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ASPECTS OF UTILIZATION OF SINTERED BASALT PARTS IN MACHINE BUILDING

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Abstract

Experimental wearing tests with parts from sprinklers, harvesters, cereal, hay and straw gathering machines demonstrated that the use of sintered basalt in machine building contributed to a twofold-threefold decrease of energy, brass, graphite, cast iron and aluminium consumption, along with much steadier technological quality indices.

The diffraction lines of natural rocks and, then, those of sintered basalt parts were analysed using diffractometric investigation methods. The diffractograms examined verified the factors that contribute to the wear resistance modification, and the necessity of varying the technologies for shaping and mechanical processing of parts in connection with calcination and sintering heat treatment.

Keywords: sintering, basalt, machine building, sprinklers, agricultural machines.

1. Introduction

Basalt parts can be obtained through casting, followed by a recrystallization heat treatment, or by the method of powder sintering. The basic raw material is the natural basalt rock. Basalt improves its main chemical, physical and mechanical properties through melting and recrystallization. Molten basalt can be cast in various metallic moulds, resulting in polyfunctional and efficient parts for different industrial fields, including machine building.

The elaboration of modern producing technologies of basalt parts having superior physical and mechanical qualities implies study and research of substances the basalt rock is made of. After having applied the heat treatments, the structure parameters and Miller indices of parts were measured. Heat treatments result in structural changes and the occurrence of new substances as an outcome of sintering chemical reactions [3, 6].

2. Experimental Methods Concerning Basalt Parts Elaboration

Turning basalt as raw material into a product or finished part implies several operations: choosing the raw material and its processing till it will be transformed in powder (washing, drying, sorting, crushing, screening, grinding, preparation and screening of powder-binder mixture, shaping and pressing of parts), drying and calcination, machining and sintering.

2.1. Choosing Basalt Rocks

In order to observe changes of crystalline phases during the elaboration process of parts exposed to machine building, substances were identified through X-ray diffractometric methods with basalt rocks collected from Racoş, Oneşti, Braşov, ICSITPSMC. The X-ray diffraction by the substances in the basalt rocks pointed out the structure of these materials.

Considering the diffractograms recorded with the rocks collected from the 4 centres we obtain that they consist of the following substances; anorthite ($CaOAl_2O_32SiO_2$), magnetite (Fe_3O_4), olivine $(MgFe)_2SiO_3$, dolomite ($CaCO_3$-$MgCO_3$), ilmenite ($FeTiO_3$).

When analyzing the values of diffraction angles read on diffractograms and the calculated d_{hkl} distances one can notice that the basalt rocks from Braşov and Oneşti display 12 anorthite diffraction lines (white colour, glassy, and it crystallizes mono- or tricyclically). Oneşti rocks also have magnetite lines each (octahedrical crystals or beady/grainy aggregates; it crystallizes in cubic system), olivine (green-olivine colour, crystallizes rhombically) and ilmenite (grayblackish colour, semi-metallic glitter; crystallizes trigonally). The rocks from Braşov do not have ilmenite but display 3 d_{hkl} lines of olivine and two of magnetite.

The basalt rocks from Racoş only display 6 d_{hkl} lines of anorthite and 3 d_{hkl} lines of magnetite, olivine and ilmenite. The parts made of these rocks are more resistant.

The basalt rocks from ICSITPSMC are characterized by 8 anorthite diffraction lines, 3 lines of magnetite and one line of olivine and dolomite (it is transparent, colourless and crystallizes in trigonal system).

2.2. Technological Aspects Concerning the Achievement of Basalt Parts

Technological experiments [4] on test pieces of various shapes and dimensions demonstrated that when making basalt parts the following aspects should be considered:

– the compactness, structure, cohesion of basalt-binder mixture and the compacting during sintering process are influenced by the force employed for pressing the material into the dies.

– the quality of the parts made of basalt through sintering is influenced by the pressure of shaping and by the sintering temperature. The parts made at pressures of 1.5 force tons and 2 force tons are more compact, the dimensional deviations are smaller, and as the shaping pressure in dies rises, the contraction coefficient decreases along with the improvement of the parts' quality.

The sintering technologies [4] depend on the shaping regime, the calcination regime and the sintering regime, i.e.:

– the shaping regime is established according to the proportion of mixture components and the parts shaping pressure;

– the calcination regime depends on the heating rate and on the sintering temperature;

– the sintering regime as well as the calcination regime depend on the heating rate and on the sintering temperature.

The sintering regime of differently shaped and dimensioned parts has been established on the basis of sintering parameters with rates of 85° C/h, 125° C/h and 140° C/h, i.e.: the heating time, the duration of one impulse, the number of impulses and the time afforded for keeping parts in the sintering process have been calculated for the specified speeds.

