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"Journal of Economics and Social Sciences"

Overview of achievements in the refractory industry

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Abstract

The refractory industry has been developed for a long time. Currently, many types of refractory materials are known. These are bricks, tiles, and various types of building materials. The development of the refractory industry is one of the key factors in the development of industry in any country, since refractories are used in almost all spheres of human activity. This article discusses the latest achievements in the field of the refractory industry, the main results obtained, the developments of scientists who work in this field, an overview of economic advances in the refractory industry, and a brief review of the literature.

Keywords: Refractories; refractoriness; wear resistance; ceramic products;

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1. Introduction

Refractory materials are widely used in the production of precious metals for lining melting furnaces, making crucibles, furnace and crucible covers, agitators, sampling devices, protective covers for thermocouples, filling funnels and other heat-resistant equipment. The variety of physical and chemical properties, technologies for melting precious metals, as well as methods for lining, manufacturing and operating conditions of melting units and devices require different designs, initial state and properties of refractory materials. When choosing refractory materials for lining or manufacturing of melting equipment or devices, it is necessary to take into account the properties of precious metals, the requirements of the melting technology, and the operating conditions of the equipment that is being lined or manufactured from these materials. At the same time, it is necessary to take into account the factor of scarcity and cost of materials.

2. Overview of publications

In [1] want analyzed trends in industries refractory products in recent years: new trends in the structure of production and application of refractory materials, their production and sales, including changes in the range, the quality of raw materials used, the approaches to assessing the economics of the use of refractories.

In [10], the issues of the refractory industry in China and the development trends of refractories for steel production are considered. The Chinese refractory industry has recently been through a difficult period due to the global economic crisis and the impact of numerous factors, such as industry consolidation, raw material problems, globalization, energy and environmental problems, continuous consumer pressure for higher quality and service life and lower cost of refractories, as well as a continuous decline in global steel production in 2008-2009. The development of the global refractory industry depends on the supply of vital minerals such as magnesite and bauxite, which are imported from China.

The paper [3] considers the prospects for the development of the market of refractories for the steelmaking complex of Ukraine. The main effect in reducing the specific consumption of refractories is achieved by creating new types of refractory materials, technological improvements in their production, developing new structural schemes for lining technological units, improving the operating conditions and repair of the lining, etc. In this regard, the metallurgical enterprises of Ukraine in recent years have seen a fairly stable trend of increasing the resistance of the lining of converters, arc steel furnaces, steel filling and intermediate buckets.

In [8] the paper presents theoretical and applied aspects of predicting future refractories. The main conditions and criteria for forecasting the range of refractory materials and products of the future are considered. Materials science, raw material geochemistry, manufacturability, ecology and economics of their production are suggested as criteria for the development of refractories. The main factor determining the material composition and assortment of future refractories is the optimal combination of the maximum values of thermal energy density (relative wear resistance) and the minimum production cost.

The paper [9] provides an overview of developments in refractories. Achievements in the field of refractories, such as the development and improvement of MgO; Cr_2O_3 and MgO-C-products; microsilicon in alumina refractories; improvement of raw materials;non-molded refractories (concretes) , etc. are described.

Recent developments, including grinding of kyanite by abrasion, nano-bonded MgO-C refractories, kermet C TiB2 and filter material made of ceramic foam, as well as the latest US patents, are also considered. Some topics that may be relevant for future research were discussed, including improving aggregates, particle sizing, matrix aggregate interface, new microstructure model, recycling of used refractories, high-purity raw materials, "bendable" concrete, and so on.

Research on the use of granulated blast furnace slag as an active filler in the manufacture of geopolymers is described in [2]. In the course of this work, it was found that the setting time of the geopolymer correlates well with the temperature, concentration of potassium hydroxide, addition of metakaolinite and sodium silicate. The physical and mechanical properties of the geopolymer also correlate well with the concentration of the alkaline solution and the amount of added metakaolinite. The highest achieved compressive strength was 79 MPa. In fire resistance tests, a 10 mm thick geopolymer panel was exposed to a flame at 1100 ° C, with the measured backside temperatures reaching less than 350 ° C in 35 minutes. The products can be manufactured for construction purposes and have great potential for engineering applications.

