KINETICS OF CEMENT HYDRATION THE MODIFICATION OF NANOTUBES

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Abstract. The problem of the effectiveness of the nanomodification of systems and structures of cement hardening cement paste. Implemented kinetic approach in studying the process of hydration of cement in a modification of the nanostructure of cement stone. The introduction of nanotubes optimal dosages accelerates the hydration of cement. The nanomodified system of hardening the effective activation energy is reduced by an average of 2.5 times. Chrysotile nanotubes accelerate the hydration process of cement clinker minerals, being directly involved in chemical reactions. Carbon nanotube structure the mixing water and form its cluster structure. This can create a more delicate crystal chemical structure of the cement system, a light weight water supply to the cement grains. This contributes to further accelerate the hydration process and more intense accumulation of cementitious material in the process of curing system.

Keywords: nanotubes, the process of hydration, system hardening cement, nanomodification, the effective activation energy

One of the modern trends of producing high-strength concrete is a modification of the structure connecting building composites nanoparticles of different composition and morphology [1]. Ensuring conditions for effective development of the cement hydration process at nano modification is the optimal combination of the kinetic and diffusion components of structure.

The paper studied the kinetics of hydration nanomodified and not modified cement stone. As the nano-modified additives used chrysotile nanotubes (ChNTs) [$Mg_3Si_2O_5(OH)_4$] (synthesized by the hydrothermal method for the author's method [2]) and carbon nanotubes (CNTs) brand Nanocyl-7000. Upon receipt of the cement paste with water - cement ratio of 0.33 was used Portland cement CEM I 42,5 (GOST 31108-2003) and nano-additive with a dosage of 0.01% by weight of cement. Studies of the kinetics of cement hydration process parameters were performed under thermostatic control at temperatures of 0; 20; 40; 60 ° C, with a duration of implementation of the process for 1, 3, 7 and 12 hours, more 1, 3, 7, 14, 28 days. The phase composition of the reference and nanomodified cement stone monitored by X-ray (CuKα-radiation, λ = 1,541788 Å, diffractometer ARL X'TRA); data processing was carried out automatically using PDWin 4.0 computer program.

A generalization of experimental data shows that in systems with nanomodifitsiruyuschey additive accelerates the cement hydration process substantially as a daily duration of hardening at 20 °C the degree of hydration reaches values of at least 70 – 80 %. Thus in the unmodified system such value hydration degree is not achieved at all. This is due to a decrease in 2.3 - 2.7 times the effective activation energy for the process in terms of modification of nanotubes (see table).

Table

Kinetic parameters of the cement hydration process, modified nanotubes a function of temperature

Composition	Constant hydration rate at temperatures of hardening				n.	$E_{act.}$, kJ / mol
	273 K	293 K	313 K	333 K		
Cement + Water	17.53	25.40	27.72	31.68	0.13	173.4
Cement + Water + ChNTs	45.73	54.09	56.89	57.59	0.08	64.7
Cement + Water + CNTs	42.84	53.55	56.00	57.29	0.08	76.2

When modifying cement nanotubes systems marked change in modified cement stone structure with respect to the reference system. For systems with fixed chrysotile nanotubes high amount of basic low calcium hydrosilicates ($xCaO \cdot SiO_2 \cdot zH_2O$) and calcium hydroaluminates ($3CaO \cdot Al_2O_3 \cdot xH_2O$), which have fibrous morphology. For systems with carbon nanotubes is the dominant phase of highly basic calcium hydrosilicates, as well as the presence of a small amount of tobermorite phase.

The recorded acceleration of the cement hydration process and change the modified cement stone microstructure due to the following factors. Chrysotile nanotubes accelerate the hydration process of cement clinker minerals, being directly involved in chemical reactions. They also act as the active nucleation sites, which allows to form cement stone structure with an increased content of low basic calcium silicate. Carbon nanotube structure the mixing water and form its cluster structure. This can create a more delicate crystal chemical structure of the cement system, a light weight water supply to the cement grains. This contributes to further accelerate the hydration process and more intense accumulation of cementitious material in the process of curing system. Carbon nanotubes are also nano- and microarming elements, and as a result, can significantly zoned space crystal structure of cement stone.

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