University of Belgrade
Technical Faculty in Bor and
Mining and Metallurgy Institue Bor

51st International October Conference on Mining and Metallurgy

PROCEEDINGS

Editors:

Prof. dr Srba Mladenović
Prof. dr Čedomir Maluckov

Bor Lake, Serbia,
October 16-19, 2019

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the 51st International October Conference on Mining and Metallurgy (IOC 2019) held at Bor Lake, Serbia, 16 – 19 October 2019.

The IOC 2019 has been organized by the University of Belgrade, Technical Faculty in Bor, in cooperation with Mining and Metallurgy Institute Bor. It is devoted to presenting recent research results and advances in the fields of geology, mining, metallurgy, materials science, technology, environmental protection, and related engineering topics. The primary goal of IOC is to bring together academics, researchers, and industry engineers to exchange their experiences, expertise and ideas, and also to consider possibilities for collaborative research.

These proceedings include 81 papers from authors coming from universities, research institutes and industries in 15 countries: Bosnia and Herzegovina, Croatia, Japan, Kazakhstan, México, Montenegro, Poland, Romania, Russia, Slovenia, Turkey, Ukraine, Switzerland, Brasil and Serbia.

Financial assistance provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia is gratefully acknowledged. The support of the sponsors and their willingness and ability to cooperate has been of great importance for the success of IOC 2019. The Organizing Committee would like to extend their appreciation and gratitude to all the donors and friends of the Conference for their donations and support.

We would like to thank all the authors who have contributed to these proceedings, and also to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to IOC 2019. Sincere thanks to all the people who have contributed to the successful organization of IOC 2019.

We look forward to welcoming you to the 52nd International October Conference on Mining and Metallurgy (IOC 2020), which will be held in October 2020.

On behalf of the 51st IOC Organizing Committee,
Prof. dr Srba Mladenović

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Abstract

The paper examines the cavitation resistance of the sintered basalt samples. A change in the sample mass in function of the cavitation time was monitored for the evaluation of cavitation resistance. The level of degradation of the surface of the sample was quantified using the image analysis. Analyzing the progression of erosion samples of sintered basalt, it can be concluded that the mass loss is small, for 120 min exposure is 2,26 mg, with a cavitation rate of 0.02 mg/min and total surface damage of the sample surface of 15%. It has been shown that sintered basalt samples can be applied in conditions in which high cavitation loads are expected.

***Keywords**: sintered basalt, cavitation rate, cavitation damage, image analysis*

1. INTRODUCTION

Basalt is hard volcanic rock. It has good technical characteristics and is used to obtain glass-ceramics by processes of sintering, melting and casting from basalt aggregate. Glass-ceramic based on basalt find application in all industrial branches where the problem with the chemical resistivity and wearability is actual: metallurgy and mining, chemical engineering, civil engineering [1-3]. In the world, basalt is used as a raw material for the production of basalt wool, thin and super thin basalt fiber, cast and sintered products, composite materials, basalt plastics, anti-corrosive materials, building materials, thermal insulation materials [4, 5]. For general application, basalt is used for making technical ceramics, art ceramics, for making decorative furniture, dishes, glazes and other products [6, 7].

The paper investigated the resistance of basalt to the effect of cavitation. Cavitation is process of creation, growth and collapse of the cavitation bubble in the flowing fluid. In doing so, there are high temperatures, pressures and large materials damage in contact with the flowing fluid. One way to reduce the impact of cavitation is to choose materials that have a high resistance to damage under the effect of cavitation [8, 9].

2. EXPERIMENTAL

Samples of sintered basalt (SB) were obtained by pressing the basalt powder of 20 μm grain size using the Leitz pressure device under the pressure of 1 MPa. The sample sintering at 1150°C was according to the following regime: raising the temperature to 1000 ºC with a heating rate of 5 ºC/min in a time of 200 min; then, heating up to 1150 ºC with heating rate of 2 ºC/min in a time of 100 min; sintering at 1150 ºC in a time of 1 hour. Basalt sample were analyzed using X-ray diffractometer, ″Philips″ model PW-1710. The microstructure of the sample was characterized with the scanning electron microscope JOEL model JSM 6610 LV.

The ultrasonic vibration method (with stationary samples) was used to test cavitation resistance according to both the ASTM G32 standard [10] and the procedure described in earlier works [1, 2, 8]. The selected sample time (min): 15, 30, 60, 120. After each test sequence, mass loss of the sample was measured and sample surface was photographed. The change in the morphology of the sample surface with the test time was followed by scanning electron microscopy. Sample surface degradation level was quantified using the image analysis [11].

3. RESULT AND DISCUSSION

Figure 1 shows the XRD and SEM microphotography of the sintered basalt sample. The mainly minerals feldspat (basic plagioclase) and pyroxene (diopside) are present. In the structure of sintered sample, the plagioclase and pyroxene crystals in the basalt mass are uniformly distributed. Bubbles of different size filled with gas or glass are present in the structure.

