

## 学 位 論 文 の 要 旨

専攻	安全システム工学 専攻	ふりがな 氏 名	あん へい 安 萍
学位論文題目	Process Design and Simulation of Light Calcination of Magnesite with High Efficiency (マグネサイトの高効率かつマイルドな煅焼プロセスの設計とシミュレーション)		
<p>学位論文要旨</p> <p>Magnesia has been widely used in the field of fire-resistant materials, construction materials, chemical industries, environmental protections, pharmaceutical industries, agriculture, magnesium metal and magnesium alloys. For decades, the combination of water gas generator and reverberatory furnace has been adopted in traditional caustic calcined magnesite (CCM) production process with undesirable characteristics of high energy consumption, difficult quality control, serious environment pollution. Thus, the technology for the production of CCM needs to be greatly upgraded.</p> <p>This study mainly focused on the design and simulations of novel light magnesite calcination technique with high energy efficiency for CCM production using a two-stage fluidized bed gasification system with a transport bed flash calcination process. Firstly, a two-stage fluidized bed gasification (TSFBG) system for fuel gas production was systematically simulated by Aspen Plus to identify the pre-drying effect of coal with its initial water content varying from 10-65 wt.% on gasification performance, particularly relating to the energy efficiency. The results show that the energy efficiencies based on lower heating value (LHV) (<math>\eta_{LHV}</math>) and higher heating value (HHV) (<math>\eta_{HHV}</math>) of feed coal are about 1.5%-7% and 1.5%-5% higher than the case when coal is fed to the system directly without the pre-drying. For the TSFBG system, the higher the water content is, the greater the energy efficiency reduction by the pre-drying is. The analysis of energy allocations reveals that the heat loss due to the pre-drying of coal is mainly responsible for the decrease of energy efficiency in operations with the pre-drying. With an increase in the initial water content from 10 to 65 wt.%, the <math>\eta_{LHV}</math> of the TSFBG system without the pre-drying of coal using air/steam as gasification agent reaches its maximum of about 91% at an initial water content of 26 wt.%. The <math>\eta_{LHV}</math> and <math>\eta_{HHV}</math> of the TSFBG system using oxygen/steam as the gasification agent increases energy efficiency by about 1%-2% compared to that using air/steam. For TSFBG using air/steam to gasify coal without the pre-drying, the preferred initial water content of coal is below 50 wt.%.</p> <p>Then, a transport bed flash calcination (TBFC) process applied for magnesite is systematically investigated through a process simulation to optimize the energy-saving strategy. The</p>			

high-temperature calciner flue gas is used to preheat the fed magnesite, while the sensible heat with the CCM product is cooled by air sending to the calciner. Pre-decomposition of magnesite during preheating is considered on basis of the kinetics measured using a micro fluidized bed reaction analyzer (MFBRA) that allows the minimized effect of external diffusion on reaction. With staged fuel gas supply, the TBFC process allows the equivalence ratios around 1.2 for combustion. The preferred arrangement of stages for magnesite preheating and CCM cooling are respectively 4 and 2, leading to the energy consumption of 4100 kJ/kg-CCM and the energy efficiency of 66.8%, which is almost doubly higher than the 33.9% of the conventional reverberatory furnace (RF). The pre-decomposition occurs mainly in the 1<sup>st</sup>-stage preheater, and the maximal conversion is about 13%. Varying the stages of preheating appears more influential on the energy saving than varying the cooling stages, while residence time above 1 s in the preheaters has limited effect.

Finally, the detailed and comprehensive  $\text{CaCO}_3$  decomposition under different flue gas atmospheres and different pressures through simulation are conducted to provide more fundamental and complete information for the reaction kinetics in the product gas which could strongly inhibit atmospheres and certain reference values for industrial applications. The results show that  $\text{CO}_2$  seriously inhibits the decomposition of  $\text{CaCO}_3$  and this inhibition seems to be more obvious on the initial decomposition temperature when compared with the complete decomposition temperature. The higher  $\text{CO}_2$  concentration of flue gas may lead to a narrower but higher whole temperature range for the decomposition of  $\text{CaCO}_3$ . Both the initial and complete decomposition temperatures of  $\text{CaCO}_3$  increase with the increasing of reaction pressure for different  $\text{CO}_2$  concentrations in the flue gas, indicating that the decrease of pressure is favorable for the decomposition of  $\text{CaCO}_3$ .

All in all, in this work, the high energy efficiency for light calcination of magnesite for CCM production is successfully achieved by the optimum process design and simulation. It is expected to give the guidance for the design and application for the upgrading of CCM production technique.

注) 和文 2,000 字以内又は英文 800 語以内

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