STRUCTURE AND PROPERTIES OF ELECTRO-CORUNDUM GRINDING TOOLS

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The crystal structure of electro-corundum grinding grains

From the point of view of the manufacture of grinding tools as well as of the grinding process, the crystal structure of the grinding grains is equally important because, in a final analysis, all the properties of these grains can be retraced to this factor. In a previous communication [1] the mineral, and the crystal structure, respectively, of fine electro-corundum (alumina electro-corundum) has been discussed in detail. Here some results of studies concerning normal electro-corundum grains will be described.

Microscopy of normal electro-corundum grains points out differences between colour and surface morphology of each grain. A strict correlation between mineral structure and the causes of the visually ascertainable differences could be verified by X-ray diffractometry, and by electron microscopy. From a point of view of both the manufacture of grinding tools and the grinding process the practically uniform and in each case reproducible mineral structure of grinding grains is important because only such ones can yield reproducible quality grades at narrow tolerances.

For the separation into fractions of practically uniform mineral composition of the normal corundum particles that are heterogeneous according to their crystal structure, a method has been worked out, and a patent application has been filed. In the case dealt with here, this method had been applied to separate the sets of particles into six fractions.

According to our investigations, in the grain of the normal corundum remarkable changes take place on thermic effects, influencing the grinding wheels made from them.

To study this fact the fractions of normal corundum were heat-treated at 1300 °C and 1700 °C.

The former temperature is in the range of producing, i.e. firing of grinding wheel, the latter is a value near to the thermic effects at the usage.

The momentaneous temperatures at the usage can be, as it is well known, much higher than the mentioned value.

The afterdrawn copies of the original X-ray diffractometer diagrams of the fractioned and heat-treated normal corundum samples are — visually

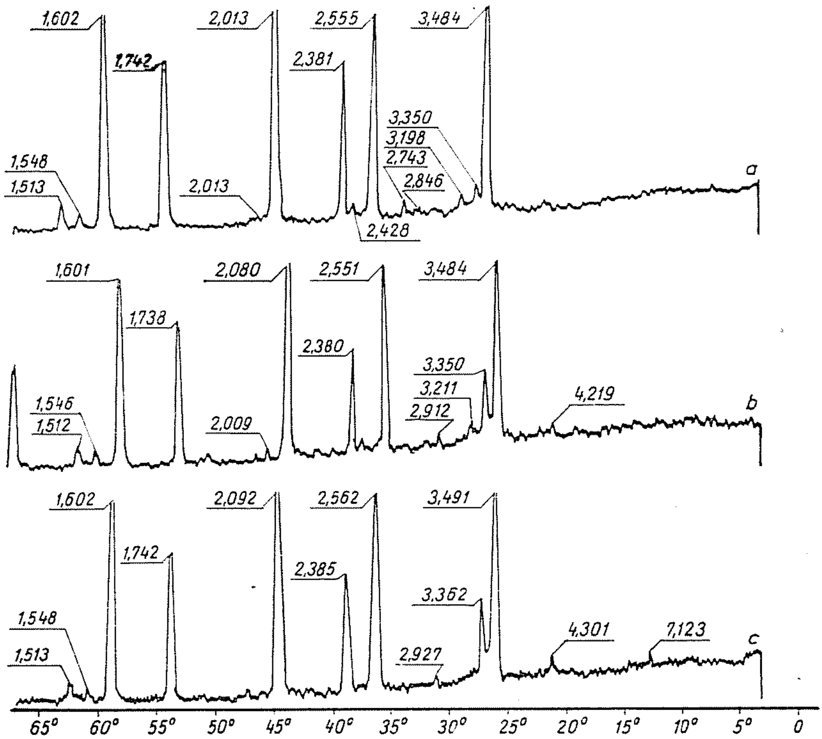


Fig. 1. a) Fraction 1, untreated; *b)* Fraction 1, treated at 1300 °C; *c)* Fraction 1, treated at 1700 °C

