



Usure des grains abrasifs d'alumine liés en pastilles de rodage

Nabil Belkhir

► To cite this version:

Nabil Belkhir. Usure des grains abrasifs d'alumine liés en pastilles de rodage. CFM 2013 - 21ème Congrès Français de Mécanique, Aug 2013, Bordeaux, France. <hal-03441349>

HAL Id: hal-03441349

<https://hal.science/hal-03441349v1>

Submitted on 22 Nov 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Wear of the alumina abrasive grains bound into grinding pellets

N. BELKHIR^a, A. CHORFA^b, D. BOUZID^a

a. Applied Optics Laboratory, Institute of optics and precision mechanics, Ferhat Abbas University Setif1, Algeria

b. Department of Mechanics, University of Skikda, Algeria

Résumé :

Le processus de finition par abrasifs liés, appelé le rodage par pastilles, est une technique qui permet le traitement de la surface des composants optiques par l'enlèvement des défauts macro géométriques et la préparation de la surface au polissage. Plusieurs paramètres technologiques peuvent influencer l'efficacité du rodage et la qualité de la surface obtenue, en l'occurrence l'usure des grains abrasifs constituant les pastilles et les paramètres d'élaboration. Ainsi, une étude de l'usure des grains abrasifs des pastilles sous l'effet des conditions d'élaboration s'avère nécessaire afin de quantifier son influence sur le processus de rodage. Dans cette étude, des pastilles de rodage du verre optique à base de grains abrasifs d'alumine ont été élaborées avec différentes conditions. Après emploi des pastilles en rodage, les grains abrasifs ont été récupérés puis leur usure a été étudiée. Plusieurs techniques de microscopie optique et électronique ainsi que d'autres techniques de la métallurgie des poudres ont été employées. Les résultats obtenus ont permis de déduire que les poudres abrasives subissent une faible usure au cours d'une phase de doucissage. En plus, les paramètres d'élaboration peuvent influencer l'usure de la pastille, cependant seule la pression de compactage peut provoquer l'écrasement des grains lors de la mise en forme des pastilles et ainsi influencer leur usure.

Abstract :

The bounded abrasive finishing process, known as the pellets grinding, is a technique that allows the surface treatment of optical components by the removing of the macro geometrical defects and the surface preparation for polishing. Several technological parameters can influence the grinding effectiveness and obtained surface quality, in this case the wear of the abrasive grain forming the pellets and the elaboration parameters. Consequently, a study of the pellets abrasive grains wear and the influence of the preparation conditions is required to quantify their influence on the grinding process. In this study, grinding pellets containing alumina abrasive grains were prepared with different conditions. After employs of the grinding pellets, the abrasive grains were recovered and their wear was investigated. Several techniques of optical and electron microscopy and other techniques of powder metallurgy were used. The results led to conclude that the abrasive powders undergo low wear during a grinding phase. In addition, the preparation parameters can influence the pellet wear, however only the compaction pressure can cause fracture of the grains during the pellets forming and thus influences their wear.

Keys words: Alumina, Grinding, Pellets, abrasive wear

1 Introduction

Conventional lapping technology was performed by loose abrasive lapping (slurry lapping). The significant loss of time and grains has contributed to the use of the bonded abrasive in several applications [1-2], this process is commonly called fixed abrasive grains grinding or pellets grinding. In this process, the abrasive grains (typically alumina or diamond) are incorporated into small pellets using metal, vitreous, or resin as bond. During the grinding operation the pellets are fixed on cast iron machine platens. The ground surface

during pellets grinding is formed by the top surfaces of all the pellets. In most cases, the difference between the pellets used in grinding process is the abrasive grains nature (alumina, diamond, silicon carbide...), the cost and the manufacturing simplicity (elaboration parameters, time consuming...). The nature of abrasive grains used in elaboration of pellets depends on their use. Indeed, alumina pellets are efficiency in the glass finishing and diamond is better in the metals and ceramics finishing [2]. The grinding process is necessary to eliminate the form deviations and the surface roughness of the surface to be prepared for polishing. Material removal by abrasion in brittle materials is still not fully understood. The interactions of process parameters complicate the comprehension of grinding. Some authors [3-5] explain that during the grinding operation, the biggest asperities on the surface are eliminated by brittle fracturing causing microcracks with contribution of the glass hydrolysis.

