Research on electroplated diamond wheel dressing and precision grinding of optical glasses

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Abstract

In the present paper, one high-precision dressing proposal for electroplated diamond grinding wheel (91um grit-size) and the subsequent surface grinding experiments for three kinds of optical glasses (BK7, fused silica and fused quartz) are discussed. Results show that, the coarse grinding wheel was ultimately well conditioned by means of D3 steel dressing method with the wheel rotary accuracy 6um detected by a micrometer. Under selected machining parameters, the high-precision dressed electroplated diamond grinding wheel can produce the nanometric quality surface.

1 Introduction

With the increasing demand for precision machining of optical elements, especially large-size glasses, more attention is being paid to processing costs and machining efficiency. Some literatures stated optical glasses can be precision ground by coarse diamond grinding wheels, which were dressed by brazed diamond block or by fine-grained bronze bonded diamond wheel [1-3]. But only a few consider conditioning cost, efficiency and the dressing quality together. This paper is to choose a more effective material to dress the coarse diamond grinding wheel, so that it can achieve precision grinding for BK7, fused silica and fused quartz optical glasses.

2 Simulation analysis

The AdvantEdge software is used to simulate the wear state of single diamond grit with negative rake angle when scratching steel materials, aiming to choose the most effective material for dressing the corase diamond grinding wheel. The diamond grit scratched the steel material under cutting speed 140m/min, feed depth 0.03mm as well as no grinding fluid. By comparing the grit wear amount calculated with the

Usui's Wear Model, it was drawn that the D3 steel in America metal grade can be more beneficial to enhance the diamond grit wear speed. D3 steel is cold die steel with high strength, good hardenability and good wear resistance. The enlarged drawing of the diamond grit top when scratching D3 steel is shown in Figure 1. It can be seen that under the processing conditions, the wear amount of diamond grit is 0.898um.

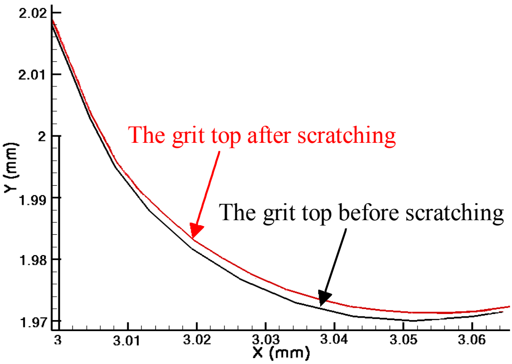
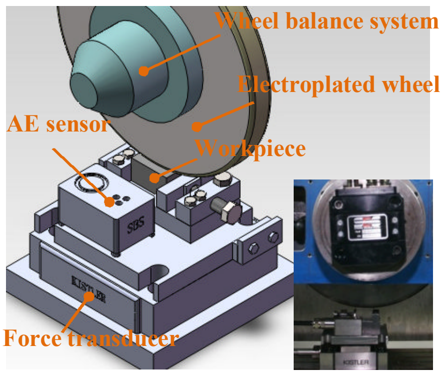


Figure 1: The grit wear state when scratching D3

3 Wheel conditioning and precision grinding experiments

3.1 Instruments and parameters

The 91um grit-size electroplated diamond grinding wheel was dressed by the D3 steel block. And then BK7, fused quartz and fused silica were precision ground by the effectively dressed wheel(see Figure 2). In addition, the machining process were effectively monitored by an acoustic emission(AE) sensor and a piezoelectric dynamometer. The machining parameters are listed in Table 1.



Firgure 2: Experimental setup illustration

Table 1: Description of the machining parameters

Conditioning	v_c=21m/s; a_e=10μm; v_{fd}=1000mm/min;
Grinding	v_c=21 m/s; a_e=2μm; v_{fd}=200 mm/min;

* v_c: dressing/ grinding speed;
v_{fd}: feeding speed;
a_e: dressing/grinding depth

3.2 Experimental results analysis

3.2.1 Wheel conditioning experiment

The 91um grit-size electroplated diamond grinding wheel was dressed using the D3 steel. From Figure 3, the run-out curves measured by the keyence laser micrometer indicate the wheel run-out errors decreased from the original 20.8μm to the final 5.8μm within 6 hours. The affinity interaction and chemical reactions between steel and carbon may occur in the contact area, which accerates the dressing speed.

