УДК 66.06.55

INTELLIGENT INFORMATION MEASURING SYSTEM TO CONTROL THERMAL CONDUCTIVITY OF NANOCONCRETES

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Key words and phrases: energy saving; information measuring system; intelligent system; knowledge base; nanoconcretes; thermal conductivity.

Abstract: The paper describes an intelligent information-measuring system, which controls the thermal conductivity of nanoconcretes, enabling to provide high quality of nanoconcrete, according to the given specifications of thermal conductivity and, therefore, to ensure energy saving and high energy efficiency of buildings and structures constructed using nanoconcrete.

Energy efficiency and conservation are the priority directions of science, technology and engineering in the Russian Federation. Ensuring the development of these directions largely depends on the use of innovative materials with low values of thermal conductivity in the construction of buildings and structures. Application and monitoring of the quality of nanoconcrete will provide significant saving of energy and costs for heating.

For research we used the concrete based on nanostructured granular filler (**NGF**) [1]. Preparation of active NGF is shown in the functional diagram of the process (Fig. 1). Controlling thermal conductivity is conducted by intelligent information-measuring system (**IIMS**), non-destructive testing (**NDT**), which should be carried out in three stages of obtaining nanoconcrete, which allows achieving high quality of the product.

The first stage involves controlling the thermal conductivity of source raw materials that can be transformed by a screw granulator *1* in granules, consisting of the core and containment. The core is obtained from a mixture of silica component (silica, gaize in Korkinsky deposits), alkali metal hydroxide and sodium silicate solution in a weight ratio. The resulting mixture is fed to a screw granulator, where it is converted into granules of the given size. Further, in a

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drum mixer *2* there is a formation of protective shell: granules are pelletized in a dry mixture of powdered lime and sodium fluorosilicate. Concrete manufacturing on the basis of NGF consists of two stages.

The second phase comprises the control of the thermal conductivity of the cement used for nanoconcrete (in this case, CEMI 42,5N manufacture of JSC "Belgorod cement"). At the initial stage cement and NGF in a certain concentration are blended with the mixer *3*, and then the products such as blocks are molded, then blocks are cured for three days in the processing chamber *4* of the shop. The second stage consists of monolith formation of composite coarse-pored structure and replacement the core granules with pores. To do this, the product is placed in a curing room *5* at temperature 80…90 ºC, where the components interact with the content of granular filler. In the granules shell, consisting of sodium fluorosilicate, and ground lime, penetrate soluble hydro-silicates, formed by the interaction of the active silica with alkali metals. Hydro-silicates fill the micropores of nanoconcrete, penetrating between the granules. In the third phase, the system controls the thermal conductivity of the produced nanoconcrete [2].

With the introduction of NGF as a filler of the composite the total porosity increases up to 55…60 %, which leads to a decrease in the thermal conductivity of nanomodified concrete by 9–12 times. Reducing the thermal conductivity is explained by the fact that in the place of granulated silica-containing nanostructured filler are formed pores with thicker walls lowering the intensity of the heat flow throughout the volume of produced composite.