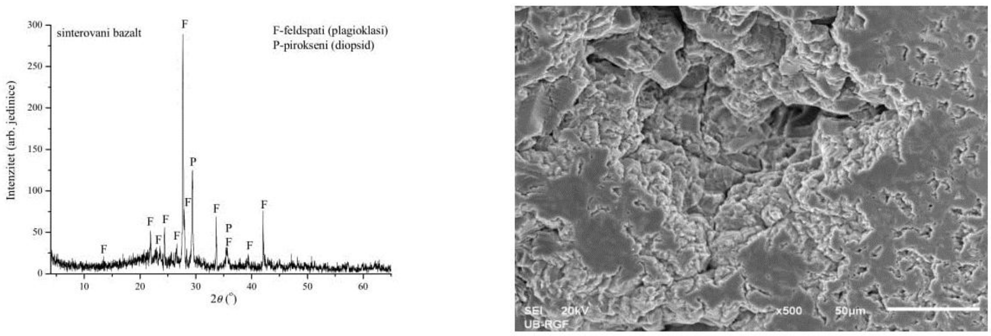
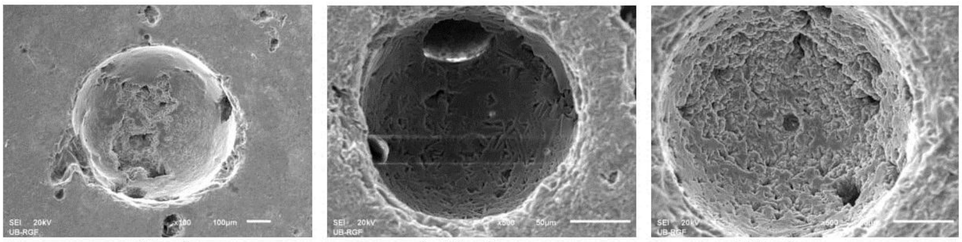


Figure 1. XRD and SEM microphotography of SB sample.

On the surface of the sample, small pits are located near the bubbles. The pits are arranged along the edge of the bubble and very little change during the cavitation test, Figure 2.



a. 30 min b. 60 min c. 120 min

Figure 2. The appearance of the bubbles and pits during the cavitation test: small changes in size of the pits and surface of the bubbles.

This corresponds with a small loss of sample mass. At the end of the test for 120 min, the mass loss is 2,26 mg, the cavitation rate is 0,02 mg/min. Analyzing the formation and development of damage to SB samples under the effect of cavitation, a large number of small pits may be formed in the first 30 min, which are merged and re-formed. The surface damage mechanism is carried out by continuous and joining of small pits whose average surface is small, at the end of the test, 120 min, the formed pits were merged, P_{av}, mm^2 is 0,9 mm^2 and the surface degradation level is

15%. Figure 3 shows the mass loss of the sample during the cavitation testing and the results of the image analysis: the level of damage to the surface of the sample, P/P_0, (%), the number of formed pits (N_p) and the average area of the formed pits P_{av}, (mm^2). The pits change the shape and dimensions very little until the end of the test.

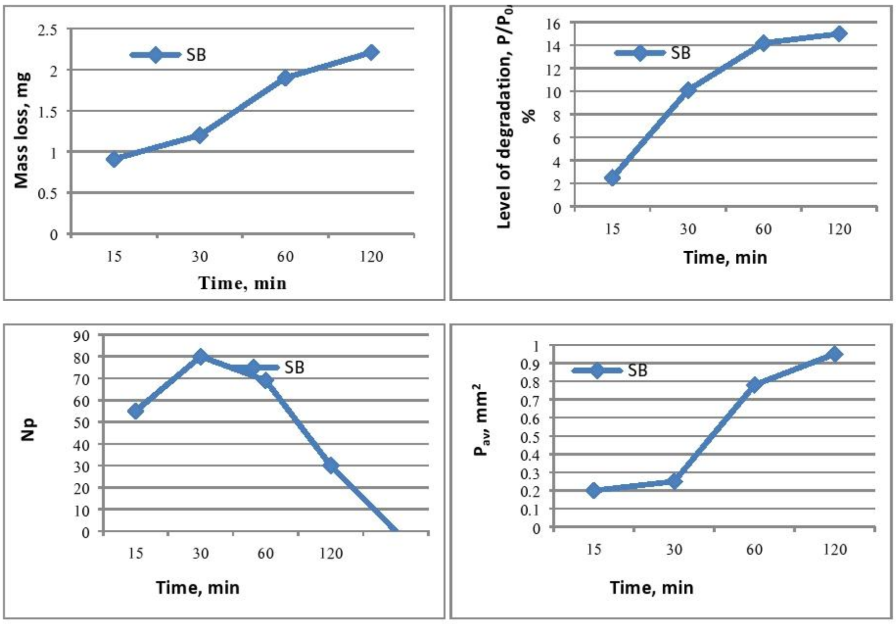


Figure 3. Results of sintered basalt samples during the cavitation testing: mass loss of samples (mg); surface degradation level, P/P_0, %; number of formed pits, N_p; average area of formed pits, P_{av}, mm^2.

The high resistance of sintered basalt samples can be interpreted with a fine-grained structure of basalt, in which the smaller crystals of plagioclase and piroxene are evently distributed in basalt structure.

4. CONCLUSION

The cavitation erosion of the sintered basalt samples is characterized by the appearance of small pits located near the bubbles in the basalt structure and their number increases at low speed during exposure. It has been shown that glass ceramic samples based on sintered basalt can be applied in conditions in which high cavitation loads are expected.

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