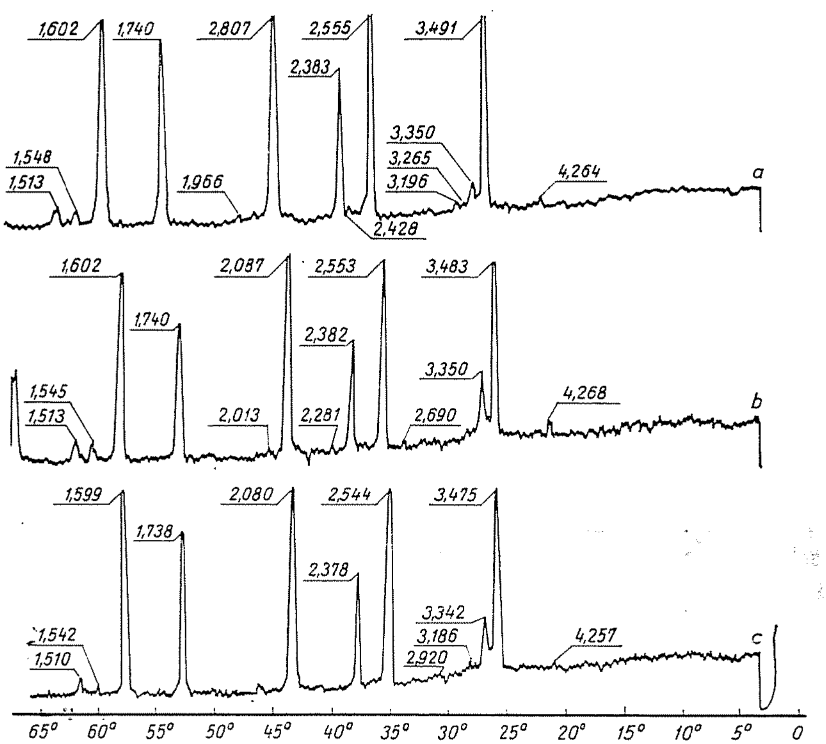


Fig. 2. a) Fraction 2, untreated; *b)* Fraction 2, treated at 1300 °C; *c)* Fraction 2, tre ated a 1700 °C

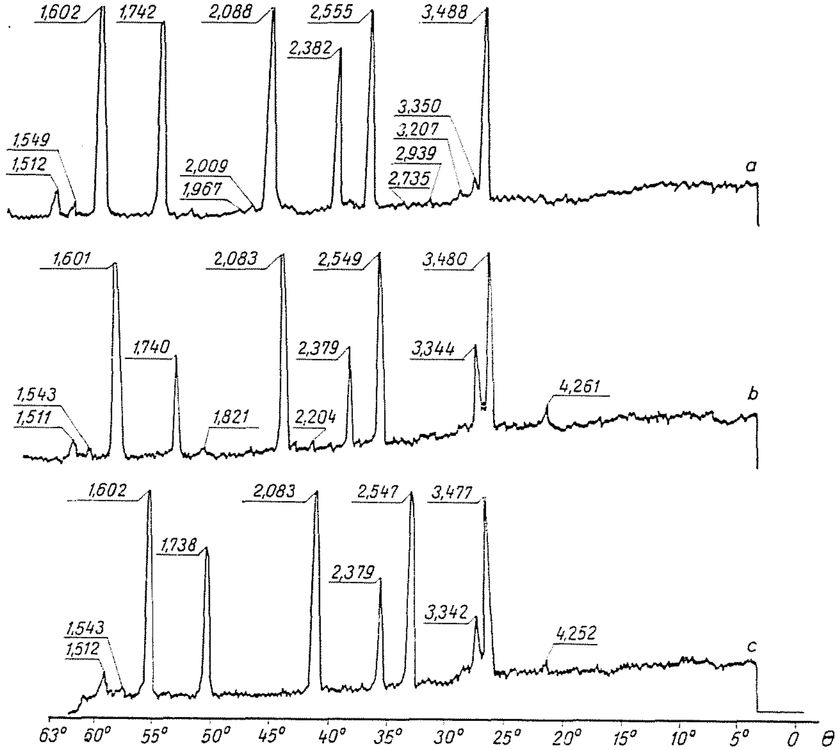


Fig. 3. a) Fraction 3, untreated; *b)* Fraction 3, treated at 1300 °C; *c)* Fraction 3, treated at 1700 °C

