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Energy Efficient Technology of Obtaining Advanced Composite Grinding Materials and Tools in "Silicon Carbide – Corundum" System from Aluminium-Containing Residual Products

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Abstract

A promising composite material for the production of abrasive tools has been obtained. It is a set of numerous cutters of silicon carbide in corundum matrix. In such grains, the destruction of crystals – microcutters is localized at the border of the phases constituting the composition, which provides for the strength of the grain. This grain is promising for the use in power and rough grinding.
The analysis of the results of physico-mechanical tests of these samples showed that they exceed silicon carbide and corundum in terms of microstrength. Their two-phase structure in action has greater plasticity and suppresses fractures in their motion.
The molded products were subjected to heat treatment; after visual inspection and removal of unsuitable samples and wheels the strength and hardness of the finished products were tested.
It was established that the obtained composite material can be used in the manufacturing of abrasive tools on ceramic and bakelite bonds, in the framework of the existing technology of production.
It was also found that the grinding ability of the wheels of the obtained product is 30% higher than that of silicon carbide and fused alumina.
The studies have revealed that the establishment of an abrasive based on corundum and silicon carbide is very promising.

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Keywords: polishing; composite materials; silicon carbide; corundum; energy-efficient technology; abrasive tools.

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1. Introduction

Modern production of abrasive materials requires a considerable amount of electricity. In particular, the production of 1 ton of silicon carbide consumes 7 – 8 thousand kWh. Such large amounts of energy are required because the process is based on endothermic reaction of carbon reduction of silica [1,2]

$$SiO_2 + 3C \rightarrow SiC + 2CO \tag{1}$$

that in theory would require 600 kJ, which is equal to 4 kWh of electricity per 1 kg of silicon carbide.

If in the reaction (1) we replace some of the carbon, required for reduction of silica to silicon with aluminum, the reaction will proceed according to the following equation:

$$SiO_2 + 4/3\,Al + C \rightarrow SiC + 2/3\,Al_2O_3 \tag{2}$$

with the release of heat of about 300 kJ or 2 kWh per 1 kg of SiC [3-4].

Reduction of silica with a complex reductant of carbon and aluminum implements energetically efficient metallo-thermic process of obtaining abrasive material from silicon carbide and corundum. It is known that the spontaneous flow of alumo-thermic process is possible only in the case where the amount of heat released in reaction is more than 230 kJ per 1 g of charge material, therefore, it is expected that the reaction (2) should go spontaneously.

2. Formulation of the problem

Since the actual obtaining of aluminum is energy-intensive process, practical application of alumo-thermic reduction of silica can only be considered when using recycled aluminium or aluminium-containing slag, obtained by the electrolysis of alumina.

As can be seen from the reaction (2), there is no disengagement of carbon monoxide and there is another abrasive material - corundum, that is generated simultaneously with silicon carbide. Simultaneous generation of corundum and silicon carbide in one system should provide a composition with fine-crystalline structure of eutectoid type. The abrasive grains of this material are a set of cutters made of silicon carbide in the matrix of corundum. When the grain is in action, breaking of individual crystals-microcutters is localized at the border of the phases constituting the composition, which enhances the strength of grain. Such grain might be well-used in power or rough grinding. Works on obtaining composite materials based on silicon carbide and corundum are as well conducted in other countries.

3. Practical part

Physical and mechanical properties of test specimens were determined using the developed instruments and methods for the control of grinding materials [5-15]. The composition of the reaction mixture corresponded to the mass content of 33,26% and 18% of aluminium in the charge and was calculated on the content of the resulting product of 63,56% and 46% of electro-corundum.

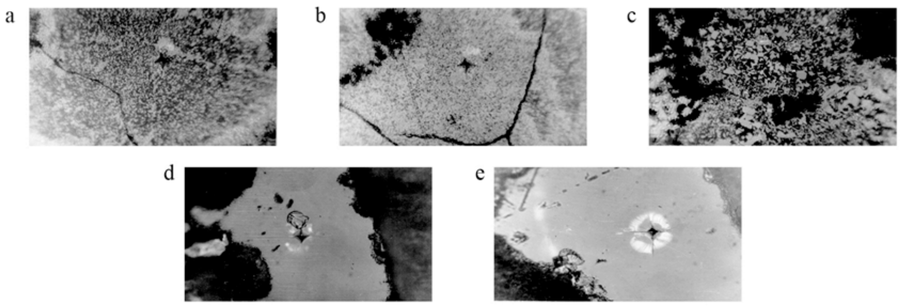

Fig. 1. The microstructure of samples with the imprints of the Vickers Pyramid if P = 100 N: (a, b) – two-phase structure of the composites material samples based on SiC and Al_2O_3; (c)– coarse-grained two-phase systems SiC and Al_2O_3; (d) - corundum; (e) – silicon carbide.