When elaborating the execution technologies for the parts to be used in machine-building, the parameters of shaping, calcination and sintering regime were established experimentally [4], considering the shape, dimensions and weight of parts.

The raw basalt parts obtained after shaping are taken as semi-products, having the dimensions augmented according to basalt contraction percentage. They reach normal dimensions during heat treatment, drying, calcination and sintering. That is why the dimensions of the dies as well as the thermic regime specific for each part type must be calculated according to the dimensions and tolerance field established in the documentation [7, 8].

3. Experimental Results and Discussion

The experimental wear test with some parts of farm sprinklers (whirling nozzles, pump rotors, chain tightening rolls, gaskets), straw and hay picking machines (guiding roll, spacers, pusher, ring and roll) and cereal harvesters (ball joint, the piston in hydraulic cylinder and gasket-holding bushing) have demonstrated that not all of these meet reliability requirements for production use.

It reveals from the analysis of the diffractograms drawn for the parts made of sinterized basalt that, during the calcination and sintering process, no significant chemical reactions occurred [7, 8].

The substances identified on computer in terms of ASTM cord index are registered on diffractogram.

Furthermore, the analysis of d_{hkl} distances indicates that the parts made of basalt consist of substances having a high frequency of anorthite, followed by olivine, magnetite, hematite, dolomite and pyrite.

The study of diffractograms of the rocks used in producing parts and those of the basalt parts demonstrates that, within the elaboration process and mainly during the heat treatment, no structural changes occur at the level of elementary cells able to cause the alternation of physical and mechanical characteristics.

The high frequency of anorthite in the mass of materials made of basalt makes the parts obtained via sintering have a glassy state, so they lack elasticity. To improve the quality of the parts, this glassy state should be altered through heat treatments. That is the reason why the parts made of basalt must be subjected to sintering followed by crystallizing heat treatments the temperature of which is to be determined through further thorough research.

The most representative samples of parts made of basalt have been subjected to electron microscopic analysis. The micrographs obtained have been magnified 1,000 and 300 times for each separate part. The parts made of basalt have been subjected to calcination (800° C) and sintering (1,280° C). The analysis of the micrographs of various types of parts leads to conclusions that help to find out the causes of certain wear resistance of parts.

