An integrated study of limestone behavior during calcination and hydration processes

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One of the most important processes in industrial scale, represents the dissociation of carbonates to lime and CO_2. This process, called calcination, occur at relative high temperatures ($>900^0$C). Lime rapidly reacts with the water, liberating high amounts of heat producing $Ca(OH)_2$.

For the purpose of the present study five samples of different limestones from different quarries from Greece were collected. The aim of the study was to analyze the behavior of the limestones during calcination and test the hydraulic properties of the quick lime.

Limestone particles (1.6-2 cm) were reacted in a pre-heated oven at three different temperatures (900, 1050 and 1200^oC) for 30 min in order to produce quick lime. Petrographic features of studied limestones were done using secondary electron microscopy (SEM). X-ray diffractometry and Raman micro-spectroscopy were applied in order to identify the carbonate phases (calcite and dolomite) in the studied limestones. Chemical composition of limestones and limes were determined by Atomic absorption spectroscopy (AAS) method. 25 gr of the produced lime were hydrated by adding 100 ml distilled water having a room temperature ($\sim25^0$C) to produce $Ca(OH)_2$ through the exothermic reaction $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$. We measured the temperature difference in the water until a maximum value is reached; this value represents the reactivity of the produced slaked lime. Chemical composition and reactivity estimation were done following European Standards EN-459-2.

The reactivity of quick lime depends on various factors with the most important being the internal structure of the limestone, calcination temperature/duration applied to the limestone, the admixtures such as the MgO content, hard-burned phenomena etc.

The treatment of the experimental results suggests the following:

i) The $(CaO+MgO)_{Lime}$ value have similar variation for both samples calcined at temperatures of 1050^oC (58-90 wt%) and 1200^oC (57-94 wt%); whereas the samples calcined at 900^oC share a small $(CaO+MgO)_{Lime}$ value (5-17wt%).

ii) The limestones calcined at 900^0C have the lowest reactivity values in oppose to the samples calcined at 1050^0C which show the highest reactivity. The temperature rise of the limestone samples calcined at 1200^0C was lower than that of the 1050^0C.

iii) At constant reactivity rate the water required to complete hydration is lower; for example, the quick lime calcined at temperature of 1050^0C needs much less water for hydration relative to the equivalent samples at 1200^0C.

A thorough interpretation of our results suggest that the low reactivity values for the samples calcined at 900^0C could be due to the low calcination temperature or the calcination time of 30 min was too short to produce enough lime. The differences in hydraulic behavior of the samples calcined at higher temperatures of 1200^0C probably indicates that the structure of quick lime becomes more dense and compact and the grains recrystallized tending to become larger, leading to reduction of the existing pore space. Consequently, the hydration process cannot entirely proceed into the interior mass of the quick lime requiring more time to be accomplished.