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The research use of silicate coatings with aluminosilicate filler

National Research Tomsk Polytechnic University

Vitaliy Borovoy [a]

[a] School of New Production Technologies, Tomsk Polytechnic University

Abstract

Today, there are many operating coal-fired thermal power plants in Russia, the burning of which, among other things, produces a huge amount of ash. The main method of ash disposal is the storage of ash and slag waste, which occupies large areas. However, ash and its components can be used in other industries. For example, aluminosilicate microspheres (ASM) are used as a component of ash waste in construction are used to create lightweight concrete, dry mortar, mortar, soundproof coatings. They are also used in mechanical engineering for the production of composites, tires, and repair fillers. In this work, we studied the effect of aluminosilicate microspheres on the properties of silicate coatings.

Key words: Aluminosilicate microspheres, silicate coating, thermal conductivity, wear resistance, construction;

1. Introduction

Aluminosilicate hollow microspheres (ASM) — aluminosilicate glass-ceramic beads, which are formed during high flaring coal. It is the most valuable component of the ash wastes of thermal power plants.

This paper, takes into account deals with the characteristics of the composition, structures and properties of ASM, considers the microspheres which contain a high (up to 55 SiO_2 and 19% Al_2O_3) amount of refractory oxide, have a spherical shape (diameter 5 to 400 um, with an average wall thickness of 7 um), a melting point above 1350 ^{0}C. As a result of the combination of these properties there appeared the idea that the introduction of the ASM in a liquid glass composition would improve its characteristics.

Liquid soluble glass is produced by melting silica with alkaline components (the name of (the liquid glass is trivial). Liquid soluble glass includes aqueous alkaline solutions of silicates, regardless of the caption, the concentration of silica, and its polymer structure. Liquid glass can be potassium, sodium, lithium, and also high-silica, transforming into stabilized silica as alkalinity decreases. Both soluble and liquid glasses are produced in large qualities as a result of inorganic synthesis. In recent years the interest in these technical products is resulted from their valuable properties: environmentally-friendly manufacture and application, non-flammability and non-toxicity, and in many cases the low price and availability of raw materials [4].

2. Influence of aluminosilicate microspheres on the coefficient of thermal conductivity of silicate coating

The goal is to determine the influence of the amount of aluminosilicate microspheres produced at thermal power plants (TPP) on the thermal conductivity to produce silicate thermal insulation coating.

The use of microspheres as a component of composite coating gives the material insulating properties. Such composite coatings have high insulating qualities good adhesion and high strength at very low thickness. If compared glass and aluminosilicate microspheres one might see the following advantages: low cost, average cost of ASM being from 200 rub/kg, whereas glass microspheres are from 700 rub/kg. As for technical specifications of ASM, they are hollow floating microspheres, not heavier than glass ones, with the density of 0.2 – 0.7 g/cm^3, but much stronger50 MPa as compared to 30 MPa. They have a higher melting temperature 1300 ^{0}C. ASM are light with the low thermal conductivity of 0.08 W/m·K at 20 ^{0}C [5]. Therefore, it is possible to use microspheres as an insulating additive for production of materials for construction industry.

2.1. The sequence of the operation

The following composition was prepared for this study based on liquid glass that consisted: 6% of ZnO and 5% talc, 8% chalk, 5% glycerin and 66% water glass. In this case we introduced ASM in the amount ranging from 5 to 20% [3].

Dry part is mixed in a planetary mill, and then the liquid portion is added in the form of liquid glass with glycerol (H_2O is added if necessary). After mixing, ASM is manually introduced. The silication process of paint occurs during one day in the composition that is applied to the samples. After drying, the coefficient of thermal conductivity is measured by means of a measuring device ITP – MG4 [1].

The research was conducted using 2 samples in the form of concrete tiles with the size of (10x10x15) mm, coated with ASM silicate paint in the amount from 5 to 20% by weight and without covering. The results of the experiment are presented in Figure 1.

