Precision Grinding of SF57 Glass with Engineered Grinding Wheels

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Abstract

This paper introduces the application of precisely trued and dressed engineered grinding wheels for the precision grinding of SF57 glass. The target was to investigate the influence of the grinding layer topography of dressed, coarse grained diamond grinding wheels on the material removal mechanisms in cross circumferential grinding. All grinding experiments were analyzed regarding the specific normal and tangential grinding forces F'_n and F'_t. The resulting surface roughness of the precision ground workpiece surfaces was characterized by evaluating the surface parameters Sa and Sz.

1 Indroduction

Precision grinding processes are indispensable for the manufacturing of optical components from difficult to machine materials [1]. To reduce the time and cost intensive finishing processes such as polishing, the surface quality produced by precision grinding processes becomes even more important [2]. Usually, precision grinding processes are carried out with fine grained, multi-layered resinoid diamond grinding wheels. Due to the high wear rates of these fine grained grinding wheels continuous dressing or periodically dressing cycles are necessary for reshapening and recreating the grinding wheel profile [3]. With defined dressed, coarse-grained diamond grinding wheels for ductile grinding of optical glasses these difficulties can be mastered.

2 Experiments

All precision grinding experiments were carried out on a 5-axes ultraprecision machine tool with 3 hydrostatic linear axes and 2 air bearing rotational axes. For the grinding experiments single layered, electroplated, coarse grained diamond wheels with a grain size of d_G = 151 and 181 µm, stochastic grain distribution (D151-100 and D181-100) and active brazed, defined grain patterns (D181-ETHZ) were applied. All grinding wheels have been dressed by a special conditioning process which leads to uniform abrasive grain protrusion heights and flattened grains (Figure 1).

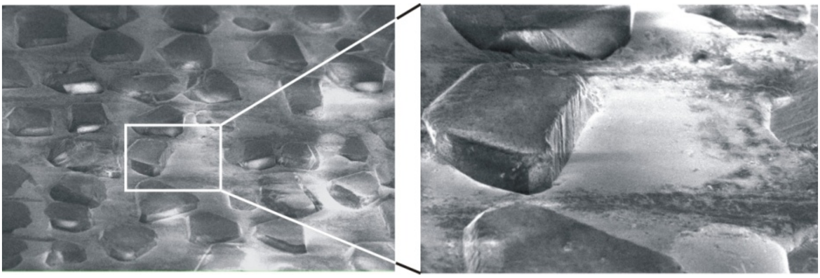
Figure 1: SEM Image of dressed Engineered Grinding Wheel

The dressing progress is quantified by the cumulative collision number i_d [4], representing the number of collisions of the engineered grinding wheel grains with the abrasives of the dressing wheel. During the grinding experiments the process forces were recorded by a 3-channel force dynamometer.

3 Results

Figure 2 shows the influence of the collsion number i_d on the specific normal and tangential grinding forces F'_n and F'_t for machining SF57 glass with three different types of engineered grinding wheels.

