NATURAL WOLLASTONITE – BASED REFRACTORY MATERIALS AND PRODUCTS FOR ALUMINUM INDUSTRY

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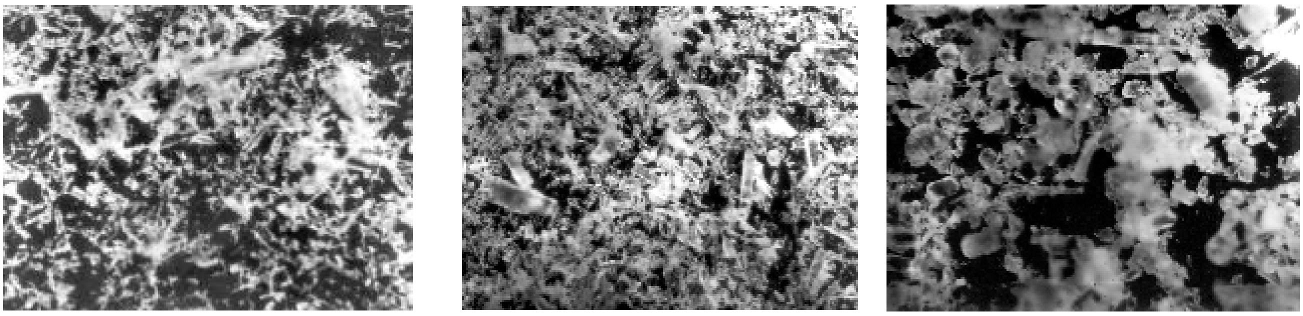
Introduction

Wollastonite – calcium metasilicate with the $CaSiO_3$ composition – is now a basic material for aluminum casting equipment in western countries. It is associated with the combination of the following characteristics of wollastonite:

- it is not moistened with aluminum;
- it is inert to aluminum;
- it has low thermal conductivity;
- it is nontoxic.

Natural wollastonite often consists mainly of acicular crystals of xonotlite – calcium hydrosilicate C_6S_6H. At 700^{o}C xonotlite transforms to β-wollastonite with the retention of crystals morphology. This results in a specific structure of ceramic materials obtained by sintering of such wollastonite and also in their high heat-resistance.



Verkhne-Badamsk deposit, Kazakhstan | Finland | Altai, Russia

Fig.1 The structure of wollastonite powders from different deposits

Methods of manufacturing articles from wollastonite

The articles from wollastonite are manufactured with the use of “autoclave” technology which implies the use of mixture of silica and lime raw materials with various composition and with the CaO: SiO_2 ratio close to 1. The mixture components interact with each other when the water vapour pressure in autoclave is 0.9 – 15.0 MPa and the temperature is 175-260^{o}C.

We have developed an alternative technology which implies the use of natural enriched wollastonite and the use of conventional and simple techniques shown in the diagram.