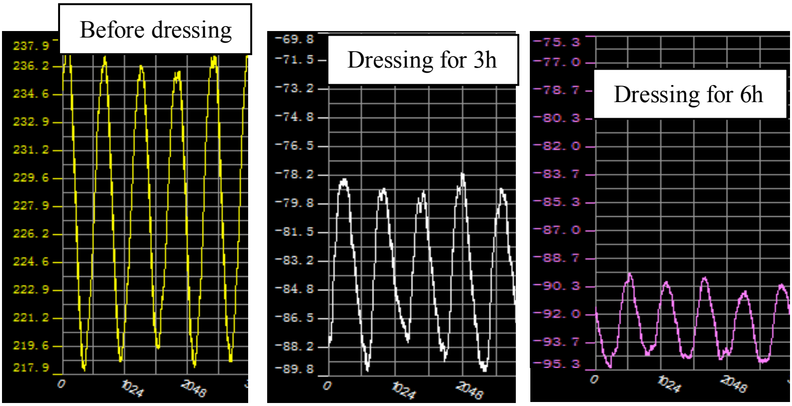


Figure 3: Wheel run-out curves during the conditioning process(run-out errors were 20.8um, 11.2um, 5.8um as follows)

Malkin[4] stated that dressing involves bond fracture and abrasive crushing, which can be divided into macro broken and micro-fragmentation. Figure 4 shows that the more highly prominent abrasives display macro broken and micro-fragmentation phenomenon after being dressed. But there is few bond breakage due to the higher bond intensity, thus no abrasive passivation. When the prominent abrasive tip is flattened or broken, the run-out error of the dressed grinding wheel will be reduced.

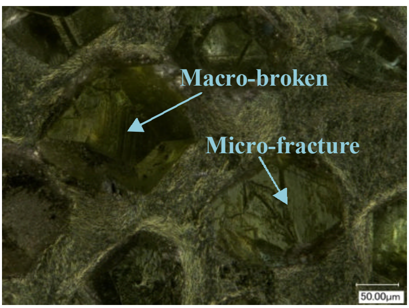


Figure 4: The dressed diamond grits pictures from Renishaw microscoper

3.2.2 Precision grinding experiment

BK7, fused quartz, fused silica optical glasses were surface ground by the dreesed electroplated diamond wheel. The workpieces surface roughness measured by the profiler and AFM were shown in Figure 5. It can be seen that these three kinds of optical glasses all achieved precision grinding surface with the Ra value less than 23nm (by Talor Horbson) and 30nm(by AFM) .

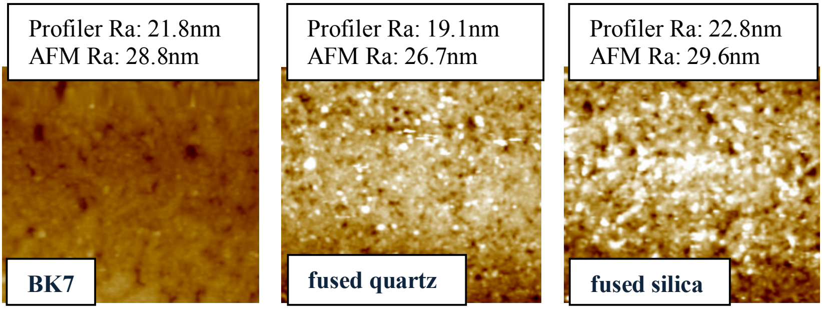


Figure 5: The AFM images and Ra values from profiler and AFM of workpieces

4 Conclusions

The 91um grit-size eletroplated wheel was ultimately well conditioned using D3 steel with run-out error less than 6um. The optical glasses were produced to nanometric quality, allowing the coarse abrasive grinding wheels to be reviewed in regard to their suitability and cost effectiveness for precision grinding optical elements.

References:

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