Design of Energy Systems of Biomass Utilization in Quicklime Plants with the Technologies of Gasification and Torrefaction

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Abstract

Approximately one-third of global energy demand comes from industrial processes. The need of integration of renewable sources in energy intensive industries, such as lime, cement, iron and steel industries, is highly demanded due to the millions of tons of CO₂ emitted every year. The aim of this paper is to provide a comprehensive overview of the possibilities leading to reduction of the emitted pollutants in lime industries by incorporating fuel switching to biomass with novel fuel tranformation technologies such as gasification and torrefaction. The case study focuses on the application in a lime industry. Large amounts of energy are required for lime production, predominantly derived from fossil fuels combustion. Biomass gasification derived gas can replace part of the pet coke used conventionally. Biomass is turned into a usable gas mixture - the product gas (or syngas) is rich in CO, CH₄ and H₂. Syngas injection in the combustion furnace can effectively replace pet coke to a great extent and reduce the fuel derived CO₂ emissions. On the other hand, torrefaction, a mild pyrolysis process carried out at 200 – 300°C, is considered as an effective thermochemical biomass pre-treatment method to produce a more dense and easy to handle solid fuel. Part of the fuel’s moisture and volatiles are removed, resulting in the so called torrefied solid biomass that has higher energy density, can be crushed in fine particles more easily and has a hydrophobic nature. These attributes are great advantages compared to raw biomass. This case study uses AspenPlus™ to simulate the lime process, the gasification process and the torrefaction process and works towards the optimal integration of the renewable fuel transformation technology with the existing flowsheet. After the simulation models were validated with experimental data the optimization of the operating conditions for the gasification and torrefaction processes is achieved considering the biomass feedstock quality variability and the energy demand fluctuations. Torrefaction technology exhibited several advantages associated with the solid nature of the fuel and the ability to produce and store the solid fuel at periods with high
biomass availability.