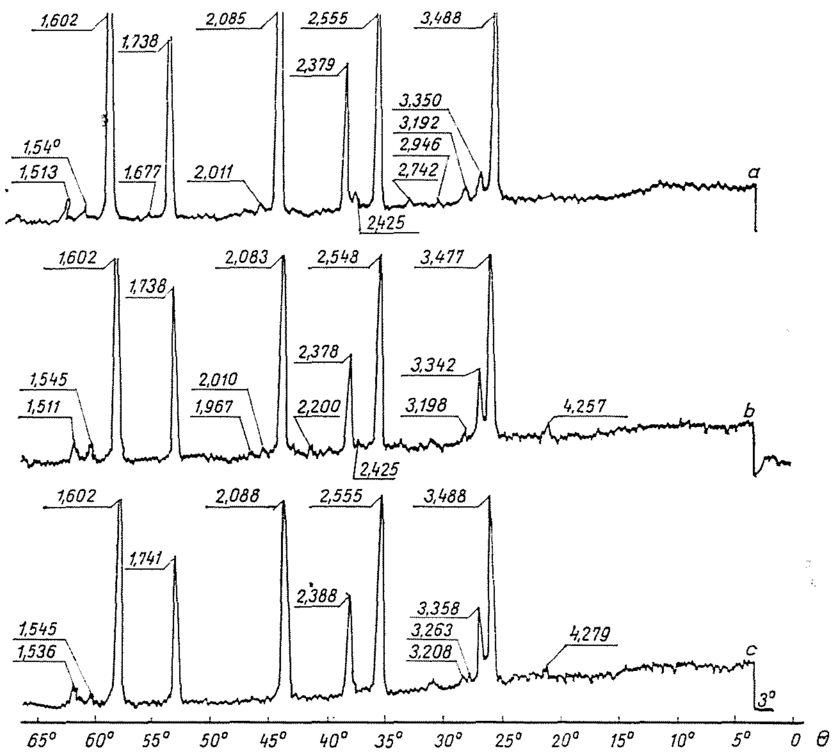


Fig. 4. a) Fraction 4, untreated; *b)* Fraction 4, treated at 1300 °C; *c)* Fraction 4, treated at 1700 °C

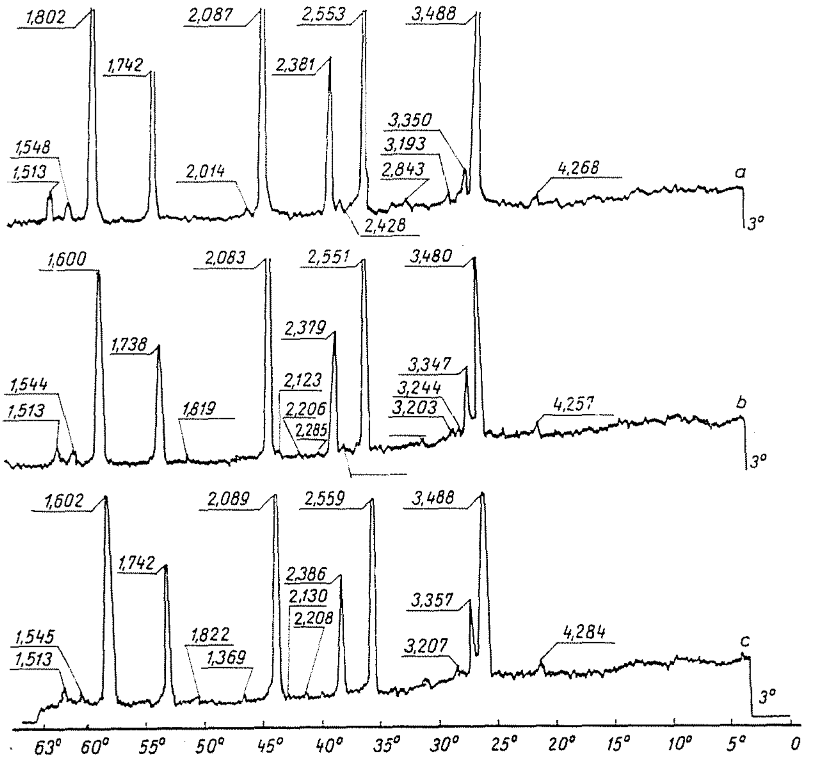


Fig. 5. a) Fraction 5, untreated; *b)* Fraction 5, treated at 1300 °C; *c)* Fraction 5, treated at 1700 °C