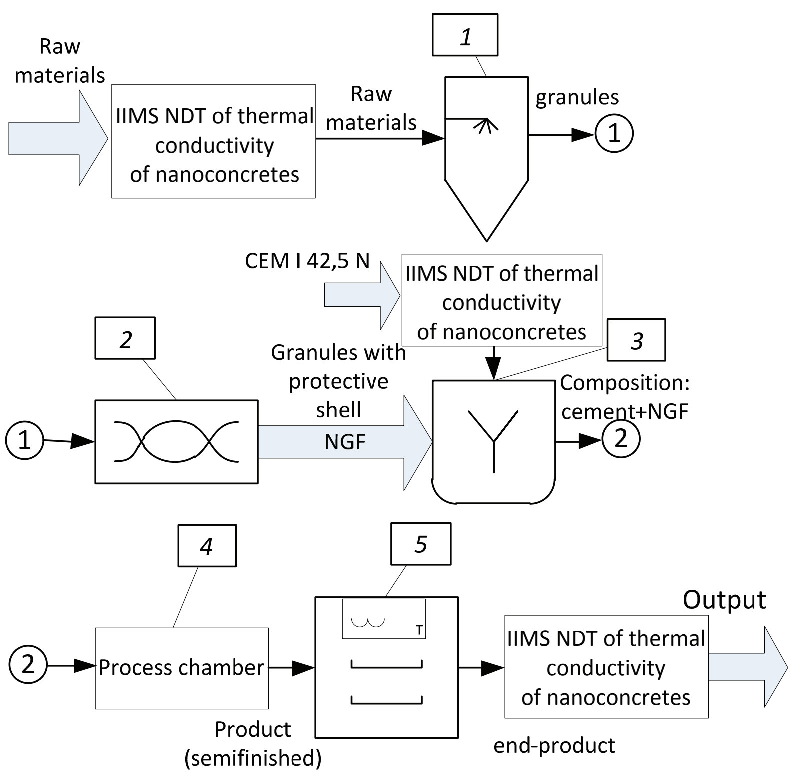

Fig. 1. Technological scheme of nanoconcrete production based on nanostructured granular filler

A mathematical model, enabling to establish the variation of nanoconcrete thermal conductivity depending on the nanostructured filler and other factors affecting the quality of nanoconcrete, was obtained as a result of experimental research and the development of analytical models depending on the composite nanomaterial λ (cement + NGF) on the total porosity, strength, water absorption, density.

Mathematical model of λ dependence on the porosity of nanoconcrete was obtained by approximation of the experimental curve by the regression equation (parabolic dependence) and has the following form:

$$\lambda_1' = -0{,}0003\,\Pi^2 + 0{,}0005\,\Pi + 1{,}11,$$

where Π is the total porosity, %; λ_1' is the thermal conductivity of composite nanomaterial obtained by the parabolic approximation.

Mathematical model of λ dependence on the strength of nanoconcrete was developed on the basis of experimental studies and has following form

$$\lambda_2' = -0{,}0005\,\sigma^2 + 0{,}0531\sigma - 0{,}31,$$

where σ is strength, MPa; λ_2' is the thermal conductivity of composite nanomaterial obtained by the parabolic approximation.

Mathematical model of λ dependence of nanoconcrete on water absorption $\lambda = f(V)$, was developed from experimental data and presented in the following form

$$\lambda_3' = 0{,}0129\,V^2 - 0{,}1V + 0{,}35,$$

where V is water absorption, wt %; λ_3' is the thermal conductivity of composite nanomaterial obtained by the parabolic approximation.

A mathematical model based on the approximation of the experimental dependence of $\lambda = f(\rho)$

$$\lambda_4' = 0{,}0011\rho - 1{,}14,$$

where ρ is density, kg/m^3; λ_4' is the thermal conductivity of composite nanomaterial obtained by linear approximation.

These analytical expressions are used in the knowledge base (**KB**) of IIMS nanoconcrete to determine thermal conductivity depending on other parameters in accordance with the technological requirements for parameters of obtained nanoconcretes and customer requirements. The structure of used information-measuring system is shown in Fig. 2.

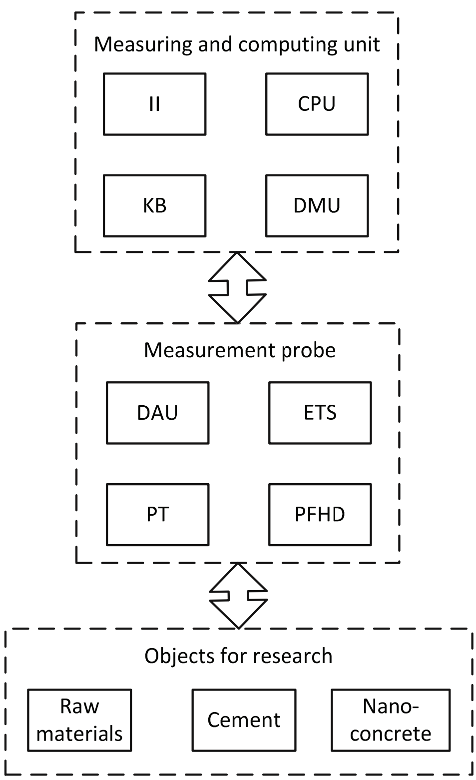

Fig. 2. IIMS NDT of nanoconcrete thermal conductivity

Information-measuring system includes the following devices: PT is the primary transmitter; DAU is differential amplifiers unit; PFHD is pulse forming heat device used in the implementation of the thermal conductivity control method, which lies in the thermal effects of the probe heater on the object of study with subsequent registration of time-temperature characteristics in the plane of contact of the probe and the object used to calculate the heat in the CPU; ETS is environment temperature sensor; KB is knowledge base; II is intelligent interface; DMU is decision-making unit; CPU is central processing unit.

