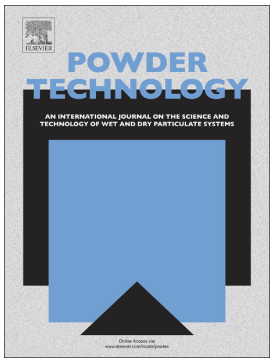

Novel 3-D homogeneity metrics of multiple components in gas-stirred liquid systems

Qingtai Xiao, Yanxia Zhang, Xiule Zhu, Jianxin Xu, Jianxin Pan, Hua Wang

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Novel 3-D homogeneity metrics of multiple components in gas-stirred liquid systems

Qingtai Xiao[1,2,3] qingtaixiao2016@kmust.edu.cn, Yanxia Zhang[1,4], Xiule Zhu[5], Jianxin Xu[1,4] xujianxina@163.com, Jianxin Pan[6] jxpan1996@126.com, Hua Wang[1,2] wanghua65@163.com

[1]State Key Laboratory of Complex Nonferrous Metal Resources Clean Utilization, Kunming University of Science and Technology, Kunming 650093, China

[2]Faculty of Metallurgical and Energy Engineering, Kunming University of Science and Technology, Kunming 650093, China

[3]School of Mathematical and Statistical Sciences, The University of Texas Rio Grande Valley, Edinburg Texas 78541, USA

[4]Quality Development Institute, Kunming University of Science and Technology, Kunming 650093, China

[5]Faculty of Science, Kunming University of Science and Technology, Kunming 650500, China

[6]School of Statistics and Mathematics, Yunnan University of Finance and Economics, Kunming 650221, China

[*]Corresponding authors.

Abstract Effective and powerful techniques to characterize the quality of a mixture with multiple components have been recently reviewed and linked with mixing mechanisms using 2-D images. However, there is no universally accepted method against experimental data in 3-D domains so far. In this paper, we introduce two novel statistical metrics for defining and characterizing homogeneity of mixture in 3-D domain using centered L_2-star discrepancy (CD) and wrap-around L_2-star discrepancy (WD). The CD and WD can be alternatives and superior to other 2-D approaches because they both exhibits some advantages such as permutation invariance, rotation invariance (reflection invariance) and the ability to measure projection uniformity. The feasibility of those developed techniques was verified by simulation and gas-liquid-particle mixture flowing in a gas-stirred liquid reactor with top-air injection. Experimental results are presented of gas-liquid two-phase flow by two indices (CD and WD) and correlation with operating conditions. The study led to a different approach to assessing mixing behaviors in 3-D domains.

Keyword gas-liquid contact system; mixing state quantification; measure of uniformity; mixing time; particle image analysis; generalized discrepancy.

1 Introduction

In metallurgical and chemical engineering processes, gas-liquid mass transfer rate is the major factor determining the reaction process Xiao et al. (2018); Zhong et al. (2016). Mixing is an important component of enhancement of gas-liquid mass transfer rate. The objective of mixing process is to obtain a certain degree of mixing uniformity in non-reactive systems, optimizing the reaction performance in reactive systems Coënt et al. (2005); Cabaret et al.