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Investigation of alumina pellets for optical glass grinding

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ABSTRACT

Purpose: is in vestigation of alumina pellets for optical glass grinding from a mixture made of an abrasive powder of high purity α alumina and of a binding vitreous material.

Design/methodology/approach: The different manufacturing tests on the pellets tools made it possible to optimize certain parameters. This remains, however, insufficient to obtain a tool with optimal efficiency. It is in fact; difficult to simultaneously take into account all of the manufacturing parameters.

Findings: The sizes of the grains, the densification loading and the firing duration have an influence on the quality of the ground surface, on the amount of material removed and on the porosity of the pellets, a characteristic, that determines their lifetime.

Researches limitations/implications: The weak resistance to wear of the coarse and fine tools can be explained by the grains becoming detached from the binding matrix during the grinding process. The used grains are blunted during the grinding process.

Originality/value: An optimal combination of grinding process parameters was found for each phase of the glass grinding (coarse, medium and fine grinding).

Keywords: Optical glass; Alumina abrasive; Grinding; Polishing

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PROPERTIES

1. Introduction

In some cases in fabrication of optical parts lapping processes can be substituted by grinding with pellet-tools of alumina oxide and a suitable binding material, whereby typical disadvantages of lapping, like expendable tool sets and high wastage of the slurry, can be excluded or reduced. Compared in diamond pellets the investigated pellets have the advantage of a simpler manufacture of tools. In diamond pellets [1], the surface roughness obtained is 3.40 μm rms after 10 min of grinding, and by fine grinding with alumina grains in slurry is 0.640 μm rms.

Practical application of such processes requires the investigation of the grinding performance of those grinding tools and optimization of their composition.

An intermediate surface grinding process can be necessary, first of all, to eliminate the last micro deviations of the curvatures radii of the curved components and the peaks of the asperities on the glass surface, and also to reduce the roughness to such a level that fine surface finishing would be possible.

It is only after this stage that the effects of the micro cracks as described by Preston and others [2-5] and the glass hydrolysis come into play. Grinding can be done using free abrasive grains in suspension or by a pellet tool.

It has been shows [6-8] that the effectiveness of surface grinding by agglomerate grains is particularly influenced by the following manufacturing parameters: compacting pressure, firing temperature and duration, the kind of binding material and the proportion abrasive to binding materials.

2. Experimental procedure

Alumina abrasive grains pellets were manufactured using the abrasive grains and some others additions and prepared by special die manufactured for this subject. The morphology of the used abrasive grains is shown by Fig. 1.

Figure 1 shows the morphology of the abrasive grains. It is noticed that the grains have an angular form with sharp ridges in order to scratch the glass surface. Few lamellar grains can also be observed.

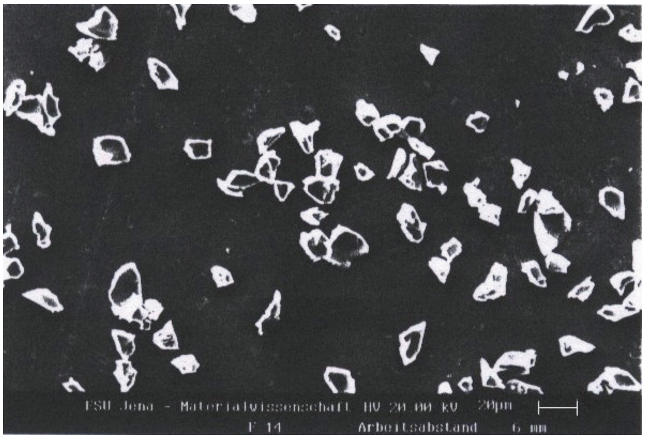


Fig. 1. Morphology of alumina abrasive grains

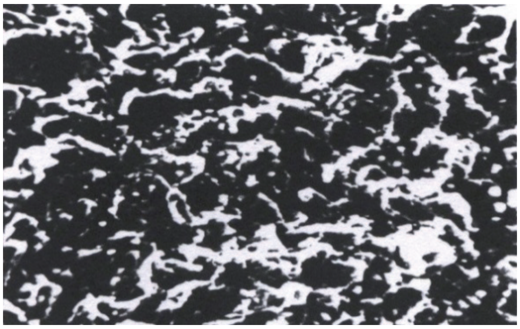
Figure 2 represent microstructures of the pellets P14, P28 and P80 respectively. The pellets are used for the fine, medium and coarse grinding correspondingly. It is noticed that the binding material wraps around the grains without changing their initial form. The porosity has been evaluated as 10.07%, 16.16% and 23% for P14, P28, and the P80 pellets respectively.

The sizes of the binding material grains are about one tenth of a micrometre (~ 0.1 µm) and their specific surface is 5.448 m²/g. The binding material softening temperature, evaluated by a heating microscope, is between 1150°C and 1200°C. Table 1 summarizes the characteristics of the alumina pellets elaborated.

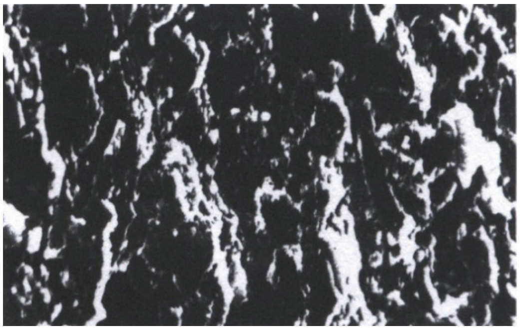
The manufacture of the alumina pellet was carried out by uniaxial compression at ambient temperature using a hydraulic press. Figure 3 shows the realization principle of the pellet. This manufacturing method is simple and economic.