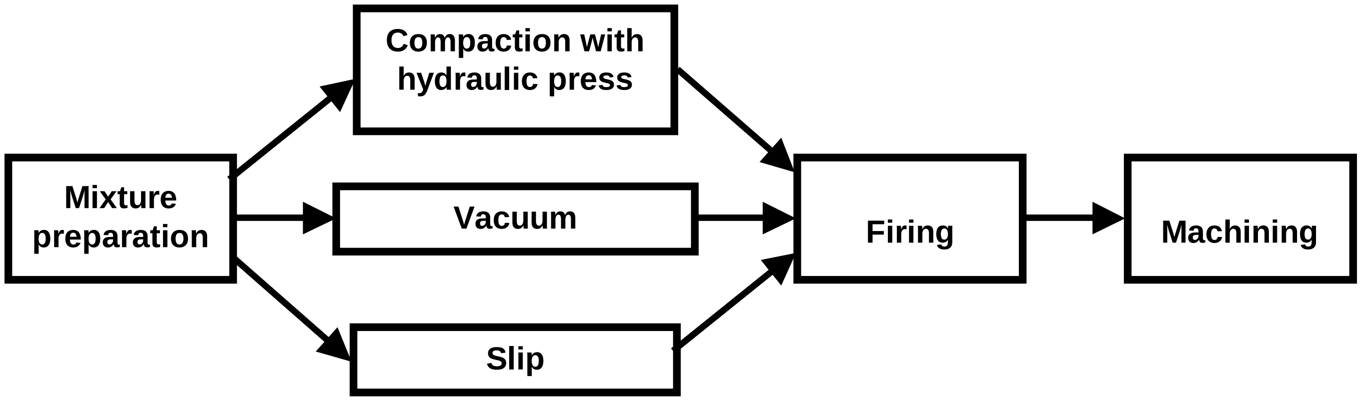


Fig.2

At the stage of mixture preparation the plasticizers are introduced to facilitate the compaction and sintering activators of flux type are also added which decrease the temperature of firing down to 900-1000oC.

The introduction of light coarse fillers of vermiculite type and also inorganic fibers is an effective way to increase the heat resistance of wollastonite ceramics.

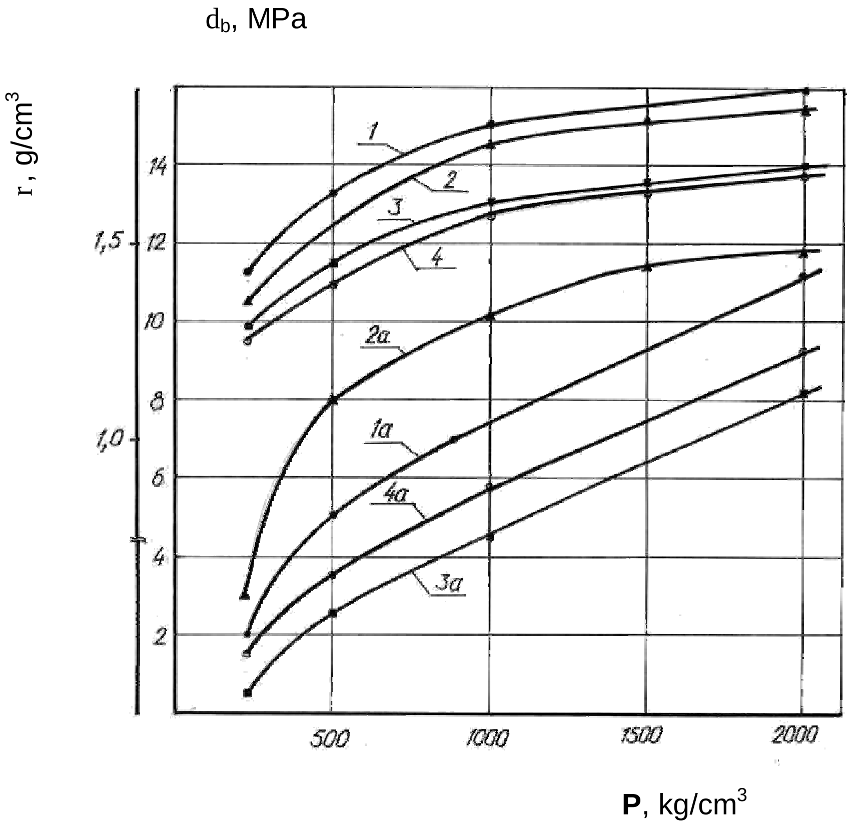


Fig. 3. The dependence of ultimate bending strength d_b(1a-4a) and apparent density **ρ**$_{ap}$. (1-4) of wollastonite ceramics with 20% of fibers on the compacting pressure **P**:
1a, 1 – kaolin fibers; 2a, 2 – mullite-silica fibers; 3a, 3 – silica fibers; 4a, 4 – silica chopped fibers.

Ceramics strength and density decrease with the increase of total mass fraction of the fiber. This effect is less pronounced with the increase of compacting pressure.

Thermocycling of the specimens within 20-800^{o}C revealed that the addition of even 20% of fiber to ceramics gives a sufficient increase of heat resistance. The density of composite ceramic materials is within 0.5-1.6 g/cm^{3} depending on the nature and amount of the added fibers.

