Advanced Powder Technology 23 (2012) 185–190

Contents lists available at ScienceDirect

Advanced Powder Technology

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

Original Research Paper

Theoretical calculation of uncertainty region based on the general size distribution in the preparation of standard reference particles for particle size measurement

Hideto Yoshida [a,*], Tetsuya Yamamoto [a], Kunihiro Fukui [a], Hiroaki Masuda [b]

[a] Department of Chemical Engineering, Hiroshima University, 1-4-1, Kagamiyama Higashi-Hiroshima, Hiroshima 739-8527, Japan
[b] Kyoto University, Invited Special Research Fellow, Cooperative Research Center of Life Science, Kobe Gakuin University, Minatojima, Chuou-ku, Kobe 650-8586, Japan

ARTICLE INFO

Article history:
Received 25 November 2010
Received in revised form 25 January 2011
Accepted 31 January 2011
Available online 11 February 2011

Keywords:
Particle size
Standard reference particles
Truncated log-normal distribution
Uncertainty region
Size measurement

ABSTRACT

In order to confirm the reliability of particle size measurement technique and to prepare standard reference particles for calibrating particle size measurement devices, experimental and theoretical studies have been conducted about the uncertainty region of particle size measurement for the general particle size distribution. A new theoretical equation to calculate fundamental uncertainty region in the case that the maximum and minimum particle sizes are known, is derived based on Tschebyscheff theory. The uncertainty regions calculated based on the proposed method are applied to poly-disperse particles and a picket-fence distribution composed of two kinds of nearly mono-disperse particles.

For the poly-disperse particles, the uncertainty region increases with the increase in particle diameter. For the picket-fence distribution composed of two kinds of nearly mono-disperse particles, the uncertainty region increases around the intermediate particle diameters between the two kinds of particles.

Numerical simulation of uncertainty region for the picket-fence distribution has also been carried out. The uncertainty region decreases with the increase in sample size or the decrease in geometric standard deviation.

1. Introduction

Particle size distribution is measured by various methods such as microscopic method, laser diffraction and scattering method, dynamic light scattering method, electrical sensing zone method and liquid sedimentation method. Though the laser diffraction and scattering method, dynamic light scattering method and electrical sensing zone method have the advantage of shorter measurement time and good repeatability, they need complicated calibration by direct method, because these methods are number based measurements. In order to calibrate such particle size measurement devices in mass basis, it is necessary to prepare standard reference particles. As for the reference particles, spherical particles having a size range appropriate to the resolution of the measurement technique are preferable. Yoshida et al. studied on the particle size distributions of three kinds of poly-disperse spherical glass beads (MBP1–10, MBP3–30, MBP10–100) based both on improved type sedimentation balance method (mass base measurement) and microscopic method (number base measurement) with sample size larger than 10,000 particles [1,2]. These reference particles are ranged from 1 μm to 10 μm, 3 μm to 30 μm, and 10 μm to 100 μm, respectively. Round robin tests are also carried out on the two kinds of spherical particles (MBP1–10, MBP10–100), and the results are reported by Mori et al. [3].

In order to represent particle size distribution obtained by microscopic method, uncertainty region of the mass base distribution should be calculated. On this purpose, Masuda et al. derived analytical equation to calculate the necessary sample size under known fundamental uncertainty region and vice versa [4,5]. However, the original theory is thought to be applied only for the log-normal distribution.

In the real microscopic counting process, the data of particle size distribution with the maximum and minimum size for the general particle size distribution is usually obtained. In such a case, the uncertainty region of the general size distribution should be considered, but this problem has not been clearly solved.

This paper presents a new equation to estimate the uncertainty region of the general size distribution in the case that the maximum and minimum particle sizes are known. And the equation is applied to the two cases; (1) poly-disperse particles and (2) picket-fence size distribution composed of two kinds of nearly mono-disperse particles. The numerical simulation is also carried out to examine the reliability of the proposed new model. The method proposed may be applied to the uncertainty estimation of particle size distribution for the reference particles.

* Corresponding author. Tel./fax: +81 082 424 7853.
E-mail address: r736619@hiroshima-u.ac.jp (H. Yoshida).

0921-8831/$ - see front matter
doi:10.1016/j.apt.2011.01.011