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Using Acoustic Emissions for an in-situ evaluation of the polishing process and its parameters

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Abstract. Mechanical chemical glass polishing is a complex process with mechanical and chemical interactions. While we have used Acoustic Emissions (AEs) already for basic measurements, we have researched the process and its parameters e.g., the density of the polishing slurry or the glass type for further investigation. We also have carried out crack tests on samples to investigate the crack mechanism. We suggest the further investigation of AEs to improve the above mentioned process and to prepare a transfer of this approach for further processes.

1 Introduction

Acoustic Emissions (AEs) are waves (stress or pressure) that are generated during a dynamic process in the material [1]. They are used for mainly three applications: structural testing and surveillance, process monitoring and control, and material characterization [2].

We have been using AEs to monitor the glass polishing process. The goal is the understanding of processes within glass polishing. We want to use this method to improve the polishing process, may it be in terms of the quality of the final product or a more reliable process.

During our first research, we focused on the general form of the polishing process and first preliminary results [3] and the evaluation of the signal [4]. We could demonstrate at least a falling trend for the RMS value of AEs during polishing with decreasing loudness.

In this further work, we investigated the situation during polishing with different polishing slurry densities and the research of a crack formation. In our first works, we could see a break of the glass sample during polishing. We wanted to isolate the cracking on a sample to see the effect of a single cracking.

2 Glass polishing – process overview

Glass polishing is the process of removing the roughness and surface defects after grinding a sample. It is a complex process with overlapping chemical and mechanical effects, also described as “chemical process within the presence of mechanical friction” [5]. More than 20 parameters interact in the process, making it complex to improve and control [6]. The influence of the chemical contribution of the polishing must not be underestimated and goes so far, that some research speak of a “chemical tooth” of polishing grains [7].

Glass polishing produces an optical functional surface that can be coated in the following process step [6]. Parameters to describe the efficiency and quality of the polishing process are the material removal rate (MRR) and the roughness in nm of the final workpiece after polishing. Both parameters depend heavily on the material parameters of glass, polishing grains, polishing carrier, and machine settings.

We are carrying out a synchro speed polishing process on a commercial polishing machine (Stock RSP 40). This machine is a standard polishing machine. Within this machine, we integrated a microphone for AEs. The microphone is connected to a so-called conditionWave system (company Vallen). All components are commercially available.

3 Experiments

For this work, we focused mainly on two points: researching the effect of the density of polishing grains on the AEs and the polishing process and to improve our knowledge about the breaking of glass. In our first investigations, we were able to measure the breaking of glass.

3.1 Variation of the CeO_2 amount

For standard polishing tests, the amount of polishing material (PZ-500, CeO_2) should be 40 g/l. This leads to a density (measured) of about 1.025 g/cm3. The tolerated density range is 1.020 to 1.030 g/cm3.

For our experiments, we polished a Fused Silica (FS) glass sample with 1250 RPM and a pressure of 0.7 Bar. The polishing carrier was LP-87.

The amount of PZ-500 is 0 g, 20 g, 40 g (standard value), 80 g, 120 g. Every combination is repeated three times, while the first glass of each combination is polished in two steps. This is done to see the roughness development during polishing.

3.2 Investigation of cracks

It was possible to see the development of a crack off the sample during polishing in previous works (compare fig. 2). We wanted to isolate the breaking of a glass sample for further investigation and to check, whether it was

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possible to see the cracking of the glass within the frequency spectrum.

To investigate this, we connected the microphone for AEs with a glass plate for microscopy. The glass plate was broken after that while recording the AEs.

4 Results

The amplitude of the AEs changes with the amount of CeO_2. With 0 g CeO_2, it is about 0.003 to 0.004 mV. Later it decreases to about 0.0025 mV (20 g, 40 g, and 80 g) and then goes down to 0.0015 mV (120 g). We assume a different distribution of grains and a more "stable" polishing situation being responsible for this effect. Fig. 2 shows the development of the MRR during the process. It is visible, that the MRR increases with the amount of CeO_2 until a certain point and then decreases slowly.

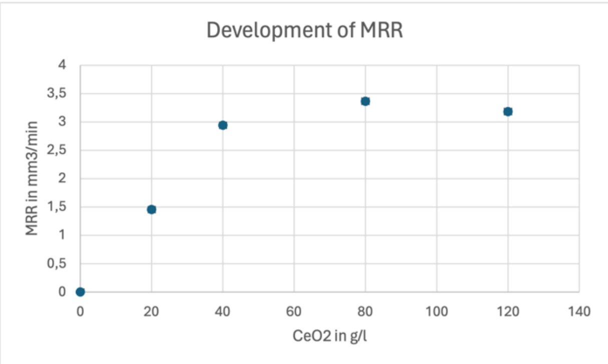

Fig. 2. Development of the MRR with the addition of CeO_2.

Fig. 3 shows the roughness development on a logarithmic scale. The roughness decreases with an increasing amount of CeO_2.

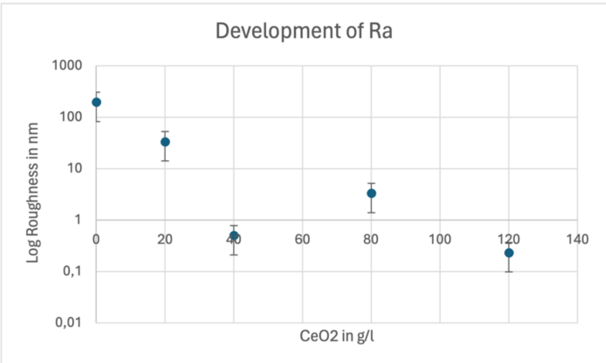

Fig. 3. Development of the roughness Ra with the addition of CeO_2.

We were able to see the breaking of a glass during polishing [4]. Using this graph as a starting point, we wanted to evaluate the change of the signal in the frequency space for an isolated glass breaking (without machine influences). Figure 4 shows the result of a selected experiment.

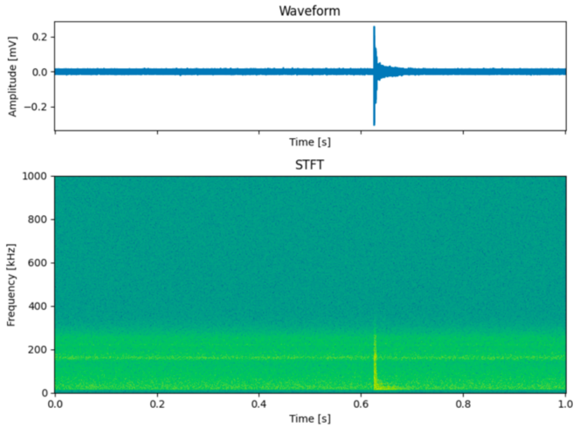

Fig. 4. Isolated breakage of the glass and change in the frequency spectrum.

5 Conclusion

AEs allow an insight the behaviour of the polishing slurry with varying amounts of polishing grains. It also enables the detection of a crack during processing. This crack is also good visible in the frequency space. The shown examples show the high potential of AEs for an automated process monitoring.

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