Table 1.
Characteristics of the alumina pellets

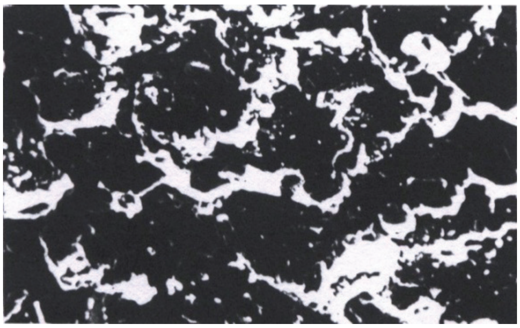
Grinding Pellets	Grinding phase	Mean size of grains, µm	Specific surface, cm²/g	Density, g/cm^3
P80	Coarse	80	361.16	3.533
P28	Medium	28	1119	4.057
P14	Fine	14	1855.4	4.080



P14



P28



P80

Fig. 2. SEM photograph of the pellets (——— 30 µm)

The compaction loadings used varied between 157 and 314 MPa. The compact product obtained was fired at 1200°C for 2 to 3.5 hours. The grinding tests with the manufactured tools were done on the same machine under the same conditions. The grinding tool is made of 9 pellets tied together on a metallic support with a resin. It rotates at a speed of 132 rpm. The glass sample Schott BK7, also rotates at a speed of 450 rpm, was applied against the pellets- tool. Its relative movements make it oscillate in the plane of the pellets with amplitude of 10 mm. The sample is continuously sprayed with distilled water at a rate of 500 ml/min. Figure 4 illustrates the grinding process.

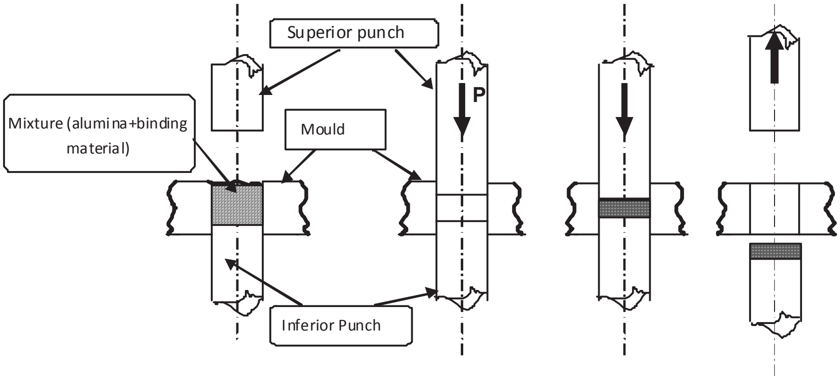


Fig. 3. Realisation of alumina pellets

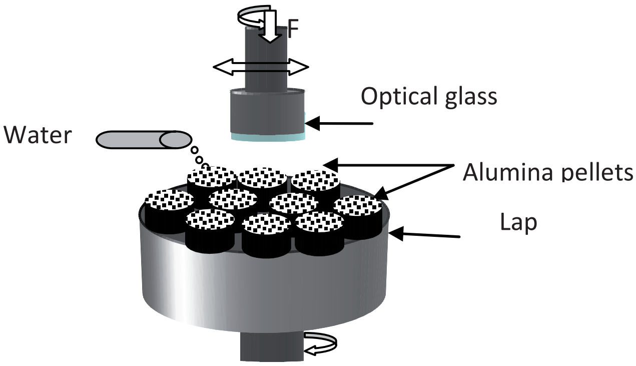


Fig. 4. Optical glass grinding process

3. Results and discussion

We notice that on the coarse grinding, the compaction pressure has no appreciable effect on the optimal duration which is about 5 minutes for all applied loadings. The lowest roughness for this grinding phase is obtained by the smallest loading (2.15 μm for 157 MPa). For the medium and fine grinding, however, the lowest roughness corresponds to the highness loading (0.615 μm at 314 MPa for P28 and 0.670 μm for P14) and the optimal duration are 4 min and 3 min respectively, The results on the effects of compaction pressure indicate that high loadings induce the fracture of the coarse grains (P80). This changes their sites and makes them inadequate for the coarse grinding phase. A loading of 314 MPa is too high for the F80 phase but it suitable for the F28 and the F14 phases. We can also see from the obtained results that it is better to have a longer firing duration in order to obtain maximal densification of the pellets. The medium grinding tool seems to be more resistant to wear and consequently has a longer lifetime. The weak resistance to wear of the coarse and fine tools can be explained by the grains becoming detached from the binding matrix during the grinding process. The used grains are blunted during the grinding process.

4. Conclusions

The different manufacturing tests on the pellets tools made it possible to optimize certain parameters. This remains, however, insufficient to obtain a tool with optimal efficiency. It is in fact; difficult to simultaneously take into account all of the manufacturing parameters. The sizes of the grains, the densification loading and the firing duration have an influence on the quality of the ground surface, on the amount of material removed and on the porosity of the pellets, a characteristic, that determines their lifetime. These parameters are interdependent. One of the most important parameters is the firing temperature. It should be chosen in such a way that it shortens the firing duration, conserves the initial grain size and morphology and obtains a liquid phase with a controlled viscosity and surface tension.

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