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48th International October Conference on Mining and Metallurgy

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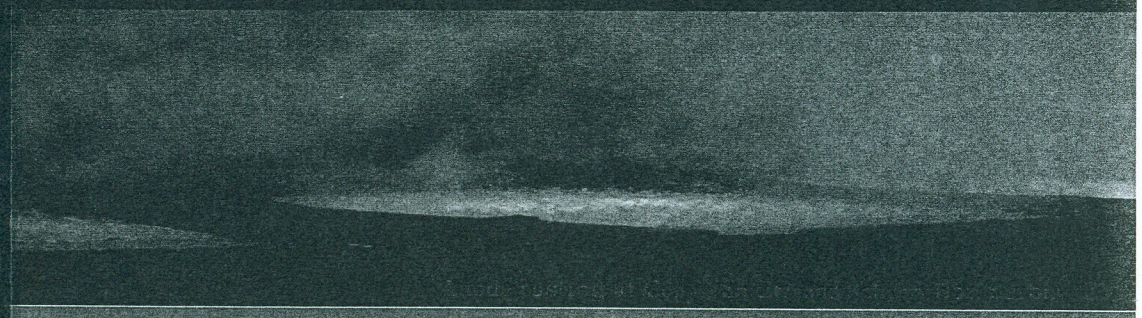

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Editors:
Nada Štrbac
Dragana Živković

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International October Conference

Bor, Serbia
September 28 to
October 01, 2016

University of Belgrade
Technical Faculty in Bor and
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PREFACE

The 48th International October Conference (IOC) on Mining and Metallurgy has been jointly organized by University of Belgrade - Technical Faculty in Bor and Mining and Metallurgy Institute Bor. The aim of the Conference is gathering the eminent scientists, experts and researchers in fields of geology, mining, metallurgy, materials science, technology, environmental protection and related engineering topics. At first, International October Conference on Mining and Metallurgy was a national conference, then a conference with international participation, and since 2002 - international conference, with active participation of leading researchers in previously mentioned areas.

The program includes papers devoted to both fundamental and practical aspects of the following topics: geology, underground mining, surface mining, mineral processing, extractive metallurgy, metal processing, materials science, inorganic technology, environmental engineering, industrial engineering, recycling technologies, manufacturing technologies, quality management, software engineering applications, mechatronics, machining, design and construction and other related fields. The Conference program includes 121 papers with participants from 16 countries: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Iran, Japan, Kazakhstan, Libya, Macedonia, Mexico, Montenegro, Russia, Slovakia, Slovenia, and Serbia. We would like to underline that major of presented papers from Serbia resulted from work on numerous projects in the fields of Fundamental Research and Technological Development, which are financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

What is important to note that this year, for the first time, as part of the October Conference, 3rd International Student Conference on technical sciences will be held - ISC 2016. The aim of ISC 2016 is to promote scientific research of students of technical sciences from the country and the region and exchange their ideas and experiences.

Organization of the Conference was financially supported by the Ministry of Education and Science of the Republic of Serbia, for which we are very grateful.

Conference organization was also supported by Mining and Metallurgy Institute Bor as co-organizer. Company Fugro (Austria) participate as a silver donor, on which we are very grateful. Organization was also supported by RTB Bor Group, Copper Smelter and Refinery Bor (TIR Bor), Copper Mines Bor (RBB Bor) and local government Bor. We would also like to mention companies D.O.O. Martenzit Bor, Jewelry Magdalena Serbia, Doncafe Group and National Museum Zaječar and Zaječarsko (Heineken Serbia) as friends of the Conference. During the Conference, Company Fugro will present their products and services.

Sincere thanks to all the members of the Scientific and Programme Committee for their support. We would also like to thank plenary lecturers, authors, speakers, session chairmen and paper reviewers for their contribution and participation at the Conference.

Special thanks to 48th IOC Organizing Committee members for their help during Conference organization and Proceedings preparation. Finally, we would like to thank all people who contributed to successful organization of the 48th International October Conference.