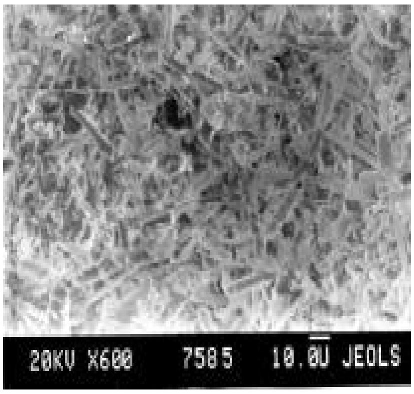


Fig. 4. Microstructure of wollastonite ceramics with quartz fibers

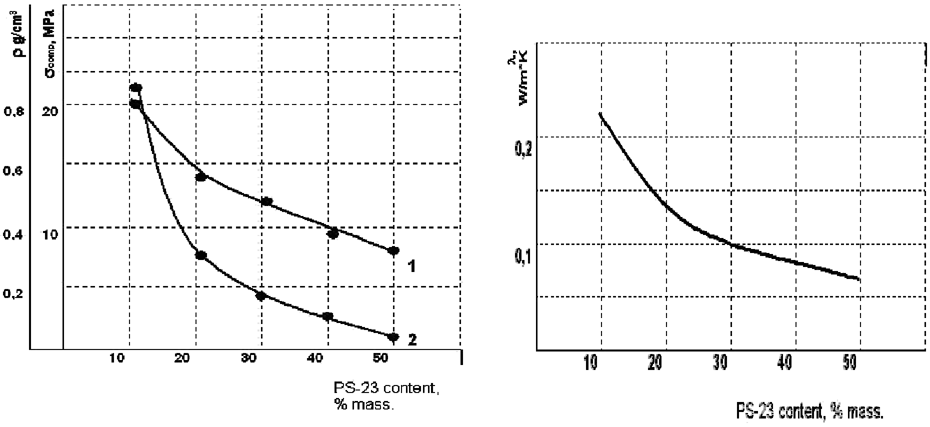


Fig. 5. The dependence of $\rho_{ap.}$, d_{comp}., λ of composite Ceramics on the content of silica fibers PS-2B.

These ceramic materials offer promise as the thermoprotective materials for lining thermal units with operating temperatures up to 1000^{o}C.

The tests of the specimens from composite ceramic materials with silica fibers revealed practically limitless heat resistance of the specimens under cyclic heating, nonwettability with aluminum melt, lack of cracks under repeated immersion in aluminum melt.

Table 1. The properties of the developed materials in comparison with wollastonite of the firm “SILCA” obtained with the use of autoclave technology.

Characteristics	**SILCA**	**ORPE “Technologiya”**			
	Silicate NT4	**Basic Wollastonite**	**Wollastonite with 20% of fibers**	**Wollastonite N-1**	**Wollastonite VN-1 with vermiculite**
Operating temperature, ^{o}C	850	850	850	850	850
Density, g/cm^{2}	0,8	1,5-1,7	0,5-0,8	1,4-1,6	1,15-1,30
Heat conductivity, W/m*K	0,15	0,6	0,1-0,2	0,5-0,6	0,15-0,2
Linear shrinkage during 24 hours at 800 ^{o}C, %	0,0	0,0	0,0	0,0	0,0
Compression strength in cooled state, kg/mm^{2}	1,05	2-8	1-2	2-4	6-9

ORPE “Technologiya” has mastered the production of components from natural wollastonite. The components successfully work at the factories of “Russian aluminum” and other enterprises involved in aluminum production and processing.

Some of the components are shown in figures 6-9.

Fig. 6   Lining plates
Service conditions: up to 800°C, molten aluminum
Main function: lining for molten aluminum transition lines
Overall dimensions: 500x500x50 mm

Fig. 7 Sections of cast spouts for aluminum transition lines
Main function: lining for aluminum transition lines
Section length: up to 600 mm

Fig. 8 Lower and upper hot tops
Main function: formation of aluminum column
Diameter: up to 225 mm
Height: 300 mm

Fig. 9 Aluminum transition line elements
Length : up to 600 mm