An empirical study of factors influencing lime slaking Part II: Lime constituents and water composition

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Abstract

Chloride, carbonate and sulphate ions are common constituents of many waters and are often found in high concentrations in water used for the slaking of lime. Furthermore, magnesium oxide is a common constituent of many limestones and can, after calcining, also affect the hydration rate of the lime if it is present as magnesium oxide. The purpose of this investigation was to assess quantitatively the effect of these various chemical influences, whether it be from a geological origin or present in the slaking water, on the slaking rate of lime. It was found that the presence of chloride ions in the slaking water increased the lime reactivity, while sulphate and carbonate ions in the slaking water retarded the hydration reaction. Magnesium oxide also had a detrimental effect on the slaking rate of lime.

Keywords: Lime, slaking, chloride, sulphate, carbonate.

Introduction

Limestone (mainly $CaCO_3$) is one of the most widely occurring industrial minerals world-wide. It is therefore not surprising that lime, obtained by calcining limestone, is a frequently used industrial base and features on the list of the top 50 industrial chemicals (National Lime Association, 1990). When applied as an alkali, unslaked lime, CaO, is commonly converted to slaked lime, $Ca(OH)_2$, by reacting it with water. The conversion of limestone to lime and its slaking with water, can be represented by the following reactions:

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g) \quad (1)$$

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq) \quad (2)$$

Although it is the $Ca(OH)_2$ species that is desired in the application, its production is closely linked to a number of physical and chemical influences. These include, among others, the origin of the limestone from which it is derived, calcining conditions in the kiln and constituents in the water used for slaking. The effects of calcining and storage conditions have already been reported on in a separate paper (Potgieter et al., 2002a) but the effects of different chemical constituents in both the limestone material as well as the water used for slaking have not been discussed.

Chloride, carbonate and sulphate ions are common constituents of many waters and are often found in high concentrations in water used for the slaking of lime. Furthermore, MgO is a common constituent of many limestones and can, after calcining, also affect the hydration rate of the lime if it is present as MgO. The purpose of this investigation was to assess quantitatively the effect of these various chemical influences, whether it be from a geological origin or present in the slaking water, on the slaking rate of lime. Ultimately the aim is to assist consumers in the correct choice and optimal use of the product.

Experimental procedure

Samples: The samples investigated were obtained from Lime Acres in the Northern Cape Province and represent the chemically most pure limestone deposit in South Africa. It is also the source of the bulk of unslaked lime sold in the country. The chemical composition of the material, as obtained by XRF analysis, is given in Table 1. Using the values for the percentage CaO in the sample, it was calculated that the maximum amount of $CaCO_3$ in the Lime Acres material is 98.7%.

TABLE 1
Chemical composition of the lime used in this investigation

Element	% (m/m)
SiO_2	0.8
Al_2O_3	0.3
Fe_2O_3	0.3
Mn_2O_3	1.1
TiO_2	<0.1
CaO	94.1
MgO	2.1
P_2O_5	0.0
SO_3	<0.1
Cl	0.0
K_2O	<0.1
Na_2O	0.2
LOI	1.1
Total	100.0
Av. CaO	87.8 ± 0.2
CO_2	0.7

Slaking test: The experimental procedure used has been described in detail (Potgieter et al., 2002b). It basically entails monitoring the time that a fixed mass of lime of particle size 1 to 2 mm takes to raise the temperature of a selected mass of water from 20°C to 60°C.

Grit measurement: An additional test introduced in this investigation in order to distinguish between hydration rates in various solutions, is a determination of the amount of grit produced during

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