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# Aerated concrete used as an insulating material at higher temperatures

**ABSTRACT:** This article is dedicated to the use of aerated concrete as an insulating material at higher temperatures. It is also point out the benefits of insulating elements made of aerated concrete against current insulating systems, which can work at temperatures up to 500°C. Today, there has been strong effort to push the price down and to make the building cost more effective. It is important to look for savings within operations of heat installations. This is possible by use of the adequate type of insulating material.

**KEY WORDS:** aerated concrete, high temperatures, insulating material

## 1. Introduction

The cornerstone of any successful business is a continuous effort to improve things around. Production must be more and more effective, it must be always improved on and on and developed further. A common question is about where we shall go so that the quality of resulting products cannot be reduced. As the first line, it is the best way to be done to remove sources of unnecessary losses, among which we may include losses of heat. Huge problem lies in the energy waste throughout the high-temperature devices such as furnaces, ducts, chimneys, etc. There is a huge amount of heat losses through the walls of these high-temperature equipments, this energy could be saved by using the appropriate insulation. However, such insulation must be resistant against high temperatures. All currently manufactured insulation materials which are resistant to high temperatures are not sufficiently flexible for insulation of structures with more complicated shape, or their production is very expensive too. It can be solved by material which is sufficiently flexible and heat resistant, the material made on silicate-base, the material which utilizes waste materials during its production.

## 2. Insulation of high-temperature equipment

There are a lot of technical high-heat-demanding devices whose current insulation is inadequate or even non-existing at all. And there are considerable heat losses detected in these devices. The counteraction against these losses might bring about substantial financial savings and reducing environmental problems.

Fig, 1. Equipment designed for the insulation.

## 3. Currently used materials

Technical equipment (e.g. chimneys, boilers, furnaces) have very specific requirements that must be taken into account during their insulating. We can find among them simple shapes that can be insulated by using prefabricated boards or blocks. However, there are also some complicated shapes whose surface cannot be easily covered by using simple precast dements, so it is necessary to use material which will be produced directly on the site.

The most commonly used materials for the particular application at present undoubtedly include the foamed glass. Foamed glass is resistant to water and humidity. The transport of water vapor is not possible due to its structure with closed pores. Furthermore, this material is resistant to the organic solvents, fireproof and resistant to high temperatures (500°C) as well. Among the other positives of foamed glass, we can also include dimensional stability and ecological safety. The disadvantage is the high production cost and hence the price. The mineral and glass wool, expanded pearlite and isinglass are the other materials suitable for use at higher temperatures.

All these materials have excellent technological properties. However, their production is energy complicated, which means a high cost. Therefore, to resolve this problem, we can consider an idea of new economical material of low-cost and, simultaneously, maintaining the desired properties.

## 4. Raw materials suitable for insulating materials resistant to higher temperatures

Based on our own analysis related to the suitability of insulation materials currently used, there have been the silicate-based materials chosen as the best ones, according to the technical properties, low production costs and the possibility of modifying the technology. Obviously, in these material the silicates are formed as a binder, starting from lime or cement. To increase thermal resistance, it is also possible to use high-alumina cement.

During the production of aerated concrete, it is also possible to use fly ash, in addition to siliceous sand. It is necessary to take into account the aerated concrete high sensitivity for inappropriate substances, such as sulfates, alkali, isinglass etc. We can afford, if working with aerated concretes, a larger variability of input raw materials which are not so vulnerable to failure during attack of prescribed chemicals.

The inlet components of secondary raw materials, which came to our short-list of the suitable ones upon the process of optimization, include slag, waste slag, boiler dust, waste sands and fly-ash, all meeting the fundamental requirement of high temperature resistance.

## 5. Innovative solutions

The starting point is in using the manufacturing process in which the fundamental role is not played by the burning or heating to high temperatures, making the production more expensive. Even a small heat-saving plays an important role in the efforts to reduce environmental load.

The ideal solution seems to be based on the use of silicate materials. To meet the requirement for sufficient thermal resistance, it is necessary to enrich the material with sufficient amount of closed pores in order to reduce the thermal conductivity. Therefore, it is very appropriate to use either aerated or foam concretes.