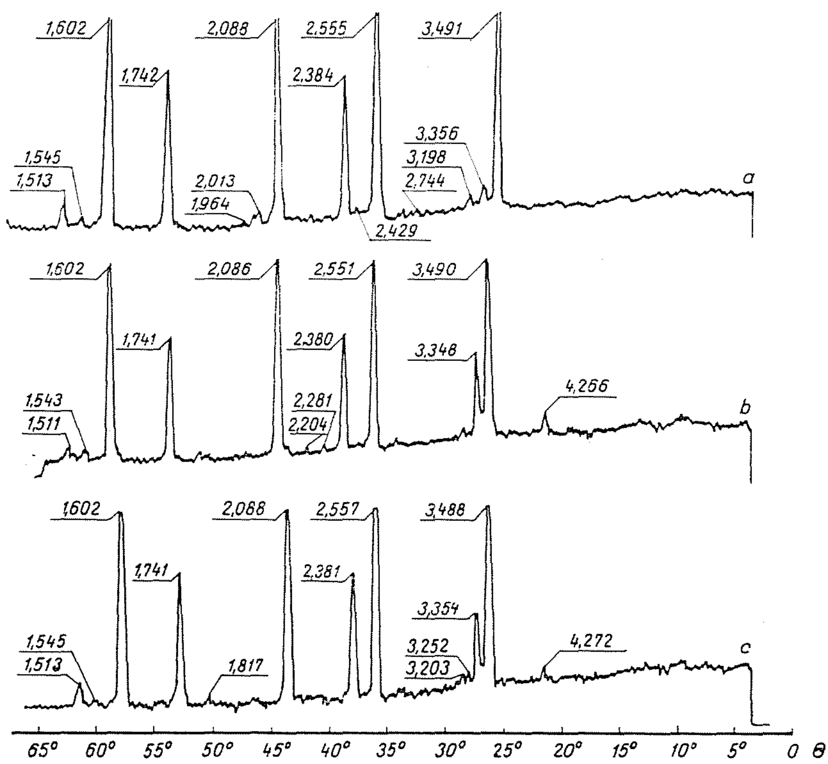
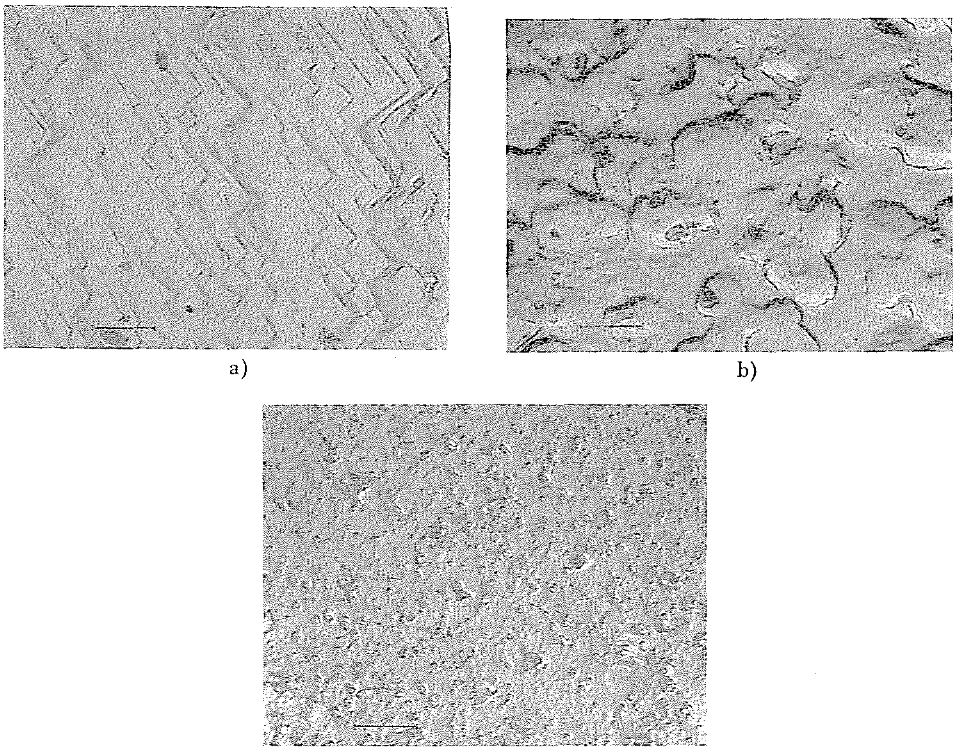


Fig. 6. a) Fraction 6, untreated; *b)* Fraction 6, treated at 1300 °C; *c)* Fraction 6, treated at 1700 °C

compared — suitable to show the differences, and this was the aim here. (Figs 1a—c to 6a—c).