Demirci [6] in their study on the influence of the grinding process parameters, have indicate that three different damage regimes are observed: the first one is the partial ductile with cutting action accompanied by chip formation, the second is the crushing or fragmentation regime and the third one is the partial ductile by ploughing action with the displaced material. The bond plays a very important role, as it is responsible of retaining the rigid inclusions against pull out mechanisms. The different binders are used in order to meet certain requirements as the surface roughness or the form accuracy. However, the satisfaction of these requirements can generate disadvantages. Indeed, the resins are employed for obtaining surface with lower roughness however it presents a very fast wear of the pellets [7-9]. Several other parameters of the pellets are very important for the understanding of the grinding process such as the density, repartition and shape of grains, nature and grains wear. The surface quality of ground glass is correlated with wear of abrasive grains [10] and obtained roughness is linked with wear of abrasive grains [11-13].

2 Experimental procedure

2.1 Pellets elaboration

The elaboration of the pellets was done using a-alumina abrasive grains type (ABRALOX, Quality E, Supplier Pieplow & Brandt GmbH) and three kinds of binders (resin, polyurethane and recycled glass). The chemical composition and the characteristics of the used abrasive grains are illustrated in Table 1 and their morphology is shown in Figure 1.

Elements	Al ₂ O ₃	TiO ₂	SiO ₂	Na ₂ O	ZrO ₃	Fe ₂ O ₃	MgO+CaO
%	95.96	2.5	0.85	0.01	0.21	0.20	0.27
Characteristics	Pellets	Grinding stage	Mean diameter grain(μm)		Density (g/cm ³)		
	P80 P40	Coarse Medium	80 40		3.93		

Table 1. Chemical composition and Characteristics of alumina abrasive grains.

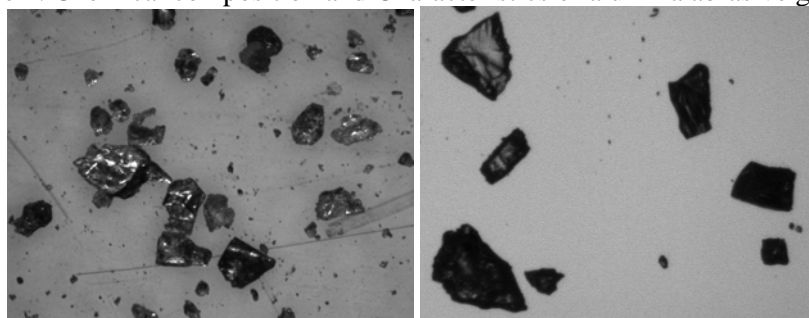


FIG. 1 – Micrographics of the used alumina abrasive grains ($\varnothing 80\mu\text{m}$) (x200).

The pellets elaboration was made in several steps. The first step was the mixture of the abrasive grains and the binding material powders. The second one is the mixture compaction which was done by hydraulic press in a closed die using uniaxial compression. Then the product was sintered. It's to be noticed that the choice of the elaboration parameters was done on the basis of preliminary experiences and the retained elaboration parameters are summarized in Table 2. The obtained pellets were visualized by SEM and LSM (Laser Scanning Microscope).

Binder	Resin	Glass	Polyurethane
Compacting Force [kN]	50	50	50
Firing temperature [°C]	150	850	120
Firing duration [min]	30	30	30
Diameter [mm]	8	8	8

Table 2. Pellets elaborations parameters

2.2 Grinding process

The elaborated pellets were used in grinding process (see fig.2) on a grinding machine using the parameters illustrated in Table 3. During grinding 9 pellets were fixed on a lap to form the grinding tool. The used samples are the BK7 Schott optical glass.

