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ANALYSIS OF THE DEVELOPMENT OF TECHNOLOGY OF ISOLATION OF MICROSPHERES FROM ASH WASTE IN THE WORLD AND THE REPUBLIC OF KAZAKHSTAN

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Abstract: *The possibility of solving environmental issues of the use of waste fuel and energy complex of Kazakhstan in the production of building materials. Comparison of aluminosilicate microspheres with the nearest analogues. The analysis of possibilities of technology of production of aluminosilicate microspheres (cenospheres) from ash and slag waste of thermal power plant in the Republic of Kazakhstan is carried out. And also shows examples of solving environmental problems, based on the experience of developed countries, through the use of waste in the production of building materials.*

Keywords: *glass microspheres, "Shirasu ballons", perlite microspheres, cenospheres, industrial wastes of thermal power plant*

ӘЛЕМДЕ ЖӘНЕ ҚАЗАҚСТАН РЕСПУБЛИКАСЫНДА КҮЛ-ҚОЖ ҚАЛДЫҚТАРЫНАН МИКРОСФЕРАЛАРДЫ БӨЛУ ТЕХНОЛОГИЯСЫНЫҢ ДАМУЫН ТАЛДАУ

Аңдатпа: *Құрылыс материалдарын өндіруде Қазақстанның отын-энергетикалық кешенінің қалдықтарын қолданудың экологиялық мәселелерін шешу мүмкіндігі қарастырылуда. Алюмосиликатты микросфераларды жақын аналогтармен салыстыру. Қазақстан Республикасында ЖЭО күл-қож қалдықтарынан алюмосиликатты микросфералар (ценосфер) алу технологиясының мүмкіндіктеріне талдау жүргізілді. Сонымен қатар, құрылыс материалдарын өндіру саласында қалдықтарды қолдану арқылы әлемнің дамыған елдерінің тәжірибесіне сүйене отырып, экологиялық проблемаларды шешу мысалдары көрсетілді.*

Түйінді сөздер: *шыны микросфералар, «Shirasu ballons», перлитті микросфералар, ценосфералар, отын электр станцияларының өнеркәсіптік қалдықтары*

АНАЛИЗ РАЗВИТИЯ ТЕХНОЛОГИИ ВЫДЕЛЕНИЯ МИКРОСФЕР ИЗ ЗОЛОШЛАКОВЫХ ОТХОДОВ В МИРЕ И РЕСПУБЛИКЕ КАЗАХСТАН

Аннотация: *Рассматривается возможность решения экологических вопросов применения отходов топливно-энергетического комплекса Казахстана в производстве строительных материалов. Сравнение алюмосиликатных микросфер с ближайшими аналогами. Проведен анализ возможностей технологии получения алюмосиликатных микросфер (ценосфер) из золошлаковых отходов ТЭЦ в Республике Казахстан. А также показаны примеры решения экологических проблем, опираясь на опыт развитых стран мира, путем применения отходов в области производства строительных материалов.*

Ключевые слова: *стеклянные микросферы, «Shirasu ballons», перлитовые микросферы, ценосферы, промышленные отходы ТЭС*

The most valuable component in the composition of fly ash is aluminosilicate microspheres (cenospheres) – a light fraction of fly ash. Aluminosilicate microspheres are a loose fine powder consisting of thin-walled hollow particles of a rounded shape, aluminosilicate composition, with a diameter of several hundred microns. At thermal power plants, ash and slag waste is removed in the form of pulp, due to its low density, aluminosilicate microspheres float to the surface of water pools of ash dumps, forming various thin foam layers on the surface of the ash dump. (Fig.1)

Fig.1. Aluminosilicate microspheres in the form of a "foam layer" on the surface of the ash dump. Almaty, Kazakhstan.

In the United States of America, in the European Union, as well as in other developed countries, a special industry was created for the disposal of ash and slag waste in certain industries. Most often, aluminosilicate microspheres are used as fillers of various composite materials based on inorganic and organic binders. Their cost may exceed $ 1000 per ton.

The closest analogues of aluminosilicate microspheres are glass microspheres. Their history of obtaining is closely related to each other.

