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Optical Measurement Method for Monitoring High-Mass-Concentration Slurry Sprays: An Experimental Study

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Abstract

In this study, we present a basic idea for a robust optical measurement method for the practical monitoring of slurry sprays with high mass concentrations, as typically used in combustion processes. The proposed approach is based on analyzing the transparency properties of individual dynamic droplets within the slurry spray. These so-called dynamic slurry droplets consist of a base fluid and suspended solid particles. Our method enables the determination of the mass concentration of solid particles and provides an estimate of their average size. The resolution of this technique allows for the detection of errors in the slurry-mixing process and even in the milling process of the solid particles prior to mixing. To atomize slurries with high mass concentration, an experimental setup with a gas-assisted coaxial nozzle was employed. Slurries with three different mass concentrations and three particle size distributions were tested, resulting in five combinations. The theoretical expectations and experimental results show a strong correlation, highlighting the potential of the proposed method for slurry-spray monitoring.

Keywords: monitoring slurry spray; mass concentration; optical measurement technique

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1. Motivation and Introduction

Facing the consequences of climate change, there is increasing global demand for sustainable energy solutions and a shift toward a circular economy to reduce carbon dioxide emissions. Additionally, the transition to a circular economy, which enables efficient resource management through the reduction, reuse, and recycling of materials, is essential. This transition also necessitates a shift from chemical production processes reliant on traditional petrochemical feedstocks to process routes capable of converting waste-based input streams [1,2]. These lower-quality streams differ significantly from established feedstocks due to their high heterogeneity and elevated levels of contaminants. Consequently, the development of suitable diagnostic techniques and measurement instruments for analyzing their chemical and physical properties is essential, which constitutes the primary goal of this work.

One promising route to close the anthropogenic carbon cycle is the conversion of biogenic and anthropogenic waste streams into high-value chemicals and energy carriers via pyrolysis, gasification, and synthesis, which has been investigated as an example technology by Eberhard (2017) [3], Dammann (2024) [4], and Fleck (2018) [5]. High-pressure entrained-flow gasification is a favorable gasification technology due to the high-quality syngas it produces with minimal hydrocarbons, soot, or tar. The syngas is generated by