Autoclaved aerated concretes can be used in the form of prefabricated panels and blocks that are suitable for insulating simple-shaped structures. On the other hand, when working with more complicated shapes of structures, you should rather use the material that can be prepared directly on site to ensure complete filling of all the problematically accessible places and voids. Therefore you cannot use the hardening autoclave process and appropriate hydrothermal reactions.

The material can be applied to previously prepared forms which protect the structure and in which the process of expansion will take place. Or it will be the sprayed material that you can cut into desired shape after expansion and sufficient hardening. Together with reducing production costs, you must not ignore preserving the technology requirements. It is necessary that the material shall be able to withstand heat up to 500°C, and it shall also maintain sufficient stability and thermal insulation properties, even at this temperature.

### *5.1. Option A: prefabricated elements*

Production of prefabricated elements is virtually indistinguishable from the production of classical autoclaved aerated concrete. The only difference is in use of more heat-resistant fillers to obtain the material resistant at temperatures up to 500°C, or in the replacement of filling component by the high-alumina cement. However, this option is possible for insulating the easily shaped structures only.

For insulation of more complicated shaped structures, there are more suitable options as discussed below.

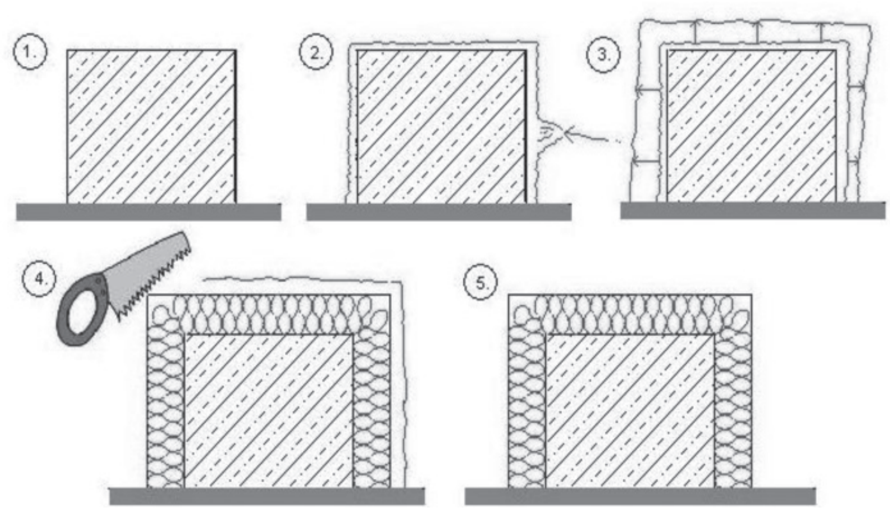


Fig. 2. Technology of applying the sprayed foam concrete (1 – existing facilities, 2 – applying the sprayed foam concrete in a thin layer, 3 – expansion, 4 – cutting the excess material, 5 – insulated equipment).

### *5.2. Option B: monolithic covering of the structure*

First, make a close timbering of desired shape around the insulated structure, which should take into account all the parts that should remain accessible. Pour the mixture containing frothing agent to the timbering surrounding the insulated object. The frothing agent should be added to the mixture not earlier than right on the site of application in order to prevent the formation of premature expansion which should occur later after the dispensation to the timbering. After sufficient hardening of the mixture, you may remove the timbering and potentially make some finishing surface treatment. After cutting the excess material, it would be better not to make any major modifications of the surface.

### *5.3. Option C: sprayed foam concrete*

Application of sprayed foam concrete can be implemented by two possible ways, namely in either dry or wet process.

#### *5.3.1. Dry Process*

Pre-prepared mixture of aggregate with bonding compound is to be dosed in dry process to a hose by using a special feeder. Then in the hose, the mixture is to be blended with water and frothing additive, and with an additive accelerating the process of hardening. Being under the pressure, the mixture is pushed to the surface in a thin layer. Then the process of expansion of the mixture appears. After sufficient hardening which should occur at the period of several hours, use the mechanical hand tools and shape the mixture into the desired form.

