The methods of receiving coal water suspension and its use as the modifying additive in concrete

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Abstract. Results of research of the coal water suspension (CWS) from a cake received in the electrodigit ways in the fluid environment and gas are given in article and also the possibilities of its use as the modifying additive in concrete are considered. Use of a coal cake is perspective as it is a withdrawal of the coal and concentrating enterprises and has extremely low cost. Methods of receiving CWS and possibility of formation of carbon nanomaterials (CNM) are given in their structure. Research and the analysis of a microstructure of a surface of exemplars before electrodigit processing, their element structure, dependence of durability of a cement stone on a look and quantity of an additive of CWS is conducted. For modification of cement the carbon nanomaterials received from the following exemplars of water coal suspensions were used: foams from a cake from a scrubber of the plasma modular reactor, coal water suspension from a cake from electrodigit installation. The product which can find further application for a power engineering as fuel for combustion, and also in structural materials science, in particular, as the modifying additive in concrete allows to receive these methods.

1. Introduction
Use as a part of composition of carbon nanomaterials, as a result of their complex physical and chemical impact on modes of formation and concreting of cementitious matters, leads to increase of strength indexes of termination products. In literature works on research of introduction of carbon nanomaterials to composition of cement concretes [1-4] are rather widely lit. In researches it is noted that gel-forming participation and the modifying influence of carbon nanomaterials can be result of the following interdependent mechanisms:

1) the mechanism providing decrease of the common porosity, structural change of porosity of material. The nanodimensional particles which are present at system are capable due to increase in volume is adsorptive and hemosorbtionno the water connected by them to reduce the volume of the capillary and bound and free water, to lead to change of rheological behavior of the cement test;

2) mechanism, the bound to a catalytic role of nanodimensional particles as crystallization centers and acceleration of process of hydration;

3) mechanism of zoning of structure of concreting;

4) the mechanism, the bound to a possibility of immediate chemical participation of nanodimensional particles in heterogeneous processes of phases formation of hydrated connections (such opportunity is defined as a substantial sign – by chemical and mineralogical structure of
2. The pilot unit and technique of researches
In the conducted researches for modification of cement the carbon nanomaterials received from the following exemplars of water coal suspensions were used: foams from a cake from a scrubber of the plasma modular reactor (fig. 1), coal water suspension (CWS) from a cake from electrodigit installation (fig. 2).

![Figure 1. Plasma modular reactor.](image)

1 – reactor; 2 – magnetic coil; 3 – batcher; 4 – raw materials bunker; 5 – cathode; 6 – ejector; 7 – steam generator; 8 – muffle chamber; 9 – division chamber; 10 – gas conclusion pipe; 11 – activation camera; 12 – scrubber; 13 – filter; 14 - collection of dust of a scrubber; 15 – cyclone.

In this plasmochemical installation, in the form of soot, having formed nanocarbon substances under the influence of electric arc plasma of the material of electrodes and coal given for heat treatment settle on the water-cooled top cover of the chamber having lower temperature that promotes preservation of the formed nanostructures of carbon. Also there is their ablation in a prerefining scrubber because the exhaust blower for the removal formed at plasma processing of coal of synthesis gas of an electric arc zone of the reactor is connected to installation.

Heavy particles of coal of a past plasma processing fall in an activation camera, but the mild ash unit together with synthesis gas "is sucked in" in a scrubber where there is its final condensation in the form of water coal suspension. There is a small negative pressure, gives the chance to separate large particles of coal from the sooty unit, owing to the fact that soot having low weight goes with gases to a scrubber.

At a temperature from 2000 to 4500 °C during time 0,2 – 1 sec. occur sublimation desublimation a microcomponent about coal surfaces, and also the processes of gasification and maximal opening of micropores in the center of a coal particle combined with optimum energy consumption.

Distinctive design signs of the plasma modular reactor are:
- receiving the uniform profile of temperature 2000-4500 °C in a transverse section of a camera of the combined plasma reactor by means of formation of the rotating electric arch that allows to reduce time of processing of coal up to seconds and to give to termination products special characteristics which are difficult for receiving in the existing technologies of receiving carbon nanomaterials;
- serial installation behind the plasma reactor of a chamber of a muffle, a chamber of division, a chamber of the activation combined with a pyrolysis chamber provides more flexible process control of receiving an absorbite;
in the course of plasma processing carbon nanomaterials can be formed not only of material of electrodes (by the known methods), but also that is very important, of the coal passing processing by plasma. This fact gives particular advantages for receiving carbon nanomaterials.

When carrying out experiment on electrodigit installation in capacity coal dust, with fraction from 100 microns was filled up, mixed up with water and then the received mix was processed by electric current. After giving of tension process of electrochemical processing of mix in the course of which fuming was observed proceeded. Electric discharge proceeds between an internal electrode 3 and a housing of capacity. For the uniform electrochemical processing of coal water suspension the internal electrode is executed in spherical shape and evenly rotates the electric motor 2.

![Figure 2](image)

**Figure 2.** The pilot unit for preparation of water coal fuel by the electrolytic method:
1 - autotransformer; 2 - electric motor; 3-electrode-mixer; 4 - container with water coal suspension.