We developed an algorithm of IIMS of thermal conductivity of nanoconcretes to control the quality of the nanoconcretes, which includes thermal conductivity control of the three studied objects in the implementation of control method in nanoconcrete manufacturing process technology: raw materials, cements, nanoconcrete. The algorithm allows comparing the measured thermal conductivity with valid values of nanoconcrete thermal conductivity, and, moreover, to introduce corrections to the destabilizing factors

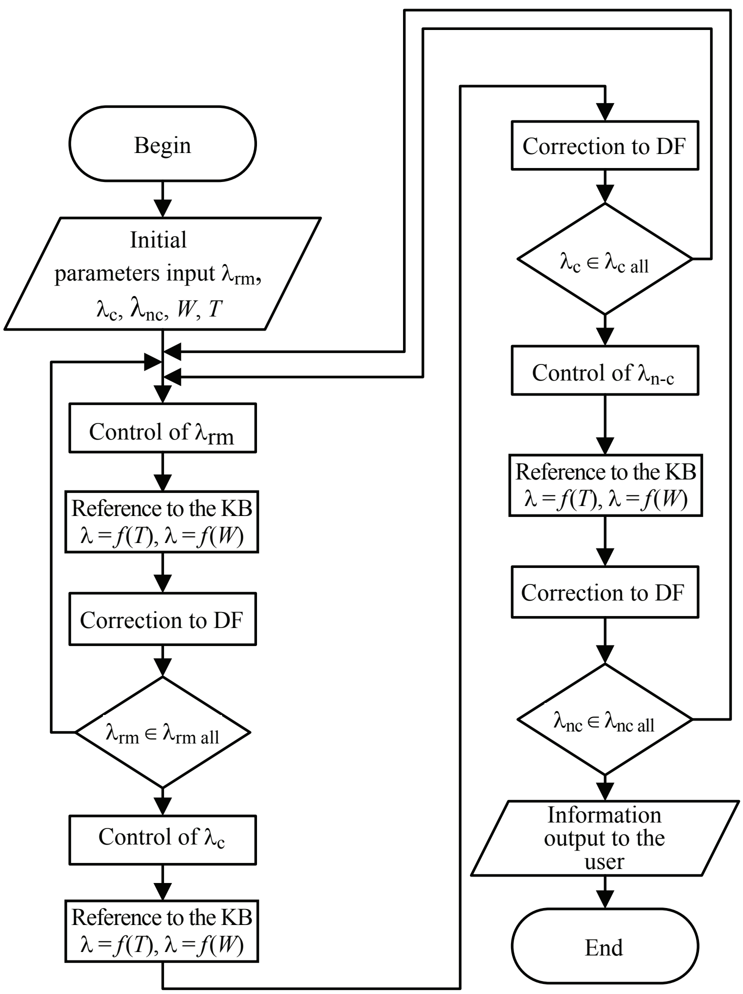

Fig. 3. The algorithm of IIMS thermal conductivity of nanoconcretes

(humidity and temperature) during the measurements (Fig. 3). When determining the λ_{nc} IIMS controls the objects under study: the raw materials λ_{rm}, the quality of cement λ_c and thermal conductivity of nanoconcrete λ_{nc}.

The proposed approach enabless to produce high quality nanoconcrete in accordance with the specifications, thermal conductivity and, therefore, to ensure energy saving and high energy efficiency of buildings and structures built with nanoconcrete.

References

1. Соловьева, Л.Н. Конструкционно-теплоизоляционные бетоны на основе гранулированного наноструктурирующего заполнителя : автореф. дис. … канд. техн. наук : 05.23.05 / Л.Н. Соловьева. – Белгород, 2010. – 16 с.

2. Селиванова, З.М. Интеллектуализация информационно-измерительных систем неразрушающего контроля теплофизических свойств твердых материалов : монография / З.М. Селиванова. – М. : Машиностроение-1, 2006. – 184 с.

Интеллектуальная информационно-измерительная система для контроля теплопроводности нанобетонов

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Ключевые слова и фразы: база знаний; интеллектуальная система; информационно-измерительная система; нанобетоны; теплопроводность; энергосбережение.

Аннотация: Представлена интеллектуальная информационно-измерительная система, осуществляющая контроль теплопроводности нанобетонов, позволяющая обеспечить высокое качество получаемого нанобетона, соответствие его техническим требованиям, заданной теплопроводности и, следовательно, обеспечить энергосбережение и высокую энергоэффективность зданий и сооружений, построенных с использованием нанобетона.