Development of technology for the production of hollow microspheres began in the United States in the 50s of the last century. The main goal was to develop a technology for the production of glass microspheres. The patent for the production of hollow microbeads from solutions of alkaline metal silicates was introduced by the American Corporation "Standart Oil Co.". The specialists of this Corporation proposed to reduce the pure loss of petroleum products by evaporation from the exposed surfaces of storage, due to the coating of a layer of light particles on the surface of the storage, which later could be removed if necessary. An unambiguous solution to the problem was to obtain hollow microspheres of glass. The method consisted in the fact that the main property of solutions of sodium silicates and potassium silicates during the heating process with a sharp increase in volume – to foam. Today, the industrial production of hollow glass microspheres is carried out not only in the United States, but also in all industrialized countries of America, Asia and Europe. The high choice of the product range and its quality are determined by the fields of application. [1]

To date, most hollow glass microspheres are obtained by passing small particles through the high-temperature zone of gas-flame burners. (Fig.2) In these zones, due to the high temperature, they melt and soften, and the gas formed as a result of combustion processes forms cavities inside the particles, expanding them. One of the main manufacturers in the world market specializing in the production of hollow glass microspheres is the American company "3M - Minnesota Mining Manufacturing Co", which has developed an original way to obtain them. The essence of this method is that the microspheres are made of ordinary glass, crushed to tens of microns and, subsequently, processed in pairs at elevated temperatures.[2]

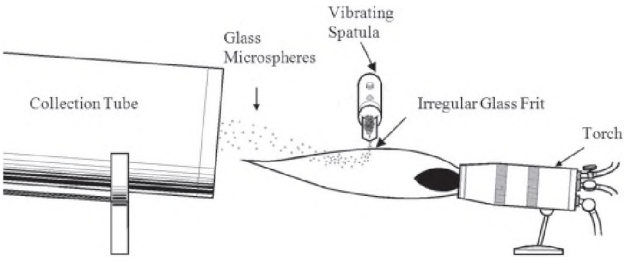

Fig.2. The process of obtaining glass microspheres.

In the early 70-ies of the last century, Japanese specialists of the Technological Institute on lake Kyushu (Agency of Industrial Science and Technology) conducted comprehensive studies of natural mineral raw materials "shirasu". Due to this natural material under the influence of

heavy rains in the South of Kyushu there were landslides. The purpose of these studies was to determine the possibility of using this mineral in industry. In the process of research it was found that when firing fine-grained fractions "shirasu" under certain conditions it is possible to obtain small hollow balls ("Shirasu balls").[3,4]

The technological scheme of the process of obtaining "Shirasu ballons" consists of three stages [4,5].

1. Grinding of mineral raw materials "shirasu" to fractions of 40-250 microns;

2. Mixing with agglomerating additives and with foam at 800 - 1200°C for 10 minutes;

3. Separation of the material is carried out in water or in a separating centrifuge. Industrial production of such microspheres is carried out in tubular rotary kilns. (Fig.3)

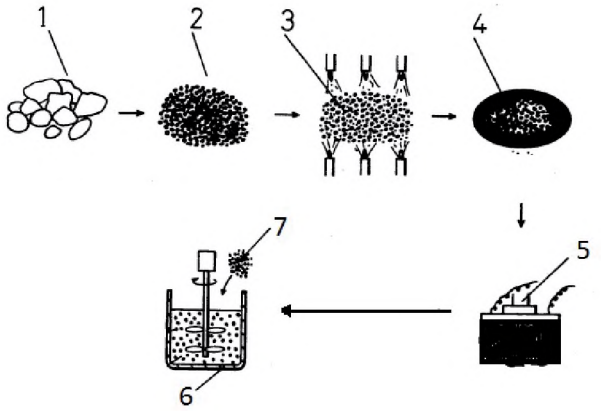

Fig.3. Technological scheme of microspheres based on natural mineral raw materials "shirasu".

1 - initial mineral raw materials; 2 - the crushed mineral raw materials to fraction of 40-250 microns; 3 - mixing of raw materials with sintering additives; 4 - the received mix;

5 - the process of swelling at a temperature of 800 - 1200°C; 6 - the process of separation of the material in water; 7 – obtained microspheres floating on the water surface.

Compared with glass microspheres, "shirasu" microspheres have a number of defects, they include: the thickness of the walls of spheres, irregular shape, cellular structure, etc., which causes their low strength and high density. However, the aluminosilicate composition of the product provides high resistance to acids and alkalis, heat resistance and less hygroscopicity.

Huge reserves of inexpensive raw materials, simple production technology and low cost of microspheres can make them promising materials. This is evidenced by new developments of Japanese scientists aimed at improving the properties of these microspheres. However, the problem of production technology of microspheres from natural raw materials are engaged not only in Japan but also around the world. So us experts have put forward their development to produce hollow microspheres of perlite – a common volcanic rock.

Production of lightweight building materials from industrially processed perlite rocks is most developed in the United States, where there are large branched network of processing plants owned by large firms. [5,6,7] At that time, Italy ranks first in the production of expanded perlite in Europe. Industrial processing of perlite is also developed in Germany, Hungary, Bulgaria and England. [8,9] Also huge reserves of perlite are located on the territory of the former USSR. Kazakhstan ranks 3rd in the identified areas of perlite raw materials, behind Armenia and Ukraine, followed by Azerbaijan, Georgia and Tajikistan. [10]

Swelling of perlite in vertical gas-flame furnaces of tubular type is still the main industrial method.[11,12,13] The basic principle of this method – crushed perlite is poured into an upward flow of hot gases coming from the gas burner, perlite is expanded and carried away with the combustion products into the precipitator. Non-foamed particles fall out of the working chamber into the collection located under the working chamber. The temperature is in the range of 1000-1200°C.

