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INFLUENCE OF THE BASALT STRUCTURE AND PROPERTIES ON DEVELOPMENT THE CAVITATION DAMAGE

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Abstract

This paper analyzes the formation of cavitation damages depending on the technology of fabrication, structure and properties of basalt from the Vrelo-Kopaonik deposit. The methodology for monitoring the level of damage caused by cavitation and estimation the material life span base on parameters was developed: change in the mass loss, measurement the degradation level of the sample surface, dynamics of the formation of pits, changes in their average area surface, determination the line profile. A change in the surface morphology with the test time was followed by a scanning electron microscopy. The level of surface degradation of samples was quantified using the image analysis. The results indicate that the cast basalt has a high degree of cavitation resistance.

***Keywords**: cavitation, basalt, cavitation damage, cavitation resistance, image analysis*

1 INTRODUCTION

Basalt is a cheap and widely distributed raw material which, by melting and certain cooling treatment, can be applied to produce glass and glass ceramics with the specific mechanical properties, high strength and low abrasiveness [1,2]. Good technical properties allow the use of basalt in civil engineering [3,4], for production of aggregate for the modern road and rail shroud [5], glaze for decoration of various ceramic and other products [6], making the decorative furniture, dishes [7], synthesis of the new materials and products used in the machinery industry, automotive industry, shipbuilding [8,9]. The paper explores the possibility of using basalt for the production of parts of industrial equipment for metallurgy and mining, which will be exposed to the high temperature, wear, aggressive suspension and fluid, corrosion in exploitation. A cavitation erosion test was applied, according to the standard ASTM G-32, using the ultrasonic vibratory cavitation test method described in the papers [10-12].

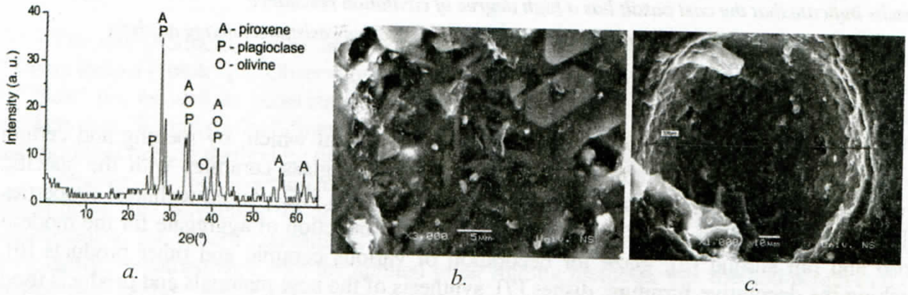
2 EXPERIMENTAL PROCEDURE

For the test, samples of basalt dimensions (10x10x10) mm were cut from the cast plates. Tested basalt plates, dimensions (200x150x15) mm, were obtained by the processes of: melting crushed rocks of raw basalt at temperatures of 1250°C; casting in the sandy molds, relaxation cooling of castings in the regime of 820-850°C/2h, and slowly cooling with a furnace in order to reduce the internal stresses. The basic properties of basalt, which influenced its choice for exploring cavitation resistance and assessing the possibilities of application in the engineering practice, as the substitutes for metallic materials, were: density 2460-2960 kg/cm^3; basically amounts of glass 10-15%; melting point 1300-1400°C; high hardness 6,5-7 Mosh scale; compressive strength 80 MPa; porosity 3,78%; hygroscopicity 1-4%; moisture content 1,2%; high resistance to frost; wear resistance; high resistance to acids, alcalines and heat; ecological and hygienic quality [1,3,8,9].

Basalt samples were analyzed using a X-ray diffractometer, "Philips" model PW-1710. The microstructure of samples was characterized with the scanning electronic microscope JEOL model JSM 6610 LV. Selected time for testing the cavitation resistance of basalt samples using ultrasonic vibration method, according to standard ASTM G-32, was in (min): 15; 30; 60; 120. After each interval of testing, a change in mass loss was measured, and the sample surface was photographed in order to monitor the resulting damage by a cavitation. The morphology of the damaged surfaces was analyzed by a scanning electron microscope. Software analysis of the sample surface was carried out using the Image Pro Plus software analysis image.

