ENERGY OF CHEMICAL, PHYSICAL-CHEMICAL AND PHYSICAL-MECHANICAL PROCESSES AND ITS APPLICATION

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Recommendations on using chemical, physical-mechanical and physical-chemical processes of energy in generating ettringite crystals, hydrating calcium oxides, thermal processes, etc. in engineering and construction as well as in solving the problem relating to the future of power engineering are provided. The problem is solved by providing an absence of CO_2 emission.

Key words: ettringite, self-cogging, hydration, self-dispersing, rapidly hardening concrete, highly exothermic process.

Introduction

Thermal processes of chemical reactions are not sufficiently used in the construction and power engineering. Well known highly exothermic, chemical processes are not the main moving forces for solving actual practical problems.

Together with thermochemical processes, physical-chemical (for instance, crystal growth for cement self-reinforcement or for using the energy of growing crystal pressure, etc.) or physical-mechanical (for instance, self-dispersing) processes being the result of high exothermical, thermochemical reactions of hardening systems (cement and various additives) are not fully used.

Besides, for solving the problems of future power engineering (without CO_2 emission), the application of highly exothermical processes of magnesium-, silica- and aluminothermics with concurrent obtaining of hydrogen from various waters (natural, crystal, zeolite, adsorb, chemically associated, etc.) is especially important.

Inexhaustible silicium and aluminum reserves within the earth crust and magnesium – in the ocean and the sea including the chain reactions of their redox processes, except for the energy, can be also applied for producing special metals and magnesium oxide, silicium and aluminum (for obtaining high-refractory, lasers, fiber optics, materials of microelectronics, etc.).

Theory and practice of the set problems.
Energy of ettringite generation.

It is known, that ettringite mineral - $3Ca0{\cdot}Al_20_3{\cdot}3CaS0_4{\cdot}32H_20$ the generation heat of which is about 347 kcal/kg [1] making about 5% of combustion heat of fuel equivalent to 7000 kcal/kg is generated during cement hydration and hardening. However, the difference is in process kinetics (speed), as fuel burns quickly and ettringite is generated slowly and stage by stage, i.e. the energy of ettringite generation is spread in time and that is why it is not considered for heat treatment of large concrete and reinforced concrete products and structures, and large amount of fuel is consumed.

Besides, heat during steaming large products and structures is exchanged slowly and step by step from the surface to the inside of the sample which conditions various cement and concrete hardening conditions in various structure layers which is associated with the fact that the structure steaming lasts long (10-20 hrs).

The process occurs in a completely different way if highly exothermical chemical reaction occurs along the entire concrete mass of the structure and hardening at this time is quicker and heat exchange occurs from the bottom zone of concrete thickness to the structure surface. In such case, the structure steaming is either totally excluded or it is takes 2-5 times less time (up to 2-4 hrs).

The task is to use such an additive in the concrete which will provide the generation of large ettringite crystals at very first minutes and hours of the concrete hardening in the earth conditions, under water (at various water temperatures) etc. Scientific basics for producing such additive are provided in [2].

Using the mentioned scientific basics the following industrial items have been produced: centrifuged pressure pipes, chutes and slabs for canals of amelioration systems, building blocks and boards, floor slabs, sanitary cabins, etc. Waterproofing of the reservoirs and basins in the earth conditions is conducted, shotcrete is applied in subway and hydraulic tunnels, in New Afon caves, etc.

Energy of ettringite crystal growth

During independent hydration of the suggested concrete additive, from 20 to 90% of large ettringite (with 10-20 micrometer length and 3-5 micrometer width, see figure) crystals can be generated in it.

Given the construction requirements, customer can regulate the additive content in the concrete. Large ettringite crystals cause self-reinforcement of cement and increase its flexural strength by 20-30% or even more.

The energy of ettringite crystal growth in hardening cement system makes about 50-100 atm. This energy can be used for producing expanding and self-stressing cement, tendon jacking, constructing underground self-cogged high-pressure concrete tunnel [3], deteriorating ore, rocks, demolishing buildings and structures, etc. [4]. The mentioned scientific point was applied in 1997 for the reconstruction of main pressure tunnel of Enguri HHP by constructing the underground self-cogged pressure structure (tunnel diameter – 9-10m). Author of the structure was Engineer P. Akhalkatsi.

Production of the self-cogged high-pressure reinforced-concrete pipes and large diameter tanks (including spherical tanks, nuclear facilities, oil and gas well casings, oil and gas pipelines, etc.) based on this principle is suggested.

Energy of hydration and self-dispersing of calcium oxide.