The paper [4] discusses the use of alkaline activated ash as various additives in refractory materials.

Alkaline activation is a chemical process that uses powdered aluminosilicate, such as fly ash, mixed with an alkaline activator to produce a paste that can set and solidify for a long time in a fairly short period of time. The strength, shrinkage, acidity, and fire resistance of the resulting material depend on the nature of the aluminosilicate used and the activation process variables.

3. Overview of patent achievements

Currently, scientists have developed and obtained many additives that are used in the refractory industry. Based on them, new refractory materials were obtained that differ from each other in their refractoriness, high-fire resistance, and other physical and chemical properties. A variety of patents on the basis of new refractories were obtained. Let us look at some of them.

For example, in [5], a patent for preparing a charge for the manufacture of non-annealing refractories was developed. The invention relates to the creation of non-annealing refractory materials intended for lining thermal units of various industries.

Table 1. Composition of the resulting charge

Charge composition	wt.%
high-carbon ferrochrome production slags	72,3-84,0
serpentinite	10,0-20,0
liquid glass	5,0-7,0
sodium silicofluoride	0,7-1,0

When using products from this charge at temperatures up to 120 °C, there is no softening of the refractory lining.

The invention [6] relates to the production of refractory materials and can be used to obtain cinder-and-slag-resistant compositions used for the repair of steel buckets, as well as for the manufacture and repair of refractory lining of furnace units, including refractory concretes. Refractory mass contains 2 to 18 wt.% of titanium dioxide in the form of industrial waste-slime, titanium scale or ash, or in a combination of scale and ash; 15-50 wt.% of the phosphate-ion-containing component in terms of pure phosphoric acid; 4-5 wt.% alumoborophosphate concentrate; 0.5-2 wt. % boric acid; filler-the rest. The invention makes it possible to obtain high-quality refractory masses from non-recyclable industrial waste.

The refractory mass contains titanium dioxide in the form of industrial waste, phosphate-ion-containing component, boric acid and filler.

New is that the mass additionally contains alumophosphates concentrate. As industrial waste, it includes titanium dioxide in the form of slurries containing waste paint materials, in the form of titanium scale or in the form of ash from the annealing of paint materials, or in a combination of scale and ash at the following ratio of components

Experiments have shown that titanium scale and ash from the annealing of paint materials differ from other industrial waste by the specific molecular structure of titanium dioxide. This feature is associated with the experimentally found optimal ratio of components that provides high temperature resistance and physical and mechanical characteristics of linings.

In [7], methods for obtaining a ceramic product are considered. The invention relates to methods for producing ceramic materials intended for high-temperature structural products, such as elements of the combustion chamber and the nozzle apparatus of a gas turbine engine.

The proposed sintering mode at a temperature of 1670-1750°C at a heating rate of 412.5-432.5°C / hour and holding at this temperature until the end of the shrinkage process provides a closed, rounded, evenly distributed fine porosity in a product made of a ceramic composite material, while a dense smooth crust is formed on the surface of the product, devoid of open porosity. Due to the rapid heating of the product during firing, shrinkage and compaction occurs in the surface layers of the material with the formation of a dense surface layer that prevents the escape of vapors, and during further heat treatment, shrinkage also occurs in the inner layers of the product with the formation of closed pores. Closed pores serve as blockers of cracks that occur during operation.

Conclusion

Thus, this article provides an overview of the literature on patent searches in the field of refractory materials. A lot of research has been conducted, and many new methods and methods have been developed for producing refractory materials that have and differ from each other in their refractoriness, wear resistance, and other physical and chemical properties. Of course, there is still a lot to study and research, to analyze the data obtained in the field of the refractory industry, which will also lead to the production of new refractory materials.

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