3 RESULTS AND DISCUSSION

The mineral composition of the cast basalt sample is as follows: plagioclases, pyroxenes, olivines, Figure 1.a. The structure of sample is constructed from cryptocrystalline with the appearance of fine crystals, it is inhomogeneous, composed of different aggregates between which a clear border is seen, Figure 1.b. The structure contains bubbles of various sizes, filled with air or glass, and involved in the glass base of basalt, Figure 1.c.



a. b. c.

Figure 1 *Basalt sample: a. XRD; b. SEM microphotograph of structure; c. Bubble in the structure*

Following the change in morphology of the sample surface during the test, it was found that the surface erosion was caused by the formation of small pits, without the appearance of cracks that would cause the fracture of samples. The pits were most commonly formed in the vicinity of already existing surface damage, caused by the presence of bubbles. During the test, there is almost no change in the dimensions of pits. This can also be seen on evenly profiled lines, obtained using a red filter that gives the best resolution between the damaged and undamaged surfaces. The development of cavitation damage to the basalt samples is shown in Figure 2. Measurement of the mass loss of samples under the effect of cavitation during the test time is shown in Figure 3a. The total mass loss of sample during the test defines the cavitation rate of test material. Cavitation rate of basalt is 0.294 mg/min. The results of damage surface of samples, shown in Figure 2, correspond to the results of damage to the surface area of samples, determined using the Image Pro Plus for an image analysis during the cavitation time, Figure 3b. The total level of surface damage was 12%. It was noted that, during the operation of cavitation process, a smaller number of small pits is formed. So, there is almost no change in the dimensions of pits, Figures 3c and 3d.

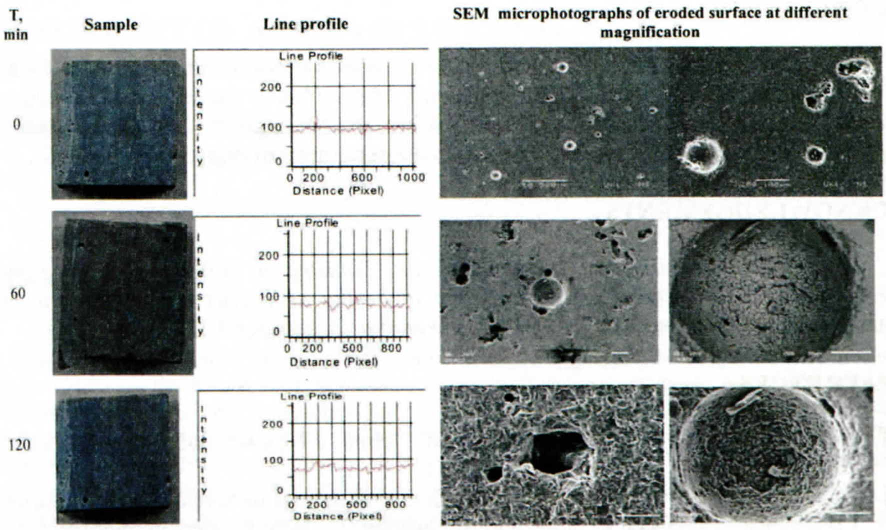
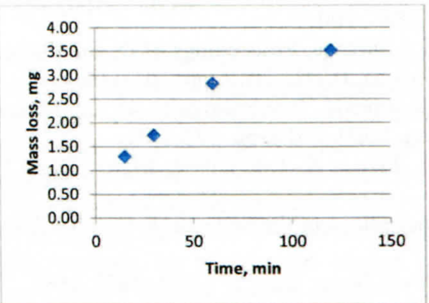
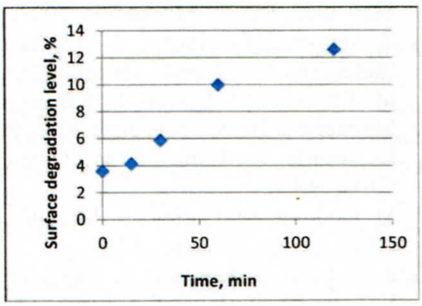