Hydration heat of calcium oxide makes 279 kcal/kg [1]. Hydration of highly active calcium oxide occurs instantaneously in contacting with water and ends within several minutes from the formation of soot of calcium hydroxide. In a given case, thermochemical reaction causes self-damage (self-disperse) of lump material (lump sizes 50-100 mm). Powder with micro and nano-disperse particles is produced at the same time and large amount of heat is generated very quickly. Concurrent self-dispersing (i.e. strong and quick increase of particle surface and volume) and heating (up to 70-100^{0}C) of the material can be effectively applied in various engineering and construction fields, as pressure from the material expansion to 100-300 atm and even more is developed in trail closed medium at this time.

Pressure energy of the self-disperse processes and heat stress in the closed medium is used for deteriorating strong ore and rocks, demolishing solid foundations, buildings and

structures, etc. in mines, tunnels, at large open cast mines for producing marble, granite, basalt, etc. [4].

Application of unexplosive breaking substances provides environmental safety. Works are performed without explosion, noise, toxic substance emission, radiation, etc.

According to the customer demands unexplosive breaking substances with maximum breaking energy at the very first hydration minutes and hours (active) or with slow breaking within 1-2 days and more (passive but with high breaking energy) are prepared. Free expansion of unexplosive breaking substance (without expansion limitation) makes 20-100% and more.

Energy of magnesium, silicium and aluminum oxidation

Silica- and aluminothermics processes during which silicium and aluminum powders recover the metals from their oxides at high temperatures and they themselves oxidize and deliver large amount of heat heating the environment to 2000-3000^{0}C are widely known in metallurgy.

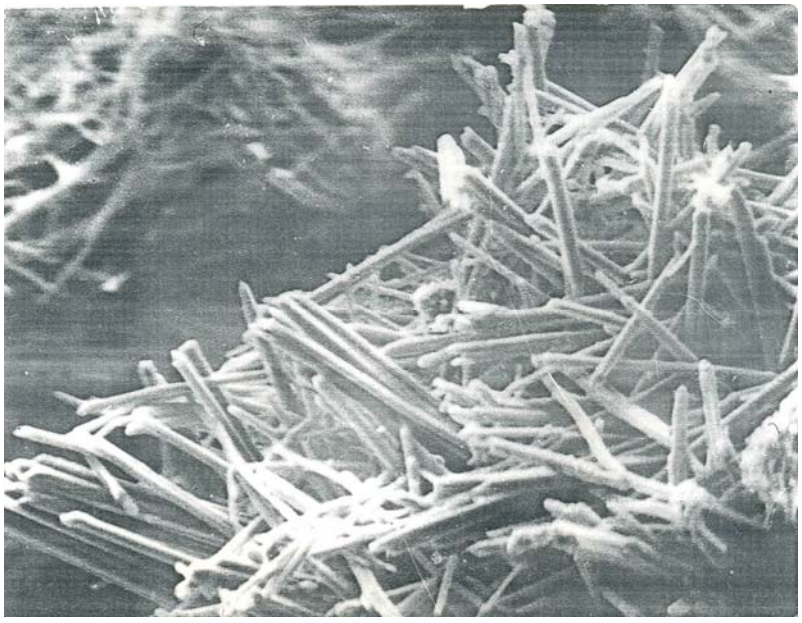

Figure. Electronic Microphotography of Ettringite Crystals $3Ca0 \cdot Al_20_3 \cdot 3CaS0_4 \cdot 32H_20$

Under the data [5], combustion heat of easily oxidizing elements makes: Mg - 6000, Al - 7200, Si - 7400, hydrogen – 34200 kcal/kg. Simple silicon inflames in oxygen at 6000^{0}C and joins it delivering large amount of energy (208,3 kcal/mole). The reaction is observed at 800^{0}C:

$$Si + 2H_20 \rightarrow Si0_2 + 2H_2 .$$

We prepared granules and pills from the mentioned oxides and elements which were heated in electric oven at 600^{0}C. Granules delivered large amount of heat, flared up to high temperature, enabled dehydration of crystalline hydrates and decomposition of discharged water vapor together with forming hydrogen.

In future it is anticipated to create the facility for implementing the mentioned reactions and applying the obtained energy in complex for receiving superclean oxides, for crystal dehydration, hydrogen and power generation and the development of future power engineering without CO_2 emission.

The work is associated with material costs, therefore it is preferred to conduct it together with the investor which will allow to speed up the process of solving the problems relating to future power engineering.

So, various types of chemical, physical-chemical and physical-mechanical energies are used for:

- **speeding up hardening of the concrete and reinforced concrete products and structures;**
- **preparation of self-cogged and reinforced pressure pipes and tanks and construction of underground pressure tunnels and structures;**
- **deterioration of ore, rocks and structure demolishment without explosion;**
- **production of hydrogen, special clean oxides and generation of energy of future without CO_2 emission.**

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