Among the components affecting the properties of the normal corundum the iron oxides do not form a special phase, but can be found in the phase of α-corundum in different quantities and so the intensity relations of the α-corundum reflections show significant differences.



a) b) c)

Fig. 7. Electron microscopy of normal corundum grains; $\times$ 16 500

The most important α-corundum lines of the diffractograms are often cleft so that the second line is stronger.

This fact proves that here are two phases with very slightly different lattice constants.

In the investigated normal corundum felspar can be found in traces, and litioforit (β-$Li_2Fe_2O_4$) which can be found in bauxite, too.

On the basis of results of the described studies the following conclusion could be drawn.

The separation of grinding grains of heterogeneous mineral structure into practically homoge-

neous fractions and their heat treatment under different conditions assure possibilities for quality gradations formerly not realizable in the manufacture of grinding tools.

We mentioned that normal corundum grains show various surface morphologies. This statement is valid also for sub-microscopic surfaces, as evidenced by electron microscope pictures.

Structural constitution of ceramic binder matrices and of grinding tools

The formation and properties of ceramic matrices have been discussed in detail in reference [1]. Here some features will be mentioned which deserve notice from the point of view of the properties of both the ceramic matrices and grinding tools.

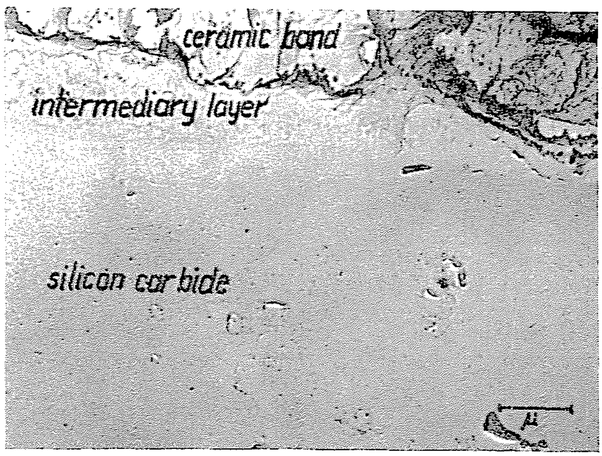


Fig. 10a. The binding characteristics of the ceramic binding material and silicon carbide grains. × 15000

Experiments made by means of a high temperature microscope have shown that during fusion both the grinding grains and the binder bridges are displaced within given limits and thus there is a sensitive response of the structural constitution of a tool to ignition technology. In the period of rapid cooling that follows ignition peak temperature in chemically bonded grinding tools the viscosity of the binder rapidly increases prior to the final development of structural constitution. The longitudinal creases on the more viscous binder bridges clearly show the permanent traces of the twisting of grinding grains.

Both figs 8 and 9 clearly show that the binder smelts into the electro-corundum grains. The coalescence of the two phases occurs only in the case of electro-corundum grains. In the case of silicon carbide grinding grains the porcelain type binder forms with the so-called intermediary layer of a few microns thickness a less strong connection. In Fig. 10, the intermediary layer be-

