3^{rd} International Brazilian Conference on Tribology – TriBoBR 2018
Florianópolis, Brazil, 3-5 December 2018

Effect of polishing load on roughness, surface porosity and material removal rate of engineering ceramics (Al_2O_3, ZTA and SiC)

Strey, N.F.* and Scandian, C.

Department of Mechanical Engineering, Federal University of Espírito Santo, Vitória, 29075-910, Brazil
*Corresponding author: nathan_strey@hotmail.com

1. Introduction

Control of surface finish of engineering ceramics for tribological applications, which determines surface crack size distribution, is critical to prevent early damage by brittle wear mechanisms [1]. However, polishing costs to obtain adequate roughness levels for practical applications can be high. Therefore, the optimization of the process become important for economic reasons [2].

The aim of this work is to investigate the effect of polishing load on average roughness (Ra), surface porosity and material removal rate (MRR) of Al_2O_3, zirconia-toughened alumina (ZTA) and SiC.

2. Materials and Methods

Samples consisted of sintered discs (53.8 mm × 7.0 mm) of alumina (Al_2O_3, 99.5 vol%, 1400 HV_1, K_{IC}=4 $MPa.m^{1/2}$), zirconia-toughened alumina (ZTA, 10 vol% ZrO_2, 1500 HV_1, K_{IC}=5.5 $MPa.m^{1/2}$), and silicon carbide (SiC, 2700 HV_1, K_{IC}=4 $MPa.m^{1/2}$).

Polishing was done in a Struers TegraPol-25 machine equipped with TegraForce-5 head for controlling load and rotation and TegraDoser-5 for abrasive slurry supply control. The first polishing step (P1) used a water-based 3 µm monocrystalline diamond suspension (DiaDuo-2 3 µm) and woven polishing cloth (MD-Mol), while the second step (P2) used DiaDuo-2 1 µm and nap cloth (MD-Nap). Evaluated polishing loads were 40, 50 and 60 N for each step. Other parameters of the process are shown in Figure 1.

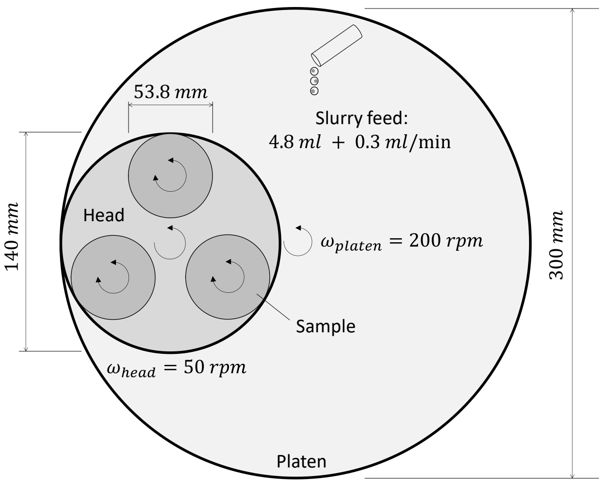

Figure 1 Operational parameters of the process.

Roughness, surface porosity and MRR were determined by profilometry (Taylor-Hobson Surtronic-25), optical microscopy (Nikon Eclipse MA 200) and weight loss (Sartorius CP225D), respectively.

3. Results and Discussions

ANCOVA showed that neither polishing load nor material affected roughness for P1 (Ra_1), when controlled by initial roughness (Ra_0). The following relation was found: $Ra_1=0.68\times Ra_0-0.05$; $R^2=0.93$. For P2, Ra_2 was affected by material, even when controlled by Ra_1, but again load did not play a significant role ($Ra_2=0.93\times Ra_1-0.02$; $R^2=0.94$). The 95% confidence intervals for final roughness (Ra_2) were 0.21-0.40 µm (Al_2O_3), 0.17-0.26 µm (ZTA) and 0.08-0.21 µm (SiC).

Surface porosity depended only on material for P2 but on material and polishing load for P1, when higher loads resulted in less porosity. SiC was the material that showed greater uniformity and lowest surface porosity, being as low as 0.5% after P2. ZTA's surface porosity was equal or lower than Al_2O_3, depending on position of the sample and polishing load. The lowest 95% CI surface porosity for Al_2O_3 and ZTA was 8-14% and 12-19%, respectively, reached after P2.

MRR for SiC was the highest in all tested conditions and was proportional to polishing load, while the load did not affect it significantly for oxide ceramics. MRR during P2 was considerably lower than during P1 for all materials. Figure 2 summarize these results.

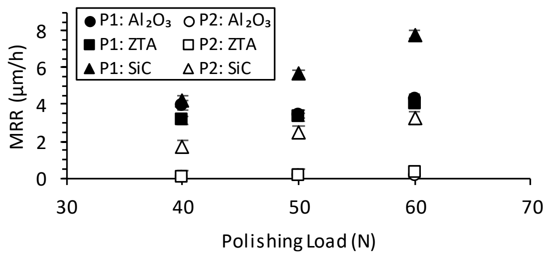

Figure 2 Material removal rates as function of load.

The synergy between the mechanical action of abrasives and tribochemical reactions between SiC and water from the slurry explains the high MRR observed for this material, that remove asperity peaks, reducing average roughness and surface porosity. Higher polishing loads resulted in greater surface temperatures that increased the rate of chemical reactions and, therefore, MRR. Al_2O_3 and ZTA were less susceptible to chemical reactions for the conditions tested and relied only on mechanical polishing mechanisms to improve their surface quality.

4. References

[1] K. Kato, *Tribology of ceramics*. Wear, 1990. 136.1.
[2] Marinescu, I.D. et al. *Tribology of abrasive machining processes*. Elsevier, 2004.