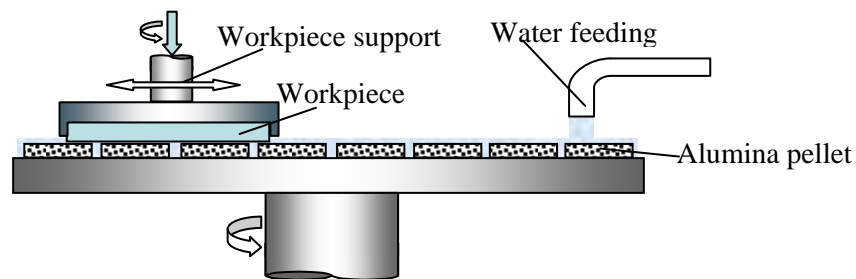


FIG. 2 – Principal of glass pellets lapping.

Grinding parameters	
Tool rotation speed	132 rpm
Sample rotation speed	450 rpm
Oscillation amplitude	10 mm
Water Feeding	500 ml/min
Grinding charge (N)	Without charge

Table 3. Grinding conditions

2.3 Characterization

During the grinding process, the quality and the efficiency of the process was characterized. The glass surface quality described by the quadratic roughness (rms) was measured using the mechanical profilometer FormTalysurf (Taylor-Hobson). For the efficiency described by the sample weight loss, it was measured by precision balance. In addition, the pellets wear was characterized by the thickness loss measured by optical microscope. The abrasive grains recovered from the working zone were visualized by optical CNC – Coordinate measuring machine ScopeCheck®200 (Werth Messtechnik GmbH).

3 Results and discussion

3.1 Pellets quality

The micrographics of the elaborated pellets obtained by SEM and LSM are shown in Figure 3 and 4 respectively.

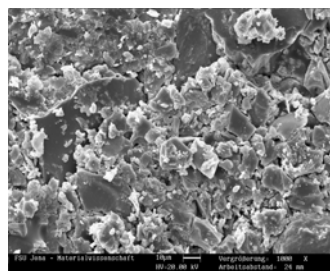
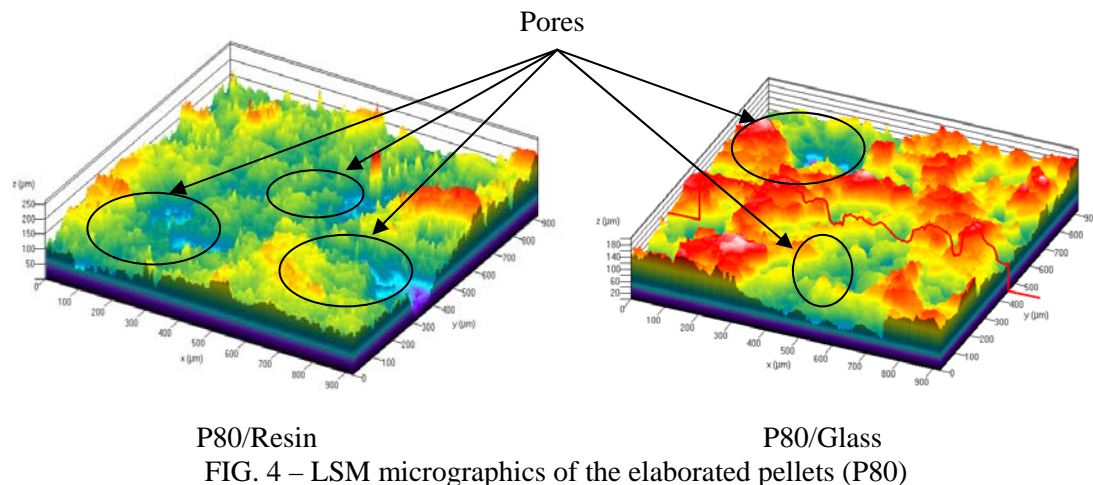


FIG. 3 – SEM micrograph of pellet (P80/Resin).