#### *5.3.2. Wet Process*

All ingredients are mixed as in the previous process, except for frothing additives and hardening accelerators (binder, filler and mixing water). This mixture is fed through hose into the nozzle where it is mixed with frothing agent and accelerating admixtures. Like with the previous method, the mixture is to be applied in a thin layer which increases its volume and it is shaped into the required form after the process of hardening.

## 6. Creating porous structure of insulating material based on silicate

We can create the porous structure by using the foam-creating admixture (stable foam) at the process of maturation under normal conditions (aerated concrete is to be made), or by a chemical reaction of gas-creating additive at higher temperature and pressure (autoclaving); then the aerated concrete is made up.

To produce porous structure, we can use several basic frothing reactions which use is possible for the particular application. We cannot achieve high strengths without autoclaving, but it is not necessary for non-supporting elements. The supporting function will be provided by the existing insulated structure.

$$2Al + 3Ca(OH)_2 + 6H_2O \rightarrow 3CaO{\cdot}Al_2O_3{\cdot}6H_2O + 3H_2$$

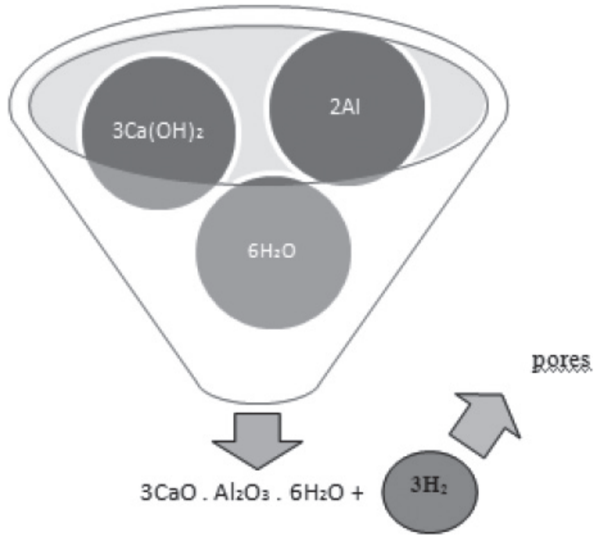


Fig. 3. Reaction of aluminum powder with calcium hydroxide.

There is the reaction of aluminum powder with calcium hydroxide accompanied by producing hydrogen which causes swelling of the mixture. The advantage lies in the content of $Ca(OH)_2$ in the bonding compound, so it does not have to be added to the mixture.

$$3CaO{\cdot}CaCl_2 + H_2O_2 \rightarrow CaCl_2 + Ca(OH)_2 + O_2$$

Reaction of calcium chloride with hydrogen peroxide results in oxygen formation. Thanks to gaseous oxygen, a pore structure is produced.

$$CO(NH_2)_2 + 3Na(OCl) \rightarrow CO_2 + 3NaCl + 2H_2O + N_2$$

Urea reacts with sodium hypochloride. The nitrogen is produced in this reaction.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

The interaction of calcium carbide and water produces gaseous acetylene which causes swelling of the mixture.

## 7. Conclusion

This article outlines the possible use of aerated concrete for the purpose of insulating thermally-sophisticated equipments.

The material should combine some of the advantages of currently produced aerated concretes and foam concretes (low volume weight, low production costs) with high heat resistance. The benefit of this new material is its ability to perform its function even at higher temperatures. By creating a substance based on silicate which is filled with waste materials with improved thermal resistance, and by its subsequent aeration, we will obtain a material resistant at high temperatures (up to 500°C) and having sufficient heat resistance. This material is less expensive in production, as compared with the other insulating materials of comparable properties.

The production of this insulating material and its application are still at an early stage of development. The article only provides the alternative possibilities of using the porous material based on silicate as a thermal insulator with higher thermal resistance.

This contribution was created with the financial support from the state budget through the Ministry of Industry and Trade under the project of FR-TI2/340 named as: “Research and development of industrial thermal insulation system based on silicate with using secondary raw materials”.

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