

Interpretation of SEM images of Portland cement materials doped nanodiamonds

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Nowadays new cement materials doped fullerenes, nanodiamonds, shungites are created all over the world because of their significant influence on the properties of construction material [1]. However, the mechanism of such effect is not completely clear. This work in this field is devoted to investigation of SEM analysis effectiveness to research the influence of detonation nanodiamonds (DND) additives on the properties of Portland cement materials.

The results of researching synthesized hydrous Portland cement materials doped DND based on the clinker from Suhologsky cement work are presented. There were two series of syntheses with different DND contents (0, 0.1, 0.2, 0.5, 1–9 wt.%), distinguished by the absence (1st series) or presence (2nd series) gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ addition in the amount of 5 wt.%. To determine phase composition of hydrated samples X-Ray method (STOE STADI P powder diffractometer, transmission geometry, $\text{CuK}_{\alpha 1} = 1.54056$, $2\theta = 5-55^\circ$, $\Delta 2\theta = 0.02^\circ$, exp. 100 s.) was used. To found DND particles and to reveal the features of its distribution the scanning electron microscopy (Quanta 200 3D) was applied. SEM research was carried out in reflected electrons (high vacuum, $U = 15-20\text{kV}$, analyst S.J. Yanson).

X-ray phase analyses demonstrated that samples of both syntheses series contains at least five phases: alite Ca_3SiO_5 (C_3S), belite Ca_2SiO_4 (C_2S), and two calcium aluminate phases $\text{Ca}_3\text{Al}_2\text{O}_6$ (C_3A) and $\text{Ca}_4(\text{Al,Fe})_4\text{O}_{10}$ (C_4AF), and portlandite $\text{Ca}(\text{OH})_2$. In clinker with 5 wt.% DND (1st series) its amount is maximum, whereas with 9 wt.% this phase is almost absent, as it correlates with the strength of materials. In clinkers of 2nd series its maximum contain is in samples with 9 wt.% of DND.

On SEM-images DND particles are good seen. In the samples with 5 wt.% DND these particles create approximately equal size clusters of about 80 μm and distribute in the hydrated cement matrix uniformly. In clinkers doped 9 wt.% of DNA, the size of clusters varies from 40 to 140 μm , which are arranged randomly. Besides, the nanodiamond aggregates are associated with $\text{Ca}(\text{OH})_2$ accumulations, which is a measure of the Portland cement clinker hydration degree [2].

In general, the application of the scanning electron microscopy significantly complements results of X-Ray analysis. Interpretation of SEM images demonstrates DND additives affect the hydration of Portland cement materials, which largely determines its properties.

[1] Shablinsky G.E., Lukutsova N.P., Pikin A.A. et al., *Newsletter of MSSU* **2**, 231 (2010).

[2] Reichel W., Canrad D. Beton: in 2 B. B. 1. Eigenschaften Projektierung Prüfung. VEB Verlag für Bauwesen, Berlin, 1976.