The micrographics in Figure 3 show that the abrasive grains have always the same morphology (sharp edges) after the elaboration process. In other way, the distribution of the abrasive grains and the bond is homogenous in the pellet, which permits the contribution of the entire pellet in the material removal during the grinding process. The LSM micrographics in Figure 4, show the abrasive grains surrounded by binders with the existence of some pores which can contribute to the grains detachment during the grinding process.

3.2 The pellets wear

The results of the pellets wear during grinding are illustrated in the Figure 5.

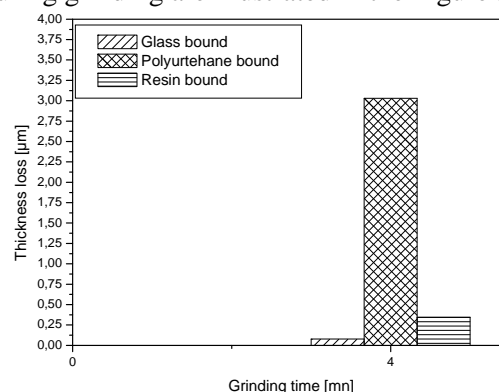


FIG. 5 – Evolution of the pellets wear.

The results show a difference of the pellets wear according to the binder nature. The higher wear is obtained for the pellets bounded by polyurethane. The influence of the binder on the pellets wear can be explained in several points. The first one can be the distribution of binder in the pellet after mixture which can cause the creation of pores or its nonexistence between the grains and makes their detachment very fast. The second point is the wettability between abrasive grains and binder, which may reduce the maintain force of the grain and then their loss will be easier. The last point is the effect of sintering temperature on the binder which can produce the formation of bigger bond grains and their existence in separate zones from the abrasive grains. This phenomenon produce disrupting of binder distribution in the pellet volume and thus a large number of grains stays free and be removed easily at the first contact with the glass surface.

3.3 The abrasive grains wear

The obtained results on the wear of the pellets bounded by polyurethane have allows as to make a judgment on this kind of pellets that they cannot be used in the glass grinding process.

The abrasives grains of the pellets bounded by glass and resin where recovered during the grinding process and where analyzed to define the influence of the binder nature on their wear. Pellets bounded with polyurethane were not considered because of their very high wear which made the grinding operation as a free abrasive lapping process. The granulometric distributions of the alumina abrasive grains are shown in Figure 6.

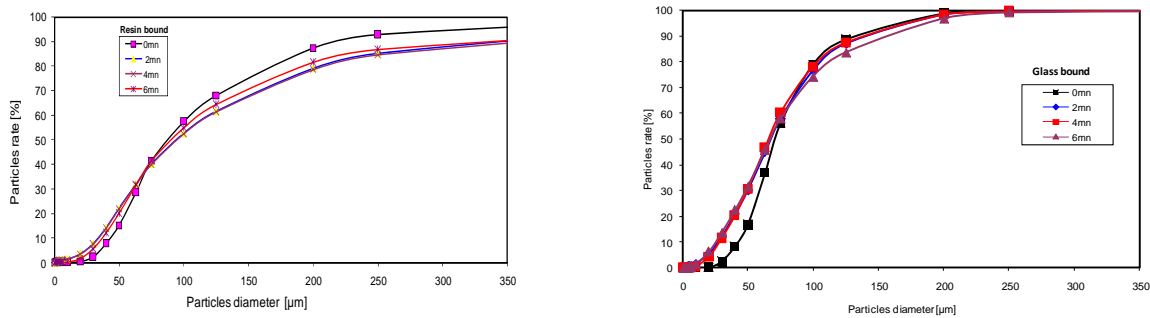


FIG. 6 – Evolution of the abrasive grains wear (P40)

The obtained granulometric distributions show the conservation of the abrasive grains to their dimensions after their use for 6 minutes which present a period longer than the optimal grinding phase. Indeed, the granulometric curves are nearly the same in the different grinding times for the two kinds of pellets. The results can be explained by the fact that the grains are detached from the pellets before their wear which allows them to conserve their dimensions. The abrasive morphology is also conserved as shown in micrographics in Figure 7. Indeed, comparably to the initial grains shape (see fig.1 and 3) the micrographics in Figure 7 shows that the alumina abrasive grains have always their irregular form with sharp edges.