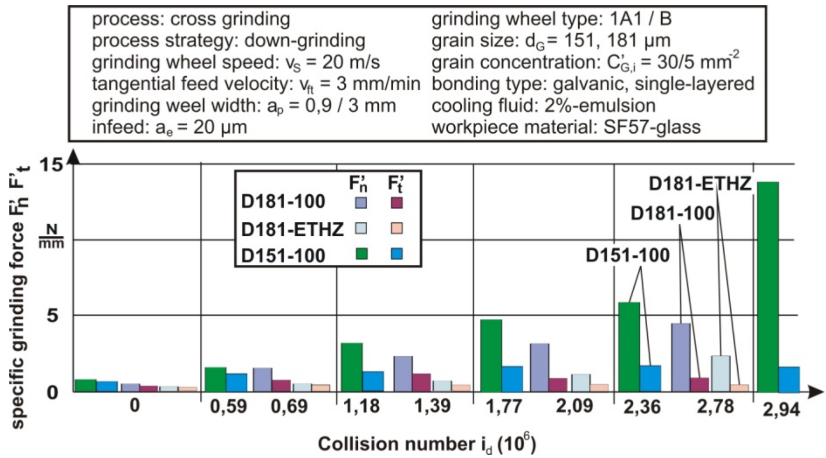

Figure 2: Specific process forces of ground SF57 glass

The specific force values show a linear trend for all grinding wheels due to the increasing collsion number i_d during the dressing process. This leads to an increasing grain plateau area of the flattened diamond grains on the envelope of the grinding wheel which results in higher grinding forces. All grinding wheels show a clear increase of the grinding forces. Especially the specific normal force F'_n of the grinding wheel type D151-100 increase up to 14N while the specific normal force F'_n of the grinding wheel type D181-100 and D181-ETHZ rises up to 4N and 2N respectively. Figure 3 shows the surface roughness Sa and Sz with respect to the collision number i_d of the engineered grinding wheels. The surface roughness decreases with increasing collision numbers i_d because the cutting mechanism turns into ductile removal (cf. Figure 4, right).

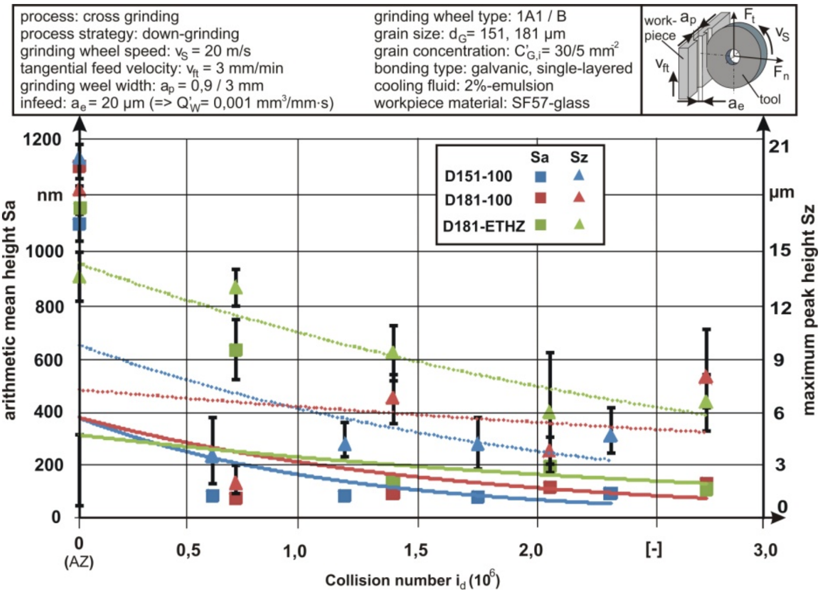

Figure 3: Surface roughness parameters Sa and Sz of SF57 glass ground with dressed engineered wheels

Initially individual, exposed grains generate deep grooves (Figure 4, left) while dressed grains have been flattened and the material was cut in ductile mode (Figure 4, right). The local overload of the material caused by sharp and pointed diamond grains leads to brittle material removal and, thus, high surface roughness.

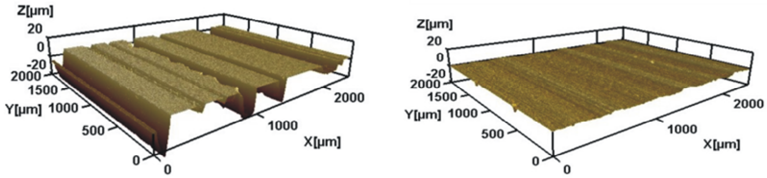

Figure 4: Surface topography of SF57 glass ground with engineered wheel in the initial state (left) and dressed state (right)

Especially the decrease of the surface roughness from the initial state to the state after first conditioning is noteworthy. An exception is the grinding wheel type D181-ETHZ. Due to the defined grain pattern of the grinding wheel the gaps between the grains are quite large. Therefore, also after the first conditioning only some few grains machine the workpiece, which results in higher surface roughness compared with the grinding wheels with stochastic grain distribution (D151-110 and D181-100).

4 Conclusion

The grinding results show that not only fine grained diamond wheels but also precisely dressed engineered grinding wheels can be applied to machine SF57 glass in optical quality. The grinding wheel topography of the engineered grinding wheels has a strong positive influence on surface roughness. The intention for the future is to investigate the sub-surface damage of ground glass substrates.

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