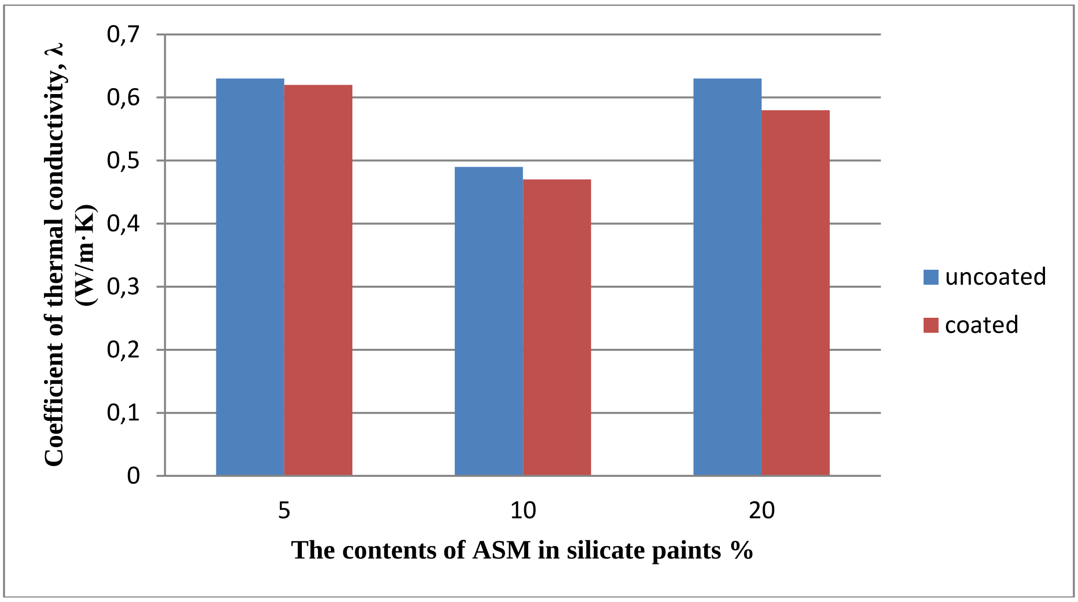


Fig. 1. The value of thermal conductivity coefficients of samples with coating and without coating

During the experiment it was established that the introduction of aluminosilicate microspheres (ρ=0,2 – 0,7 g/cm^3) in an amount of 20% by weight in the composition of the liquid glass (silicate paint) applied to the surface of the concrete sample of 2 mm thickness resulted in decreasing the thermal conductivity coefficient of the material from 0.6 W/m * K to 0.5 W/m * K, which corresponded to the reduction ratio of Δλ to 7 %.

In the future we plan to conduct an experiment to establish the influence of aluminosilicate microspheres on the properties of the plaster mixture, applying them to the surface of a thickness of 15 mm. This should effectively decrease the conductivity in comparison with thin-layer coating.

3. The effect of the microspheres of the wear resistance of the silicate coating

The goal is to determine the influence of the amount of aluminosilicate microspheres on wear resistance of the silicate coating.

To protection of various transport steel structures from corrosive and erosive destruction various coverings produced by priming paint with the use of liquid rubber mixtures based on polymer rubbers are used. Polymeric anticorrosion mastic based on thermoplastic elastomers is more effective, but has the following disadvantages: high production cost and environmental sensitivity. Therefore, the hypothesis on the application of the silicate coating with the additive of heavy ASM was proposed for priming and painting the metal. In addition to the high strength, the ASM are heavy and have high hardness up to 7 on the Mohs scale, therefore, the introduction of ASM in the silicate coating should result in the increase in the material resistance to abrasive wear [6].

3.1. The sequence of operation

The test was carried out according to GOST 20811 – 75 [2]:

The essence of the method consists in determining the weight loss of coatings in grams as a result of abrasion of the coating surface, a moving belt of abrasive paper at a predetermined load on the specimen. The testing equipment is shown in Figure 2:

Fig. 2. Grinding machine Corvette 51

1. To conduct this study the composition based on liquid glass was prepared, see Table 1, in which hydromagnesite was replaced by carbon black in the same amount.
2. Dry part is mixed in a planetary mill, and then a liquid part is added in the form of liquid glass with glycerin. After mixing, the resulting mass is divided into two portions and heavy ASMs are manually introduced in one serving. The paint silication process takes place during one day. The paint is applied to samples 3 sample portions without ASM for the other three portions contain ASM.
3. Samples of six metallic plates were studied according to GOST 16523-89 or GOST 9045-80 and black tin GOST 13345-85 of size 70x100 mm of thickness not exceeding 1 mm. The plates should not be curved.
4. Before the test the correction factor of the sandpaper was determined:

$$K = \frac{0{,}013}{m_K}, \qquad (1)$$

where m_K is the mass loss of the control of the zinc plate, worn away by abrasive paper, g