However, all attempts to manufacture hollow microspheres from perlite led to the fact that the finished product did not meet the characteristics, although its particles were chemically inert and adaptable to high temperature conditions[14]. These microspheres had a cellular structure, which adversely affects their application in liquid systems, as they lost their emptiness. The liquid filled all the voids, displacing the

gases in them. Hence the increased finite density of the system. Therefore, the production of hollow spherical balls from perlite raw materials remains relevant to this day.

At the moment, experts from the United States are actively engaged in the development of technology for producing hollow microspheres from natural perlite raw materials. The most active companies are «General Refractories Co», «Manvill Service Соф», «Johns Manvill Corp» - USA.

The process of ash removal at thermal power plants of the Republic of Kazakhstan is largely similar to the system of hydraulic ash removal used in thermal power plants of the Russian Federation. (Fig.4) The features of these systems are determined by the ash collection system adopted at the station and the design of slag removal devices. Devices with screw or scraper feed are mainly used to remove ash and slag waste from the boiler hopper,

Fig. 7 shows the scheme of ash removal at a thermal power plant [15]

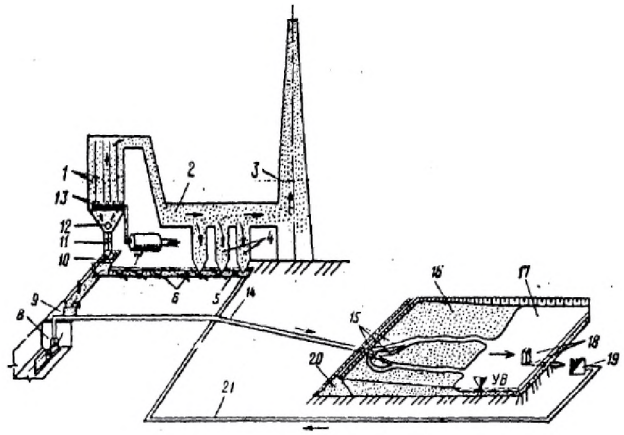

Fig.4. The scheme of ash removal at a thermal power plant.

1 - boiler unit; 2 - smoke channel; 3 - smoke stack; 4 - ash catcher; 5 - flush channel; 6 - motive nozzles; 7 - pulverized coal mill; 8 - bagger pump; 9- sump; 10 - filter of large slag inclusions; 11 - slag crushers; 12- slag mine; 13 - nozzles for pulverized coal fuel supply; 14 – slurry pipeline; 15- the flow of pulp; 16 - surface slope of alluvium; 17 - sedimentation tank; 18 - well; 19 - pumping plant; 20 - dump dam; 21 - purified water supply.

In the United States, where about 30 million tons of ash are formed annually by combustion of 300 million tons of coal, several methods of microspheres selection have been developed: electrostatic deposition, flotation, sieving [16].

At the moment, more than 600 million tons of ash and slag waste have accumulated on the territory of Kazakhstan, every year these figures grow by 19 million tons. If the use of ash and slag waste remains at the same level, by 2020 the volume of waste will exceed 650 million tons, and by 2030 – 1 billion tons. To date, a small number of private companies are engaged in the processing of ash in Kazakhstan. Less than 1.9 million tons of ash and slag waste is processed annually. Only a small part of the ash microspheres used in industry - oil and gas industry, engineering, chemical industry, in the production of various building materials. Basically, microspheres are exported to the EU countries: Spain, Sweden, Poland, Germany, Slovakia, etc.

Manufacturing and application of microspheres is a dynamically developing field of technology, and it is no coincidence that over the past 30 years (since the first publications on ash microspheres) the annual number of publications has increased by more than 10 times. World experience of consumption of ash microspheres amounted to approximately 60-80 thousand tons per year and is constantly increasing. Large suppliers of ash microspheres from the EU and the USA, such as “Omega Minerals” (Germany), “Microfine Minerals Ltd” (UK), “Sphere Services” (USA), systematically study new commodity markets of microspheres, focusing primarily on sources from India, China, Russia and Kazakhstan.

The development of rational methods of isolation of microspheres from fly ash, selection of microspheres in ash dumps of power plants, as well as their subsequent processing is an urgent problem for industry in many countries.

Introduction of technology of processing of ash and slag waste in order to obtain aluminosilicate microspheres and their subsequent use in the industry of the Republic of Kazakhstan is economically and environmentally sound. Based on international experience.

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