UTILIZATION OF WASTE MATERIALS IN THE DEVELOPMENT OF LIGHT CONCRETE FOR HIGH TEMPERATURE

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Abstract: This article is dedicated to possibilities of use of aerated concrete as an insulating material for higher temperatures. 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 along heat installations. This is possible by use of the right type of insulating material.

Keywords: Insulating material, high temperature, waste materials

1 Introduction

The cornerstone of any successful business is a continuous effort to improve things around. Production must be made 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 losses of high-temperature devices such as furnaces, ducts, chimneys, etc. There is a huge amount of energy leaking through 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 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 of structures that can be insulated by using prefabricated boards or blocks. But also complicated shapes of structures whose surface cannot be easily covered by using simple shapes, 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 the present times undoubtedly include foam glass. Foam glass is resistant to water, humidity. Due to its closed structure, it does not leak water vapours. Furthermore, it resists to organic solvents, it is fireproof and resistant to high temperatures (500 °C). Among the other positives, we can also include dimensional stability and ecological safety. The disadvantage is the high production cost and hence the price.

Other suitable materials for use at higher temperatures, are mineral and glass wool, expanded pearlite and isinglass. All these materials have excellent technological properties. However, their production is energetically complicated, which means a high financial cost. As the solution to this problem, we can see a design of new material that will benefit from low-cost modern technology while maintaining the desired properties.

3 Choosing of waste raw materials

It exists a huge amount of waste materials. Theirs utilization should reduce environmental deterioration, but not all waste products are usable in specific condition of use.
The new material must fulfill requirement of thermal resistance, to prevent failure by elevating temperatures. Thank this need is for the classification of secondary raw materials the first criterion clear. Next condition, which should be satisfied by the new insulating material, is suitability of use in combination with the silicate binder.
Among materials, which are fulfilling these two basic requirements, belongs concrete waste, mixed construction waste, aerated concrete, ceramic waste, bricks, roof tiles, sand-lime brick, glass wool, mineral wool, waste sand, waste stone, waste dust exhaust, gas boiler dust, slag, waste soot, ash, dross, scrap metal, waste glass, waste glass containing pollutants, keramzite-concrete, slag-concrete, dross-concrete, aggloporite-concrete, pearlite-concrete and ceramic brick-concrete.
The optimization analysis helps us to understand better the suitability of secondary raw materials for this application by comparing thermal and technical characteristics of these waste materials.

The output of the optimization analysis (using the pair comparison criteria) can be clearly expressed by the following chart.

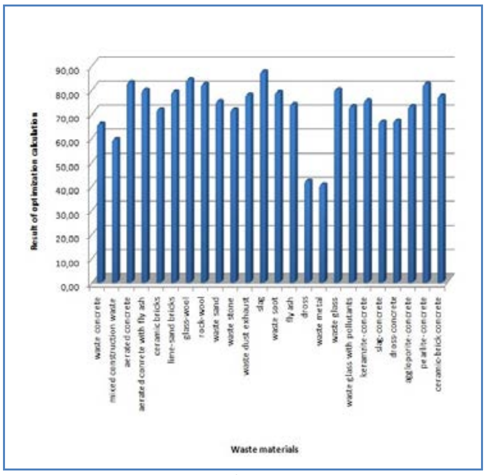

Fig. 2: Evaluation of optimization analysis

Comparison of thermal and technical characteristics indicate, that the most appropriate secondary materials are slag, glass-wool, aerated autoclaved concrete, waste pearlite-concrete, rock-wool, glass waste, aerated autoclaved concrete with fly ash, sand-lime brick waste, carbon black, boiler dust ceramic brick-concrete, keramzite-concrete, waste sand, fly ash , agloporite-concrete. But not all of these waste materials could be used as a filler for new insulating system. It is necessary to review their benefits, the economic performance of the elimination of their conditionally applicability and quantities of waste appearance.

4 Increasing of thermal resistance

The main purpose of the proposed material is thermal insulation resistance of existing constructions with high temperature. The largest consumer of thermal energy (from a group of construction for which is the material intended) is industrial furnace.
Increasing of the specific thermal resistance is shown at the simplified example of heat transfer through external cladding of model furnace with fireclay lining with thickness of 0.10 m and with sheathing with thickness of 0.40 m. The design temperature inside the furnace is about 1000 ° C.

When are these materials with high coefficient of thermal transmission used, there is enormous heat loss, which could be eliminated by adding of suitable insulation.
For example, after adding of designed thermal insulation with thickness of 0.15 m, is the temperature distribution in the construction changed consequently:

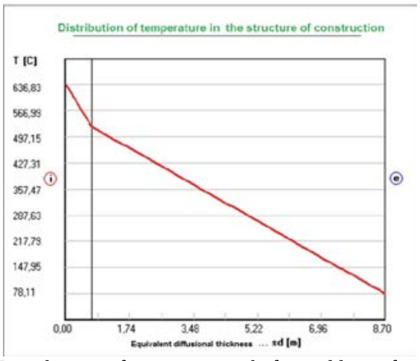

Fig. 3: Distribution of temperatures before adding of insulating material

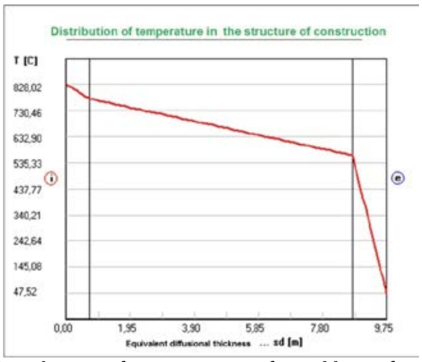

Fig.4: Distribution of temperatures after adding of insulating material

In keeping the supplied heat in the furnace chamber, temperature will increase by adding extra insulation on internal surface of the construction to about 200 °C.

Tab.1: Simulated specific thermal resistance and coefficient of thermal transmission according to ČSN EN ISO 6946

	sign	**unit**	**actual state**	**with added insulation**
Specific thermal resistance	R	m^2K/W	0,38	1,13
Coefficient of thermal transmission	U	W/m^2K	1,80	0,77

Adding of extra insulation will significantly reduce the coefficient of thermal transmission and closely related increase of specific thermal resistance. The increase of specific thermal resistance of the construction will reduce the cost of delivered heat energy into burning space.

5 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, high heat resistance, 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 capable of resistance to high temperatures (up to 500 °C) and having sufficient heat resistance; the material whose production is less expensive compared with other insulating materials of comparable properties.

Possibilities of its production, application and use 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.

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