particle flow direction. Therefore, an "unusual" charge-transfer, which couldn't be explained solely by the contact potential difference, was confirmed also by the Faraday cage. Although the charge-transfer between the beads and the inclined stainless plate with high impact speed has been examined, the sign of the current is positive for all data. It was found that the "unusual" charge-transfer in this study couldn't be caused by the high speed impaction. An negative current in air by using a stainless steel needle detected at the ejector for $D_{p,50} = 51$ μm while an positive current in air detected at the branch and straight pipe. The reason is suggested that the ion balance in the air does not keep between the ejector and the branch pipe due to both the adsorption of some negative ions on the pipe wall and the decrement of negative charge of particles. Therefore the "unusual" charge-transfer consists of not only the ionization caused by the self-discharge but also an adsorption of ions on the inner wall of the pipe.

1. Introduction

Particles in powder handling processes usually contact and rebound from the walls of equipment. During the short period of contact and rebound, charge-transfer occurs between the particles and the surface of the wall. This causes the electrification of particles [1,2] and may cause problems such as dust explosion [3] and deposition or blockage of pipelines [4,5]. On the other hand, electrically charged powders are used effectively in modern processes, such as electro-photography (copy machines or laser printers) [6], particle separation [7,8], and electrostatic powder coating [9–11]. In any application, however, it is necessary to understand the mechanism of particle charging.

Previous reports on particle contact-charging have revealed that the amount of charge transferred varies with several factors, such as particle size [12], contact potential difference (or work functions) between the metal target and the particles [7,12–14], initial charge of particles [15–17], atmospheric conditions [16–19], surface roughness of wall [20], contamination of the surface [21], and the normal component of the impact velocity [12,15,22]. Furthermore, A. Ema et al. [23] showed that the tribo-charge had a maximum value at a certain impact angle. In order to explain this phenomenon, they [23] suggested a model from the viewpoint of an effective contact area in charge-transfer. This model [23] includes rolling and slipping of the particle on the metal target. H. Masuda et al. [24] reported that the contact-charge-transfer between a rotating aluminum disc and glass beads decreased with time and approached to a constant value. Furthermore, they [24] reported that the polarity of the constant value changed for high impact angles, $\theta > 80°$, and high impact velocities, $v_p > 2.6$ m/s. Based on these findings [24], charge-transfer experiments have been conducted between an inclined stainless-steel plate and glass beads for high impact angles and high impact velocities.

* Corresponding author. Tel.: +81 836 85 9122; fax: +81 836 85 9101.
E-mail address: tano@yamaguchi-u.ac.jp (K. Tanoue).

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