The following stage of selection of carbon nanomaterials from exemplars of coal water suspension is their processing by non-polar solvent (toluene, benzene, etc.) for the purpose of extraction and division of substances. Soluble carbon nanomaterials (fullerens, nanotubes) are extracted in solvent, and the insoluble part of soot settles on the bottom of a vessel. For the purpose of increase of extraction it is possible to apply a mechanical agitation, stirring or heating in Sakslet's device, it is also possible to apply ultrasonic extraction to acceleration of process and increase in concentration.

The further stage consists in

### 3. Results of researches and their discussion

Analyses of carbon nanomaterials were carried out by means of a microscopic and spectral ultimate analysis on the scanning raster microscope JEOL JSM-6510LV. The element structure and structure of a surface of a cake before processing are presented in tab. 1 and fig. 3.4.

**Table 1. Element structure of a cake.**

| Element | Weight % | Atomic % |
|---------|----------|----------|
| C       | 43.98    | 55.26    |
| O       | 38.69    | 36.50    |
| Mg      | 0.16     | 0.10     |
| Al      | 4.76     | 2.66     |
| Si      | 7.77     | 4.17     |
| S       | 0.33     | 0.16     |
| K       | 0.41     | 0.16     |
| Ca      | 0.62     | 0.23     |
| Ti      | 0.25     | 0.08     |
| Fe      | 1.66     | 0.45     |
| Zr      | 1.37     | 0.23     |
| **Total** | 100.00  |          |
The element structure and structure of a surface of extraction of a cake after processing in elektrodigit installation are presented in tab. 2 and fig. 5,6.

**Table 2.** Element structure of a cake later elektrodigit processing.

| Element | Weight % | Atomic % |
|---------|----------|----------|
| C       | 84.05    | 88.43    |
| O       | 13.47    | 10.64    |
| Al      | 0.13     | 0.06     |
| Si      | 0.42     | 0.19     |
| S       | 0.98     | 0.38     |
| Cl      | 0.44     | 0.16     |
| Ca      | 0.32     | 0.10     |
| Fe      | 0.20     | 0.04     |
| Total   | 100.00   |          |
The element structure and structure of a surface of extraction of a cake after processing in the plasma modular reactor are presented in tab. 3 and fig. 7,8.

| Element | Weight % | Atomic % |
|---------|----------|----------|
| C       | 76.26    | 84.94    |
| O       | 14.98    | 12.53    |
| Al      | 0.64     | 0.32     |
| Si      | 2.04     | 0.97     |
| S       | 1.20     | 0.50     |
| Cl      | 0.28     | 0.11     |
| K       | 0.22     | 0.07     |
| Ca      | 0.52     | 0.17     |
| Fe      | 0.70     | 0.17     |
| Pt      | 3.14     | 0.22     |
| Total   | 100.00   |          |

From micrographs it is visible that after electrodigit and plasma processing the surface of a cake has more dispersed and homogeneous structure, and results of an ultimate analysis show increase in a composition by weight of carbon by 32-40% and decrease in a composition by weight of oxygen by 23,71-25,22%.

Changes of element structure and microstructure of a cake as a result of electrodigit processing in liquid and gas have similar character though the mechanism of influence of gas discharge plasma and electric discharge in liquid significantly differ.

Positive influence of carbon nanomaterials on characteristics of a cement stone and concrete is in full shown on condition of their uniform distribution on all volume of a composite. Cavitationsal and pulse processing (ultrasonic processing, a hydrodynamic cavitation) of mixing water with nanodispersible additives is for this purpose used. For distribution of particles of coal water suspension in water volume of a zatvoreniye ultrasonic processing within 15 min. was carried out.

When adding in a cement matrix there is a change of physicomechanical properties of a cement stone. As a result of researches dependences of durability of the modified cement stone on a look and quantity of additives of exemplars of water coal suspensions (fig.9) were filled.
Research of physicomechanical properties of a cement stone showed that for different types of additives the effect of increase in durability varies depending on their quantity. So, for exemplars of a cement stone with the carbon nanomaterials received by cake foam from a gasifier scrubber, optimum results are received at the maintenance of an additive 0,1 Mas. %. In too time, for exemplars of a cement stone from coal water suspension from electrodigit installation more good results are received at the maintenance of an additive 0,01 Mas. %. At increase the maintenance of additives to 1% cement strength loss is observed, at the same time the received results are lower than control. In our opinion, it is bound to various range of distribution of particles in exemplars of additives. Particles of the carbon nanomodifier serve as crystallization centers of products of hydration of cement that accelerates processes of hydration and concreting of cement, especially in initial terms of concreting. The effect of increase in durability of cement is shown in small dosages of additives. At the increased content of carbon nanomaterials there is so-called "poisoning" of system when nanoparticles block cement grain, reducing extent of hydration of cement.

4. Conclusion
Thus, adding of water coal suspensions positively affects improvement of properties of cement. The greatest effect of improvement of properties is shown at dosages of additives of 0,01-0,1% depending on a type of water coal suspension. Improvement of properties of cement at introduction of trace amounts of carbon nanomaterials will promote creation of high-strength and long-lived composites.

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