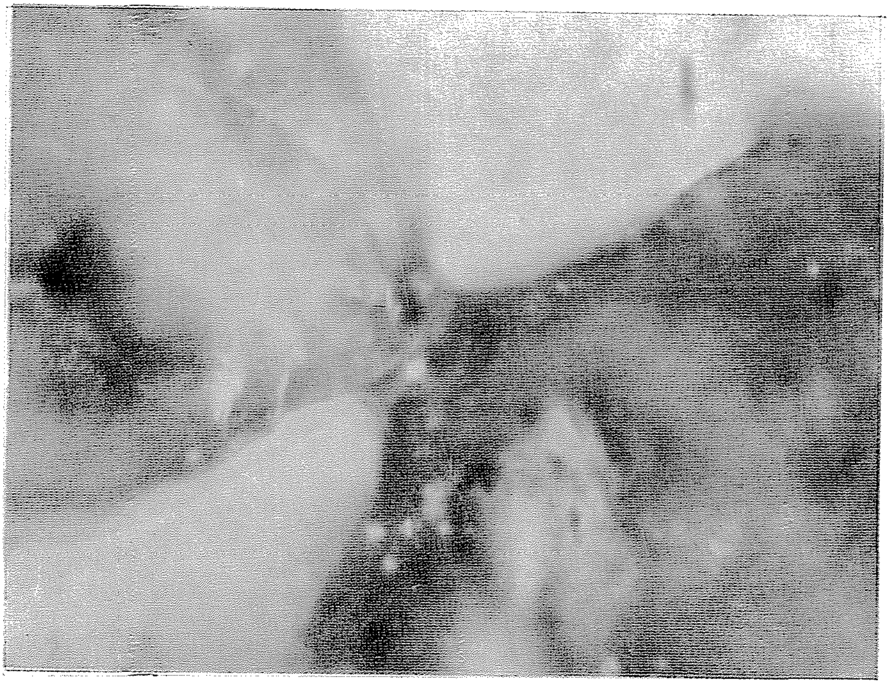


Fig. 8. Binder bridge joining electro-corundum grains, magn. × 300

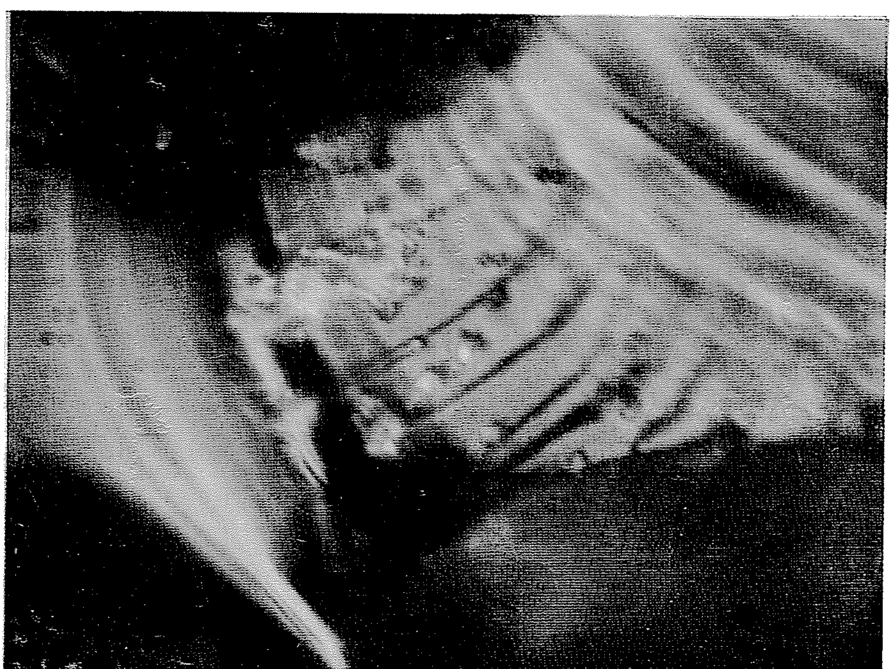


Fig. 9. Longitudinal creases in binder bridges, magn. × 900

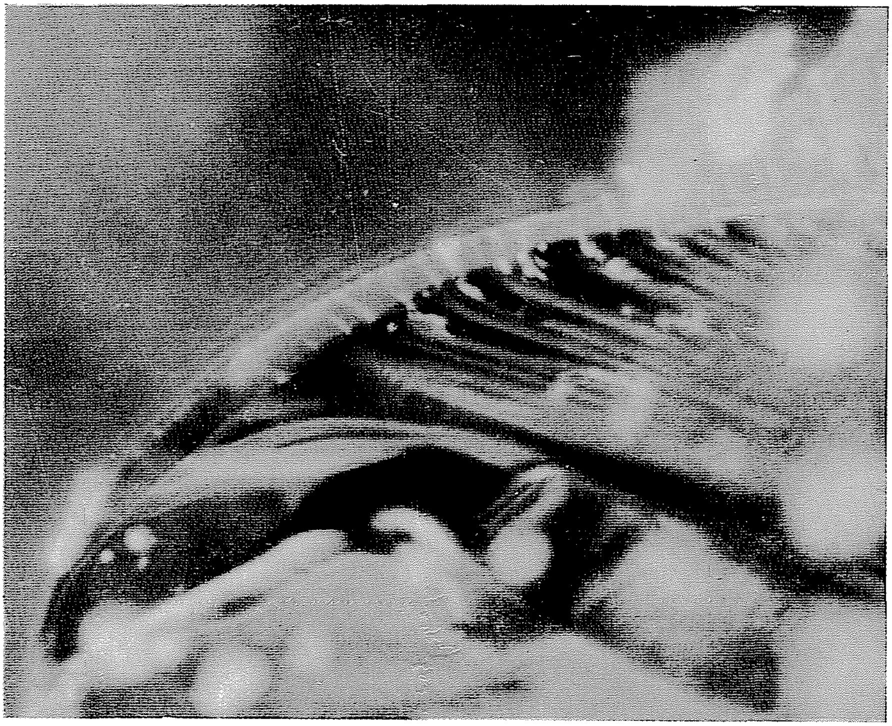


Fig. 10. Position of ceramic binder on green silicon carbide grains, magn. × 400

Fig. 11. Position of binder bridges on electro-corundum grains, magn. × 250

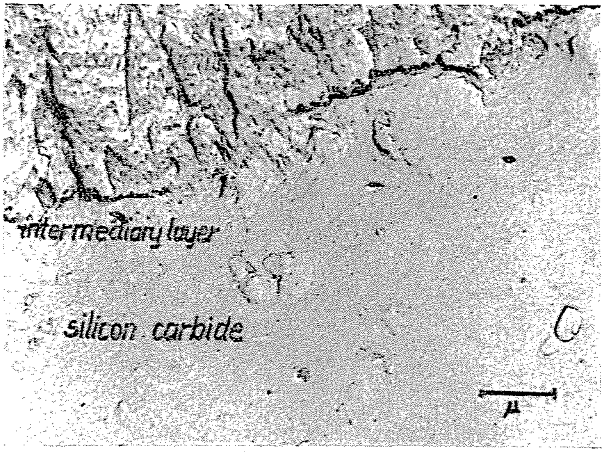


Fig. 10b. The binding characteristics of the ceramic binding material and silicon carbide grains; × 15000

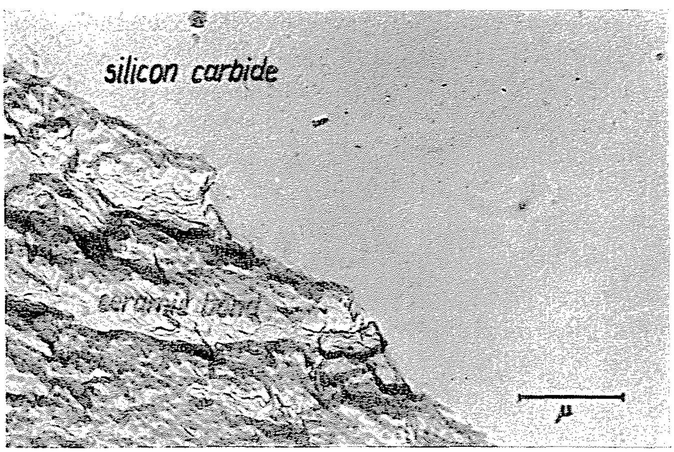


Fig. 10c. The binding characteristics of the ceramic binding material and silicon carbide grains; × 21000

tween the white, burnt ceramic binder and the green silicon carbide grain is discernible.

The binding characteristics of silicon carbide grains and the ceramic binding material can be well observed on the electron microscopic diagrams.

The dimensions, arrangement and number of the binder bridges greatly depend on the dimension and shape of the grinding grains. This is clearly seen in Fig. 11.

In reference [1] we have drawn attention to the fact that, in contrast to the general opinion, the optimum properties of grinding tools are not assured by the perfectly vitreous binder but by a suitable ratio of crystalline to vitreous phases, in the binder this ratio being very sensitive to conditions of heat treatment.

Since the heat treatment conditions lend themselves to control the ratio of crystalline to vitreous phases, and thereby the "hardness of bond", without changing the binder proportion, importance of hardness grades obtained by the conventional method of altering the binder proportion is reduced, this method being more up-to-date, more sensitive, and permitting hardnesses in a wider range to be obtained.

Effect of production parameters on the modulus of elasticity of grinding tools

As a result of theoretical and practical studies carried out by PEKLENIK [2], the traditional concept of bond hardness, and the prevalent methods of its measurement, have been superseded by newer, more up-to-date theories and methods of measurement. The utilization of the modulus of elasticity to characterize grinding tools dates back to long ago [3], yet it was demonstrated but recently, by measurements and up-to-date methods of study due to PETERS and SNOEYS [4] that the modulus of elasticity provided a better means of qualifying the grinding tools than the inadequately defined concept of hardness.