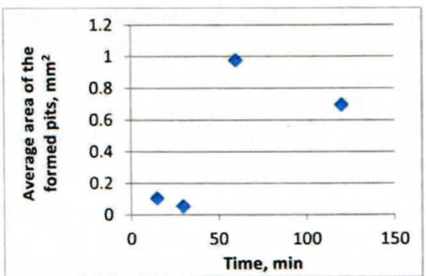
Figure 2 *Development of cavitation damage basalt samples in time 60 and 120 min*



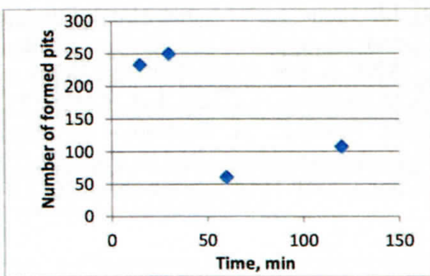
a. Mass loss



b. Surface degradation level



c. Average area of the formed pits



d. Number of formed pits

Figure 3 *Results of research on development the cavitation damage of basalt samples during the cavitation erosion test*

4 CONCLUSION

Investigations of cavitation damages on samples of cast basalt in duration (min): 15; 30; 60 and 120, showed a high resistance of samples to the effect of cavitation, (cavitation rate of 0.294 mg/min and total surface area damage of 12%). This indicates the possibility of using this type of material in the conditions of high cavitation loads.

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REFERENCES

[1] A. Karmanov, S. Ergul, M. Akyldiz, M. Pelino, J.Non-Crystall.Sol., 354 (2008) 290-295.
[2] M. Pavlović, S. Grujić, A. Terzić, Lj. Andrić, Proceedings of Serbian Ceramic Society Conference - Advanced Ceramic and Application II – New frontiers in multifunctional material science and procession, Book of Abstracts, Belgrade, Serbia, 2013, p. 36 (P7).
[3] R. Simić, A. Prstić, N. Gilić, Proceedings of the Conference - Cement 2002, 15-17 May 2002, Struga, Macedonia, 2002, pp. 156 – 160.
[4] Z. Aćimović, Lj. Andrić, V. Milošević, S. Milićević, Proceedings of IX Conference Metals and Non-Metals Materials 2012, Zenica, B&H, 2012, pp. 105-110.
[5] M. Pavlović, M. Sarvan, F. Klisura, Z. Aćimović, Proceedings of 4th Conference Maintenace 2016, 02-04 June 2016, Zenica, B&H, 2016, pp. 175-183.
[6] Lj. Andrić, Z. Aćimović, M. Trumić, A. Prstić, Z. Tanasković, Mater. Des., 33 (2012) 9-13.
[7] M. Pavlović, M. Đuričić, A. Mumđić, Proceedings of the SED 2015, October 2015, Užice, Serbia, 2015, pp. 53-60.
[8] A. Todić, B. Nedeljković, D. Čikara, I. Ristović, Mater. Des., 32 (2011) 1677–1683.
[9] V. Fiore, G. Di Bella, A. Valenza, Mater. Des., 32 (2011) 2091-2099. doi:10.1016/j.matdes.2010.11.043
[10] J.P. Franc, J.M. Michel, (Eds). Fundamentals of Cavitation, Series Fluid Mechanics and its Applications, Kluwer Academic Publischers, New York, 2004, Vol. 76, XXII, p. 306, ISBN: 1-4020-2233-6.
[11] M. Dojčinović, Chem. Ind., 67 (2013) 2 323-330.
[12] M. Pavlović, M. Dojčinović S. Martinović, M. Vlahović, Z. Stević, T. Volkov-Husović, Compos. Part B- Eng., 97 (2016) 84-91, doi.org./10.1016/j.compositesb.2016.04.073.