On behalf of the 48th IOC Organizing Committee.
Prof. dr Nada Štrbac, president

CAVITATION DAMAGE OF MULLITE CERAMIC: IMPLEMENTATION OF IMAGE ANALYSIS

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Abstract

The paper presents the results of testing the mullite ceramics in terms of cavitation erosion Mullite samples were sintered at 1200°C. To determine the cavitation resistance the ultrasonic vibration method with stationary specimen was used. Mass loss and level of degradation of surface samples were monitored using the image analysis. Test results showed a high cavitation resistance of mullite ceramics and its possible application to various areas- metallurgy, mining, construction, chemical industry, where it is expected the presence of cavitation erosion.

Keywords: *mullite ceramic, cavitation erosion, image analysis.*

1. INTRODUCTION

Mullite ceramics ($3Al_2O_3{\cdot}2SiO_2$) is stable at high temperatures, it has high mechanical properties, chemical resistance and resistance to thermal shock. Mullite thanks to its properties: density of 3.16 to 3.22 g/cm^3, hardness 7.5 by Mosh scale, relatively low coefficient of thermal expansion ($6{\cdot}10^{-6}$ °C^{-1}), the coefficient of thermal conductivity (1.3 W/m· K), chemical resistance, is widely used in the industry to obtain different products of dense and porous ceramics [1-3]. Advanced mullite ceramics is used for creating different filters for diesel engines and other parts. This is a porous mullite ceramics sintered at low temperatures (below 1000°C), bulk density below 60%. Filters based on porous mullite ceramics are characterized by stability at high temperatures, excellent chemical inertness, a very good resistance to mechanical shocks, even at porosities above 60 %. High performances of filters are achieved by controlled conditions of formation of structures with a certain grain size, a particular pore size distribution, high fineness of surface texture. These performances contributes to improving of the filtering process, achieving a vacuum, more efficient catalytic properties of interacting with soot [4-7]. Mullite is a key ingredient in many refractory and ceramics applications. As a raw material mullite is used to obtain mullite refractory bricks, as one of the components for electrical porcelain masses, for special purposes. Mullite is a good lower cost alternative to dense alumina. Typical applications include, but are not limited to, thermocouple applications, furnace muffle tubes, kiln rollers, sight tubes, rods and kiln furniture [8-11].

2. EXPERIMENTAL

2.1 Materials

In this paper synthesized mullite is used from a mixture of alumina and quartz using mineralizers 1% NaF. Synthesis of mullite was performed in a laboratory furnace with oxidation atmosphere type Netzsch the sintering temperature with 1200 °C, 1h. For obtaining dense ceramic bodies size

and shape of mullite grains are very important. For this study mullite powder with rounded grains, with average grain size was used, 12,48 μm (100 % -12 x 10-6 m) and the shape factor 0.6. For characterization of the mullite samples, X-ray diffraction analysis was applied in the X-ray diffractometer PHILIPS, model PW-1710. The microstructure of the samples was characterized by scanning electron microscopy method (SEM) using a JOEL JSM-6390Lv microscope. Fig.1. shows XRD of the sintered mullite sample with dominant presence of mullite and α-corunde. Fig.2. shows SEM microphotograph of sintered mullite sample, at homogenous structure, high density and very little porosity (dark part of the surface).

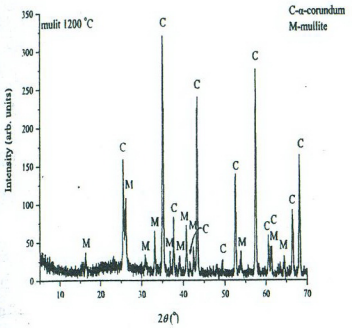


Figure 1 - XRD of mullite sample sintered at 1200°C.

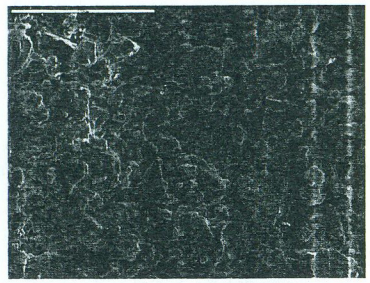


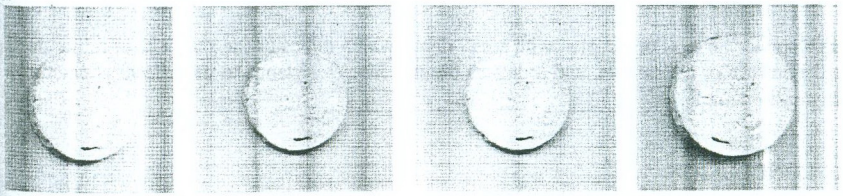
Figure 2 - SEM microphotograph of mullite samples sintered at 1200 °C

