Thesis of the doctoral (PhD) dissertation

THE EFFECT OF THE MINERAL CONSTITUENTS OF WORKED NATURAL GRANITES INFLUENCING THE SURFACE QUALITY

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Introduction and the aim of the work

In my thesis, I dealt with the surface roughness of natural rocks, including granites, and the influence of the natural minerals that make up the rocks on their surface properties. On the surface of the natural rocks from different deposits, strips with different parameters were formed on which I performed the tests.

After precision machining, these natural granites can be used as tables for measuring machines and as beds for machining machines, which is a popular material for these equipments due to its vibration-damping effect. It can be used as a raw material for kitchen counters and dining tables, even if it is a little far from industry, where the unique pattern resulting from its heterogeneous composition makes it salable. In addition, it is often chosen as the raw material for gravestones because of its good resistance to changing weather conditions.

My aim is that the tests carried out on the surface contribute to making subsequent machining processes faster and more economical. With less material loss, the surface defined by the customer should be available, the amount of scrap during machining should be reduced, and the final parameters required for machining should be easier to determine. Once you know the results, start the material separation with a set of parameters that will hold their own for a large part or even completely without further changes

Experimental activity

I made 5x5 cm sample pieces from the previously formed rock pieces with a CNC-controlled milling machine, on which I performed the tests. First, I identified the minerals that make up the given sample pieces with a light microscope, and then examined them with an electron microscope. At that time, the focus was already on the unique (atomic percentage) composition of minerals. In order to clarify these results, I also determined the elemental composition of the samples using an X-ray diffractometer. After that, I examined the area-based surface roughness of individual minerals with a 3D measuring system. Knowing the

results, it became clear to what extent which granite-forming mineral influenced the change in the surface roughness value.

I carried out further tests, where I measured the Vickers hardness after polishing the surfaces. I looked for the relationship between the previously examined elemental composition and Vickers hardness, and I came to the conclusion that the combined presence of certain elements affects both the surface roughness and the hardness of the rocks.

Knowing these results, it is easier to achieve adequate surface roughness, and the machining parameters can be determined precisely.

Thesis

1. Regarding the surface quality of the various minerals that make up natural granites, the following statement can be made within the material separation speed range of 37,7 – 226,2 [m/min]. **The surface roughness value of the minerals on the milled surface of natural granite rocks varies between 14,1 µm and 2,77 µm, and it continuously decreases as the material separation speed increases. This relationship is consistent across all investigated minerals on the granite surface, including quartz, albite, microcline, labradorite, orthoclase, and biotite.** This regularity proved to be true regardless of grain size.

Related publication: E. Cserta and I. G. Gyurika, 'Effects of the granite-forming minerals on the surface roughness in the milling processes', International Journal of Advanced Manufacturing Technology, vol. 112, no. 11–12, pp. 3041–3052, 2021, doi: 10.1007/s00170-020-06534-w

2. Due to their variable mineral composition, granites exhibit inhomogeneous surface roughness, complicating their processing. The following correlation can be established between the type of minerals that make up granite and the resulting surface quality after milling within the material removal speed range of 37,7 – 226,2 [m/min]. The different minerals in granite affect the surface roughness to a different degree, in this regard - from the highest roughness to the lowest - the following order can be established:

I. quartz

II. microcline

III. labradorite

IV. orthoclase

V. albite

VI. biotite.

The scale is relative, the minerals are ranked based on their relative effect on the surface. This order is consistent across all granite samples examined. The above finding supports the milling of granites resulting in the best possible surface quality.

Related publication: E. Cserta, I. G. Gyurika: Investigation of the influence of mineral types on surface quality in the case of milled granite surface, Proceedings of the 6th World Congress on Mechanical, Chemical, and Material Engineering (MCM'20), doi: 10.11159/mmme20.122, 2020

3. The elemental composition of the mineral types that make up natural granite varies. The different elemental composition of minerals affects the surface roughness. The following statement can be made regarding the relationship between the surface roughness of minerals and their elemental composition. In the case of milling biotite and feldspar minerals (albite, labradorite, microcline, orthoclase) at a material removal rate of 37,7 [m/min], the surface roughness increases as the $\boldsymbol{Fe + Si}$ content increases. The presumed reason for this is the higher local hardness, which usually results in a poorer surface quality in the case of rocks.

Related publication: E. Kelemen-Cserta and I. G. Gyurika, 'Influencing effect of minerals composition in natural granite rocks on surface roughness', Results in Materials, vol. 21, p. 100504, Mar. 2024, doi: 10.1016/J.RINMA.2023.100504.

4. The hardness of the constituent minerals is an important factor in the milling of natural granite media, impacting both workability and tool life. The following conclusions can be made regarding the relationship between the hardness and elemental composition of minerals. The $\boldsymbol{Mg, K, Ca}$ amount of constituents have no well-defined effect on the hardness of the minerals, including quartz, albite, microcline, labradorite, orthoclase, and biotite. At the material removal speed of 37,7 [m/min], the Vickers hardness measured on the polished surface decreases as the $\boldsymbol{Na + Al}$ content increases in the case of the examined feldspars, including albite, microcline, labradorite, orthoclase.

Related publication: E. Kelemen-Cserta, I. G. Gyurika, 'Influencing effect of minerals composition in natural granite rocks on microhardness', Hungarian Journal of Industry and Chemistry, vol. 49, 2021, doi: https://doi.org/10.33927/hjic-2021-11

Publication by Eszter Kelemen-Cserta

Publication related to thesis

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