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Application of Wavelet Transform for Analysis of Defluidization Caused by the Reaction Involving Gas-Volume Reduction

Norihiro TANAKA[1], Takami KAI[1], Kei MIZUTA[1], Tsutomu NAKAZATO[1]
And Mitsuyuki NAKAJIMA[2]

[1] Graduate School of Science and Engineering, Kagoshima University
[2] IHI Plant Engineering Corporation

Abstract

Fluidized beds have been used as catalytic reactors since the development of the fluid catalytic cracking process. Although good fluidization establishment is necessary for the stable operation of a fluidized catalyst bed, the bed is disturbed by the defluidization that occurs when the reaction performed in the bed is accompanied by a decrease in the gas volume [1]. Some methods have been proposed to prevent the defluidization caused by the decrease in gas volume [2, 3]. However, even if these methods are utilized for these types of reactions, defluidization is not perfectly suppressed. In this paper, we studied the effectiveness of pressure fluctuation signals to detect defluidization causing conditions when CO_2 methanation was performed in a fluidized catalyst bed. In addition, we studied whether the onset of defluidization itself could be predicted. For these purposes, continuous wavelet transfer (CWT) analysis was performed to determine the frequency characteristics of pressure drop fluctuations. On the basis of the results, the autocorrelation function was used to identify the fluidization conditions.

The occurrence frequency of channeling and bed lifting depended on the reaction conditions. Even when the conditions were in the defluidization region [4], the bed was observed to be fully fluidized most of the time. We investigated the characteristics in this pseudo-stable region. The pressure drop was stable in this region, and the fluctuation amplitudes were not large as compared with the results in the good fluidization region. However, a comparison among the CWT analysis results clearly reveals that the intensity above 10 Hz decreased when the conditions were in the defluidization region.

The pattern of the autocorrelation function was affected by the fluidization region. When the conditions were in the good fluidization region, the autocorrelation function changed periodically and the peak value gradually decreased with lag time. The dominant frequency was approximately 14 Hz. When the conditions were in the defluidization region. Because the maximum peak values decreased, the periodicity of the fluctuations was lowered. In addition, the dominant frequency was slightly lower than that in the good fluidization region. Generally, the dominant frequency of pressure fluctuations is related to the bubble frequency. High frequency of pressure fluctuations implies the existence of small bubbles [5]. Therefore, bubble size was probably increased in the defluidization region. Even when the bed appears to be fully fluidized according to our visual observation, the peak values of the autocorrelation functions decreased and/or the dominant frequency was lowered in the defluidization region.

When the bed was fully fluidized in the defluidization region, the fluidization quality decreased because the emulsion phase expansion was reduced by the decrease in gas volume due to the reaction. Generally, the reactant concentration is high around bubbles and accordingly the reaction rate is high in this zone. Therefore, the voidage distribution in the emulsion phase was affected by the movement of bubbles. This probably influenced the frequency and the periodicity of the pressure drop fluctuations.

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