2.2 Methods

Cavitation erosion testing was performed using ultrasonic vibration method (with stationary specimen) according to standard ASTM G32 [8]. The usual characteristics for the frequency and peak-to-peak displacement amplitude of the horn were used, as well as characteristics of liquid [6,7]. During cavitation erosion test surfaces of samples were photographed with stereomicroscope. Macroscopic photos and footages were subjected to image analysis in order to determine the loss of mass destruction and monitoring of surface samples under the influence of cavitation erosion. For data processing and analysis a software program Image Pro Plus (IPP) was used [9].

3. RESULTS AND DISCUSSION

Sintered mullite samples were photographed before end during the cavitation erosion test, Fig.3. Mass loss and level of surface damage of mullite samples during the cavitation test are shown in Figure 4 and 5, respectivly.



20 min 40 min 60 min 80 min

Figure 3 - Photographs of sintered mullite samples before and during cavitation erosion testing

Fig.3. shows the appearance of small pits on the surface of the samples in the form of walls, which, during the testing time increases slowly. This corresponds to the results of the gradual loss of weight of the sample during the test, Fig. 4, and appears smaller incremental damages to the surface of the sample, Fig. 5.

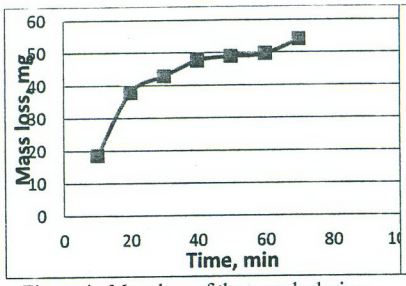


Figure 4 - Mass loss of the sample during testing

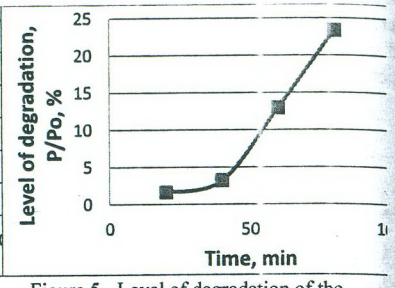


Figure 5 - Level of degradation of the sample during testing

Very good resistance of mullite samples on the cavitation effect can be interpreted based on the structure of the sintered samples, Fig.2, and based on the properties of mullite, primarily high hardness of the sample. This indicates that such a dense ceramic body may have a high resistance to the effects of cavitation. This is confirmed by examining the microstructure of specimens at the end of cavitation test, Fig.6.

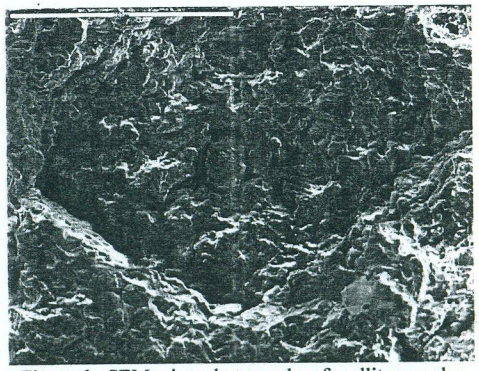


Figure 6 - SEM microphotographs of mullite samples sintered at 1200 °C after cavitation erosion testing

Fig.6 shows the look of the pits with small depth which indicates the presence of minor damage to the surface of the sample, and indicates the increased resistance to the effects of cavitation to the mullite sample.

4. CONCLUSION

The test results showed high cavitation resistance of mullite ceramics. This can be interpreted by obtaining a fine, homogenous structure of the samples of sintered mullite high hardness and compactness. Mass loss, as well as level of degradation are increasing during testing, but the

level of increasing is small. This points to the possibility of applying a dense mullite ceramics in conditions of cavitation. This is primarily related to the use in the chemical industry, metallurgy for making foundry furnace parts, making protective coatings, for making shellfish when casting special castings of high-temperature alloys. Menagement implementation methods of image analysis (IPP analysis) is fully contributed to the characterization of the sample mullite in terms of cavitation erosion and can be used for fast and reliable choice of materials for use in these conditions.

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