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Study of the hydration of CaO powder by gas-solid reaction

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ABSTRACT

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Keywords: Kinetics (A) Hydration (A) Microstructure (B) CaO (D) Anti-Arrhenius Hydration of CaO powders by reaction with water vapor has been studied in isothermal and isobaric conditions. Experimental tests were performed within the temperature range of 70 °C–420 °C and with a water vapor pressure from 5 to 160 hPa by means of a thermogravimetric device. Two powders, exhibiting slight differences in their physical properties, were studied. However, for one of the powders and under some temperature and pressure conditions, the reaction is not complete. The difference of behavior between both CaO powders was interpreted by considering the effect of the morphological properties on the mechanism of growth of $Ca(OH)_2$.

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1. Introduction

Hydration of calcium oxide (lime) by liquid water is a very well known reaction due to large domain of applications of hydrated calcium oxide in industry [1,2]. It is however surprising to see that only few papers have been published on the "dry" hydration of CaO or the interaction of water vapor with this oxide [3–6] in comparison with the recent growing interest of studies about CO_2 interactions on calcium oxides [7–9].

D.R. Glasson [3] studied the interaction of water vapor with different kinds of lime with specific surface areas from 1 to 100 m². g^{-1} and he observed the agglomeration of particles during hydration at room temperature. A theoretical model for this reaction has been developed [4] with some experiments on CaO pellets at different water vapor pressure and temperature. They found that the two most important variables were the water vapor pressure and the calcination temperature. In some recent works [5,6] on CaO based sorbents, an anti-Arrhenius behavior was observed and the author linked this phenomenon to the initial content of CaO. They also studied the CaO hydration and Ca(OH)₂ decomposition over a multitude of cycles with as starting material crushed and sieved limestone (CaCO₃). The hydration rate decreased with increasing number of cycles.

The aim of this work is to reach a better knowledge of the mechanism of this reaction, studying the influence of the water pressure and temperature. Two distinct CaO powders were used under the same experimental conditions and the differences, observed on the curves

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giving the fractional extent of the reaction versus time, are discussed on the bases of the growth mechanism of the hydroxide and morphology of the two powders.

2. Materials and methods

2.1. Materials

The two types of powders used in this work were provided by Lhoist R&D SA. The first one was called "SBL" (Soft Burnt Lime) and the second one "HBL" (Hard Burnt Lime). The chemical analysis shows that SBL powder is composed of 94.7% in weight of CaO and HBL powder of 96.4% of CaO. The unburnt part is 2.8% in SBL instead of 0.7% in HBL. The other impurities are in the same proportions in both powders. Then the X-ray patterns show the standard peaks for well crystallized CaO (Halite structure) for both the SBL and the HBL sample (Fig. 1).

Particle size distributions (PSD) were obtained by means of laser diffraction performed on a Malvern Mastersizer 2000 and the results are shown in Fig. 2. Both distributions are mainly bimodal. Both products exhibit aggregates of about 70 μ m and also small particles of less than 10 μ m. The 90% cumulated mass fraction is 94 μ m for SBL and 95 μ m for HBL.

The specific surface area obtained by measuring nitrogen adsorption isotherms at 77K (BET method) with a micromeritics ASAP 2000 was found to be $1.42 \pm 0.01 \text{ m}^2 \text{.g}^{-1}$ for HBL sample and $2.16 \pm 0.01 \text{ m}^2 \text{.g}^{-1}$ for SBL sample. Comparing the equivalent diameter of the individual particles obtained from these values to the PSD results indicates that the bigger size peaks of Fig. 2 correspond to porous

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