In the literature, the modulus of elasticity of mostly commercially available tools is correlated to other measurable characteristics, e.g. to porosity, to Norton hardness, and also correlations are sought for between the behaviour of tools in use and their modulus of elasticity.

The Chemical Technology Department of the Budapest Technological University prepares, on pilot plant scale, prototype series of various novel grinding tools which are in constant use in a great variety of mechanical workshops. The results of these practical tests are very helpful in further technological studies concerning grinding tool production.

In the case to be described here results of measurements of the modulus of elasticity of these prototype tools are brought into correlation with parameters involved in the manufacture of grinding tools.

The tests were carried out in the Electro-Acoustics Laboratory of the Hungarian Academy of Sciences, by exposure to vibrations at audio-frequencies.

The modulus of elasticity was studied in function of the binder quantity (from 10 to 17.5 per cent by weight) and in function of the ignition temperature (1200, 1250 and 1300 °C), other factors being kept constant.

Figs 12 through 15 unequivocally demonstrate that the modulus of elasticity of grinding tools can closely be adjusted or controlled by proper adjustment of either the binder quantity or the ignition temperature. The effects of other factors will not be discussed at this juncture since relevant data are

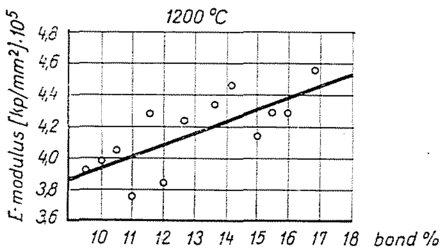


Fig. 12. Moduli of elasticity of grinding tools ignited at 1200 °C, as a function of binder quantity

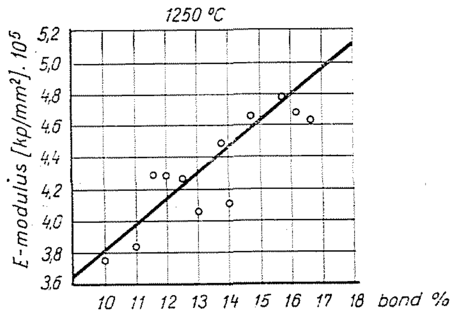


Fig. 13. Moduli of elasticity of grinding tools ignited at 1250 °C, as a function of binder quantity

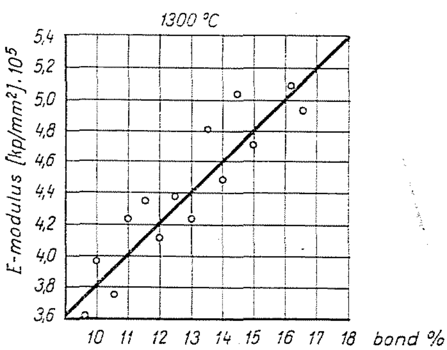


Fig. 14. Moduli of elasticity of grinding tools ignited at 1300 °C, as a function of binder quantity

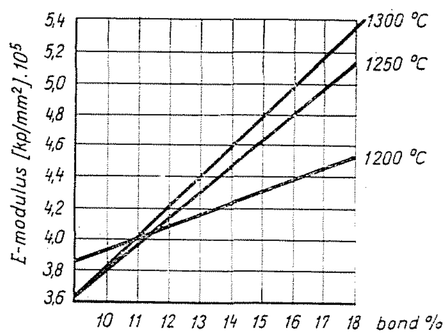


Fig. 15. Effect of ignition temperature upon the modulus of elasticity

being processed. Our aim was to draw attention to the main ways how to affect the modulus of elasticity.

Electron microscope pictures were taken in the Electron Microscope Laboratory of the Csepel Iron and Metal Works Co. To research officer Mr. E. Vattay our thanks are due for the coloured pictures.

Summary

From among the fundamental factors which bear on the production and use of grinding tools, in this work those have been studied of which investigation, knowledge, and control may serve as a basis of a novel production and evaluation system that differs in principle from those known. Excerpts of parts of this extensive work include the following. Crystal structure of

electro-corundum grains and its alteration as a function of the ignition temperature of grindin tools; ceramic binder bridges; effect of production conditions upon the actually most importan characteristic of grinding tools, i.e. the modulus of elasticity.

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