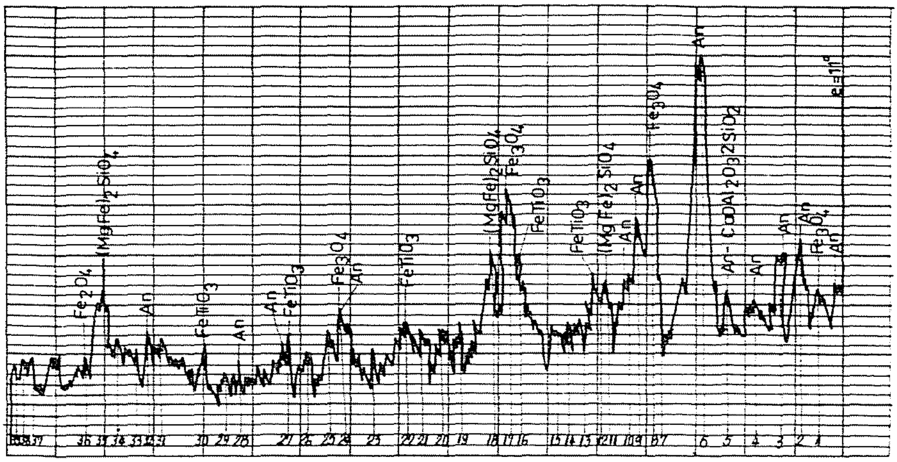


Fig. 1. Diffractogram for Racoş basalt rocks

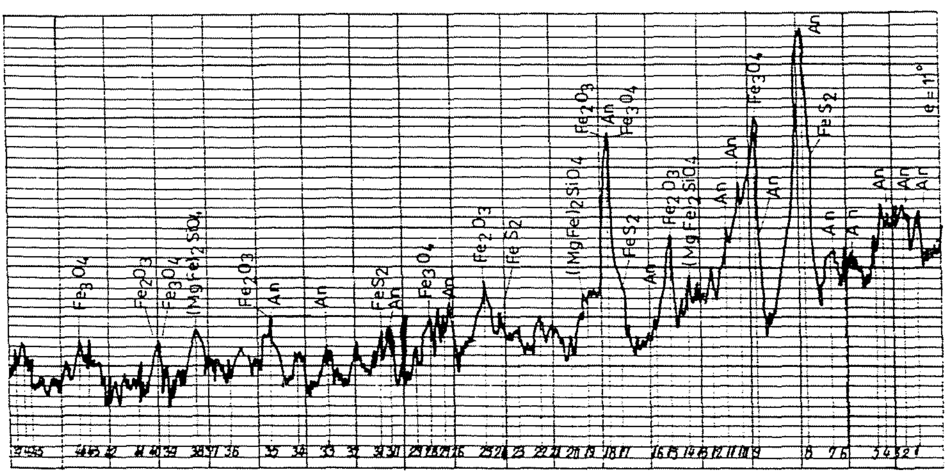


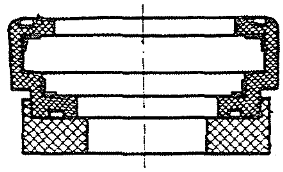
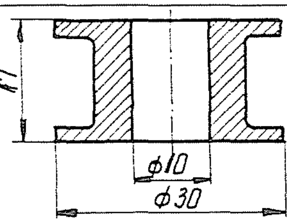
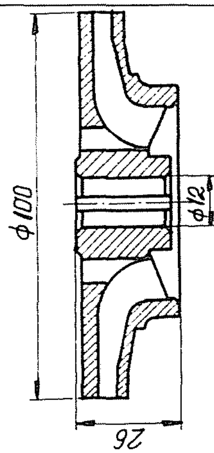
Fig. 2. Diffractogram of parts made of sintered basalt

3.1. The Operating Behaviour of Some Basalt Parts for Sprinklers

Table 1 shows the characteristics of the parts made of sintered basalt and demonstrates that the tested parts behaved very accurately with sprinklers.

The micrograph in *Fig. 3* has been made for chain tightening roll and pump rotor; it demonstrates a compact sample with acicular crystallizings

Table 1
Basalt-made parts for sprinklers

Part denomination	Part drawing	Operating behaviour
1.Gasket		– Belongs to hydraulic pump gland. – High wear resistance as compared to graphite-made gaskets. – No falls occurred because of pump untightness or premature wear. – Wear speed is 3.68-4.13 μm/h.
2.Chain tightening roll		– Belongs to chain tightening unit. – Normal operation without fissures, cracks or blockings. – Wear resistance twice as high as with current rolls. – Good guiding and chain tightness are assured.
3.Pump rotor		– Belongs to hydraulic pump unit. – Normal operation tests. – High corrosion resistance as compared to currently made rotors. – Displays the same characteristics as the pumps having cast-iron rotor. – No wear, breaking or other falls were registered with basalt-made rotors.

and very good compactness. The amorphous mass displays rounded and less marked shapes [5].

3.2. The Operating Behaviour of Some Basalt Parts for Straw and Hay Baling Presses

The parts subjected to wear resistance tests in operation were: the pusher at the guiding and cord passing mechanism, the ring at the guiding and cord

Fig. 3. Micrograph of parts made of sintered basalt for chain tightening rolls and pump rotor

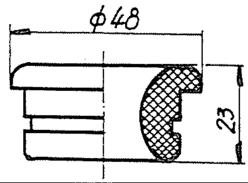
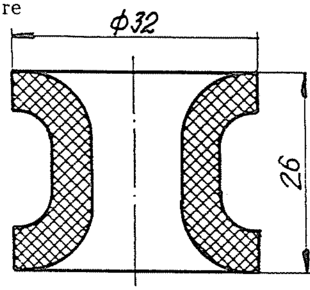
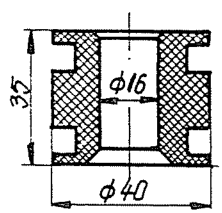
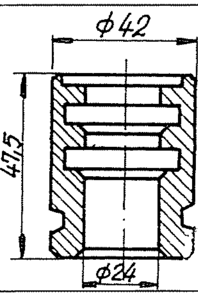
braking mechanism, the guiding roll that guides the wire along the lay-out from coil to twister (*Table 2*), and the spacers at the twisting assembly [2].

The micrograph in *Fig. 4* is characteristic for the parts used with straw and hay presses, *Table 2.* It represents the pusher of the guiding and cord-passing mechanism, and the baling wire guiding roll. When enlarged 300 times, the sample is compact, with acicular crystallization and very good compactness, without porosities. It is characterized by a larger amorphous mass and cleavage zones.

3.3. The Operating Behaviour of Some Basalt Parts for Harvester-Thresher Combines

The parts wear-tested during operation are the ball joint, the piston in the hydraulic cylinder and the gasket holding bushing, shown in *Table 2.*

Table 2
Basalt-made parts for straw and hay baling press and for harvester-thresher combines

Part denomination	Part drawing	Operating behaviour
1. Ring from cord guiding and braking mechanism		- High wear resistance, uniform tension and proper braking of bale-tying cord. - Compactness 99.61 % - Calcination at 905° C, sintering at 1080° C.
2. Bailing wire guiding roll		- Better wear resistance as compared to currently produced rolls; good baling wire guiding. - Basalt-binders mixture sifting through ∅ = 1 mm sieves. - Calcination at 965° C; sintering at 1080° C. - Wear resistance 0.2-0.3 g/cm^2.
3. Hydraulic cylinder piston		- Component of hydraulic cylinder. - Has 2 exterior canals placed 3 mm from ends, and a conical groove in the interior. - Extreme walls break at exterior canals.
4. Gasket holding bushing		- Belongs to hydraulic cylinder. - It is provided with circular seats for gaskets, both exterior and interior. - The walls between interior canals break, and so do even the walls of the seat for the steel washer.

