THE STUDIES OF Al-DOPED TRICALCICUM SILICATE HYDRATION

W. Nocuń-Wczelik and B. Trybalska

INSTITUTE OF BUILDING AND REFRACTORY MATERIALS, UNIVERSITY OF MINING AND METALLURGY, 30-059 CRACOW, AL. MICKIEWICZA 30, POLAND

The hydration of tricalcium silicate containing Al₂O₃ admixture has been investigated using calorimetry, DTA, TG and XRD methods.

The tricalcium silicate solid solutions known as alites are the main constituent phase of portland cement clinkers. Polymorphism, structure and hydraulic activity of different alites have been widely studied for a long time and they are not fully explained till now [1-3]. The sequence of Ca₃SiO₅ polymorphic transitions can be presented as follows:

\[ \text{T}_1 \rightleftharpoons \text{T}_{II} \rightleftharpoons \text{T}_{III} \rightleftharpoons \text{M}_{Ia} \rightleftharpoons \text{M}_{IIa} \rightleftharpoons \text{M}_{IIb} \rightleftharpoons \text{R} \]

The effect of aluminium on the alite structure and properties was studied by many authors. Up to 1% the Al₂O₃ admixture forms the solid solution with Ca₃SiO₅. Introducing of more than 0.45% Al₂O₃ favours the T_{II} modification stabilization. As the Al₂O₃ concentration in solid solution increases, the temperatures of Ca₃SiO₅ polymorphic transition become lower. Al³⁺ cation can substitute Si⁴⁺ in the structure while the Al₂O₃ content does not exceed 0.45%. At higher Al₂O₃ concentrations Al³⁺ occupies also the positions of Ca²⁺. The Al₂O₃ admixture to Ca₃SiO₅ higher than 0.7% brings about the formation of liquid phase microscopically detectable during heating at 1550°C.

The modification of structure, liquid phase formation, crystal defects and other effects resulting from Al₂O₃ admixture influence also the hydraulic behavior of alites containing different Al₂O₃ content.

The comparative studies of alites containing Al₂O₃ admixtures have been carried out. The alite samples have been synthesized from the homogenized CaCO₃ + SiO₂ gel + Al(OH)₃ mixtures calcined preliminary and then heated at 1550°C. The Al₂O₃ contents in Ca₃SiO₅ were 0.25% (sample A 0.25) and 1.5% (sample A 1.5) respectively. The 0.25% Al₂O₃ content ensured the T₁ modification formation and one kind of substitution. The 1.5% Al₂O₃ content gave the stabilization of T_{II}
polymorph, two kinds of ionic substitution in the structure and acceleration of sintering process due to the liquid phase formation.

Two kinds of samples were prepared by grinding: samples of the high fineness in the range of 0–10 μm and samples with the grain size distribution corresponding to the cement of good quality i.e. 0–60 μm and the specific surface of 3500 cm²/g.

The hydraulic activity has been studied by means of calorimetry (BMR differential microcalorimeter constructed by Institute of Physical Chemistry—Warsaw, Poland), differential thermal analysis and thermogravimetry (Derivatograph Q 1500 D) and X-ray diffraction (Tur M62 diffractometer).

The samples were hydrated in the calorimeter at 25°C with the water to solid ratio of 0.5. After 72 hours calorimetric measurements the samples were removed from the calorimeter and the hydration process was stopped. The dried samples were subjected to quantitative X-ray diffraction analysis in order to estimate the unhydrated alite residue and to the DTA and TG studies to measure the bound water content in the hydration products. The results are presented in Figs 1, 2 and Tables 1, 2, 3.

The increasing Al₂O₃ content in Ca₃SiO₅ phase brings about the hydraulic activity augmentation as it has been proved by means of calorimetry, TG and QXRD. The rate of heat evolution, particularly at early stages, becomes higher. The calorimetric data are confirmed by QXRD. Almost identical values of total heat evolved for the 0–60 μm alite fraction, referred to the 1 g of hydrated alite seem to