5. The samples are mounted on a wooden plate by a double-sided tape, the plate is fixed on the iron rim, a load of 1 kg is placed on the plate and kept on the machine for 1 minute. After testing each sample is cleaned from paint residues.
6. To determine the mass loss of the samples during the tests laboratory scales with the limit of weighing 200 g were applied and a maximum permissible error of ±0,0002 g was allowed. A soft brush was used to clean the sanding belt.
7. The resistance of the coating to abrasion is determined by the mass loss in grams, is calculated by the formula:

$$M = K \cdot (m_1 - m_2), \qquad (2)$$

where K–the correction factor of the sandpaper;

m_1 – the weight of specimen before test, g

m_2 – the weight of sample after test, g

Table 1 – Results of tests on the wear resistance, g

№ Sample	Samples without ASM	№ Sample	Samples with ASM
1	0,082	4	0,0174
2	0,079	5	0,0168
3	0,079	6	0,016
ΔC_p	0,081	ΔC_p	0,0167

where ΔC_p- the arithmetic average of the test results

The difference in mass loss of samples:

$$\frac{\Delta \text{ without ASM}}{\Delta \text{ with ASM}} = 4{,}8$$

3.2. Snapshots of the study on durability of silicate coatings

Table 2. Images of the surface of the samples with silicate coating without aluminosilicate microspheres before and after abrasion:

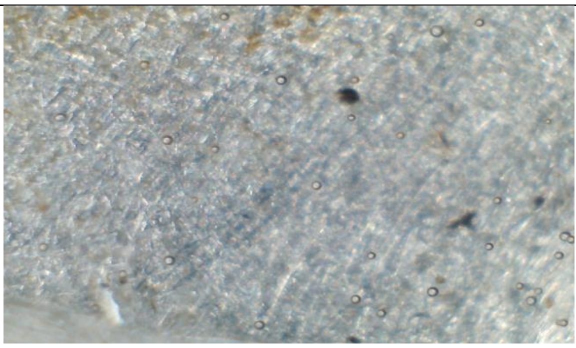
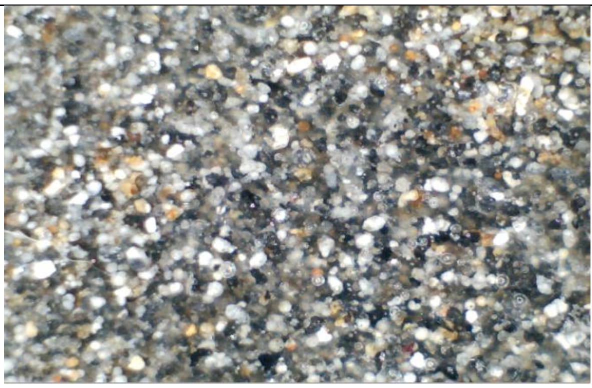
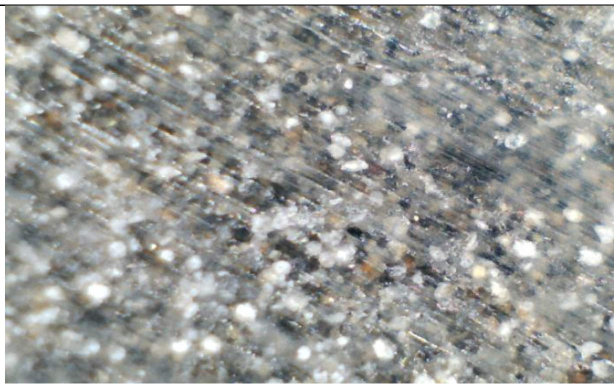
Sample №1	Sample №2
	

Table 2. Images of the surface of the samples with silicate coating before and after abrasion of aluminosilicate microspheres:

Sample №4	Sample №5
	

4. Conclusion

As a result of research in the application of aluminosilicate microspheres to silicate coating of various branches of industries it was stalled that:
1) Introduction microspheres in the amount of 20 % silicate coating reduces the coefficient of thermal conductivity 0.1 W/m•K.
2) As a result of this study, it was proven that the introduction of the ASM light fraction as a filler really improved thermal insulation properties of silicate coatings. However, a significant effect was achieved only with the increase in the thickness of insulating layer, while increasing in the amount of content of ASM in thin-film coating did not result in the positive dynamics of reduction of the thermal conductivity coefficient.
3) It is recommended to use ash microspheres as a filler of silicate composition with improved wear resistance.

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