Researches [1, 4] demonstrated that the crystalline structures in basalt were not affected by ageing, a well-known phenomenon with most metallic alloys.

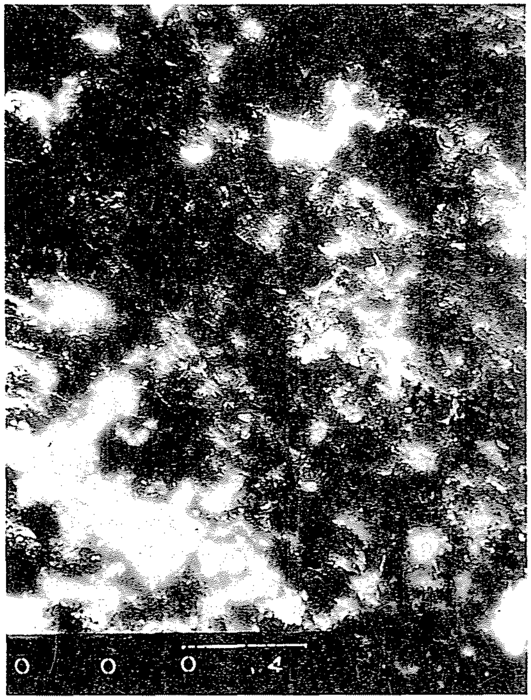


Fig. 4. Micrography of parts made of sintered basalt for bailing wire guiding roll

4. Conclusions

The studies concerning the operating behaviour of parts made of sintered basalt lead to the following conclusions:

1. The parts made of sintered basalt for sprinklers and those for straw and hay baling behave better in operation than those made of metal; they have higher wear and corrosion resistance, steadier technological indices (output, dispersion angle, spraying uniformity, etc.), the energy consumption is reduced 2-3 times, the consumption of brass, graphite, cast iron and aluminium decreases.

2. The diffractometric methods for the investigation of parts made of sintered basalt made it evident that calcination and sintering should be further studied and improved, as high contents of anorthite and olivine contribute to the reduction of compression and shock resistance; crystallization heat treatments are necessary.

3. Shaping and processing technologies have to be diversified and improved according to the construction characteristics of parts and to mechanical strains they are subjected to during machine operation.

4. The (radial and axial) mounting clearances necessary for the proper operation of machines at regime temperature must be determined by elaborating a calculation method on the basis of die-forming process because mechanical processing of finished parts is very difficult.

References

1. CHIRIAC, GH. – MARIN, N. (1989): Studii şi cercetări privind realizarea şi experimentarea de piese din bazalt pentru utilizarea la combine de cereale. Referat ICSITMUA Bucureşti.
2. CHIRIAC, GH. – MARIN, N. (1990): Realizarea şi experimentarea de piese fabricate din bazalt pentru utilizarea la prese de adunat şi balotat paie şi fân. Referat ICSITMUA Bucureşti.
3. GHEORGHIEŞ, C. (1990): Spectrul de difracţie şi tehnica de investigaţie. Editura Tehnică Bucureşti.
4. MARIN, N. (1990): Stabilirea tehnologiei de realizare a pieselor din bazalt. Referat ICSITMUA Bucureşti.
5. NICULA, AL. – SANDRU, L. (1989): Dielectric Properties of Some Ceramic Materials. *Studia Universitatis "Babeş Bolyai"* Physica nr. 2, anul XXXIV, Cluj Napoca.
6. SANDRU, L. (1992): The Structure, Dielectric and Ferroelectric Properties of Some Ceramic Materials. *Physical Studies and Researches* nr. 7, Vol. 14, Academia Română Bucureşti.
7. TOMESCU, D. – MARIN, N. – SELTEA, C. (1989): Realizarea lotului experimental din piese din bazalt şi experimentarea lor în condiţii de laborator. Referat ICSITMUA Bucureşti.
8. TOMESCU, D. – MARIN, N. – STIRBEI, I. – CRIŞ, S. – SANDRU, A. L. (1989): Studii şi cercetări privind comportarea la uzurfa a pieselor din materiale ceramice prevăzute a se folosi ca piese de schimb pentru tractoare şi maşini agricole. Referat ICSITMUA Bucureşti 1989.

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