It is to note that the very weak change in morphology is very similar to the change observed in the free abrasive grains lapping [11]. However, the grains can undergo fracture during the compaction process which can produce a morphological change and then the production of new grains with different dimensions.

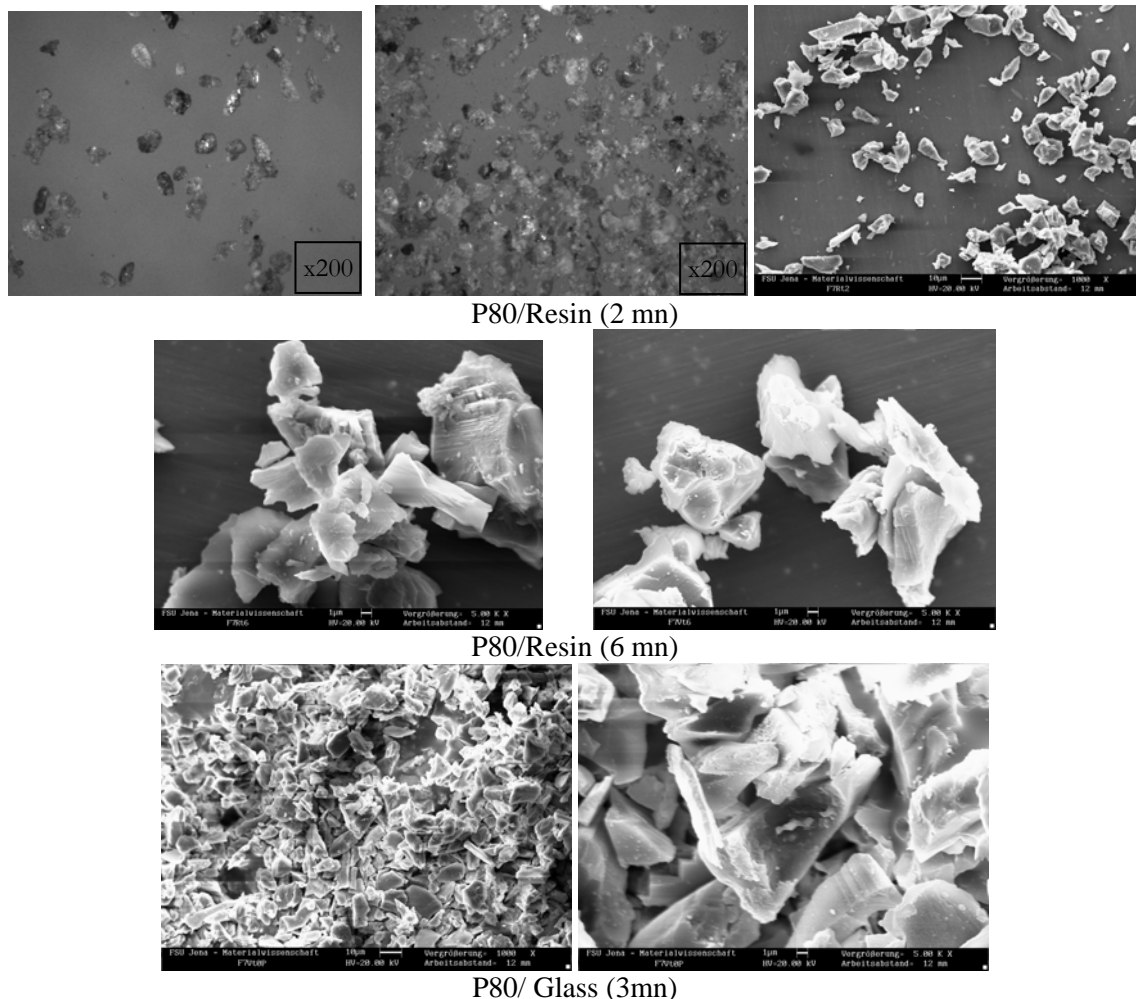


FIG. 7 – Micrographics of the alumina abrasive grains during grinding process.

Conclusion

The wear of the bounded abrasive grains and the influence of the binder were investigated to determine its influence on the pellets grinding efficiency and the surface quality. Several conclusions are drawn:

- The binder nature has a big influence on the surface quality and the removal material rate. The best results are obtained using the resin bounding material.
- The abrasive grains wear is very low. The grains wear can be caused during the grinding process as well as during the pellets compaction process.
- The wear behavior of the abrasive grains after their detachment from pellets is similar to that in free abrasive lapping process studied in a previous work [11].
- The pellets wear is much related to the binder nature. The polyurethane is not suitable as a binder for the alpha alumina abrasive grains pellets because of their very high wear.
- Despite the weaker wear of the pellets prepared by the glass binder but, the quality and efficiency are not as good as those of pellets elaborated using the resin.

References

- [1] Hed, P.P., Edwards, D.F.: Optical glass fabrication technology. 2: Relationship between surface roughness and subsurface damage. Appl. Opt. 26, 4677-4680, 1987
- [2] Filatov, Y. D., Rogov, V., V.: Features of a glass-polishing process using a tool with bonded polishing powder. Optics and spectroscopy 74(6),727-730,1993
- [3] Aleinikov, F. K.: The Effect of Certain Physical and Mechanical. Properties on the Grinding of Brittle Materials. Sov. Phys. Tech. Phys. 27, 2529, 1957
- [4] Anderson, D.S., and Frogner, M.E.: A Method for the Evaluation of Subsurface Damage. In Technical Digest, Optical Fabrication and Testing Workshop (Optical Society of America, Washington, DC, paper ThBB7 Optical Society of America, 1985.
- [5] Preston, F.W.: Chemical and Physico-chemical Reactions in the Grinding and Polishing of Glass. J. Soc. Glass Tech.14: 127-133, 1930
- [6] Demirci, I. S.Mezghani, M.El Mansori : On Material Removal Regimes for the Shaping of Glass Edges: Force Analysis, Surface Topography and Damage Mechanisms. Tribol. Let. 30 (2): 141-150, 2008
- [7] Malkin, S., Guo,C.: Grinding Technology : Theory and Application of Machining with Abrasives. 2nd Ed. Industrial press Inc, p.11-45, 2008
- [8] Venkatesh, V.C., et al. : The novel bondless wheel, spherical glass chips and a new method of aspheric generation. J. Mater. Process. Tech. 167, 184-190, 2005
- [9] Tong, S., Gracewski, S. M., Funkenbusch, P.D.: Measurement of the Preston coefficient of resin and bronze bond tools for deterministic microgrinding of glass. Prec. Eng. 30, 115-122, 2006
- [10] Luo, S.Y., Gracewski, S.M., Funkenbusch, P.D.: Studies on cut-off grinding of BK7 optical glass using thin diamond wheels. J. Mater. Process. Tech 173, 321-329, 2006
- [11] Belkhir, N., Bouzid, D., Herold, V.: Correlation between the surface quality and the abrasive grains wear in optical glass lapping. Tribol. Int. 40, 498-502, 2007
- [12] König, W., Koch, N.: Grinding of optical glasses with cup wheels. Glastechn. Ber. 62, 358 (1989)
- [13] Bouzid, D., Zegadi, R., Jungstand, U., Herold, V.: Investigation of cerium oxide pellets for optical glass polishing. Glas. Techn. 42(2), 60-63, 2001